Volume I - June 2013

Final Environmental Impact Statement

Outdoor Research, Development, Test & Evaluation Activities

Naval Surface Warfare Center, Dahlgren Division

Dahlgren, Virginia

NSWCDD-AP-12-00299 Statement A: Approved for Public Release. Distribution is Unlimited.

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Department of the Navy
Naval Surface Warfare Center, Dahlgren Division,
in accordance with Chief of Naval Operations
Instruction 5090.1C CH-1;
pursuant to National Environmental
Policy Act Section 102(2)(C)

Final Environmental Impact Statement
Outdoor Research, Development, Test & Evaluation Activities
Volume I

Naval Surface Warfare Center, Dahlgren Division
Dahlgren, Virginia
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Abstract

This EIS has been prepared by the US Department of the Navy, Naval Surface Warfare Center, Dahlgren Division (NSWCDD) to evaluate the effects of expanding research, development, test and evaluation (RDT&E) activities within the Potomac River Test Range and Explosives Experimental Area complexes, the Mission Area, and special-use airspace at Naval Support Facility (NSF) Dahlgren. These capabilities include outdoor operations that require the use of ordnance (guns and explosives), electromagnetic energy, lasers, and chemical and biological simulants (non-toxic substances used to mimic dangerous agents). The purpose of the Proposed Action is to enable NSWCDD to meet current and future mission-related warfare and force-protection requirements by providing RDT&E of surface ship combat systems, ordnance, lasers and directed energy systems, force-level warfare, and homeland and force protection. The need for the Proposed Action is to enable the Navy and other stakeholders to successfully meet current and future national and global defense challenges by developing a robust capability to carry out assigned RDT&E activities at NSF Dahlgren. Three alternatives are analyzed in this EIS: the No Action Alternative, which addresses historical and current mission activities; Alternative 1 which addresses baseline activity levels plus known future requirements; and Alternative 2, which addresses current baseline requirements, known future requirements, and projected increases in the foreseeable future based on current trends. Potential effects associated with the alternatives have been identified and evaluated. The Navy concludes that for all three alternatives there would be no significant impact to land use and plans, coastal zone resources, socioeconomics, low-income and minority populations, children, utilities, air quality, noise levels, cultural resources, hazardous materials and hazardous waste, health and safety, geology, topography, soils, and sediments, water resources, and biological resources.

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EXECUTIVE SUMMARY

ES.1 Introduction

Naval Surface Warfare Center, Dahlgren Division (NSWCDD), the action proponent, proposes to expand research, development, test, and evaluation (RDT&E) activities within the Potomac River Test Range (PRTR) and Explosives Experimental Area (EEA) Range complexes, the Mission Area, and special-use airspace (SUA) at Naval Support Facility Dahlgren (NSF Dahlgren). NSWCDD is a tenant upon NSF Dahlgren on the western shore of the Potomac River in King George County, Virginia (Figure ES-1, NSF Dahlgren Location). NSF Dahlgren, a United States (US) Department of the Navy (Navy) facility under the supporting command of Naval Support Activity, South Potomac, Naval District Washington, is located 25 miles (mi) east of Fredericksburg, Virginia and 53 mi south of Washington, DC. NSWCDD is one of the Naval Sea Systems Command (NAVSEA) surface warfare centers. NSWCDD has multiple sites, but this environmental impact statement (EIS) concerns NSWCDD's range and mission area operations at Dahlgren, Virginia and hence will be referred to as NSWCDD in this document.

The EIS focuses on RDT&E activities that take place outdoors and have the potential to affect the human environment. Much of NSWCDD's research and development takes place inside laboratories and does not generate environmental impacts on the human environment outdoors. NSWCDD's Safety and Environmental Office ensures that no indoor impacts take place. Many of NSWCDD's outdoor activities, such as tests of passive sensors, also have no environmental impact, as determined by NSWCDD's Safety and Environmental Office, and are not considered in this EIS. The operating ranges, mission area, and SUA at NSF Dahlgren are shown on Figures ES-2 (Potomac River Test Range Complex), ES-3 (Range Complexes and Mission Area), ES-4 (Special-Use Airspace), and ES-5 (Potomac River Test Range Primary Gunnery Target Area).

The environmental impact analysis in this EIS addresses activities that take place outdoors on range complexes and in the Mission Area. The analysis does not encompass all of NSWCDD's work, much of which takes place indoors in laboratories. These indoor activities are addressed in other NEPA documents – environmental assessments or categorical exclusions, as appropriate. However, the cumulative impacts of NSWCDD's indoor activities when combined with outdoor activities taking place on range complexes and the Mission Area are considered in the cumulative impact analysis in this EIS.

ES.2 Purpose and Need

The **purpose** of the Proposed Action is to enable NSWCDD to meet current and future mission-related warfare and force-protection requirements by providing RDT&E of surface ship combat systems, ordnance, lasers and directed energy, force-level warfare, and homeland and force protection.

Under 10 United States Code (U.S.C.) § 5062(d): "The Navy shall develop aircraft, weapons, tactics, technique, organization, and equipment of naval combat and service elements. Matters of joint concern as to these functions shall be coordinated between the Army, the Air Force, and the

Navy." The **need** for the Proposed Action is to enable the Navy and other stakeholders to successfully meet current and future national and global defense challenges required under U.S.C. by developing a robust capability to carry out assigned RDT&E activities on range complexes, in the Mission Area, and in SUA at NSF Dahlgren.

ES.2.1 Proposed Action

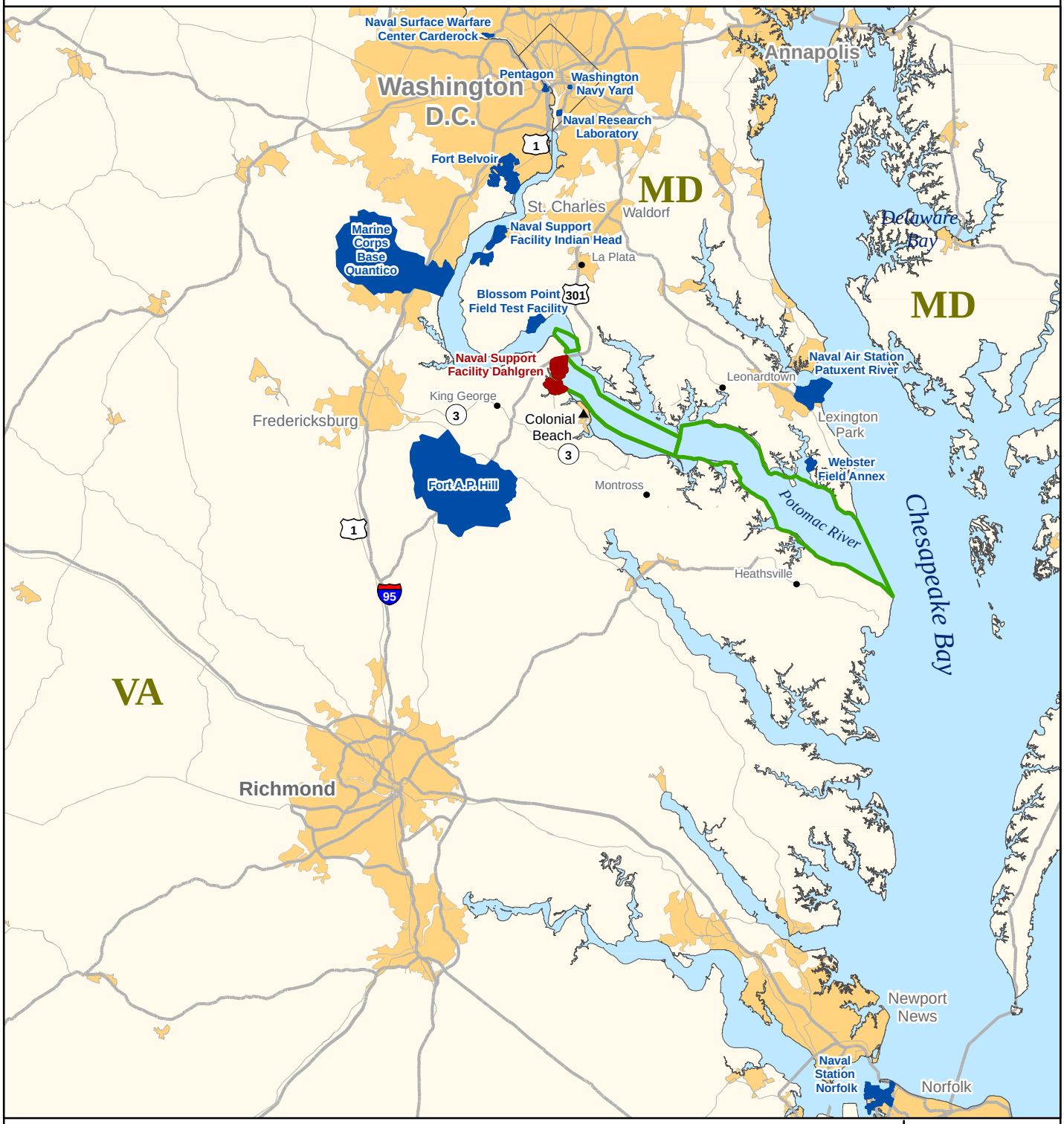
The Proposed Action evaluated in this EIS is to expand NSWCDD's RDT&E activities within the PRTR and EEA Range complexes, the adjoining Mission Area, and SUA. These activities include outdoor activities that require the use of:

- **Ordnance** – Since its beginnings in 1918 as the US Naval Proving Ground, NSWCDD has been doing proof testing, lot acceptance[1], safety testing, and RDT&E for small- and large-caliber guns (refer to Table ES-1) , and many other types of military munitions[2], some of which result in detonations. Today it is the Navy's primary center for such work. The Proposed Action would increase small-arms firing and detonations annually. Large-caliber gun firing would remain at current levels. Firing into the PRTR's upper Lower Danger Zone (LDZ) (Figures ES-2 and ES-5) would increase to a maximum of 10 days a year, which represents an increase over recent firing levels in this target area.
- **Electromagnetic (EM) Energy –** EM energy is naturally occurring and man-made energy created by the interaction of fluctuating electrical and magnetic forces that travel through space at the speed of light. The equipment used outdoors at NSWCDD emits EM energy in a frequency range that includes radio waves or radio frequency, microwaves, and infrared, visible, and ultraviolet light. Many types of EM energy emitters are present at NSWCDD, ranging from everyday, low-power radios, cell phones, and car door openers, to higher-power radars and sophisticated, one-of-a-kind test equipment used to test whether electronics and ordnance can withstand pulses of EM energy. Only emitters requiring safety zones when operating because their power, frequency, and exposure levels are above established standards for hazards of EM energy to personnel, ordnance, fuel, and/or EM interference are discussed in this EIS. The 2005 Defense Base Closure and Realignment (BRAC) Commission, which reviewed the work of all Department of Defense installations, identified NSWCDD as a center of excellence for weapon systems integration, which involves RDT&E for communications and sensors that use EM energy. NSWCDD is also the Navy's lead laboratory for the RDT&E of issues surrounding EM environmental effects. The Proposed Action would increase the number of annual activities and the power level of some activities; expand activities on the PRTR; and increase use of platforms such as unmanned systems to transmit, receive, or reflect EM energy.

[1] In order to minimize ordnance malfunctions at sea, the Navy randomly tests one or more pieces of ordnance in a lot provided by a contractor. On the basis of information yielded by the sample, a decision is made by the Navy whether to accept or reject the whole lot.

[2] U.S.C. Title 10, Section 101 defines "military munitions" as all ammunition products and components produced for or used by the armed forces for national defense and security, including ammunition products or components under the control of the Department of Defense, the Coast Guard, the Department of Energy, and the National Guard.

Location of Naval Support Facility (NSF) Dahlgren



County Seat

Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR)

Military Installation

Urban Area

20 0 20 Miles

30 0 30 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Figure ES-1

Source: NSWCDD GIS (2008 - 2011)

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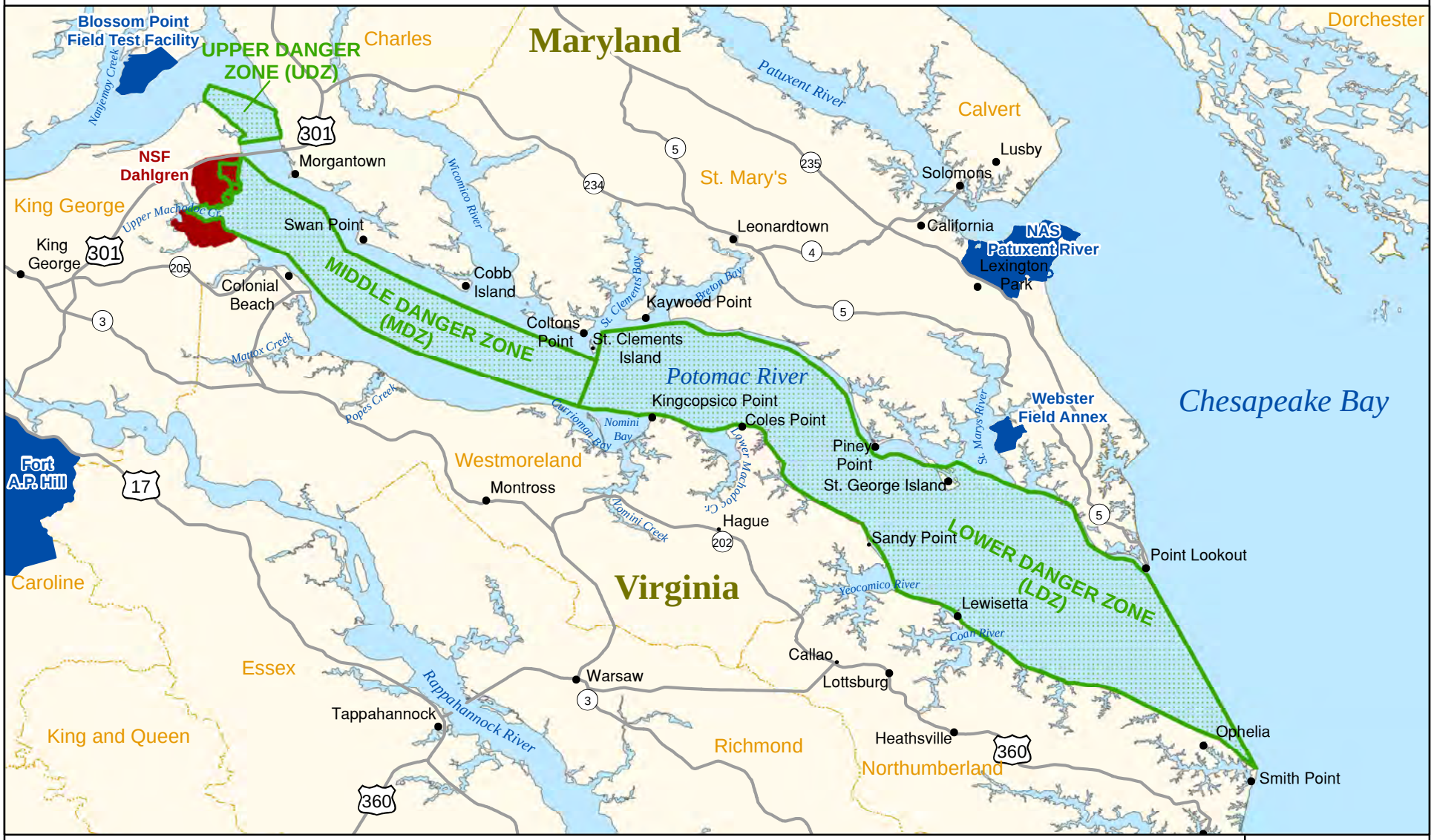
Potomac River Test Range Complex



Potomac River Test Range (PRTR) Complex
Naval Support Facility (NSF) Dahlgren
Military Installation

7 0 7 Miles

11 0 11 Kilometers

Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

NSWCDD EIS

Figure ES-2

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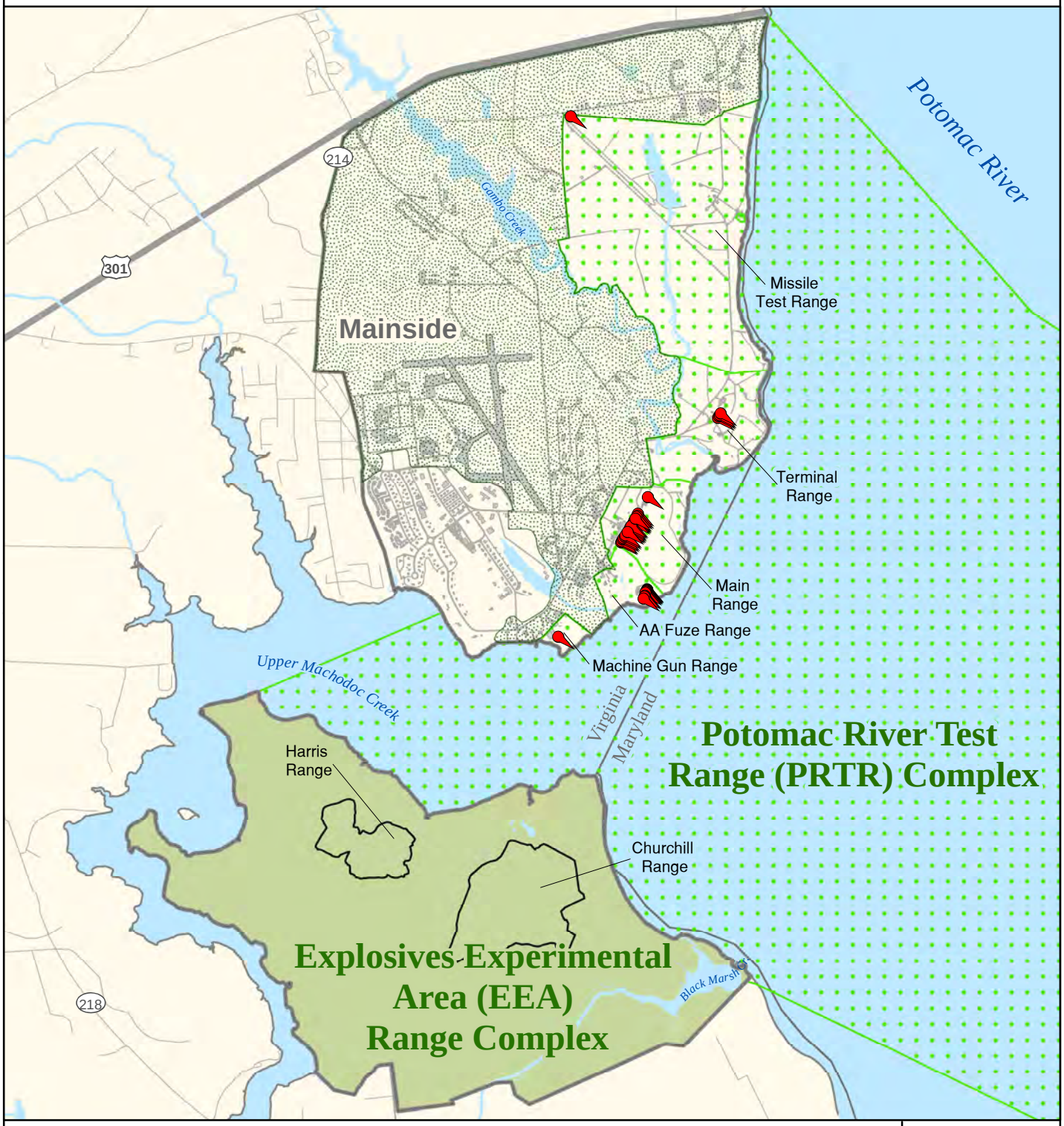
Range Complexes and Mission Area



Gun Firing Location

Potomac River Test Range (PRTR) Complex

Mission Area

Explosives Experimental Area (EEA) Range Complex

Naval Support Facility (NSF) Dahlgren

Source: NSWCDD GIS (2008 - 2011)

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Figure ES-3

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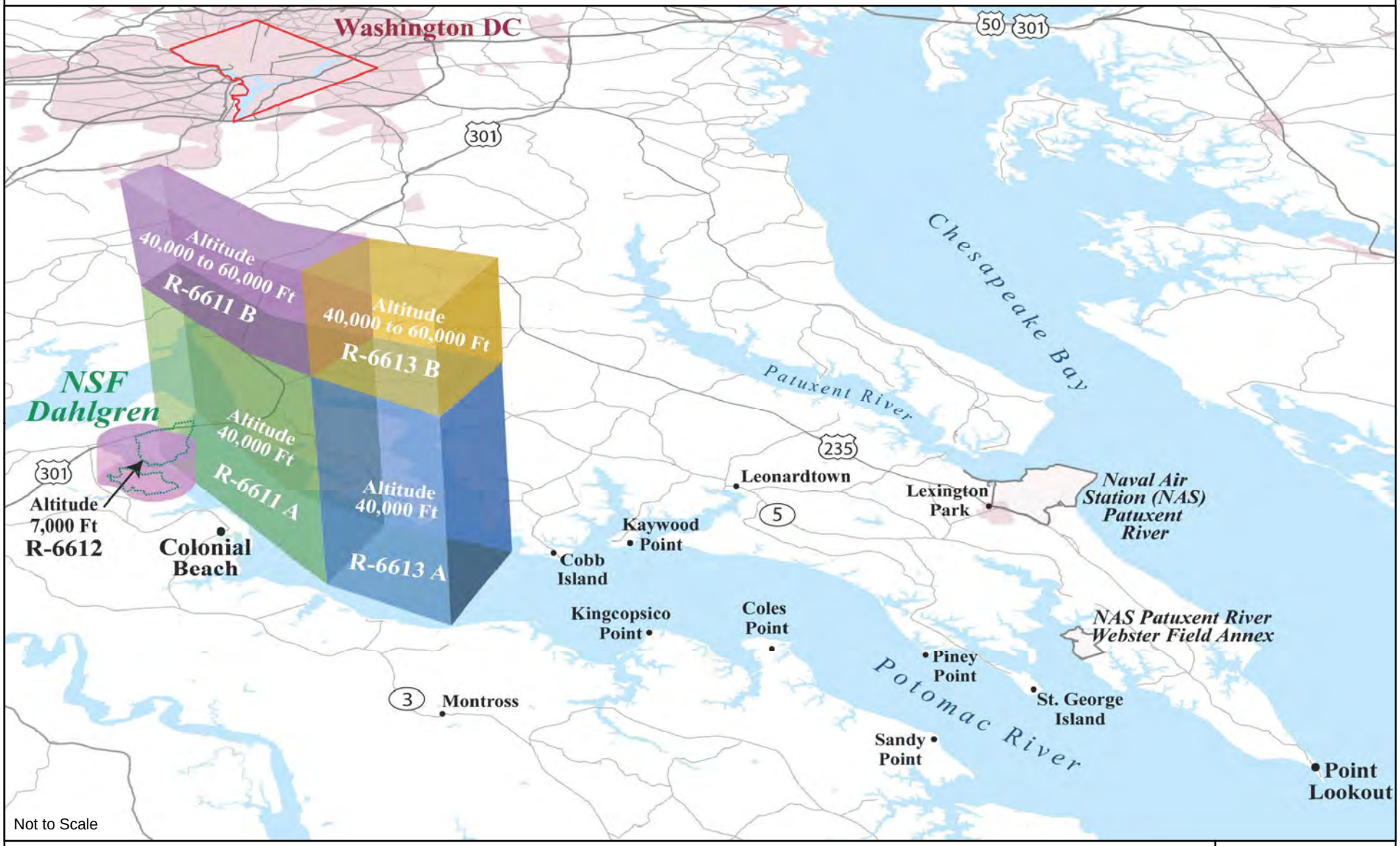
Special-Use Airspace



NSWCDD EIS

Source: FAA, 2005.

Figure ES-4

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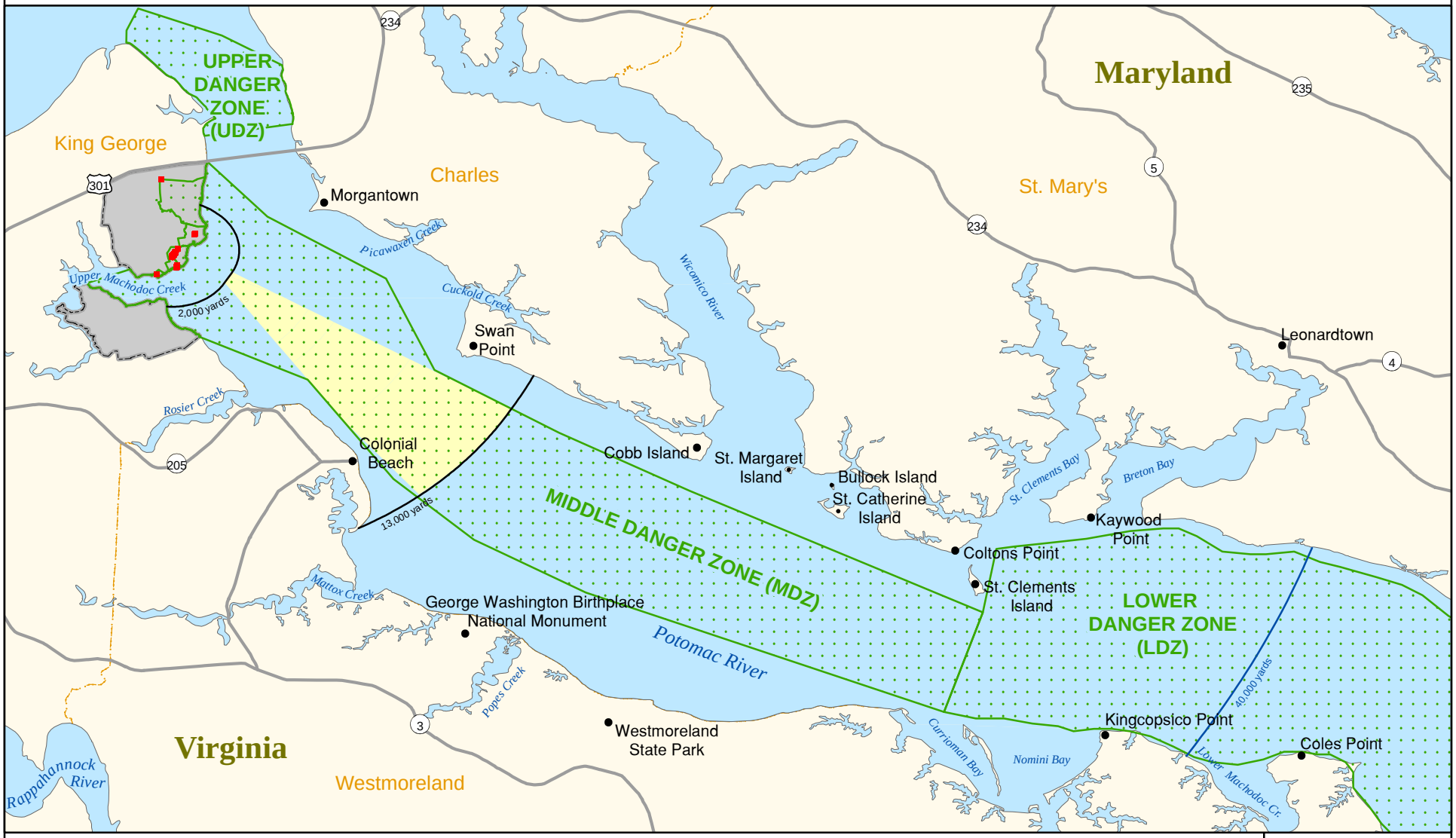
Potomac River Test Range Primary Gunnery Target Area



Gun Firing Location

Primary Target Area

Maximum Firing Range (see definition in Section 1.5.1)

Potomac River Test Range (PRTR) Complex

Naval Support Facility (NSF) Dahlgren

3.5 0 3.5 Miles

5.5 0 5.5 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure ES-5

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- **High-energy (HE) Lasers –** While HE lasers are a form of EM energy, they are treated separately in this EIS because of their unique properties, which create different types of hazards from other EM sources. A laser is a device that emits a coherent beam of light (EM energy). Most light (non-laser) is incoherent, meaning it is made up of many frequencies. Lased light is light of a single frequency, so it does not scatter but rather stays in a narrow, intense beam without dissipating quickly. NSWCDD's laser program, which began in the 1970s, has been recognized by the Navy as a center of excellence for laser RDT&E. NSWCDD's expertise in laser safety and lasers includes RDT&E of sensors, rangefinders, target designators, guidance systems, simulators, communications equipment, and weapons. The Proposed Action would increase the number of annual HE laser activities and the power level of some activities; expand activities on the PRTR; and increase use of platforms such as unmanned systems to serve as laser emitters, targets, or reflectors.
- **Chemical and Biological (Chem/Bio) Simulants –** The threat of terrorist attacks has prompted the Department of Defense to step up RDT&E to counter chem/bio terrorism. Chem/bio agents are very difficult to detect, and the key to minimizing the effects of an attack is early detection and warning. As the Navy's center for RDT&E on chemical and biological warfare sensors and protection systems, NSWCDD uses chemical simulants rather than dangerous agents in the open air to test detection and protection systems. NSWCDD conducts research indoors in the laboratory before tests are performed outdoors. Simulants are substances – many of which are found in common, everyday use, such as acetic acid (strong vinegar) and oil of wintergreen – that mimic chemical and biological agents but do not have the agents' adverse health and environmental effects. The Proposed Action includes increasing the annual number of outdoor test events using chemical simulants, introducing biological simulants, and expanding the areas where testing could take place. The biological simulants proposed for use would be biosafety level 1 (BSL-1) organisms, defined by the Centers for Disease Control and Prevention as well-characterized strains of viable microorganisms not known to consistently cause disease in healthy adult humans and of minimal potential hazard to laboratory personnel and the environment. At the BSL-1 level, precautions against the biohazardous materials are minimal. BSL-1 organisms used as biological simulants may include common bacteria, fungi, proteins, and/or bacteriophages that are naturally found in the environment. The chemical and biological simulants selected would be influenced by parameters such as global threats, homeland security, and technological developments.

Under the Proposed Action, the average number of events that could take place annually would increase above recent levels (with the exception of large-caliber gun firing events). To ensure that equipment and materials work effectively even in less-than-ideal conditions, some of the tests would take place under conditions in which they are not currently conducted, such as at dusk, dawn, and night and in adverse weather.

ES.3 Public Involvement

Public involvement is an integral component of the NEPA process, and the Navy has both kept the public informed as well as listened to what the public has to say about the Proposed Action. NSWCDD developed a public-outreach program specifically for this EIS. The program began in

2003 with 96 interviews with various community leaders, business owners, on-base residents, and residents of the five counties bordering the PRTR about their concerns with respect to NSWCDD's current activities. Drawn from the interviewees, a Public Involvement Working Group was formed, which helped to develop messages and materials for the public. The concerns of those interviewed and the Public Involvement Working Group members were taken into consideration in developing the work plan for the EIS.

The next step in the program was notifying the public that NSWCDD was considering expanding certain RDT&E activities and was going to prepare an EIS to evaluate potential impacts. A Notice of Intent to prepare an EIS was published in the *Federal Register* on June 18, 2007 (72 Federal Register 33456). Soon after, notices were placed in six newspapers in the counties around the PRTR and letters were sent to public agencies, advising readers of the EIS process and inviting them to come to one or more of five public scoping meetings held in the counties around the PRTR to learn more about, and comment on, the proposed scope of the EIS. The scoping meetings – one in each of the counties around the PRTR: King George, Westmoreland, and Northumberland counties in Virginia; and Charles and St. Mary's counties in Maryland – were held in the last two weeks of July 2007. Seventy-seven people attended. Comments were received from twenty-one individuals and three agencies (the Virginia Department of Environmental Quality, the Virginia Department of Game and Inland Fisheries, and the Maryland Transportation Authority).

Subjects raised during the scoping process included NSWCDD's mission, noise and vibration, the environment, the scoping meeting format, socioeconomics, public safety, human and animal health, wildlife resources, EIS content, air space, coastal consistency, air quality, and the Harry W. Nice Memorial Bridge improvement project.

When the Draft EIS (DEIS) was completed, a notice of availability was published in the *Federal Register* on August 17, 2012, beginning a 45-day public review period during which the DEIS was available for review in five local libraries, on the project website, or by mail, upon request. Letters indicating that the DEIS was available for review were sent and notices of the DEIS' availability were published in local newspapers. Public hearings were held to describe the environmental impacts of the Proposed Action and alternatives and to receive comment on the impacts analysis. These comments have been taken into consideration in preparing this Final EIS (FEIS).

Public hearings for the DEIS were held in King George and Westmoreland counties, Virginia, and Charles County, Maryland the week of September 10, 2012. Twenty-nine people attended the hearings. By the end of the comment period, comments had been received from ten individuals, two non-governmental organizations, and 15 public agencies. These comments were submitted orally or in writing at the meetings or by fax, e-mail, or US Mail. Appendix A includes the comments in their original form, and a matrix that includes each comment and a response to the comment, which indicates changes incorporated into the FEIS.

ES.4 Operational Range Complexes and Mission Area

NSWCDD's RDT&E activities take place on the operational range complexes, the Mission Area, and SUA at NSF Dahlgren:

- **Potomac River Test Range (PRTR) Complex** – The PRTR Complex consists of land and water test areas that support RDT&E for ordnance, EM energy, HE lasers, and chemical defense. Figures ES-2, ES-3, ES-4, and ES-5 show the water areas and land ranges that comprise the PRTR, and the special use airspace that lies over it.

  The PRTR Complex allows the Navy to conduct testing in a realistic, controlled environment, which effectively operates as a "ship on shore," collecting real-time data from a number of instrument stations. The water portion of the range is 51 nautical miles long, covers 169 square nautical miles, and is divided into areas designated on nautical charts as the Upper, Middle, and Lower Danger Zones (UDZ, MDZ, and LDZ, respectively)[3]. The upper half of the MDZ receives the heaviest use; it is 2.6 nautical miles wide, 15.4 nautical miles long, and covers 38.5 sq nautical miles (Figure ES-5). Public use of the danger zones is restricted during test events by NSWCDD range control boats and by staff observers stationed at range stations along the Potomac River. Gun firing can be performed up to 40,000 yards (approximately 20 nautical miles) down range (Figure ES-5).

  Testing over water is vital when evaluating the performance of detection and engagement systems such as radars and electro-optical tracking systems to ensure that systems work over water as well as they do on land. The over-water range provides tracker and sensor testing with low over-water targets in situations in which background clutter, reflectivity, and wave height conditions can all vary. The range has a comprehensive instrumentation system, with both fixed and mobile components located along the PRTR to accurately measure test results. The PRTR also serves as a safety buffer for land-based range activities.

  The 725 acres (ac) of land ranges that are part of the PRTR Complex (Figure ES-3) include the Main Range, Anti-Aircraft Fuze Range (a name assigned during World War II – the range is no longer used for anti-aircraft RDT&E), Missile Test Range (another historical name – the range is no longer used for testing missiles), Machine Gun Range, and Terminal Range.

- **Explosives Experimental Area (EEA) Range Complex** – The 1,641-ac EEA Range Complex (Figure ES-3) supports performance, lethality, safety, and ordnance testing on full-scale weapon systems and components containing explosives, propellants, and inert materials. Although the EEA mainly supports RDT&E and safety testing for ordnance weapon systems, such as rocket-propelled grenades, rockets, and restrained missile launchers, this complex also supports RDT&E of EM energy and lasers. The EEA is extensively instrumented for conducting explosive tests such as blast measurements, target testing, arena testing, and live-fire tests. Two ranges – Churchill and Harris – are located within the EEA, as are two EM energy test facilities.

- **Mission Area** – The 1,593-ac Mission Area (Figure ES-3) lies immediately north and west of the PRTR land ranges and is used by NSWCDD for RDT&E activities that do not use explosives. Facilities in this area include the NSF Dahlgren Airfield and EM energy facilities.

[3] The limits of the danger zones are defined in 33 Code of Federal Regulations (CFR) § 334.230 and shown on the National Oceanic and Atmospheric Administration's Nautical Charts: 12288, Lower Cedar Point to Mattawoman Creek; 12286, Potomac River – Piney Point to Lower Cedar Point; and 12233, Chesapeake Bay to Piney Point.

- **Special-Use Airspace (SUA)** – SUA has been established by the Federal Aviation Administration to prevent hazards to aircraft from NSWCDD's RDT&E activities (Figure ES-4). The maximum altitudes are 40,000 feet for Restricted Areas (R)-6611A and R-6613A, and 60,000 feet for R-6611B and R-6613B. For safety reasons, flying through special-use airspace by non-military aircraft is restricted during testing. When testing is completed early or a scheduled test is cancelled, the airspace is returned to the control of the Federal Aviation Administration for normal civilian air traffic use. Additionally, a small restricted airspace – R-6612 – lies directly over the EEA, and extends to 7,000 feet. Helicopters occasionally use the main airfield. Unmanned aerial vehicles, which fly only within the special-use airspace, are either launched from small launchers or take off and land at small landing strips on the EEA and Terminal Range.

ES.5 Alternatives

ES.5.1 Development of Alternatives

The process of developing alternatives began by establishing NSWCDD's RDT&E activity baseline. NSWCDD's programs are diverse and numerous. Over several years, the EIS team interviewed the managers of 75 NSWCDD programs at least once, with subsequent interviews focusing on programs that were expanding and that had the potential to generate environmental impacts. With extensive knowledge of their field, Department of Defense requirements, customer needs, and future trends, the program managers helped to clarify which programs were growing, describe the ways in which the technology was evolving, and define future RDT&E needs and requirements.

From these interviews and from reviewing range operational logs, the operational baseline for each RDT&E activity was established. In most cases, because of the cyclical nature of RDT&E – which can vary considerably from year to year – the baseline was generated by averaging data collected for the years 1993-2009 and then weighting the data for the highest years in the RDT&E cycle to arrive at an average annual number of large-caliber gun and small arms firings; detonations; EM energy, HE laser, and chem/bio sensor events; and PRTR use hours. The data collected for those years are typical of activity levels after 2009. The No Action Alternative column in Table ES-1 lists the average annual baseline activity levels.

For each of the components of the Proposed Action, potential alternatives were developed and evaluated based on the following criteria:

Criterion 1 – Accommodate historical and current, baseline RDT&E mission requirements for activities that have the potential to affect human health and/or the environment – namely, those involving ordnance, the use of EM energy, the use of HE lasers, the use of chemical simulants, and the use of the PRTR.

Criterion 2 – Accommodate known future requirements, which include the use of biological simulants alone.

Criterion 3 – Accommodate a margin of growth for those programs for which it is difficult to accurately forecast future needs. Mixtures of biological and chemical simulants would be included.

Criterion 4 –Minimize impacts to commercial and recreational use of the Potomac River.

Table ES-1
EIS Alternatives

RDT&E Activity	No Action Alternative Activity Magnitude	No Action Alternative Average Annual Activity Levels	Alternative 1 Average Annual Activity Levels	Alternative 2 Average Annual Activity Levels
Large-caliber Guns/ Projectiles	>20 mm to 8" caliber gun/ projectile	**4,700 projectiles**	**4,700 projectiles**	**4,700 projectiles**
Small Arms	≤20 mm caliber gun/bullet	**6,000 bullets**	**25,500 bullets**	**30,000 bullets**
Detonations	<0.01 lbs to 1,000 lbs net explosive weight	**190 events**	**200 events**	**230 events**
EM Energy	300 kilohertz to 300 gigahertz frequency 10 Watts to 500 megawatts average power	**490 events**	**590 events**	**680 events**
Lasers	500 nanometers to 11 micrometers wavelength 1 milliwatt to 100 kilowatts maximum power	**60 events** 100 kW maximum power	**125 events** 500 kW maximum power	**145 events** 500 kW maximum power
Chemical & Biological Defense	≤20 gals/event	**12 events** Chemical simulants only	**60 events** Chemical and biological simulants used separately	**70 events** Chemical and biological simulants used separately and together
PRTR Use	750 hours total annual use	**750 hours**	**870 hours**	**1,000 hours**

Alternatives that do not accommodate historical and current, baseline RDT&E mission requirements and known future requirements – and therefore do not meet Criteria 1 and 2 – do not satisfy the purpose and need for the Proposed Action and are considered unreasonable. Such alternatives were eliminated from further analysis, as were alternatives that substantially increase use of the PRTR beyond levels proposed in Alternatives 1 and 2 and therefore do not meet Criterion 4.

NSWCDD considered an alternative that would utilize the range complexes, the Mission Area, and SUA, to the maximum extent possible – up to 1,800 hours a year compared to the current 750 hours – in order to accommodate the maximum amount of growth in mission operations. This increase would more than double the number of hours during which public access could be restricted. While this theoretical increase in current outdoor RDT&E activity levels would use the range complexes and the Mission Area to the fullest feasible level, the alternative would require substantial increases in public access restrictions to the PRTR, negatively affecting public commercial and recreational use of the river well beyond the levels resulting from implementing either Alternative 1 or Alternative 2. For almost three-quarters of a century, the

Navy and its community neighbors in Virginia's Northern Neck and Southern Maryland have prospered in a much-treasured partnership that was established and is secured by the common bonds of friendship, patriotism, national defense, and economics. NSWCDD actively engages with the local community to maintain this partnership. Because this alternative would not meet Criterion 4, it was dismissed from further consideration.

The activities that comprise the Proposed Action are not new technology, nor are they programs new to NSWCDD, but rather expansions of current programs based at NSWCDD. Relocation of these programs is neither desirable nor feasible. It would involve moving existing, active programs from NSWCDD to a new location, which would needlessly disrupt program operations, cause unnecessary delays, and generate substantial additional costs, all without any additional benefits. The 2005 Defense Base Closure and Realignment (BRAC) Commission concurred with this thinking and recommended that NSWCDD's programs remain in place. Therefore, the Navy concluded that no other location for expanding these programs was a reasonable alternative.

Operations, Tests, and Events

An **operation** is a group of **tests** that has a common objective and that may take place over one or more days under one standard operating procedure (SOP). For purposes of this EIS, an **event** consists of all the tests that take place under one SOP on one day. If the same test occurs the following day, it is considered a separate event. If two groups of tests are conducted on the same day under separate SOPs, then each group counts as a separate event.

Standard Operating Procedure

A **standard operating procedure (SOP)** is prepared for every operation determined by performance of a **risk hazard assessment** to be potentially hazardous**.** SOPs are prepared to ensure the safety of participants and the public and to minimize environmental impacts. An SOP includes a description of the proposed operation; a statement of responsibilities; a listing of which persons will be in charge of what actions; the operational location; a description of personnel and material limits (including buffer zones for safety); safety requirements; emergency response and contingency plans; applicable environmental protection procedures; security requirements; a hazard control brief; an equipment list; and step-by-step descriptions of the procedures to follow, with highlighted warning and caution boxes.

The process resulted in the development of three alternatives:

- **No Action Alternative** – This alternative constitutes baseline activity levels for the portion of NSWCDD's outdoor activities that have the potential to affect the human environment – namely, those involving ordnance, the use of EM energy and HE lasers, the use of chemical simulants, and the use of the PRTR. This alternative meets Criteria 1 and 4.
- **Alternative 1** – This alternative includes baseline activity levels plus reflects the growth necessary to meet the minimum RDT&E mission requirements in the reasonably foreseeable future, and constitutes increases in current activities of: 108 percent for laser events, 20 percent for EM energy events, 325 percent for small-arms firing, 5 percent for detonations, 400 percent for chem/bio events, and 16 percent for PRTR hours of use. Large-caliber gun activities would remain at baseline levels. This alternative includes outdoor use of chemical and biological simulants separately. Alternative 1 meets Criteria 1, 2, and 4.
- **Alternative 2** – This alternative is NSWCDD's Preferred Alternative, which provides for roughly 15 percent growth in activity levels above Alternative 1, averaged across activities. There would be increases in all activities except large-caliber gun activities, which would remain at baseline levels. It satisfies current baseline requirements, includes the growth necessary to meet minimum RDT&E mission requirements for the reasonably

foreseeable future, includes the use of biological and chemical simulants together and separately, and includes a margin of growth for the most actively evolving programs – those for which the numbers of future annual test events, firings, and hours of use are harder to predict because of the uncertainties inherent in carrying out RDT&E. Alternative 2 optimizes NSWCDD's outdoor RDT&E activities and meets all four criteria.

Table ES-1 summarizes the annual activity levels for each RDT&E activity proposed under each alternative. The alternatives are described in more detail below.

ES.5.2 No Action Alternative

The annual activity levels for the No Action Alternative constitute the existing baseline condition, and the number of outdoor RDT&E large-caliber gun and small-arms firings, detonations, events, and hours of PRTR use would remain at existing levels. Even though the Navy proposes to increase RDT&E activities, including the No Action Alternative in the evaluation of impacts provides a baseline against which to measure the impacts of the other two alternatives.

Ordnance Activities

Large-caliber guns at NSF Dahlgren mainly fire inert (non-explosive) projectiles (74 percent fired from 1995-2009 were inert) but also fire live (explosive) projectiles into the Potomac River mainly within the PRTR's MDZ but infrequently into the upper LDZ. Live (explosive) projectiles produce noise both at the gun when they are fired and at the target downriver when they detonate. Inert projectiles only produce noticeable noise at the gun when they are fired. The guns range in caliber from more than 20 mm (0.8") up to 8" (203 mm). The largest gun normally fired is the 155 mm (6.1") gun, but it is fired infrequently and usually into a backstop on land. The gun fired most frequently is the 5" (127 mm) gun, which is standard on Navy ships. The 8" gun is no longer used to fire normal projectiles but rather to launch canisters filled with electronics to test how well they can withstand high gravitational forces.

In the years 1995-2009, NSWCDD fired an average of 2,900 projectiles annually, ranging from a low of 910 fired in the year with the smallest number of firings (2005) to a high of 6,170 (all inert) in 2004. In particularly active years since 1995, the average has been approximately 4,700 large-caliber projectiles fired. Not all projectiles go into the river; guns on the Missile Test and Terminal ranges sometimes fire projectiles into backstops on land rather than targets in the river.

NSWCDD's small-arms tests usually employ inert bullets with small propellant charges that produce noise levels that affect a far smaller area than the noise resulting from firing the large-caliber guns. Approximately 10 percent of the bullets are fired into the PRTR. Each bullet fired counts as one of the 6,000 bullets fired annually, on average.

Annual detonations average 190 individual detonations. The explosives used in the ordnance being detonated can vary from less than 0.1 pounds (lbs) up to 1,000 lbs of explosives. Detonations above 200 lbs of explosives are covered with at least eight feet of dirt to minimize noise and fragmentation. Most detonations take place on the EEA Range Complex.

EM Energy Activities

The EM energy devices included operate in the frequency range of 300 kilohertz to 300 gigahertz and at powers ranging from 10 watts up to 500 megawatts. An average of 490 events take place annually, three-quarters of which are ground plane tests of whether electrical and electronic systems can withstand high-power EM energy. The remaining events involve emissions from radars on the Search and Track Sensor Test Site, from the Navy Directed Energy Center to targets on the river or to the Counter Explosive Test Facility, within the Maginot Open Air Test Site, and within the Naval Ordnance Transient Electromagnetic Simulator. Devices, such as radios and range radars with power, frequency, and exposure levels below established thresholds for EM energy hazards to personnel, ordnance, fuel, and EM interference are not included in the Proposed Action.

HE Laser Activities

The HE lasers operated at NSWCDD and included under the No Action Alternative emit focused, coherent (lased) light ranging in power from more than 1 milliwatt (Laser Class 3) to 100 kilowatts (Laser Class 4) in a wavelength range from 500 nanometers to 11 micrometers. Class 3 and Class 4 lasers are HE lasers. Eye-safe Laser Class 1 (such as laser printers) and usually eye-safe Class 2 lasers (such as laser pointers) are not included in the Proposed Action because they have negligible environmental and safety impacts.

NSWCDD currently conducts approximately 60 outdoor HE laser events a year (see "Operations, Tests, and Events" text box for the definition of a laser event). For lasers and EM energy devices, effects are possible only when the device is emitting. The time of emission is usually brief – varying from less than a second to several minutes – and there are no residual effects. However, one event may entail several hundred instantaneous pulses while another event with a different device may be one single pulse of five minutes. Laser corridors over the land ranges and Mission Area as well as over the river from PRTR land ranges to the EEA have been established; laser tests take place on these corridors. Laser beams are directed from either mobile emitters or the Naval Directed Energy Center to strike targets surrounded by backstops.

Chemical Defense Activities

Activities outdoors using chemical simulants have been conducted by NSWCDD since the 1980s on the PRTR Complex. Up to 12 events using chemical simulants are conducted annually. Chemical simulants are dispersed from a blower on a land range or on a barge, helicopter, or small vessel in the MDZ. Detectors, located on a land range or on a barge or small vessel in the MDZ, remotely detect chemical simulant vapors some distance from the source using a scanner, a detector, and an electronics module to process and communicate information.

A chemical defense event is defined in the same way that EM energy and HE laser events are defined (see "Operations, Tests, and Events" text box). The quantities of simulant used for an event may vary depending on the tests being conducted. Each test may include small quantities of a number of simulants or larger quantities of one or two simulants, consisting of no more than 20 gallons of simulant per release or test.

Potomac River Test Range (PRTR) Use

Use of the PRTR for RDT&E activities would remain at present levels, which average approximately 750 hours per year. Use is defined by the number of hours that range control boats are on the PRTR to restrict public access to ensure public safety. For many of these hours, test

set-ups and equipment calibrations are occurring, so testing takes place for only some of the 750 hours. Currently, only access to the MDZ or upper LDZ to 40,000 yards from Main Range (Figure ES-5) is restricted. The MDZ is the area that receives most of the use, and it includes the main gunnery target area (Figure ES-5). Normally, only the part of the range being used is restricted, unless large guns are being fired, in which case, the whole MDZ or upper LDZ is restricted. When the range is in use, vessels are cleared from the range or the part in use to protect their safety. NSWCDD's Range Operations Center works with vessel operators to minimize waits by allowing them to pass by or across the range during lulls in testing. Small watercraft can always pass by the range on the Maryland side even when access to the whole MDZ is restricted. When the range is restricted, small vessels may wait up to 30 minutes to move through, but 10-minute waits are more typical. For deep-draft vessels, which must use the main channel through the range, delays are no more than one hour, and more typically last less than 30 minutes.

ES.5.3 Alternative 1

The numbers shown in the Alternative 1 column of Table ES-1 represent average annual activity levels under Alternative 1 and were determined by combining:

1. An average of the annual number of bullets, events, or hours, as appropriate, for each RDT&E activity from 1993 (1995 for ordnance) to 2009, weighted to take into account years with the highest activity levels (No Action Alternative levels);
2. ***Plus*** growth above No Action Alternative levels necessary to meet known RDT&E mission requirements in the near future.

Ordnance

- There would be no increase in large-caliber gun use, which would vary from year to year but would remain at the current level of approximately 4,700 projectiles on average fired in a particularly active year.
- EM launchers, a type of large-caliber gun using EM energy rather than explosives to fire projectiles, would fire inert, shaped metal projectiles at conventional targets on land and river ranges. Projectile speeds would be no greater than conventional large Navy gun projectile speeds.
- Long-range guns would fire into a target area from 32,000 to 35,000 yards in the upper LDZ approximately 10 days a year, which is more frequently than over the last 15 years.
- Outdoors small arms use would increase more than fourfold from 6,000 to 25,500 bullets fired annually.
- Detonations would increase by 10 detonations, or five percent annually.

EM Energy

- Under Alternative 1, the number of annual events using EM energy would increase from No Action Alternative levels of 490 to 590. This represents a 20 percent increase in the number of tests annually using EM energy in the frequency range of 300 kilohertz to 300 gigahertz and at average powers ranging from 10 watts up to 500 MW.
- Directed EM energy sensors and emitters may be mobile (operating from a moving vehicle or aircraft, for example).

- EM energy may be directed at unmanned aerial vehicles (drones) and unmanned surface vehicles (small vessels on the river) on the MDZ; unmanned surface vehicles may be disabled or destroyed; unmanned aerial vehicles would only be tracked.
- EM energy emitted from a land range or a vessel on the PRTR may be reflected off an unmanned aerial vehicle or similar airborne platform over the horizon to a target on the land ranges or to a platform, such as a barge, located in the UDZ, MDZ, or LDZ.
- Some EM energy operations would take place beyond the normal 8 am to 5 pm, Monday-to-Friday PRTR range schedule because of the increasing need to test systems in all kinds of weather conditions and at dawn, dusk, and at night.

HE Lasers

- Under Alternative 1, the number of HE laser events would increase from current/No Action levels of 60 annually to 125 annually, which is a 108 percent increase.
- The maximum HE laser power levels would increase from the current/No Action Alternative level of 100 kilowatts to 500 kilowatts.
- HE lasers would be directed from land ranges to a target on a barge on the MDZ.
- HE lasers would use tracking to target mobile unmanned aerial vehicles; HE lasers would disable/destroy mobile unmanned surface vehicles on the water and mortar shells in the air.
- HE laser beams emitted from a land range or a vessel on the PRTR may be reflected off an unmanned aerial vehicle or similar airborne platform located over the horizon to a target on land ranges or on various types of platforms, such as a barge, in the UDZ, MDZ, or LDZ.
- If lighter-weight power sources are developed, lasers may be fired from manned and unmanned aerial vehicles at targets on the MDZ water surface.
- Some laser operations would take place beyond the normal 8 am to 5 pm, Monday-to-Friday PRTR range schedule because of the increasing need to test systems in all kinds of weather conditions and at dawn, dusk, and at night.

Chem/Bio Defense

- Like the No Action Alternative, chemical and biological simulants would be dispersed from a blower on a land range or on a barge, helicopter, or small vessel in the MDZ. Detectors, located on a land range or on a barge or small vessel, would remotely detect chemical or biological simulant vapors some distance from the source using a scanner, a detector, and an electronics module to process and communicate information.
- The annual number of outdoor chem/bio defense events would increase fivefold from 12 to 60.
- A wider range of chemical simulants would be used for outdoor chemical defense operations.
- Biological simulants would be used as well as chemical simulants outdoors, but they would not be tested together.

- Chemical and biological simulants would be used on the land ranges, the Mission Area, and the whole MDZ. Under the No Action Alternative, only the upriver part of the MDZ and the land ranges have been used for testing.
- Some chem/bio sensor activities would take place beyond the normal 8 am to 5 pm, Monday-to-Friday PRTR range schedule because of the increasing need to test systems in all kinds of weather conditions and at dawn, dusk, and at night.

PRTR Use

- There would be an overall increase in the number of hours that public access to some part of the PRTR would be restricted from 750 hours under the No Action Alternative to 870 hours annually under Alternative 1.
- Public access to the PRTR UDZ and the LDZ would be restricted approximately two days a year each to allow, for example, for weapon systems integration operations using vessels and aircraft, compared to no restrictions under the No Action Alternative.
- Public access to the upper LDZ would be restricted up to 10 days a year for long-range, large-caliber gun firing, compared to only infrequent restrictions under the No Action Alternative.

ES.5.4 Alternative 2

This alternative is the Navy's preferred alternative because it satisfies current requirements, known outdoor RDT&E activities scheduled for the coming years, and projected increases in activities in the foreseeable future based on current trends. In most respects, Alternative 2 would include the same types of activities described for Alternative 1. The number of annual activities under Alternative 2 represents:

- An average of the annual number of firings, detonations, and events for each RDT&E activity from 1993 (1995 for ordnance) to 2009, weighted to take into account years with the highest activity levels (No Action Alternative levels);
- ***Plus*** the increase in average annual RDT&E activities under Alternative 1 above No Action Alternative levels;
- ***Plus*** roughly 15 percent growth in the number of average annual RDT&E activities above Alternative 1 levels.

This alternative satisfies current requirements, known outdoor RDT&E scheduled for the coming years, and projected increases in tests in the foreseeable future based on current trends. It provides the flexibility required in RDT&E to accommodate future developments that may influence global threats, homeland security, and future missions. Alternative 2 includes the following increases above Alternative 1 levels:

- Small-arms activities would be approximately 30,000 bullets fired annually (an 18 percent increase over Alternative 1 levels). The number of large-caliber projectiles fired would not increase (0 percent).
- The number of detonations on the EEA would increase by about 30 annually (15 percent) above Alternative 1 levels.

- RDT&E activities using EM energy events would increase above Alternative 1 levels by 90 (15 percent) annually; HE laser events would increase by 20 (16 percent); and chem/bio simulant events would increase by 10 (17 percent).
- Biological simulants may be tested simultaneously with chemical simulants. Detectors capable of immediately recognizing a mixture of chemical and biological threats would be tested.
- NSWCDD's use of the PRTR (hours when range control boats restrict public access) would increase by 130 hours annually (15 percent above Alternative 1 levels). The number of days that the UDZ and LDZ would be restricted would be similar to Alternative 1 – approximately two times a year – and the upper LDZ would be restricted approximately 10 days a year.

ES.5.5 Environmental Impacts

Each alternative was evaluated for its potential to produce environmental impacts. The following defines the impact attributes that were used to assess potential impacts:

- **Context** – Context refers to the geographic, social, and environmental circumstances within which a proposed action may have effects on an environmental resource, as well as the size of the area affected by the action.
- **Intensity** – Intensity refers to the severity of the impacts. Intensity is rated as negligible, minor, moderate, or major, in accordance with the framework presented below.
- **Short-term or Long-term** – In general, short-term impacts are those that would occur only with respect to a particular discontinuous activity or for a finite period, or only during the time required for installation activities. Long-term impacts are those that are more likely to be persistent and chronic.
- **Direct or Indirect** – A direct impact is caused by a proposed action and occurs contemporaneously at or near the location of the action. An indirect impact is caused by a proposed action but might occur later in time or be farther removed in distance but still be a reasonably foreseeable outcome of the action.
- **Positive or Negative** – A positive impact is one having beneficial outcomes on an environmental resource. A negative impact is one having adverse, unfavorable, or undesirable outcomes.

The following scale is the qualitative framework used in this EIS to evaluate the intensity of impacts:

- **No Impacts** – No change to the environmental resource.
- **Negligible Impacts** – Impacts either are non-detectable or, if detected, are well within natural or normal variability and do not appreciably affect the extent or value of the environmental resource. Adverse impacts are easily absorbed by the natural or human environment without mitigation or long-term consequences.

- **Minor Impacts** – Impacts are clearly detectable but they approximate natural or normal variability and do not appreciably affect the extent or value of the resource. If needed to offset adverse impacts, mitigation is simple and mitigation success is likely.
- **Moderate Impacts** – Impacts exceed natural or normal variability; impacts appreciably affect the value or extent of the resource, but do not affect its viability. Although mitigation typically would be needed for the environment to absorb adverse impacts without long-term deterioration, mitigation success is likely.
- **Major Impacts** – Impacts exceed natural or normal variability and likely affect the viability of the resource or, as the impacts are highly uncertain or involve unique or unknown risks, the future viability of the resource is in question. Full mitigation of adverse impacts may not be possible or mitigation success is not likely, and some long-term deterioration of the environment may be unavoidable.

Table ES-2 summarizes the environmental impacts that would result from implementing each of the three alternatives.

Table ES-2
Summary of Environmental Impacts

Resource	No Action Alternative	Alternative 1	Alternative 2
Land Use, Plans, & Coastal Zone Management			
NSF Dahlgren	No military construction proposed. Activities would continue to use existing facilities and corridors within operational ranges and the Mission Area. No direct or indirect impacts on NSF Dahlgren land use pattern. Negligible, short-term, direct, negative impacts and no indirect impacts on non-operational uses of ranges and the Mission Area on NSF Dahlgren. Consistent with Navy plans to guide development at NSF Dahlgren, except that alternative would not support regional plans to further promote district as an RDT&E center.	No military construction proposed. Activities would use existing facilities and existing plus some new areas within operational ranges and the Mission Area. Activities would take place more frequently than under No Action Alternative (Alt). No direct or indirect impacts on NSF Dahlgren land use pattern. Negligible, short-term, direct, negative impacts and no indirect impacts on non-operational uses of ranges and the Mission Area on NSF Dahlgren. Consistent with Navy plans for NSF Dahlgren. Would support regional plans to promote district as an RDT&E center and maximize existing facilities for highest and best use.	No military construction proposed. Activities would use existing facilities and existing plus some new areas within operational ranges and the Mission Area. Activities would take place more frequently than under other alternatives. No direct or indirect impacts on NSF Dahlgren land use pattern. Negligible, short-term, direct, negative impacts on non-operational uses of ranges and the Mission Area on NSF Dahlgren. Consistent with Navy plans for NSF Dahlgren. Would support, to a greater extent than Alt 1, regional plans to promote district as an RDT&E center and maximize existing facilities for highest and best use.
Dahlgren Area and Potomac River Shoreline	Master plans, market forces, and the presence of NSF Dahlgren have determined current land use pattern and development projects. Therefore, continuing RDT&E activities would have no direct or indirect impacts on land use near NSF Dahlgren or along the shoreline of the PRTR. Consistent with master plans and policies of counties and towns near the PRTR. No direct or indirect impacts on existing access to the Potomac River for commercial or recreational purposes.	PRTR use increase of 16% plus 20% increase in EM energy and 108% increase in HE laser events would have negligible, short-term, direct, negative impacts and no indirect impacts on river use. No direct impacts and negligible, long-term, indirect, negative impacts on the desirability of waterfront property based on the slight increase in noise levels in the upper LDZ. NSWCDD gives notice of restrictions in advance, boat traffic is allowed to pass during lulls in tests, and recreational boating mainly takes place on weekends when operations rarely are conducted. No direct impacts and negligible, long-term, indirect, negative impacts on land use, land use planning, and ongoing development projects.	PRTR use increase of 33% plus 39% increase in EM energy and 142% increase in HE laser events would have negligible, short-term, direct, negative impacts and no indirect impacts on river use. No direct impacts and negligible, long-term, indirect, negative impacts on the desirability of waterfront property for the reasons described under Alt 1. No direct impacts and negligible, long-term, indirect, negative impacts on land use, land use planning, and ongoing development projects.
Special-Use Airspace	No change from existing conditions; no direct or indirect impacts on civilian air traffic.	Negligible, short-term, direct, negative impacts and no indirect impacts on civilian air traffic. No change in the hours that airspace is restricted annually. Although	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
		fewer hours would be turned back to FAA for civilian use, commercial and general aviation operators normally stay out of the special-use airspace at all times; many operators consider the special-use airspace to be off-limits at all times. It is expected that few aircraft would actually use the airspace during hours normally restricted.	
Coastal Zone	The Proposed Action is consistent to the maximum extent practicable with the enforceable policies of Virginia's and Maryland's coastal zone management (CZM) programs. The Virginia Department of Environmental Quality (VDEQ) concurred that the Proposed Action will be consistent with the Virginia Coastal Zone Management Program. The Maryland Department of the Environment (MDE) received a copy of the DEIS and the Federal Coastal Consistency Determination (Appendix I) but did not respond within 60 days to the Navy's consistency determination nor ask for an extension, so under the provisions of the Coastal Zone Management Act, the state has waived its consistency rights, stating neither that it concurs with nor objects to the Navy's consistency determination.	Same as No Action Alt.	Same as No Action Alt.
Socioeconomics			
Demographics	No significant increase in NSWCDD's outdoor RDT&E personnel anticipated; unlikely to affect population projections and would have no direct or indirect impacts on demographics.	No significant increase in NSWCDD's outdoor RDT&E personnel anticipated; unlikely to affect population projections and would have no direct impacts and negligible, long-term, indirect, negative impacts on demographics.	Same as Alt 1.
Economics	Current PRTR activities have not suppressed real estate development driven by proximity to Washington, DC and attractiveness of the Potomac River. Marine navigation (freight movement, commercial fishing, and recreational boating) coexists with range use; inconvenience of delays of	Based on No Action Alt experience, the 16% increase in PRTR use and no significant increase in noise, coupled with Range Operations Center measures to facilitate river traffic movement (as described under No Action Alt), are expected to have no direct and negligible,	Based on No Action Alt experience, the 33% increase in PRTR use and no significant increase in noise, coupled with Range Operations Center measures to facilitate river traffic movement (as described under No Action Alt.), are expected to have no direct and negligible, long-term, indirect, negative

Resource	No Action Alternative	Alternative 1	Alternative 2
	up to 30 minutes (10 minutes typical) for small vessels and up to one hour (half-hour typical) for large vessels is mitigated by Range Operations Center's early notices of upcoming operations and working with vessel operators to allow them to pass during lulls in testing. No direct or indirect impacts on economic conditions in the study area because it would not change factors such as noise and river use, which are already incorporated into existing economic activities.	long-term, indirect, negative impacts on real estate development; and minor, short-term, direct and minor, long-term, indirect, negative impacts on marine commerce.	impacts on real estate development; and minor, short-term, direct and minor, long-term, indirect, negative impacts on marine commerce.
Environmental Justice and Protection of Children	No disproportionately high and adverse human health or environmental effects on minority populations and low-income populations. No disproportionate environmental health or safety risks to children.	Same as No Action Alt.	Same as No Action Alt.
Utilities			
Utilities	NSWCDD's current power requirements are being adequately supplied by the power grid and NSF Dahlgren's auxiliary generators. RDT&E activities would have no direct or indirect impacts on utilities. The Dominion Virginia Power (DVP) application to build a new 230 kilovolt transmission source and substation at NSF Dahlgren has been approved and construction is scheduled to be completed in 2014. This would meet NSF Dahlgren's needs and King George County's growth and development.	Despite 20% increase in EM energy and 108% increase in HE laser events, RDT&E activities would have no direct and negligible, long-term, indirect impacts on the Virginia power grid. RDT&E activities would have no direct or indirect impacts on other utility systems, which are sufficient to support proposed activities.	Despite 39% increase in EM energy and 142% increase in HE laser events, RDT&E activities would have no direct and negligible, long-term, indirect impacts on the Virginia power grid. RDT&E activities would have no direct or indirect impacts on other utility systems, which are sufficient to support proposed activities.
Air Quality			
Stationary & Mobile Sources	No construction of any new major stationary sources is proposed. The land-based portion of NSF Dahlgren is in an attainment area and has a state operating permit for stationary air emissions. Annual emission levels do not exceed Title V major source thresholds. The emissions from the portion of the PRTR's MDZ located within an ozone	Same as No Action Alt.	Same as No Action Alt.

Resource	No Action Alternative	Alternative 1	Alternative 2
	nonattainment area would be unchanged. RDT&E activities would result in negligible, long-term, direct and indirect, negative impacts on air quality.		
Greenhouse Gases	NSWCDD RDT&E activities make an incremental contribution to greenhouse gas emissions, representing a very small percentage of total United States emissions. Based on an estimate of CO_2 equivalents generated, NSF Dahlgren's facility-wide total greenhouse gas emissions in 2008 represented approximately 0.0001% of the total emissions for the country as a whole. NSWCDD RDT&E activities when combined with other past, present, and reasonably foreseeable future actions would have the potential for negligible, long-term, indirect, negative impacts on climate.	Same as No Action Alt because increases in greenhouse gas emissions would be negligible.	Same as No Action Alt because increases in greenhouse gas emissions would be negligible.
Other Sources	Chemical simulants released have low toxicity and are rapidly dispersed to low concentrations. NSWCDD personnel exposed to simulants use personal protective equipment. Chemical defense activities would result in negligible, long-term, direct and indirect, negative impacts on air quality.	The 400% increase in chem/bio defense events and the addition of biological simulants would result in negligible, long-term, direct and indirect, negative air quality impacts comparable to impacts under the No Action Alt.	The 483% increase in chem/bio defense events and the addition of biological simulants, which may be mixed with chemical simulants, would result in negligible, long-term, direct and indirect, negative air quality impacts comparable to impacts under the No Action Alt.
Noise			
Noise	Noise levels resulting from firing large guns and small arms and from detonations would remain the same as at present. Ordnance activities would have minor, long-term, direct, negative weapons-testing noise impacts; negligible, long-term, direct, negative vibration impacts; and no indirect noise or vibration impacts. EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect noise or vibration impacts.	Although small-arms firing would increase by 325% and detonations by 5%, there would be no significant overall increase in noise levels. Ordnance activities would have minor, long-term, direct, negative weapons-testing noise impacts; negligible, long-term, direct, negative vibration impacts; and no indirect noise or vibration impacts. EM energy, HE laser, chemical and biological defense activities, and PRTR use would have no direct or indirect noise or vibration impacts.	Although small-arms firing would increase by 400% and detonations by 21%, there would be no significant overall increase in noise levels. Ordnance activities would have minor, long-term, direct, negative weapons-testing noise impacts; negligible, long-term, direct, negative vibration impacts; and no indirect noise or vibration impacts. EM energy, HE laser, chemical and biological defense activities, and PRTR use would have no direct or indirect noise or vibration impacts.

Resource	No Action Alternative	Alternative 1	Alternative 2
Cultural Resources			
Archaeolog-ical Resources	RDT&E activities would have no direct or indirect impacts on previously identified archaeological resources and are not expected to affect unknown resources within the Archaeological Area of Potential Effect (APE) because no groundbreaking activities and no expansion of outdoor RDT&E activities are proposed. In accordance with Section 106 of the National Historic Preservation Act, the Virginia Department of Historic Resources (VDHR) and Maryland Historic Trust (MHT) concurred that this alternative would not have an adverse effect on archaeological resources within the archaeological APE.	RDT&E activities would have no direct or indirect impacts on previously identified archaeological resources and are not expected to affect unknown resources within the Archaeological APE. In accordance with Section 106 of the National Historic Preservation Act, the VDHR and MHT concurred that this alternative would not have an adverse effect on archaeological resources within the archaeological APE. No archaeological resources are known to occur in the heavily-disturbed range areas used for detonations so an increase in detonations would have no effect. There would be no increase in large-caliber gun firing.	Same as Alt 1.
Historic Architectural Resources	In accordance with Section 106, ordnance noise and vibration modeling indicates no adverse effect to either the National Register-eligible Dahlgren Residential Historic District or the three proposed districts on NSF Dahlgren. The VDHR and MHT concurred that the Proposed Action would have no direct or indirect adverse effect on National Register of Historic Places-eligible or -listed properties within the Historic Architectural APE. In accordance with NEPA, the No Action Alt would have minor direct impacts and no indirect negative impacts on historic architectural resources within the APE.	Same as the No Action Alt. Although there would be a 325% increase in small-arms use, the area affected is limited and would not include National Register-listed or -eligible resources. There would be no increase in large-caliber gun firing.	Same as the No Action Alt. Although there would be a 400% increase in small-arms use, the area affected is limited and would not include National Register-listed or -eligible resources. There would be no increase in large-caliber gun firing.
Hazardous Materials and Waste			
Hazardous Materials and Hazardous Waste	The numerous policies and programs in place to remediate and to safely use, store, transport, and dispose of hazardous materials and hazardous waste ensure that they are safely handled and do not enter the environment. The environmental restoration	The numerous policies and programs in place to remediate and to safely use, store, transport, and dispose of hazardous materials and hazardous waste would ensure that they are safely handled and do not enter the environment. The	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
	program is addressing past range use when environmental programs were less stringent. Ordnance activities would have minor, long-term, direct and indirect, negative impacts and EM energy, HE laser, and chemical defense activities would have negligible, long-term, direct and indirect, negative impacts.	environmental restoration program is addressing past range use when environmental programs were less stringent. Comparable to the No Action Alt, ordnance activities would have minor, long-term, direct and indirect, negative impacts and EM energy, HE laser, and chem/bio defense activities would have negligible, long-term, direct and indirect, negative impacts.	
Health & Safety			
Health and Safety	Activities are conducted in accordance with Navy policies, carefully-conceived management controls, and operation-specific risk hazard assessments and standard operating procedures, which are implemented to ensure safety during the RDT&E activities. Input of munitions constituents (MCs) into the Potomac River from current and past ordnance use are well below concentrations that could cause adverse effects on human health. Ordnance, EM energy, HE laser, and chemical defense activities would have negligible, long-term, direct and indirect, negative impacts. PRTR use would have negligible, long-term, direct, negative impacts and no indirect impacts.	The 325% increase in small-arms firing and 5% increase in detonations would not increase releases of MCs on or off range or pose unacceptable risks to human health. Most bullets are fired into butts and those entering the PRTR are likely to be buried in sediments and be isolated from exposure pathways. The MC contribution of the additional number of bullets settling near the surface of the sediments is negligible (0.1% of duds and inert bullets or about 26 bullets). Treatment of explosive waste from the additional detonations would take place at NSWCDD, consistent with current operations. Biological simulants would be tested, but simulants proposed for use are common and found naturally in the environment. Ordnance, EM energy, HE laser, and chem/bio defense activities would have negligible, long-term, direct and indirect, negative impacts. PRTR use would have negligible, long-term, direct, negative impacts and no indirect impacts.	The 400% increase in small-arms firing and 21% increase in detonations would not increase releases of MCs on or off range or pose unacceptable risks to human health. Most bullets are fired into butts and those entering the PRTR are likely to be buried in sediments and be isolated from exposure pathways. The MC contribution of the additional number of bullets settling near the surface of the sediments is negligible (0.1% of duds and inert bullets or about 30 bullets). Treatment of explosive waste from the additional detonations would take place at NSWCDD, consistent with current operations. Biological simulants would be tested, but simulants proposed for use are common and found naturally in the environment. Biological simulants tests could be performed in combination with chemical simulants; there are no known synergistic interactions between the proposed types of biological organisms and low-toxicity chemical simulants. Ordnance, EM energy, HE laser, and chem/bio defense activities would have negligible, long-term, direct and indirect, negative impacts. PRTR use would have negligible, long-term, direct, negative impacts and no indirect impacts.

Resource	No Action Alternative	Alternative 1	Alternative 2
Geology, Topography, Soils & Sediments			
Geology, Topography, Soils and Sediments	Ordnance activities would have minor, long-term, direct, negative impacts on soils and sediments, based on localized disturbances to soil and sediments, and no direct or indirect impacts on geology or topography. EM energy, HE laser, and chemical defense activities would have negligible, short-term, direct impacts and no indirect impacts on geology, topography, soils, or sediments, as there would be minimal contact with these features. Use of boats during activities on the PRTR would have no direct impacts and negligible, long-term, indirect, negative impacts on geology, topography, soils, and sediments.	Same as No Action Alt.	Same as No Action Alt.
Water Resources			
Surface Water	RDT&E activities would have little contact with surface water resources and minimal potential to affect them. Low concentrations of MCs and simulants enter surface water with predicted concentrations below standard detection levels. Ordnance activities and PRTR use would have negligible, long-term, direct and indirect, negative impacts on surface waters. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. Any incidental EM/laser energy would be quickly diminished by reflection, absorption, or scattering by water. Chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts. PRTR use would have negligible, long-term, direct and indirect, negative impacts on surface waters.	Same as No Action Alt. Naturally-occurring biosafety level (BSL)-1 organisms used in bio defense tests would not affect surface water.	Same as Alt 1.
Wetlands and	Ordnance and PRTR use would have no direct impacts and negligible, long-term,	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
Floodplains	indirect, negative impacts on wetlands and floodplains. EM energy, HE laser, and chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts.	would not affect wetlands and floodplains.	
Groundwater	Ordnance activities would have no direct impacts and negligible, long-term, indirect, negative impacts on groundwater. EM energy, HE laser, chemical defense activities, and PRTR use do not contact groundwater and therefore would not directly or indirectly impact groundwater.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not enter the groundwater.	Same as Alt 1.
Potomac River Biological Resources			
Submerged Aquatic Vegetation (SAV)	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on SAV communities. Exposure concentrations of MCs and simulants are below levels that could cause adverse effects in aquatic organisms. EM energy, HE laser, and PRTR use would have negligible, short-term, direct, negative impacts and no indirect impacts on SAV. Chemical defense activities would have no direct impacts and negligible, short-term, indirect, negative impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect SAV.	Same as Alt 1.
Plankton	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on plankton communities. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. Chemical defense and PRTR activities would have no direct impacts and negligible, short-term, indirect, negative impacts.	Same as No Action Alt.Naturally-occurring BSL-1 organisms used in bio defense tests would not affect plankton communities.	Same as Alt 1.
Aquatic Invertebrates	Ordnance, activities would have negligible, long-term, direct and indirect, negative impacts on aquatic invertebrate communities. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect	Same as No Action Alt.Naturally-occurring BSL-1 organisms used in bio defense tests would not affect aquatic invertebrate communities.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
	impacts. Chemical defense and PRTR activities would have no direct impacts and negligible, short-term, indirect, negative impacts.		
Fish	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on fish communities. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. Chemical defense activities would have no direct impacts and negligible, short-term, indirect, negative impacts. PRTR use would have negligible, short-term, direct and indirect, negative impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect fish communities.	Same as Alt 1.
Essential Fish Habitat (EFH)	The RDT&E activities conducted by NSWCDD on the PRTR may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The National Marine Fisheries Service (NMFS) concurred that the proposed action would not substantially adversely affect EFH or habitat areas of particular concern. In accordance with NEPA, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on EFH. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on EFH. Chemical defense activities would have no direct impacts and negligible, short-term, indirect, negative impacts. PRTR use would have negligible, short-term, direct and indirect, negative impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect EFH.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
Potomac River Birds			
Potomac River Birds	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on Potomac River birds. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. Chemical defense activities would have no direct impacts and negligible, short-term, indirect, negative impacts. PRTR use would have negligible, short-term, direct and indirect, negative impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect birds. .	Same as Alt 1.
NSF Dahlgren's Biological Resources			
Ponds, Streams, and Creeks	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on biological resources associated with NSF Dahlgren's ponds, streams, and creeks. Large-caliber guns are mostly fired into the river rather than at land targets; 90% of small arms are fired at targets on land that trap the bullets, but 10% are fired at targets in the water up to 4,000 yds out and end up in the river. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts, as most activities occur well away from ponds, streams, and creeks. Chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect ponds, streams, and creeks.	Same as Alt 1.
Vegetation	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's vegetation. HE laser, EM energy, and chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect vegetation.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
Wildlife	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's wildlife. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. EM and laser corridors are checked for presence of wildlife before and during tests. Chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect wildlife.	Same as Alt 1.
Special Interest Areas (SIAs)	Ordnance, EM energy, HE laser, and chemical defense activities would have no direct or indirect impacts on biological resources associated with SIAs.	Same as No Action Alt/Biological defense activities would have no direct or indirect impacts on biological resources associated with SIAs.	Same as Alt 1.
Hunting and Fishing	Ordnance activities would have no direct impacts and negligible, long-term, indirect, negative impacts on hunting and fishing. EM energy, HE laser, and chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts. These activities have little or no spatial overlap with hunting and fishing areas.	Same as No Action Alt. Biological defense activities would have little or no spatial overlap with hunting and fishing areas.	Same as Alt 1.
Protected Species			
Fish	NMFS has provided concurrence in accordance with Section 7 of the Endangered Species Act (ESA) that existing RDT&E activities may affect, but are not likely to adversely affect the endangered shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, ordnance activities and PRTR use would have negligible, long-term, direct and indirect, negative impacts on the shortnose sturgeon and Atlantic sturgeon. EM energy, HE laser, and chemical defense activities would have no direct or indirect impacts.	Same as No Action Alt. Biological defense activities would have no direct or indirect impacts.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
Sea Turtles	Ordnance use is more than 6.5 nautical miles above the lowest reach of the Potomac River where sea turtles (ESA-listed loggerhead, Kemp's ridley and green) are found seasonally. There is minimal spatial overlap between RDT&E activities conducted by NSWCDD on the PRTR and sea turtles using the lower Potomac River. NMFS has provided concurrence in accordance with Section 7 of the ESA that the baseline RDT&E activities impacts are considered to be insignificant or discountable, and may affect, but are not likely to adversely affect sea turtles. In accordance with NEPA, ordnance activities would have no direct and negligible, short-term, indirect negative impacts on sea turtles. EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not change the conclusions.	Same as Alt 1.
Birds	Ordnance, EM energy, HE laser, chemical defense activities, and PRTR use would not affect the birds protected by the Bald and Golden Eagle Protection Action (BGEPA), Migratory Bird Treaty Act (MBTA), Lacey Act, or the ESA. In accordance with NEPA, ordnance, EM energy HE laser, chemical defense activities, and PRTR use would have no direct or indirect impacts on the bald eagle or other protected bird species.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not change the conclusions.	Same as Alt 1.
Marine Mammals	There are no reasonably foreseeable takes of marine mammals associated with ordnance, EM energy, HE laser, chemical defense activities, and PRTR use in accordance with the MMPA. In accordance with NEPA, ordnance, EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect impacts on marine	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not change the conclusions.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
	mammals.		
Insects	The ESA-listed threatened northeastern beach tiger beetle is found on sandy beaches in the lowest reach of the Potomac River, but no RDT&E activities, inclusive of ordnance, EM energy, HE laser, and chemical defense activities, would take place near the shoreline of the LDZ. In accordance with Section 7 of the ESA, RDT&E activities would have no effect on listed insect species. In accordance with NEPA, ordnance, EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect impacts on tiger beetles.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect the tiger beetle, and in any event, would not be released near the beaches on which they live.	Same as Alt 1.
Plants	A USFWS Virginia Field Office online project review of the Proposed Action determined that because suitable habitat exists for the ESA-listed sensitive joint-vetch in tidal wetlands within NSF Dahlgren, the Proposed Action may adversely affect the sensitive joint-vetch. However, based on site- and project-specific information, the No Action Alt would have no effect on this species. Even if the species occurs in tidal wetlands on the installation, it is unlikely to be present in the parts of the range used for ground-disturbing activities, because there is no suitable habitat in these areas. Further, the No Action Alt would not cause ground disturbance outside of existing target areas and other areas subject to recent and continuing disturbance. In accordance with NEPA, ordnance, EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect impacts on rare, threatened, or endangered plants.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not change the conclusions.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
Cumulative Impacts			
Cumulative Impacts	The baseline RDT&E activities when combined with other past, present, and reasonably foreseeable future actions would have the potential for negligible or minor, but recoverable, negative impacts to the resources evaluated in this EIS.	Same as No Action Alt. The addition of biological defense activities would not change the conclusion.	Same as No Action Alt. The addition of biological defense activities alone or in combination with chemical defense activities would not change the conclusion.

ES.6 Protective Measures

In order to minimize the environmental impacts of current RDT&E activities, NSWCDD and NSF Dahlgren have developed environmental management processes, comprising the established NSWCDD Environmental Management System (EMS) and Safety Program, the NSF Dahlgren Comprehensive Work Approval Process, and protective measures. For the purposes of this EIS:

- *Protective measures* are actions taken by NSWCDD to protect sensitive resources, but that are not implemented in response to the impact findings of this EIS.
- *Mitigation measures* differ from protective measures in that they would be implemented specifically in response to the impact findings described in Chapter 4 of this EIS.

The protective measures already implemented for current No Action Alternative activities, which rely heavily on ongoing process improvements, would continue to be used as the means of mitigating environmental impacts for the Proposed Action alternatives. NSWCDD identifies environmental and safety risks for current No Action activities and responds with mitigation and protective measures based on experience from earlier RDT&E. Developing mitigation based on the projected risk when the RDT&E activity is being planned and then implementing these responsive measures when the activity takes place can effectively reduce the impact of the activity below that level at which the impact would be significant.

The impact findings summarized in Table ES-2 were determined in the context of the existing environmental management processes and protective measures that are integral to current and future NSWCDD RDT&E activities. Basically, mitigation is and would continue to be built into current activities and future activities under the Proposed Action. Because the protective measures in place reduce the impact of activities discussed in this EIS below the level at which the impact would be significant, no mitigation measures are necessary. NSWCDD is committed to applying the same processes used to mitigate safety and environmental impacts for current activities to all future activities under the No Action Alternative, and Alternatives 1 and 2. NSWCDD's Safety and Environmental Office is responsible for carrying out these processes for NSWCDD's current activities and would do so for future activities.

In order to minimize potential impacts, and consistent with NSWCDD's Environmental Policy and current environmental procedures, NSWCDD would include **general safety and environmental protective measures** in the planning and implementation of activities under the Proposed Action and ensure that:

- All activities proposed under the Proposed Action strictly adhere to all health, safety, and environmental protocols, including Risk Hazard Assessments (RHAs), SOPs or General Operating Procedures (GOPs) with associated Operation Procedures Supplements (OPSs) that cover RDT&E activities.
- All activities proposed strictly adhere to all safety zones – i.e., PRTR danger zones, Airfield Safety Zones and special-use airspace, explosive safety quantity distance (ESQD) arcs, unexploded ordnance (UXO) areas, EM hazard arcs, and laser safety buffer zones.

- Members of the public and personnel not involved in a test are excluded from ranges and the Mission Area prior to and during tests on the waters of the PRTR through the use of patrol boats and range restrictions and on land through the use of lookouts, road barriers, and signs.
- The Range Operations Center (ROC) in general notifies the public in advance of upcoming range activities through the Naval Surface Warfare Center Dahlgren Division (NSWCDD) website and a toll-free telephone recording. The information given includes daily range schedules, types of tests, use of substances such as smoke or lights, hours of testing, where on the PRTR tests will take place, whether tests are on schedule, whether noise will be made, and contact numbers to obtain more information.
- ROC notifies the public specifically of any activities that will restrict access within and from Upper Machodoc Creek or when any test is scheduled to take place before or after normal PRTR operating hours of 8 am to 5 pm weekdays. ROC notifies the public through NSWCDD's range website, its toll-free information line, and by placing notices in local newspapers.
- ROC coordinates with the operators of private vessels via the range control boats or marine radio to minimize delays when activities are taking place on the PRTR and public access to an operational area is restricted. ROC allows vessels to pass through the operational area on the PRTR during lulls in testing; delays for smaller craft are normally no longer than one-half hour, and, for larger vessels that must use the shipping channel in the middle of the range, are normally no longer than one hour (and in most cases, less than these times).
- Noise from an activity does not exceed the standards in the Outdoor Noise Management Process (NSWCDL, 2011, included as Appendix C). When there is a possibility that noise levels higher than policy standards may occur, mitigation measures are implemented to ensure that installation personnel and the public are not exposed to hazardous noise levels. Potential mitigation measures may include avoiding testing when weather conditions are likely to result in higher noise levels to avoid exposing the public to increased noise levels and/or single and double hearing protection for on-installation personnel conducting the testing.
- Impacts to wildlife during testing are avoided when possible or minimized. Before an activity begins, trained observers look for wildlife in the target area or test area, and alert operators if any are present. Either the test is postponed temporarily or the wildlife is startled within legally allowable means to encourage movement out of the area. Trained observers watch for wildlife that may move into the target area or operations area during tests, and the test is stopped while they clear the area. Dead animals are removed prior to tests on land to limit the chances of scavenging wildlife's entering the test area.
- Bald eagle protection zones around active bald eagle nests are respected during the planning and execution of test activities, and, as necessary, coordination with the US Fish and Wildlife Service (USFWS) and the Virginia Department of Game and Inland Fisheries (VDGIF) occurs.

- Testing of new ordnance and EM directed energy and HE laser equipment scales up gradually, and monitoring takes place to ensure that higher intensity levels do not generate impacts.
- Trees, shrubs, and taller grasses and herbaceous plants that grow in range and Mission Area operating areas and are obscuring lines-of-sight are trimmed prior to tests.

For **activity-specific protective measures** NSWCDD would ensure that for chem/bio defense activities under the Proposed Action:

- Weather conditions are monitored and simulant releases modeled before chem/bio simulant tests to ensure that simulant releases stay on ranges and the Mission Area.
- Simulant concentrations are monitored during and after releases to provide feedback for future modeling and to verify that modeled levels are not exceeded. The SOP includes the distance at which vapors and aerosols are diluted to a safe level based on the simulants and maximum quantities used. It also specifies that release point will be selected so that the simulant cloud must travel this distance before landfall.
- Simulant releases are spaced so that no land or water area would be exposed multiple times to the same simulant.
- Prior to each chem/bio operation, coordination takes place with the NSF Dahlgren Environmental and Safety Divisions, the Maryland Department of the Environment (MDE) and the Virginia Department of Environmental Quality (VDEQ), as applicable, concerning the types and quantities of simulants proposed for use.

In addition, NSWCDD is developing and will implement a new, formalized Project Environmental Review and Monitoring Process for ordnance, EM energy, HE laser, and chemical and biological defense projects under the Proposed Action. NSWCDD's Safety and Environmental Office will be responsible for carrying out the new process under the Environmental Management System (EMS). The Project Environmental Review and Monitoring Process will be integrated with the NSWCDD safety program and the NSF Dahlgren CWAP, and together with those processes will ensure that:

- All new proposed RDT&E projects either will be covered under the scope of this EIS or will have sufficient independent environmental planning (NEPA) documentation.
- New proposed RDT&E projects will incorporate all applicable protective measures, as agreed to in the EIS Record of Decision and other decision documents and authorizations.
- Ordnance, EM energy, HE laser, and chemical and biological defense activity tempos and intensities will be tracked and compared to those analyzed in this EIS.
- Protective measures will be implemented, the effectiveness of the measures to achieve desired environmental outcomes will be continually assessed, and measures will be reviewed, reconsidered, and revised as needed to increase their effectiveness.

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ACRONYMS AND ABBREVIATIONS

A	
AA	Anti-Aircraft
ac	acre(s)
ACGIH	American Conference of Governmental Industrial Hygienists
ACHP	Advisory Council on Historic Preservation
ACUB	Army Compatible Use Buffer
ADNL	A-weighted DNL
AET	Apparent Effects Threshold
AICUZ	Air Installations Compatible Use Zone
AOC	Area of Concern
APE	Area of Potential Effect
Army	Department of the Army
ASMFC	Atlantic States Marine Fisheries Commission
ASSRT	Atlantic Sturgeon Status Review Team
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient Water Quality Criteria
A/m	Ampere(s) per meter (magnetic field strength)

B	
B	Magnetic Flux Density
BA	Biological Assessment
BCC	Birds of Conservation Concern
BCF	Bioconcentration Factor
BGEPA	Bald and Golden Eagle Protection Act
B-IBI	Benthic Index of Biotic Integrity
BMP	Best Management Practices
BNOISE	DoD's Blast Noise Prediction Program
BNOISE2	DoD's large-caliber weapon-noise model
BPRF	Blossom Point Research Facility
BRAC	Base Closure and Realignment
BSL	Biosafety Level
BUORD	Bureau of Ordnance (historic)
bw	Body weight

C	
C	Speed of light in a vacuum (186,000 miles/s [299,792,458 m/s])
C3	Computer Control Center
CAA	Clean Air Act
CATEX	Categorical Exclusion
CBD	Chemical/Biological Defense
CBDP	Chemical and Biological Defense Program
CBP	Chesapeake Bay Program
CBPA	Chesapeake Bay Preservation Act (State of Virginia)
CCC	Criterion Continuous Concentration
CCD	Coastal Consistency Determination
CDC	Centers for Disease Control and Prevention
CDNL	C-weighted DNL
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CETFAC	Counter Explosive Test Facility
CFR	Code of Federal Regulations
CH_4	Methane
cm	centimeter(s)
cm^2	square centimeter(s)
CMC	Criterion Maximum Concentration
CNO	Chief of Naval Operations
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COC	Communities of Concern
COLPRO	Collective Protection
COMAR	Code of Maryland Regulations
COPC	Constituent(s) of Potential Concern
CRC	Chesapeake Research Consortium
CRI	Center for Research Information
CSEL	C-weighted sound exposure limit
CTR	Chesapeake Test Range
CWA	Clean Water Act
CWAP	Comprehensive Work Approval Process
CZMP	Coastal Zone Management Program
ºC	degrees Celsius

D	
dB	Decibel(s)
dBA	A-weighted decibel(s)
DBE	Dibasic Ether
dBC	C-weighted decibel(s)
dBP	Peak Decibel(s)
DC	District of Columbia
DDT	dichlorodiphenyl trichloroethane
DEA	Drug Enforcement Administration
DEEP	Diethyl Ethyl Phosphonate
DEIS	Draft Environmental Impact Statement
DEM	Diethyl Malonate
DEP	Diethyl Phthalate
DEWO	Directed Energy Warfare Office
DGS	Department of General Services (State of Maryland)
DHS	Department of Homeland Security
DMA	Dimethyl Adipate
DMMP	Dimethyl Methylphosphonate
DNL	Day-night average sound level
DO	Dissolved Oxygen
DoD	Department of Defense
DoN	Department of the Navy
DPGME	Dipropylene Glycol Methyl Ether
DPS	Distinct Population Segment
DRMO	Defense Reutilization and Marketing Office
DVP	Dominion Virginia Power
dw	dry weight

E	
E	Electric Field Strength
E3	Electromagnetic Environmental Effects
EA	Environmental Assessment
EC	Effective Concentration
EC50	Lowest Effect Concentration Threshold/Effect Concentration 50
EEA	Explosives Experimental Area
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EHW	Explosive Hazardous Waste
EIS	Environmental Impact Statement
EJ	Environmental Justice

ELMR	Estuarine Living Marine Resources
EM	Electromagnetic
EMF	Electromagnetic Field
EMI	Electromagnetic Interference
EMLF	Electromagnetic Launch Facility
EMREF	Electromagnetic Research and Engineering Facility
EMS	Environmental Management System
EO	Executive Order
EOD	Explosive Ordnance Disposal
ER	Environmental Restoration
ER-L	Effects Range – Low
ER-M	Effects Range – Median
ERP	Environmental Restoration Program
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute
ESQD	Explosive Safety Quantity Distance

F

f	Frequency
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FP	Federal Proposed
FE	Federal Endangered
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FGD	Flue Gas Desulfurization
FMP	Fishery Management Plan
FONSI	Finding of No Significant Impact
FS	Feasibility Study
FT	Federal Threatened
ft	foot/feet
ft/s	feet per second
ft/sec^2	feet per second per second
FW	Freshwater
°F	degrees Fahrenheit

G

G	Gauss
g	gram(s)
g/kg	grams per kilogram
GAA	Glacial Acetic Acid

gal(s)	gallon(s)
GARM	Groundfish Assessment Review Meeting
GEMS	Graphical Exposure Modeling System
GHz	gigahertz
GIS	Geographic Information System
GOP	General Operating Procedure
gpd	gallon(s) per day
gpm	gallon(s) per minute
GPS	Global Positioning System

H	
H	Magnetic Field Strength
ha	hectare(s)
HAP	Hazardous Air Pollutant
HAPC	Habitat Area of Particular Concern
HARP	Historic and Archaeological Resource Protection
HE	High-energy
HERF	Hazards of Electromagnetic Radiation to Fuel
HERO	Hazards of Electromagnetic Radiation to Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HFC	Hydrofluorocarbon
HM	Hazardous Material(s)
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HMX-1	Marine Helicopter Squadron – 1
HPM	High-power Microwave
HQ	Hazard Quotient
hr	hour(s)
HRS	Hazard-Ranking System
HSDB	Hazardous Substances Data Bank
HSWA	Hazardous and Solid Waste Amendments to RCRA
HW	Hazardous Waste
Hz	Hertz

I	
IBI	Index of Biotic Integrity
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ICPRB	Interstate Commission on the Potomac River Basin
ICRMP	Integrated Cultural Resources Management Plan
IEEE	Institute of Electrical and Electronics Engineers
in	inch(es)
in/sec	inches per second

in/yr	inches per year
INRMP	Integrated Natural Resources Management Plan
IPCS	International Program on Chemical Safety
IR	Infrared
IRIS	Integrated Risk Information System

J

J	Current Density
JSLSCAD	Joint Service Lightweight Stand-off Chemical Agent Detector

K

kg	kilogram(s)
K_h	Henry's Law Constant
kHz	kilohertz
km	kilometer(s)
K_{ow}	Octanol-water Coefficient
kV	kilovolt(s)
kV/m	kilovolts per meter
kW	kilowatt(s)

L

lb(s)	pound(s)
LC	Lethal Concentration
LC0	Lethal Concentration Zero
LD	Lethal Dose
LD50	Lethal Dose Resulting in 50 Percent Mortality
LDZ	Lower Danger Zone, PRTR
LGAC	Laser-generated Air Contaminant
LOAEL	Lowest Observed Adverse Effect Level
LPPRP	Land Preservation, Parks, and Recreation Plan
LSRB	Laser Safety Review Board
λ	wavelength

M

m	meter(s)
MA	mega amps
MAFMC	Mid-Atlantic Fishery Management Council
MBTA	Migratory Bird Treaty Act
MC	Munitions Constituent
MCB	Marine Corps Base

MCOPC	Munitions Constituent of Potential Concern
MD	Maryland
MDE	Maryland Department of the Environment
MDNR	Maryland Department of Natural Resources
MdTA	Maryland Transportation Authority
MDZ	Middle Danger Zone, PRTR
MEMC	Military Expended Material Constituent(s)
MeS	Methyl Salicylate
mi	mile
MILCON	Military Construction
mg	milligram(s)
mgpd	millions of gallons per day
MGS	Maryland Geological Survey
mg/cm^2	milligrams per square centimeter
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
mg/m^2	milligrams per square meter
mg/m^3	milligrams per cubic meter
MHT	Maryland Historic Trust
MHz	megahertz
MIDAS	Munitions Items Disposition Action System
MJ	megajoule
MK	Mark
ml	milliliter(s)
mlpd	millions of liters per day
mm	millimeter(s)
MMAP	Maryland Maritime Archaeology Program (Maryland Historic Trust)
MMD	mass median diameter
MMPA	Marine Mammal Protection Act
MOATS	Maginot Open Air Test Site
MPE	Maximum Permissible Exposure
mph	miles per hour
MPPRP	Maryland Power Plant Research Program
MR	Munitions Rule
MRI	Magnetic Resonance Imaging
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
mW	milliwatt(s)
MW	megawatt(s)
MWH	megawatt-hour(s)

m/s	meters per second
µg	microgram(s)
µg/kg dw	micrograms per kilogram dry weight
µg/l	micrograms per liter
µm	micrometer(s)
µs	microsecond(s)

N	
N_2O	Nitrous Oxide
NA	Not Applicable or Not Available
NAAQS	National Ambient Air Quality Standards
NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Command
NAVSEA	Naval Sea Systems Command
Navy	Department of the Navy
NAWCAD	Naval Air Warfare Center, Aircraft Division
NAWMP	North American Waterfowl Management Plan
ND	Non-detect
NDEC	Navy Directed Energy Center
NDW	Naval District Washington
NEFMC	New England Fishery Management Council
NEPA	National Environmental Policy Act
NEW	Net Explosive Weight
NFPA	National Fire Protection Association
NHC	Naval Historical Center
NHHC	Naval History and Heritage Command
NHL	National Historic Landmark
NHPA	National Historic Preservation Act
NHZ	Nominal Hazard Zone
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
nm	nanometer(s)
NM	nautical mile(s)
NMBSC	Non-migratory Bird Species of Concern
NMFS	National Marine Fisheries Service
NMP	Noise Management Procedure
NO_2	Nitrogen Dioxide
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NOB	Natural Oyster Bar
NOEC	No Observed Effect Concentration

NOHD	Nominal Ocular Hazard Distance
NOI	Notice of Intent
NOS	National Ocean Service
NOSSA	Naval Ordnance Safety and Security Activity
NOTAM	Notice to Airmen
NOTES	Naval Ordnance Transient Electromagnetic Simulator
NO_x	Oxides of Nitrogen
NPL	National Priority List
NPS	National Park Service
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NRL	Naval Research Laboratory
NSDWS	National Secondary Drinking Water Standard
NSA	Naval Support Activity
NSF	Naval Support Facility
NSWC	Naval Surface Weapons Center / Naval Surface Warfare Center
NSWCDD	Naval Surface Warfare Center, Dahlgren Division
NSWCDL	Naval Surface Warfare Center, Dahlgren Division at Dahlgren
NTP	National Toxicology Program
NWI	National Wetland Inventory
ν	Frequency

O

O_3	Ozone
OB/OD	Open Burn/Open Detonation
ONR	Office of Naval Research
OPNAVINST	Chief of Naval Operations Instruction
OPS	Operation Procedures Supplement
ORC	Operational Range Clearance
ORM	Operational Risk Management
OSC	Operations Safety Committee
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
oz	ounce(s)

P

Pa	Pascal(s)
PAO	Public Affairs Office
Pb	Lead
PCBs	Polychlorinated Biphenyls

PEG	Polyethylene Glycol
PEL	Permissible Exposure Limit
PET	Polyethylene terephthalate
PFC	Perfluorocarbons
PFN	pulse forming network
pH	Potential of Hydrogen
P-IBI	Phytoplankton Index of Biotic Integrity
PIF	Partners in Flight
PIWG	Public Involvement Working Group
PK	peak sound pressure levels
PMMA	Polymethyl methacrylate
PM_{10}	Particulate Matter with Diameters up to 10 µm
$PM_{2.5}$	Particulate Matter with Diameters up to 2.5 µm
POTMH	Potomac Mesohaline
POTOH	Potomac Oligohaline
POTTF	Potomac Tidal Fresh
PPE	Personal Protective Equipment
ppm	parts per million
ppt	parts per thousand
PPV	peak particle velocity
PRFC	Potomac River Fisheries Commission
PRTR	Potomac River Test Range
PRTRC	Potomac River Test Range Complex
psi	pounds per square inch
PZ	Protection Zone

R

R-134	1,1,1,2-tetrafluoroethane
R-152a	1,1-difluoroethane
RCA	Range Condition Assessment
RCRA	Resource Conservation and Recovery Act
RDT&E	Research, Development, Test And Evaluation
RDX	Royal Demolition Explosive (Hexahydro-1,3,5-trinitro-1,3,5-triazine)
Redox	Reduction-oxidation reaction
RF	Radio Frequency
RFW	Radio-frequency Warfare
RHA	Risk Hazard Assessment
RI	Remedial Investigation
RMA	Resource Management Area
RMP	Range Management Plan
ROC	Range Operations Center

ROD	Record of Decision
ROPS	Range Operation Policy Statement
RPA	Resource Protection Area
RPMP	Real Property Master Plan
RSD	Range Safety Director
RSEPA	Range Sustainability Environmental Program Assessment
RSIP	Regional Shore Infrastructure Plan
RSSRA	Range-Specific Screening-Level Risk Assessment
R&D	Research and Development

S

S	Power Density
S_{eq}	Equivalent Plane Wave Power Density
s	second
SAFMC	South Atlantic Fishery Management Council
SAR	Specific Absorption Rate
SARA	Superfund Amendments and Reauthorization Act
SARC	Stock Assessment Review Committee
SARNAM	Small Arms Range Noise Assessment Model
SAV	Submerged Aquatic Vegetation
SAW	Northeast Regional Stock Assessment Workshop
SCL	Straight Carapace Length
SCP	Shorebird Conservation Plan
SCS	Soil Conservation Service
SE	State Endangered
SEL	Sound Exposure Level
SF_6	Sulfur Hexafluoride
SHPO	State Historic Preservation Office/Officer
SIA	Special Interest Area
SIP	State Implementation Plan
SIPS	Sound Intensity Prediction System
SO_2	Sulfur Dioxide
SOH	Safety and Occupational Health
SOP	Standard Operating Procedure
sq ft	square foot/feet
SQG	Small Quantity Generator
sq km	square kilometer(s)
sq m	square meter(s)
sq mi	square mile(s)
sq NM	square nautical mile(s)

SQuiRT	Screening Quick Reference Table
SRT	Status Review Team
ST	State Threatened
STEL	Short-term Exposure Limit
STSTS	Search and Track Sensor Test Site
SUA	Special-Use Airspace
SW	Saltwater
SWMU	Solid Waste Management Unit
SWP3	Stormwater Pollution Prevention Plan

T

T	Tesla
TEP	Triethyl Phosphate
TMDL	Total Maximum Daily Load
TNT	2,4,6-Trinitrotoluene
TRACON	Terminal Radar Approach Control
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
TSS	Total Suspended Solids
TWA	Time-weighted Average

U

UAV	Unmanned Aerial Vehicle
UDZ	Upper Danger Zone, PRTR
UGV	Unmanned Ground Vehicle
UMS	Unmanned System
UNEP	United Nations Environmental Program
US	United States
USACE	United States Army Corps of Engineers
USACHPPM	United States Army Center for Health Prevention and Preventive Medicine
USAEC	United States Army Environmental Command
USAF	United States Air Force
USAG ALC	United States Army Garrison, Adelphi Laboratory Center
USBEA	United States Bureau of Economic Analysis
USBLS	United States Bureau of Labor Statistics
USC	United States Code
USCPSC	United States Consumer Product Safety Commission
USDOL	United States Department of Labor
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

USGS	United States Geological Survey
USHUD	United States Department of Housing and Urban Development
UST	Underground Storage Tank
USV	Unmanned Surface Vehicle
UV	Ultraviolet
UXO	Unexploded Ordnance

V

VA	Virginia
VAC	Virginia Administrative Code
VDCR	Virginia Department of Conservation and Recreation
VDEQ	Virginia Department of Environmental Quality
VDGIF	Virginia Department of Game and Inland Fisheries
VDH	Virginia Department of Health
VDHR	Virginia Department of Historic Resources
VDNR	Virginia Department of Natural Resources
VEC	Virginia Employment Commission
VIMS	Virginia Institute of Marine Science
VLSTRACK	Vapor, Liquid, and Solid Tracking Model
VOC	Volatile Organic Compound
VPDES	Virginia Pollutant Discharge Elimination System
VR	Virginia Regulation
V/m	volts per meter (electric field strength)

W

W	watt(s)
wk	week(s)
W/kg	watt(s) per kilogram
W/m	watts per meter (electric)
WHO	World Health Organization
ww	Wet weight
WWI	World War I
WWII	World War II

Y

yd	yard(s)

Misc	
<	less than
≤	less than or equal to
>	greater than
≥	greater than or equal to

1 PURPOSE AND NEED

Naval Surface Warfare Center, Dahlgren Division (NSWCDD), the action proponent, proposes to expand research, development, test, and evaluation (RDT&E) activities within operating ranges, the Mission Area, and special-use airspace (SUA) at Naval Support Facility Dahlgren (NSF Dahlgren).

NSWCDD is a tenant upon NSF Dahlgren on the western shore of the Potomac River in King George County, Virginia (Figure 1-1, Location of NSF Dahlgren). NSF Dahlgren, a United States (US) Department of the Navy (Navy) facility under the supporting command of Naval Support Activity (NSA), South Potomac, Naval District Washington, is located 25 miles (mi) east of Fredericksburg, Virginia and 53 mi south of Washington, DC. NSWCDD is one of the Naval Sea Systems Command (NAVSEA) surface warfare centers. NSWCDD has multiple sites, but this environmental impact statement (EIS) concerns NSWCDD's range and mission area operations at Dahlgren, Virginia and hence will be referred to as NSWCDD in this document.

The EIS focuses on RDT&E activities that take place outdoors and have the potential to affect the human environment. Much of NSWCDD's research and development takes place inside laboratories and does not generate environmental impacts on the human environment outdoors. NSWCDD's Safety and Environmental Office ensures that no indoor impacts take place. Many of NSWCDD's outdoor activities, such as tests of passive sensors, also have no environmental impact, as determined by NSWCDD's Safety and Environmental Office, and are not considered in this EIS. Many of NSWCDD's outdoor activities, such as tests of passive sensors, also have no environmental impact, as determined by NSWCDD's Safety and Environmental Office, and will not be considered in this EIS.

1.1 Proposed Action

The **Proposed Action** evaluated in this EIS is to expand NSWCDD's RDT&E activities within the Potomac River Test Range (PRTR) and Explosives Experimental Area (EEA) Range complexes, the adjoining Mission Area, and the SUA. These RDT&E activities include outdoor operations that require the use of:

- **Ordnance** – Since its beginnings in 1918 as the US Naval Proving Ground, NSWCDD has been doing proof testing, lot acceptance, safety testing, and RDT&E of large-caliber guns, small arms (which, for the purposes of this EIS, are defined as those with calibers 20 millimeters [mm]) or less, and many other types of ordnance (munitions), some of which result in detonations.
- **Electromagnetic Energy** – Electromagnetic (EM) energy is naturally occurring and man-made energy created by the interaction of fluctuating electrical and magnetic forces that travel through space at the speed of light. The equipment used outdoors at NSWCDD emits EM energy in a frequency range that includes radio waves or radio frequency (RF), microwaves, infrared (IR) light, visible light, and ultraviolet (UV) light (Figure 1-2, Electromagnetic [EM] Energy). Many types of EM energy emitters are present at

NSWCDD, ranging from everyday, low-power radios, cell phones, and car door openers, to higher-power radars and sophisticated, one-of-a-kind test equipment used to test whether electronics and ordnance can withstand pulses of EM energy.

- **Lasers** – While lasers are a form of EM energy, they are treated separately in this EIS because of their unique properties, which create different types of hazards from other EM sources. A laser is a device that emits a coherent beam of light (EM energy). Most light (non-laser) is incoherent, meaning it is made up of many frequencies. Lased light is light of a single wavelength, so it does not scatter but rather stays in a narrow, intense beam without dissipating quickly. NSWCDD's expertise in laser safety and lasers includes RDT&E of sensors, rangefinders, target designators, guidance systems, simulators, communications equipment, and weapons.
- **Chemical and Biological (Chem/Bio) Simulants** – The threat of terrorist attacks has prompted the Department of Defense (DoD) to step up RDT&E to counter chem/bio terrorism. Chem/bio agents are very difficult to detect, and the key to minimizing the effects of an attack is early detection and warning. As the Navy's center for RDT&E on chemical and biological warfare sensors and protection systems, NSWCDD uses chemical simulants rather than dangerous agents in the open air. Simulants are substances – many are found in common, everyday use, such as acetic acid (strong vinegar) and oil of wintergreen – that mimic chemical and biological agents but do not have the agents' adverse health and environmental effects. To imitate the real chemical or biological agents effectively for RDT&E detection purposes, simulants must have at least one physical property similar to that of the agent, such as molecular size, density, or aerosol behavior. Biological simulants have not been used outdoors by NSWCDD thus far.

Under the Proposed Action, the average number of events that could take place annually (with the exception of large-caliber gun firing events) would increase above recent levels. To ensure that equipment and materials work effectively, even in less-than-ideal conditions, some activities would take place under conditions in which activities are now rarely/never conducted, such as at dusk, dawn, and night and in adverse weather. Alternatives to implement the Proposed Action are described in Chapter 2.

1.2 Purpose of and Need for the Proposed Action

The **purpose** of the Proposed Action is to enable NSWCDD to meet current and future mission-related warfare and force-protection requirements by providing RDT&E of surface ship combat systems, ordnance, lasers and directed-energy systems, force-level warfare, and homeland and force protection.

Under 10 US Code (U.S.C.) § 5062(d): "The Navy shall develop aircraft, weapons, tactics, technique, organization, and equipment of naval combat and service elements." The **need** for the

Location of Naval Support Facility (NSF) Dahlgren

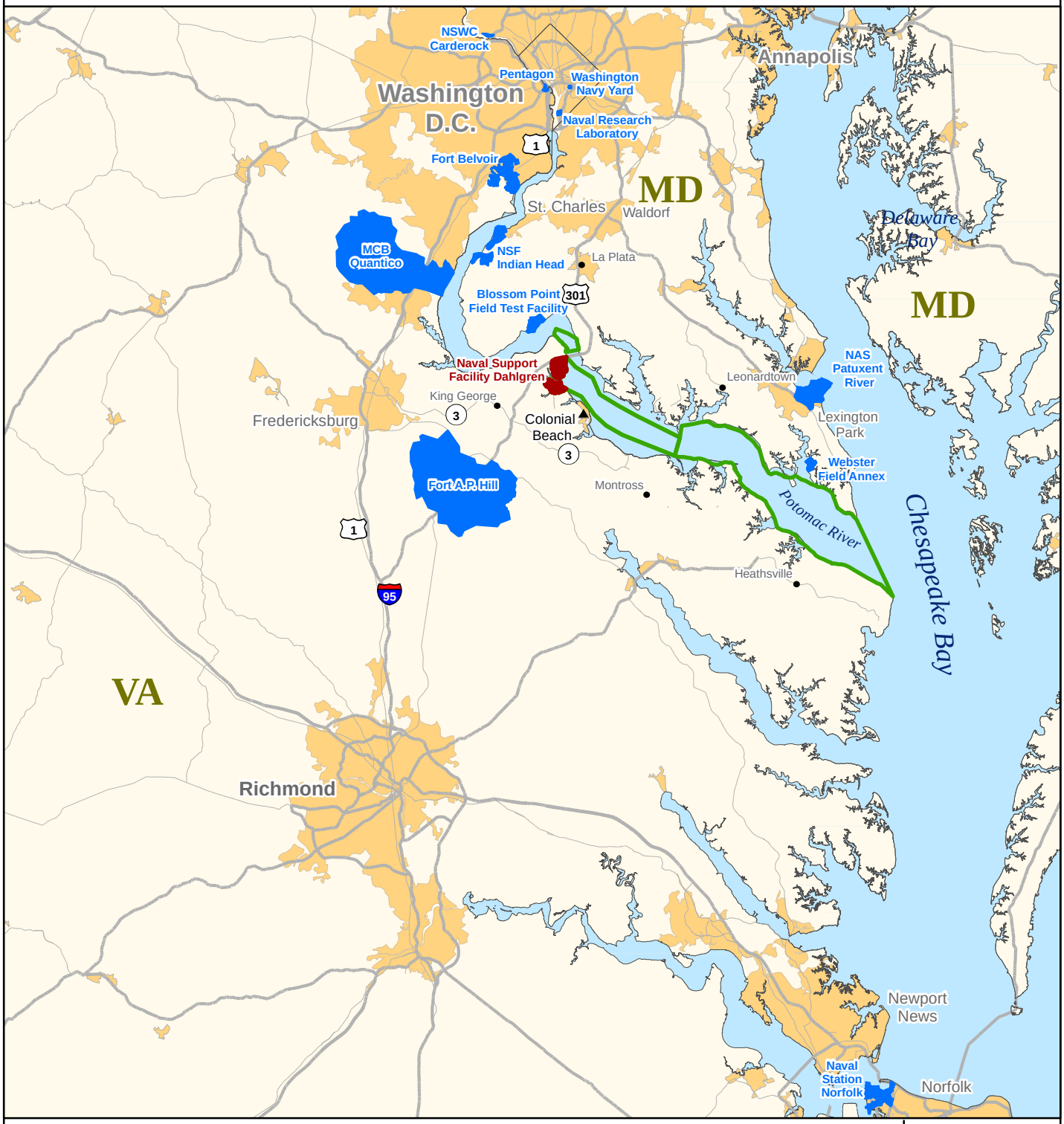

Figure 1-1

Source: NSWCDD GIS (2008 - 2011)

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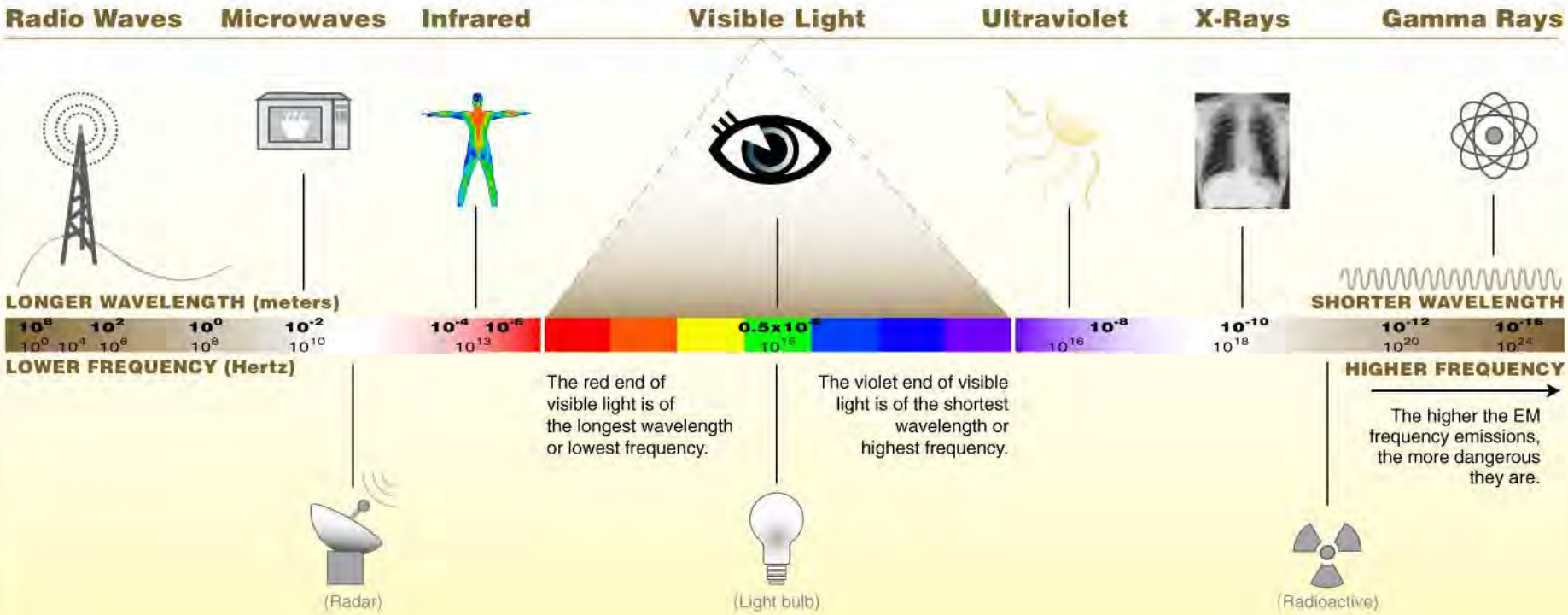
Electromagnetic Energy

What is the Electromagnetic (EM) Spectrum?

Electromagnetic (EM) radiation is energy that travels outwards from a source (i.e., radiates). The EM spectrum is the range of EM radiation and is expressed by frequency (measured in cycles per second called Hertz), wavelength (measured in meters), and energy (measured in electron volts). EM energy travels in waves – the closer together the waves, the higher the frequency; conversely, the farther apart the waves, the lower the frequency. Visible light is part of the EM spectrum. When light passes through a prism, the rays bend at different angles depending on their wavelength and are broken into component colors from red (longer wavelength) to violet (shorter wavelength). EM frequencies lower than visible light are, in order of decreasing frequency: infrared (IR), microwave (MW), and radio frequency (RF). EM frequencies higher than visible light are, in order of increasing frequency: ultraviolet (UV), X-ray, and gamma ray. NSWCDD conducts outdoor EM RDT&E activities in the range from RF to UV.



10^{x} Wavelength in meters
10^{x} Frequency in Hertz

Not to scale

Figure 1-2

NSWCDD EIS

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Proposed Action is to enable the Navy and other stakeholders to successfully meet current and future national and global defense challenges required under U.S.C. by developing a robust capability to carry out assigned RDT&E activities on range complexes, in the Mission Area, and in SUA at NSF Dahlgren.

1.3 NSWCDD Mission

NSWCDD's 3,000+ highly-skilled scientists and engineers bring their experience and talent to bear on cutting-edge applications. Their work is critical primarily to the Navy and Marine Corps but also to all of the DoD and other federal agencies. In accordance with DoD Directive 5000.01, test and evaluation support is to be integrated throughout the defense acquisition process and structured so as to provide essential information to decision-makers. This testing is used to validate technical performance parameters and to determine whether systems are operationally effective, suitable, survivable, and safe for their intended use. At NSWCDD, such testing is performed on ranges and in the Mission Area.

NSWCDD's mission is to provide RDT&E, analysis, systems engineering, integration and certification of complex naval warfare systems related to surface warfare, strategic systems, and combat and weapons systems associated with surface warfare. NSWCDD is the Navy's leading research organization for naval surface warfare and for the integration of complex warfare systems – ensuring that weapons, sensors, communication systems and warfare systems communicate and work together seamlessly, regardless of the branch of service using the equipment.

Looking northeast towards NSF Dahlgren and the Potomac River

The Navy established NSWCDD in 1918 as an over-water proving ground for naval ordnance. The PRTR Complex (Figure 1-3, Potomac River Test Range [PRTR] Complex) is the nation's largest fully-instrumented, over-the-water gun-firing range. Set in a shallow-water coastal, or littoral, environment bounded by land, the PRTR replicates the littoral areas of the world where almost 45 percent of the world's population lives and in which the Navy operates. As the focus of warfare has shifted from deepwater to coastal regions, testing equipment and technology in a littoral environment similar to those environments in which they will be deployed has become critical to ensure that warfare systems work as designed. Electronics, sensors, and warfare systems react differently in a littoral environment than in a desert, for example, where many systems are initially tested.

NSWCDD's RDT&E strengths include:

- Weapon systems integration
- Directed energy, lasers, and high-power microwave systems

- Optics
- Sensors
- Pulsed power
- Electromagnetic environmental effects
- Counter-terrorism technology
- Chemical, biological, and radiological defense
- Warfare analysis
- Ballistic missile defense technology
- Computer warfare defense technology
- Advanced ordnance

This RDT&E takes place both indoors and outdoors on the ranges and in the Mission Area.

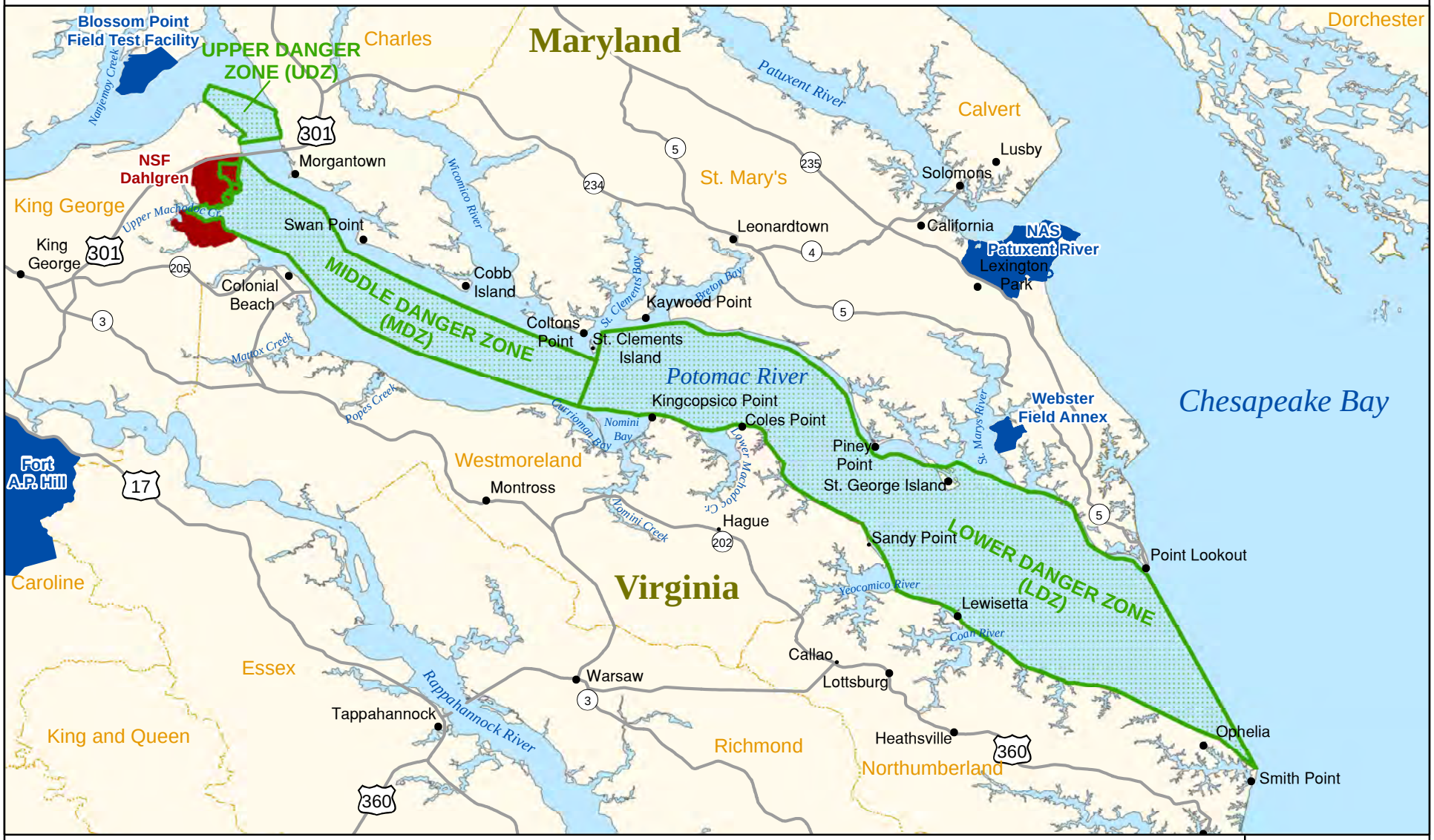
The 2005 Defense Base Closure and Realignment (BRAC) Commission, which reviewed the work of all DoD installations, identified NSWCDD as a center of excellence for weapon systems integration. It also recognized NSWCDD as “unique to the services and a center for Navy surface ship developments.” Weapon systems integration allows the weapons and communications systems of all branches of the armed forces to communicate and work together, which is critical to military effectiveness. NSWCDD tests, upgrades, and ensures the seamless functioning of multiple integrated warfare systems. Using the PRTR along with other RDT&E facilities at NSF Dahlgren allows interaction in real time with Navy forces afloat or with other branches of the military to test how well they operate together and how well weapon system components work. This real-time interaction not only provides the Navy with a cost-effective method of developing and evaluating the performance of new weapons and systems, but also speeds their development.

NSWCDD is the designated technical agent for all Navy and Marine Corps hazards of EM radiation to ordnance (HERO) RDT&E and serves many other joint-service and agency clients as well. NSWCDD also serves as the Navy's lead laboratory for RDT&E of issues surrounding E3. These services ensure the operational effectiveness and safety of systems and personnel exposed to the diverse EM environments associated with Navy and joint-service programs.

NSWCDD’s laser RDT&E program, which began decades ago, has been recognized by the Navy and the Office of Naval Research (ONR) as a center of excellence for laser RDT&E. As the Lead Technical Laboratory for Navy and Marine Corps laser safety, NSWCDD evaluates lasers and laser systems used on Navy and Marine Corps installations for hazards of EM energy to personnel (HERP).

NSWCDD’s Directed Energy Warfare Office (DEWO) is a recognized center of excellence for directed energy (focused EM energy) RDT&E. DEWO’s purpose is to lead the development, acquisition, and fielding of directed-energy systems for Navy surface, air, and ground forces.

Potomac River Test Range Complex



Potomac River Test Range (PRTR) Complex
Naval Support Facility (NSF) Dahlgren
Military Installation

7 0 7 Miles
11 0 11 Kilometers

Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

NSWCDD EIS

Figure 1-3

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NSWCDD is the Navy's lead center for chemical and biological defense RDT&E under the DoD's Chemical and Biological Defense Program. As such, NSWCDD is working at the forefront of ways to detect chemical and biological warfare agents and protect against them, particularly in the littoral environment.

1.4 Range Complexes, Mission Area, and Special-Use Airspace

NSWCDD's RDT&E activities take place on the range complexes and the Mission Area described below. Examples are given of the types of activities that take place on each.

1.4.1 Potomac River Test Range (PRTR) Complex

The PRTR Complex (Figures 1-3 and 1-4 [Range Complexes and Mission Area]) consists of land and water test areas that support RDT&E of warfare systems integration, ordnance, lasers, EM energy, sensors, unmanned systems (UMSs), and chemical simulants. The PRTR allows the Navy to conduct testing in a realistic, controlled environment – it effectively operates as a "ship on shore," collecting real-time data from a number of instrument stations. The water portion of the range is 51 nautical miles (NM) long, covers 169 square (sq) NM, and is divided into areas designated on nautical charts as the Upper, Middle, and Lower Danger Zones (UDZ, MDZ, and LDZ, respectively)[1]. The MDZ receives the heaviest use; it is 2.6 NM wide, 15.4 NM long, and covers 39 sq NM. Figure 1-5 (Potomac River Test Range Primary Gunnery Firing Area) shows the main gunnery target area. Danger zones are controlled during test events by NSWCDD range boats and by staff observers stationed at range stations along the Potomac River. Live fire can be performed up to 40,000 yards (yds) or approximately 20 NM down range.

Testing over water is vital when evaluating the performance of detection and engagement systems such as radars and electro-optical tracking systems in order to ensure that systems work over water as well as they do on land. The over-water range provides tracker and sensor testing with low over-water targets in situations in which background clutter, reflectivity, multi-path conditions, and wave height conditions can all vary. The range has a comprehensive instrumentation system, with both fixed and mobile components located along the PRTR to accurately measure test results. The PRTR also serves as a safety buffer for land-based range testing.

NSWCDD's Main Range gun line, which includes every gun currently used on Navy ships, faces down the Potomac River Test Range.

[1] The limits of the danger zones are defined in 33 Code of Federal Regulations (CFR) § 334.230 and shown on National Oceanic and Atmospheric Administration's Nautical Charts: 12288, Lower Cedar Point to Mattawoman Creek; 12286, Potomac River – Piney Point to Lower Cedar Point; and 12233, Chesapeake Bay to Piney Point.

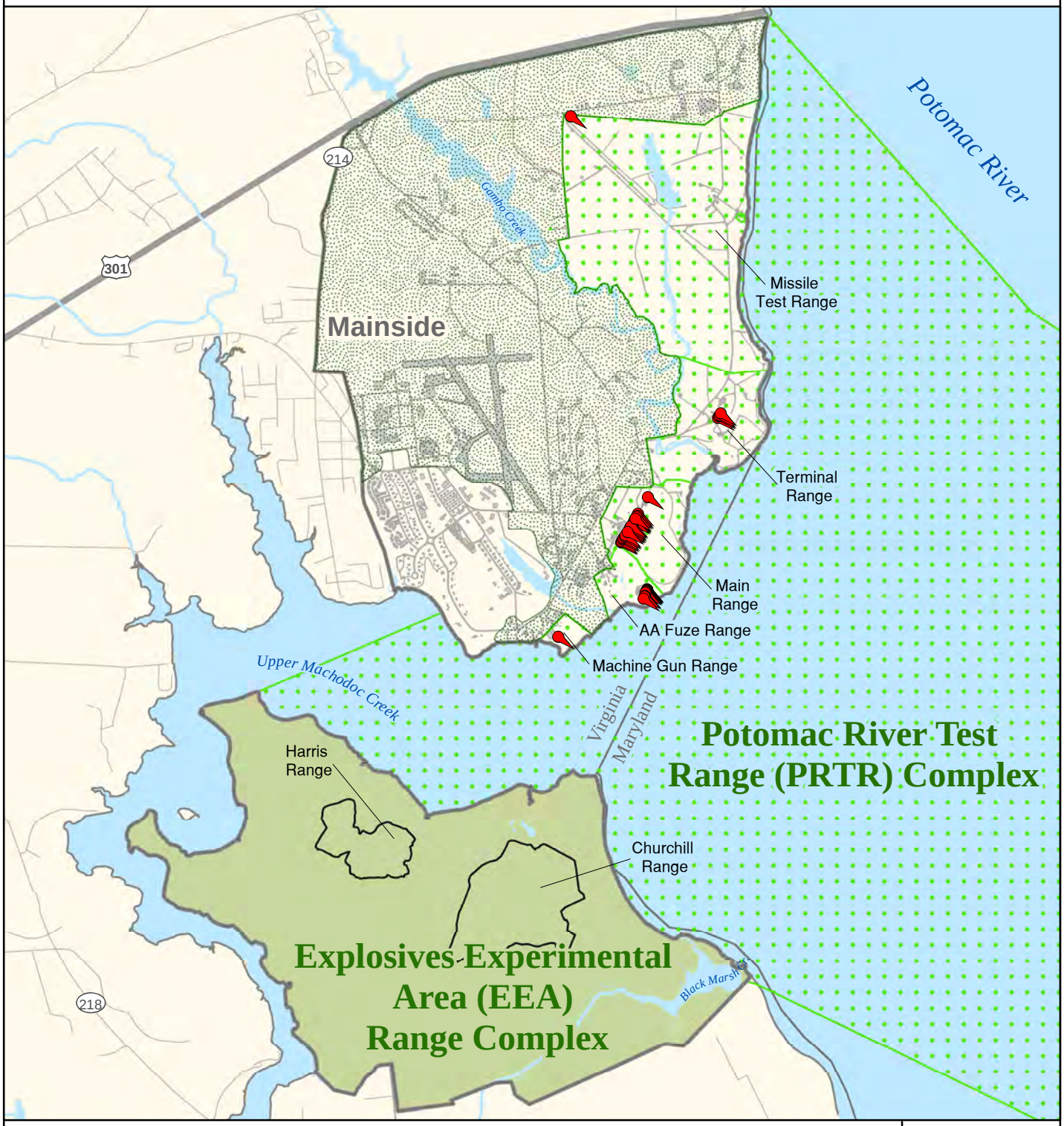
The 725 acres (ac) of land ranges that are part of the PRTR (Figure 1-4) include (with examples of the types of work conducted on each range):

- **Main Range –** Used for systems integration and testing with networked connectivity to most shipboard combat-system elements, the Main Range houses large-caliber gun systems, and includes 39 gun emplacements plus test stands for proof-firing gun-mount oscillating assemblies and gun barrels. The Search and Track Sensor Test Site (STSTS) houses radar systems used for gun fire control, systems integration, scanning the range, and controlling unmanned aerial vehicles (UAVs).
- **Anti-Aircraft (AA) Fuze Range** – Primarily used to test fuzes over the PRTR, the AA Fuze Range also is used to test large-caliber guns and projectile components. Its location adjacent to the PRTR enables over-the-water testing of fuzes – a procedure vital to the success of Navy fuzes. RDT&E support at the AA Fuze Range includes proof tests, barrel wear and heating tests, projectile ramming tests, new-projectile design evaluation, and water-surface burst data at short and long ranges.
- **Missile Test Range** –Despite this range's historic name, no missiles are fired from it these days. Instead, this range is used to conduct overland test and evaluation of vehicles and special-weapon components against targets. The range includes suspended targets, a grazing pad, and portable facilities and analysis equipment. The Electromagnetic Launch Facility (EMLF) for EM launcher RDT&E is located on this range. Shock Tube and Tisdale Roads are used for laser and EM activities. The range includes an explosive ordnance disposal training range for non-fragmenting energetic training activities.
- **Machine Gun Range** – This range consists of four indoor and two indoor/outdoor firing bays and an outdoor test area with multiple gun emplacements. Testing of 40 mm and smaller guns and ammunition is performed here, as well as penetration testing of light-armor materials. The range is also used to evaluate the effectiveness of windshields and protective armor against representative small arms threats, such as improvised explosive devices and other non-conventional threats. The range is equipped to record data such as firing stresses and strains, shock waves, projectile pressure, temperature, position, velocity, and acceleration. The Navy Directed Energy Center (NDEC) is located on this range.
- **Terminal Range** –The Terminal Range supports RDT&E and production testing of weapon systems, components, and other ordnance material (specifically, experimental items). This location allows for tests requiring large quantities of explosives, high chamber pressures, ballistic evaluation of armor plate, and penetration tests of projectiles. A projectile recovery system has been constructed to accommodate the firing of projectiles on land. Emerging-technology projectiles are recovered after tests to study gun-firing effects.

1.4.2 Explosives Experimental Area (EEA) Range Complex

The 1,641-ac EEA Range Complex (Figure 1-4) supports performance, lethality, safety, and insensitive-munitions testing on full-scale weapon systems and components containing explosives, propellants, and inert materials. Although the EEA mainly supports RDT&E and

Range Complexes and Mission Area



Gun Firing Location

Potomac River Test Range (PRTR) Complex

Mission Area

Explosives Experimental Area (EEA) Range Complex

Naval Support Facility (NSF) Dahlgren

Source: NSWCDD GIS (2008 - 2011)

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Figure 1-4

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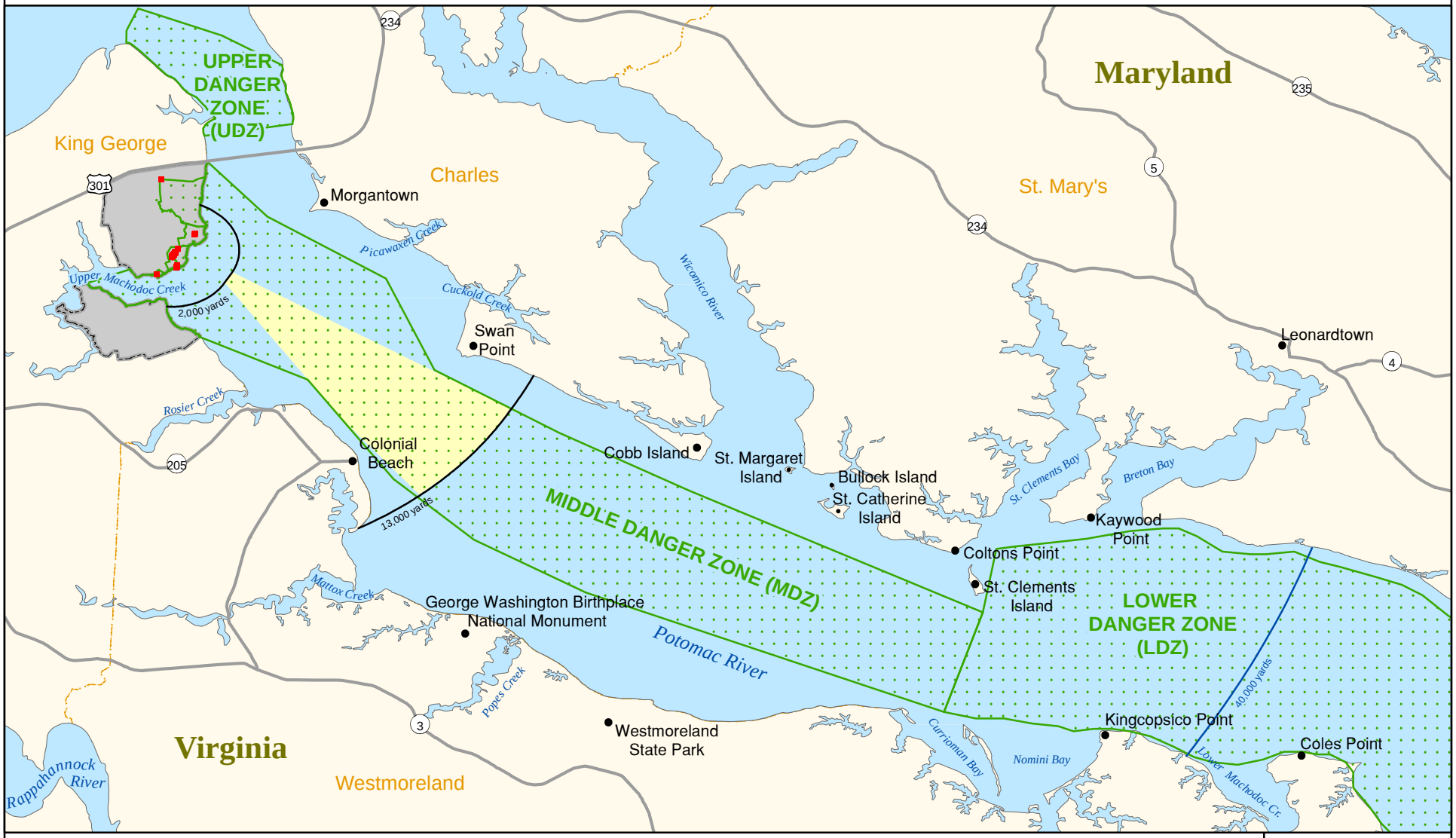
Potomac River Test Range Primary Gunnery Target Area



Gun Firing Location

Primary Target Area

Maximum Firing Range (see definition in Section 1.5.1)

Potomac River Test Range (PRTR) Complex

Naval Support Facility (NSF) Dahlgren

3.5 0 3.5 Miles

5.5 0 5.5 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 1-5

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safety testing for ordnance weapon systems, such as rocket-propelled grenades, rockets, and restrained missile launchers, this complex also supports RDT&E of lasers, EM energy, and chem/bio simulants. The EEA is extensively instrumented for conducting explosive tests such as blast measurements, target vulnerability, arena testing, and live-fire tests (described in Section 1.5.1.4). Safety testing of ordnance (munitions) includes temperature and humidity cycling, shock, vibration, and a 40-foot drop. Insensitive-munitions tests include fast cook-off[2], slow cook-off, fragment impact, shaped charge/jet impact, sympathetic detonation, and bullet-impact testing. The Counter Explosive Test Facility (CETFAC), the Naval Ordnance Transient Electromagnetic Simulator (NOTES) facility, and two ranges – Churchill and Harris – are located within the EEA.

- **Churchill Range** –This range is used for destructive testing of items with up to 1,000 pounds (lbs) of explosives, net explosive weight (NEW). Range infrastructure is in place to facilitate fast cook-off, slow cook-off, bullet impact, arena testing, and blast testing, as well as specialized testing, as required. Resource Conservation and Recovery Act (RCRA)-permitted open burn/open detonation (OB/OD) units are located on the Churchill Range.
- **Harris Range** – This range is used for destructive and non-destructive testing of items of up to 600 lbs NEW. Infrastructure is in place to facilitate slow cook-off, fragment impact, arena and other specialized testing, as required. In addition, the Harris Range supports equipment and infrastructure to conduct restrained 40-foot drop testing and full-spectrum shipboard shock testing on both explosive and non-explosive items.

1.4.3 Mission Area

The 1,593-ac Mission Area (Figure 1-4) consists of property adjacent to but not designated as part of the PRTR Complex. This area supports a myriad of outdoor RDT&E activities for NSF Dahlgren and its tenants but excludes destructive ordnance testing (allowed on military ranges including the PRTR and EEA). Facilities in this area include the NSF Dahlgren Airfield, the Maginot Open Air Test Site (MOATS), the Chemical/Biological Defense (CBD) Facility, and the Electromagnetic Environmental Effects (E3) facilities –MOATS, ground planes, airfield hangars, and the abandoned and main runways.

1.4.4 Special-Use Airspace (SUA)

SUA areas have been established by the Federal Aviation Administration (FAA) to prevent hazards to aircraft from NSWCDD's RDT&E activities (Figure 1-6, Special-Use Airspace [SUA]). There are four subdivisions of the SUA areas, two with maximum altitudes of 40,000 ft (SUA R-6611A and SUA R-6613A), and two with maximum altitudes of 60,000 ft (SUA R-6611B and SUA R-6613B). For safety reasons, flights by non-military aircraft in the SUA areas are restricted during testing. When testing is completed early or a scheduled test is cancelled, the

[2] Cook-off or thermally induced firing refers to ammunition exploding prematurely due to heat in the surrounding environment. Fast cook-off is caused by fire whereas slow cook-off is caused by a sustained thermal event less intense than fire.

airspace is returned to the control of the FAA for normal civilian air traffic use. Additionally, a small restricted airspace – SUA R-6612 – lies directly over the EEA, and extends to 7,000 ft.

1.5 Mission Activities Addressed in This EIS

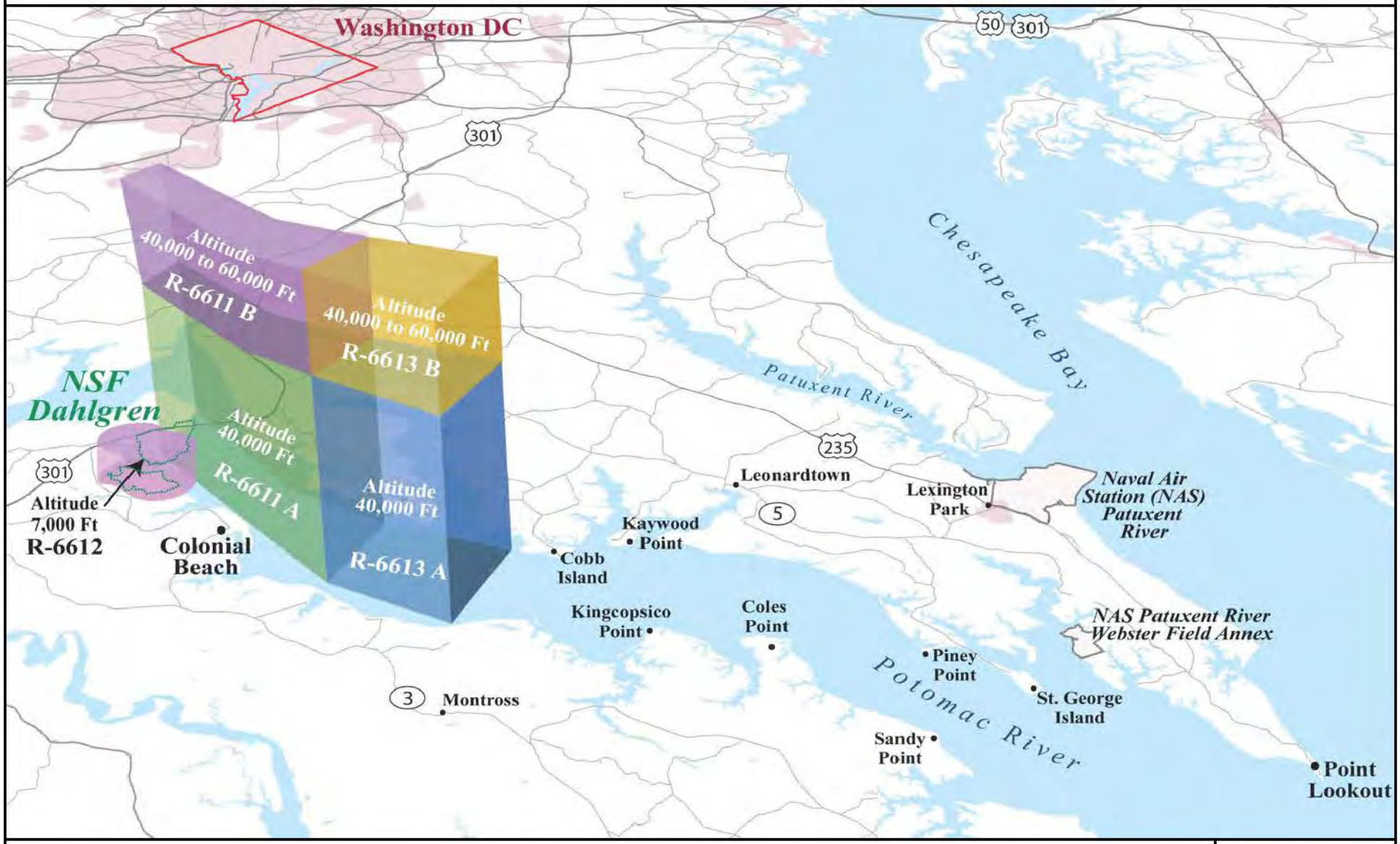
NSWCDD's work encompasses a number of mission/expertise areas within naval surface warfare. The focus of the EIS, however, is specifically on outdoor RDT&E activities that have the potential to significantly affect the human environment. As noted in the introductory paragraphs, much of NSWCDD's work takes places indoors in laboratories with ample safeguards in place to protect human health and safety, so effects on the indoor human environment are limited and are not addressed in this EIS. Similarly, much of the work NSWCDD undertakes outdoors has negligible impact on the human environment and thus is not addressed in this EIS.

NSWCDD's activities that have the potential to significantly affect the human environment involve the use of ordnance, higher-power EM energy, higher-power lasers, and chem/bio simulants, which fall under the following mission/expertise areas:

- **Surface Ship Combat Systems** – RDT&E, systems engineering, and integration to ensure that combat systems on surface ships function correctly. Major areas are air and surface surveillance sensor and detection systems; combat control systems; engagement systems; electronic warfare systems integration; and combat systems engineering, integration, testing, evaluation, and assessment.
- **Ordnance** – RDT&E to ensure the safety and capability of guns, ammunition, energetic materials, logistics, and environmental technology, as well as cartridge-actuated, pyrotechnic, and specialty devices.
- **Lasers and Directed Energy** – RDT&E using focused EM energy, particularly lasers and directed energy, in support of air and surface surveillance; electronic attack; and targeting, detection and engagement systems.
- **Force-Level Warfare** – RDT&E to ensure the integration and interoperability of each element (ship, weapon system, etc.) at the force, battle group, and theater level. Major areas are: warfare systems analysis, architecture and requirements; warfare systems engineering, integration, testing, evaluation, and assessment; and mission assurance.
- **Homeland and Force Protection** – RDT&E solutions to protect the Armed Services, other government agencies, and the nation from emerging and nontraditional terrorist threats. Major areas include: homeland security and measured response options; force protection and chemical and biological defense systems; and mission assurance.

The mission activities currently being conducted by NSWCDD that are addressed in this EIS are described in the following sections.

Special-Use Airspace



Source: FAA, 2005.

Figure 1-6

NSWCDD EIS

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1.5.1 Mission Activities Involving Ordnance

Our nation's military must eliminate an array of evolving threats in a variety of physical environments. To do so effectively requires the development of increasingly accurate and effective weapons with the capability to reliably detect, identify, and destroy a range of targets and hazards on sea, on land, and in the air.

Since 1918, NSWCDD has been a national resource for the testing of naval guns and ammunition, as well as for a wide variety of military testing utilizing explosive and non-explosive ordnance. NSWCDD is the Navy's primary RDT&E facility for most surface-launched weapons systems. Large-caliber gun testing is primarily conducted on NSWCDD's Main Range within the PRTR Complex (Figures 1-3 and 1-4) but also on the AA Fuze Range and the Terminal Range. The gun emplacements are capable of firing all types of naval guns. NSWCDD maintains at least one naval gun of each type used in the Fleet as well as older guns no longer used by the Navy but still used on the ships of its allies. Guns are fired downriver with most rounds landing in the main gunnery target area within the Middle Danger Zone (MDZ) (Figure 1-5). The maximum firing range, which refers to the maximum distance a fired projectile would travel, is 40,000 yds (19.7 NM – or approximately 20 NM). The maximum range target area is located at 35,000 yds (approximately 17 NM), which provides a margin of safety for projectiles that may not hit the target area.

1.5.1.1 Ordnance Safety

Before an outdoor ordnance operation takes place, a risk hazard assessment (RHA) and associated standard operating procedure (SOP) are developed, reviewed, validated, and approved, as described in Section 3.8.1. These measures ensure that tests are conducted safely and with a minimum of environmental impact.

Standard Operating Procedure (SOP) and Risk Hazard Assessment (RHA)

A **standard operating procedure (SOP)** is prepared for every operation determined by performance of a **risk hazard assessment (RHA)** to be potentially hazardous**.** SOPs are prepared to ensure the safety of participants and the public and to minimize environmental impacts. An SOP includes a description of the proposed operation; a statement of responsibilities; a listing of what persons will be in charge of what actions; the operational location; a description of personnel and material limits (including buffer zones for safety); safety requirements; emergency response and contingency plans; applicable environmental protection procedures; security requirements; a hazard control brief; an equipment list; and step-by-step descriptions of the procedures to follow, with highlighted warning and caution boxes.

When ordnance activities take place on the PRTR or the EEA, public access to these areas and to the airspace above them is restricted. As described in more detail in Section 3.8.1.1, danger zones are defined on nautical charts for the PRTR (Figure 1-3) to alert mariners that access to the area is restricted during testing to ensure everyone's safety. NSWCDD's Range Operations Center (ROC) restricts the range(s) before testing commences and deploys range boats flying red flags to clear the range of watercraft, if required. The ROC continuously communicates with boaters by radio. SUA is activated during ordnance tests to restrict aircraft (Figure 1-6).

1.5.1.2 Large-caliber Gun Activities

NSWCDD's ordnance mission has evolved from component (single-element) testing to systems integration and testing with networks connected to most shipboard combat-system elements (such as gun fire control, sensors, radars, and the Naval Fire Control System). The largest guns fired at NSWCDD today are the 155 mm (6.1") howitzer used by the US Marine Corps and US Army and the 8" (203 mm) gun. The 155 mm gun is fired infrequently to support the testing of fuzes and projectiles and only occasionally into the river. Typically, the 155 mm gun is fired into a projectile catchment facility on one of the land ranges, particularly the Terminal Range. The 8" gun is no longer used as a weapon but rather is a one-of-a-kind test fixture used to launch canisters containing electronic components for new projectile designs to test their ability to withstand the stress of high levels of gravity or "G" forces during launching. A reduced charge is used to fire the 8" gun; no other explosives are used.

Naval Guns

Naval gun designations generally include the: (1) model or reference designation; (2) modification designation to indicate a change from the original design; (3) caliber (diameter of the bore); and (4) barrel length, which is described in multiples of the diameter of the bore.

For example, the description **MK 45 Mod 1/2 5"/54** means that it is the 45th version of the 5" gun; has the first and second modifications to the Mark (MK) 45 design; has a 5-inch-diameter bore; and has a barrel 5 x 54 inches = 270 inches long.

The largest caliber guns that are fired frequently are the 5" (127 mm) guns. The Mark (MK) 45 Mod 1/2 5"/54, a gun commonly found on ships in the Fleet, has a maximum sustained firing rate of 20 rounds per minute and a maximum firing range of 26,000 yds (approximately 13 NM). The newer, longer-range 5"/62 gun has a maximum range of 30,000 yds (approximately 15 NM).

The number of projectiles (rounds of ammunition) NSWCDD fires annually from large-caliber guns on and from the land ranges of the PRTR Complex varies based on the types of tests being conducted in a given year. For the purpose of this EIS, large-caliber guns are considered to be more than 20 mm (0.8") in bore size. RDT&E is cyclical by nature, and tests on a particular type of weapon, weapon component, or weapon system may take place once every three, five, or even ten years. Testing of a weapon or system may occur over a period of days, weeks, or months. Firing levels may be higher in one year because a new gun or a new type of ammunition is being tested or due to world events. For example, during World War II (WWII) RDT&E occurred daily at NSWCDD.

NSWCDD fired an average of 2,900 projectiles annually in the years from 1995 to 2009, ranging from a low of 910 fired in the year with the smallest number of firings (2005) to a high of 6,170 (all inert) in 2004. In particularly active years since 1995, the average has been approximately 4,700 large-caliber projectiles fired annually.

For the years 1995 to 2009, 74 percent of the projectiles fired from the PRTR land ranges into the Potomac River were inert, and 26 percent were live explosive projectiles. The component most often tested on inert projectiles is the fuze or detonator. A fuze or detonator typically

Live and Inert Projectiles

Projectiles used at Dahlgren can be live (explosive) or inert (non-explosive). Live projectiles are composed of energetic material (the explosive core or the propellant for a projectile), plus an outer casing, fragmentation material, a fuze (a detonating device), sensors, timers, or other items. Inert projectiles have a core composed of sand or concrete with no energetic material – no explosive core – but could have a fuze with less than 0.004 lbs of explosive material, a sensor, or other items for testing.

contains less than 0.004 lbs (2 grams [g]) of explosive material. A fuze usually also contains a few ounces of non-explosive talcum-like powder to produce a puff of smoke to indicate to observers that the fuze has been successfully triggered.

The explosive rounds NSWCDD fires most commonly are 5” projectiles, which typically contain 6-10 lbs of explosives NEW. While 5” projectiles containing up to 16 lbs of explosives are made for specific purposes, NSWCDD’s use of projectiles over 10 lbs NEW is very rare. For example, the Navy developed one special projectile that contained 16 lbs of explosives for the purpose of giving off a large heat signature, but very few were made.

NSWCDD’s largest explosive projectiles are fired from the 155 mm howitzer, which is fired much less frequently than the 5” guns, usually with inert rounds, and mainly into targets on the land ranges. Most live 155 mm projectiles fired by NSWCDD contain 11-15 lbs of explosives. For comparison purposes, while the Navy no longer fires large 16” (406 mm) projectiles into the PRTR, the 16” projectiles fired until the early 1990s each contained over 150 lbs of explosives.

The types of activities conducted at NSWCDD using large-caliber guns include:

- **Lot acceptance and proof testing** – NSWCDD tests to ensure the safety and effectiveness of newly-delivered weapons and ammunition for most types of naval weapons, such as land attack, anti-aircraft guns, missiles, and projectiles, as part of Naval Surface Fire Support, a central mission of the Navy. NSWCDD serves as the final inspection and acceptance point for most naval gun barrels, ammunition, and all associated components, including fuzes, primers and propellants, to ensure that sailors and marines are provided with safe, accurate, and reliable weapons. While missile components are tested at NSWCDD, missiles are not physically launched from range complexes. Lot acceptance and proof testing, once a major portion of NSWCDD’s ordnance activities, now only accounts for about ten percent of its workload.
- **Projectile and fuze testing** – NSWCDD tests projectiles and their fuzes, firing from the actual types of guns used by the Fleet over the PRTR’s combined water and land range to accurately simulate the background “clutter” that occurs in real wartime (at-sea and littoral) environments. Because RF, IR, and other sensor characteristics are affected by water surfaces and moist atmospheric environments differently than when over land, testing on a water range is necessary to realistically assess munitions and fuzes against sea-based targets. Background clutter includes such things as surface reflectivity, optical glint, and EM interference.

MK 45 Mod 1/2 5”/54 gun being fired

- **Reactive materials** – Reactive materials are inert under normal conditions, but when they impact a target at very high speeds, they "react" with a high level of explosive force. Performance and effectiveness of reactive materials are studied at NSWCDD.
- **EM Launcher RDT&E** – NSWCDD is conducting RDT&E of a new type of naval gun. EM launcher technology uses high-power EM energy instead of explosive chemical propellants to propel projectiles farther and faster than any preceding gun. The EM launcher projectile is made with a reactive material that explodes on impact with a target from sheer kinetic force even though there is no chemical explosive as is found in explosive-based ordnance. This capability will allow ships to fire on land targets while staying well-offshore and out of range of enemy fire. The Navy's goal is to employ EM launchers as weapons on future all-electric Navy ships (NSWCDL, 2009a).
- **Development and certification of integrated targeting and fire control systems** – Today, a sensor such as radar or a laser not only detects a target, but also transmits the information to one or more platforms, such as ships and aircraft, simultaneously. NSWCDD is working to enhance the integration of information to enable almost immediate communications among sensors and platforms in order to instantly sense, target, and engage the target, if necessary, with the most appropriate weapon from each platform.
- **Missiles, rockets, and launcher components** – This work focuses on the operation of components, such as sensors and telemetry systems.
- **Operational improvements in reliability, accuracy, and safety of weapons and ammunition** – One example is RDT&E to improve gun-barrel life by using light composite material in gun barrels to produce longer-lasting, lighter weapons.
- **Long-range guns that can fire accurate and reliable projectiles at distances in excess of 50 NM** – While NSWCDD is developing and testing the capabilities of these new guns and projectiles, they would not be tested at full range at this facility.
- **High-speed penetrating projectiles** – NSWCDD is working on developing new forms of high-speed penetrating weapons to serve as "bunker busters."

1.5.1.3 Small Arms Activities

Firing of small arms (defined in this EIS as having a projectile diameter of less than or equal to 20 mm [0.8"]) can take place on any of the ranges, but primarily takes place on the Machine Gun Range, AA Fuze Range, and Main Range. In addition, penetration testing of light-armor materials and of primers (caps or tubes containing a small amount of explosive used to detonate the main explosive charge of a firearm) of all sizes occurs at the Machine Gun Range. Active gun mounts are available for firing a wide variety of small-caliber handguns, machine guns, and rifles. Usually, the projectile of a gun smaller or equal to 20 mm (0.8") is referred to as a "bullet." Approximately 6,000 bullets are fired outdoors on the ranges annually. Most bullets fired are inert – made of solid metal with no explosive filler – but some are explosive.

1.5.1.4 Detonations

Approximately 190 detonation events take place annually, based on an average of annual detonations from 1993 through 2009. Most detonations take place on the EEA's Harris and

Churchill Ranges, but a few may take place on the Explosive Ordnance Disposal training area of the Missile Test Range. In an average year, 95 percent of items detonated for RDT&E activities contain less than 100 lbs NEW of explosives. For example, the NEW of the detonations in 2007 ranged from less than 1 lb up to 623 lbs, with an average of 28 lbs per detonation. However, the NEW of half of the detonations was 5 lbs or less. In 2007 only four detonations had NEWs above 100 lbs – two at 104 lbs NEW, one at 175 lbs NEW, and one at 623 lbs NEW.

Arena Fragmentation Test

The Churchill Range has a 1,000-lb NEW limit. The Harris Range has a 600-lb NEW limit. However, detonations of this size rarely occur as part of RDT&E activities. Large NEW detonations usually take place on the EEA for treatment (the blowing up or destruction) of explosive waste. Treatment of explosive waste takes place at NSWCDD because ordnance subjected to testing is unsafe to transport to other facilities for treatment. In 2007, NSWCDD treated 66 pieces of ordnance with a total NEW of 19,000 lbs.

Pieces of ordnance of over 200 lbs NEW subjected to open detonation treatment are covered with approximately 8 feet (ft) of dirt to reduce noise and flying fragments. Detonations are heard as booms or rumbles. How far away the noise from a detonation is heard varies based on the RDT&E being conducted (e.g., quantity of NEW, burial depth, location of detonation), weather conditions, and the location of the person hearing it.

The types of activities that produce detonations are:

- **Insensitive Munitions (Ordnance) Tests –** Insensitive munitions tests are conducted to ensure that explosive munitions are relatively insensitive to unplanned stimuli, such as those that might occur as a result of an accident or deployment in combat (e.g., fire, fragment impact, or a nearby munition exploding). Insensitive munitions tests include: fast cook-off, slow cook-off, fragment impact, shaped-charge/jet impact, sympathetic detonation, and bullet impact.
- **Environmental Safety Tests –** Ordnance is subjected to extreme temperatures, water, salt fog, vibration, dropping, and shock testing to ensure its reliability and stability when transported by sea, by aircraft, and over land, and when stored in ships' holds. Data collected from these tests are used to determine various threshold limits, to identify and correct weaknesses, to identify safe operating parameters, and to write guidance documents for military personnel to ensure high safety standards and protect personnel and equipment. These tests are conducted in response to various military standard requirements. Occasionally, a piece of ordnance being tested will detonate.
- **Arena Fragmentation Tests –** Fragmentation arenas located on the Churchill Range are used to evaluate blast data; fragment spatial distribution, masses, and velocity; lethality;

warhead performance; and presented areas/shape factors. The circular "arena" is surrounded by panels of metal and wood to capture the fragmentation patterns after detonation. All shell fragments remain within the EEA ranges.

- **Performance and Safety Tests** – In order to characterize performance, tests of performance and safety, such as for warhead detonations, are conducted both within the arena and in other parts of the ranges.

1.5.2 Mission Activities Involving Electromagnetic Energy

EM energy and its application for military use is a major area of RDT&E at NSWCDD. Use of EM technology promises to be one of the most important areas for advancing the ability to communicate, detect objects or substances, protect against enemy weapons, and destroy enemy targets with levels of speed, accuracy, and safety not possible with conventional guns and missiles. Using EM energy, NSWCDD is exploring applications to instantly detect possibly harmful chemical or explosive substances and to use focused beams or directed energy, such as those used by radar or a microwave oven, to destroy incoming missiles.

The work done outdoors at NSWCDD uses EM emitters in the range from RF to UV waves (Figure 1-2). Many types of EM energy emitters are present at NSWCDD, ranging from everyday low-power radios, cell phones, and car-door openers to higher-power, sophisticated one-of-a-kind test equipment.

Electromagnetic Energy

Electromagnetic (EM) energy is naturally occurring and man-made energy created by the interaction of fluctuating electrical and magnetic forces that travel through space at the speed of light. Lightning that accompanies thunderstorms is a vivid example of naturally occurring EM energy. Televisions, radar, microwave ovens, Wi-Fi, cellular phones, and iPods are man-made uses of EM energy.

EM energy devices evaluated in this EIS operate at higher powers. Currently, an annual average of 490 events take place at NSWCDD using EM energy fields in the frequency range of 300 kilohertz (kHz) (or 300,000 cycles per second) up to 300 gigahertz (GHz) (or 300 billion cycles per second) and at average powers ranging from 10 watts (W) to 500 megawatts (MW). Activities employing higher-power EM energy are described below. (While lasers are a type of directed EM energy, they are treated separately because of their distinctive mode of operation).

Operations, Tests, and Events

An **operation** is a group of **tests** that has a common objective and that may take place over one or more days under one **standard operating procedure (SOP)**.

For purposes of this EIS, an **event** consists of **all the tests that take place under one SOP on one day**. If two groups of tests are conducted on the same day under separate SOPs, then each group counts as a separate event.

If an operation continues for a number of days, the tests conducted on each additional day under the same SOP are considered as separate events. As an example, if an operation continues for 10 days with tests taking place on each day under the same SOP, then this operation would include 10 events, for purposes of this EIS.

1.5.2.1 Electromagnetic RDT&E Safety

Most of NSWCDD's EM energy research is on the lower-frequency range of the EM spectrum (Figure 1-2). Research includes UV, visible, and IR light; microwaves; and RF waves, all of which are relatively safe. Prior to conducting any EM tests, NSWCDD personnel consider the frequencies and power the tests will utilize. Because energy and power levels decrease with increasing distance from the source, distances from the source to humans or wildlife in the area are crucial elements in designing the tests and developing SOPs. NSWCDD incorporates into all SOPs strict safety standards, for which levels have been established through extensive national and international research in EM safety. Only after meeting or exceeding these safety levels, and after satisfactorily demonstrating a complete dry run (one in which no energy is emitted), will a senior division manager approve the SOP and allow activities to proceed.

EM Variables

EM energy is classified into several types based on the **frequency** of the waves (see Figure 1-2 and EM energy text box). **Power** is the rate at which energy is transferred per unit **time**. It is measured in **watts (W)** and 1 W is equal to one joule per second.

The standard unit of electric field strength (E-field) is **Volt per meter (V/m),** which is used to specify the **intensity** (power per unit area) of an EM field**.** Energy is inversely proportional to the square of the **distance** from the source, so an object (of the same size) twice as far away, receives only one-quarter the energy.

The term magnetic field is used for two different vector fields denoted as the B- and H-fields. The B-field or magnetic flux density is measured in **tesla (T)** or **gauss (G)** and the H-field or magnetic field strength is measured in **amperes per meter (A/m).**

As with ordnance activities, SOPs developed for each operation using EM energy identify and incorporate safe operating parameters with respect to personnel, ordnance, fuels, the environment, and electronic equipment near the test site:

- **Hazards of EM Radiation to Personnel (HERP) safety zones are determined for each EM emitter –** Personnel involved with the test inside the safety zone must either leave the HERP safety zone during operations or limit their time based on approved exposure limits (DoD, 2009). These limits are similar to exposure times recommended for humans to sunbathe safely. Because EM energy dissipates exponentially as the distance from the energy source increases, safety to personnel is usually as simple as moving personnel farther away from the source. Therefore, hazards-to-personnel safety zones are calculated for each EM energy emitter.
- **Hazards of EM Radiation to Fuel (HERF) –** Fuel vapors can be ignited by EM energy field-induced arcs during fuel-handling operations close to high-powered RF radar and transmitting antennas. Therefore, no fuel storage or fueling takes place within HERF safety zones.
- **Hazards of EM Radiation to Ordnance (HERO) safety zones are determined for each EM energy emitter –** Ordnance that might detonate due to EM overexposure must be kept out of the EM source's HERO safety zones during operation.
- **The Potential for Electromagnetic Interference (EMI) –** The potential for EMI is identified prior to operation of higher-power EM energy emitters. EMI includes the potential to affect any device that uses EM energy nearby, ranging from causing static on television sets to interfering with automotive remote-entry control devices or cell phones.

NSWCDD's engineers and scientists mitigate EMI that could affect the public and other activities on NSF Dahlgren by actions such as shielding, using lower power, or changing where the energy is focused and directed.

Increasing distance from the source dramatically reduces energy and power levels, and, in turn, potential HERP, HERO, HERF, and EMI risks. As a rule of thumb, doubling the distance reduces the energy, and thus the risk, by a factor of four.

1.5.2.2 Electromagnetic Sensors

Active EM Sensors

Active sensors emit EM energy directed towards a target under investigation. The energy reflected from the target is detected and measured by the sensor. Active sensors can obtain measurements regardless of the time of day or weather. Active sensors used by the Navy include radar and lasers.

Passive EM Sensors

Remote sensors that measure naturally-available energy are called passive sensors. For reflected energy, passive sensors can only be used when the sun is providing illumination. Energy that is naturally emitted (such as thermal IR) can be detected day or night, if sufficient energy is available. Passive sensors used by the Navy include optical chemical detectors, passive electro-optical sensors (in both the visible and IR spectrum), and daylight television cameras.

EM sensors such as RF radars are the critical "eyes, ears, and brains" of nearly all military decision-making, tactical and strategic weapon systems, and intelligence collection and processing. In battle areas, sailors and soldiers must be able to respond rapidly and effectively, with little or no tactical warning, to a wide range of uncertain threats, from non-conventional forces with increasing technological sophistication to weapons of mass destruction. The overall technical focus of the sensor program is to provide the military with perfect situational awareness of the expanded battlefield in all environments. Shipboard sensors employ radar for a number of different applications, including detection of high-speed, low-altitude targets (cruise missiles). Ship self-defense is enhanced by using sensors to reduce reaction time, improve target identification, and extend threat-engagement ranges.

Testing the full spectrum of Navy and Marine Corps weapon systems over a combined land and water test area is vital when evaluating the performance of electro-optical tracking systems and their integration with radars and other sensors. NSWCDD's RDT&E using sensors includes providing technical oversight for prototype radar systems, evaluating sensors for acquisition and tracking, studying radar propagation, and locating objects using global positioning systems (GPSs).

NSWCDD's Search and Track Sensor Test Site (STSTS) (location shown on Figure 1-7, Facilities Using Electromagnetic (EM) Energy) houses the RDT&E of passive and active RF and electro-optical sensors for naval warfare systems. The STSTS includes RDT&E of exploratory and advanced sensors, as well as systems and lifecycle support and software support functions for sensor systems in the field.

Search and Track Sensor Test Site (STSTS)

Facilities Using Electromagnetic Energy

Electromagnetic (EM) Energy Facilities

Potomac River Test Range (PRTR) Complex

Explosives Experimental Area (EEA) Complex

Naval Support Facility (NSF) Dahlgren

3,300 0 3,300 Feet

1,000 0 1,000 Meters

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NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 1-7

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This capability provides quick-reaction, worldwide support to the Fleet to develop new systems, modify existing sensors, and develop and evaluate sensor countermeasures in times of crisis. The STSTS allows over-water testing of individual RF and electro-optical sensors in a littoral environment. Sensor-system testing can also use low-flying subsonic and supersonic targets. STSTS components include a variety of radars, targeting buoys, targeting computers, RF sensors, electro-optical sensors, and systems-integration devices.

RDT&E of EM sensors includes possible ways to defeat or "jam" emissions. Releasing chaff – clouds of thin strips of metal – into the air is an inexpensive and effective radar-jamming technique that was extensively tested over the PRTR and successfully used from WWII through the Vietnam War. NSWCDD also pioneered advances in smoke pots that release dark, thick clouds of smoke to prevent enemy eyes or sensors from seeing through the "smoke screen." Such work will continue in the future, although most jamming research will be based on "soft" or electronic jamming rather than the introduction of physical substances into the air.

Waves of EM energy do not move easily through water because the energy is reflected at the air/water boundary or is quickly absorbed by water molecules. The only successful property that can be accurately detected by sensors in the medium of water is sound – sound travels in water's dense environment much farther and effectively than in the air. NSWCDD occasionally conducts RDT&E in the PRTR using modified sonobuoys. Sonobuoys are small floating devices from which tiny, attached microphones drop down to a fixed depth of water to detect noise, such as might come from a submarine. Any sounds that are picked up by the microphones are amplified by the sonobuoy, and are converted into and transmitted by EM waves in the air to a receiver where the sounds can be analyzed. Such technology lends itself to detecting underwater swimmers or other devices trying to sneak into US harbors. The sonobuoys used by NSWCDD do not generate underwater sounds or noise of their own; they only detect sound.

1.5.2.3 Hazards of Electromagnetic Radiation to Ordnance (HERO) and Electromagnetic Environmental Effects (E3)

Navy ships represent one of the richest technological and EM operating environments in the world. A wealth of onboard devices, including radars, sensors, and other EM energy emitters in close proximity to one another and to humans, radiate high levels of EM energy – well into megawatt (MW) levels of power. EM radiation presents potential health impacts to humans, can cause ordnance to explode under certain conditions, and can affect the operating capabilities of systems, such as radios, sensors, and telecommunications.

From decades of experience operating in a high-energy EM environment, NSWCDD has evolved into an advanced RDT&E center for resolving problems related to the potential for EM energy to accidentally activate ordnance, thereby leading to safety (premature firing) or reliability (failure to fire when required) consequences as well. NSWCDD is the designated technical agent for all Navy and Marine Corps HERO RDT&E and serves many other joint-service and agency clients.

NSWCDD serves as the Navy's lead laboratory for the RDT&E of issues surrounding EM environmental effects (E3). NSWCDD provides these RDT&E services to ensure the operational effectiveness and safety of systems exposed to the diverse EM environments associated with Navy and joint-service programs. The goal of this testing is to identify, predict, and eliminate E3-related problems associated with operating equipment and systems before personnel are affected. NSWCDD develops E3 control measures to resolve equipment and system weaknesses

and incompatibilities. NSWCDD uses a broad suite of transmitters that provide a range of EM power and frequencies to simulate nearly all EM operating environments. During the last ten years, NSWCDD has performed such HERO and EM testing for most shipboard systems in the Navy and Marine Corps inventory.

NSWCDD currently uses three main outdoor facilities for E3 and HERO testing (Figure 1-7):

- **Naval Ordnance Transient Electromagnetic Simulator (NOTES)** – This unique facility, located on the EEA, is a simulator that produces an EM field similar to what might be produced on the earth's surface from a high-altitude nuclear blast. The facility subjects equipment to extremely short-duration – less than one millionth of a second (1 microsecond) – high-intensity EM pulses in order to determine whether electronic components have been adequately designed to withstand EM fields. The facility includes a building with an electric pulser that directs the EM pulses into an outdoor network of poles and wires within which the equipment or ordnance being tested is placed. Operations take place once or twice a year. Most of the field energy is contained within the facility structure. When in operation, a hazard safety zone is in effect around the test site. An environmental assessment (EA) prepared in compliance with the National Environmental Policy Act (NEPA) evaluated the environmental impacts of operating the NOTES facility (NSWCDD, 1992) and a Finding of No Significant Impact (FONSI) was signed on September 30, 1992 (DoN, 1992).
- **Maginot Open Air Test Site (MOATS)** – EM testing of electronic equipment is performed at MOATS, located in the Mission Area on Mainside. The MOATS equipment radiates a target using one or more RF or microwave emitters located at or above ground level. Tests are performed to determine the effects of EM emissions on electronic and other components and to verify/validate modeling of radiation propagation and its effects on targets. For a typical test, EM energy is emitted an average of 14 times a day, with 90 percent of the energy emitted in instantaneous short pulses. Non-instantaneous energy emitted lasts an average of 1.5 seconds (s). Up to 100 kilowatts (kW) of average power are used for each operation. Operations typically take place 12 to 15 times per year. When in operation, a hazard safety zone is in effect around the test site.
- **Ground Planes** – A ground plane is a flat surface of ferrous metal (such as a ship's deck) that acts as a return path for radiated EM energy. NSWCDD's two ground planes simulate a ship's deck environment and replicate the full range of EM frequencies that would be found on a ship. Tests subject electrical and electronic systems to high-power EM energy to evaluate component and overall system vulnerability, leading to solutions that protect such systems from EM energy sources. Based on data averaged from 2001 to 2005, up to 390 events take place annually using the ground

AGM-84 Harpoon Testing at Ground Plane

planes. Frequencies emitted can range up to 300 GHz, but more than 99 percent of the test events involved frequencies of between 2 megahertz (MHz) and 50 GHz. When in operation, a hazard safety zone is in effect around the test site.

1.5.2.4 Directed Energy

Directed Energy

When EM energy is focused, or directed, it can be concentrated on a small area without significantly affecting the surrounding area. Infrared heaters and kerosene heaters commonly found in stores often have a parabolic-shaped mirror behind the heating element that focuses the EM energy (in the IR spectrum, in this case) to the area directly in front of the heater, but there is little heat outside the focus area. The parabolic shape allows the heat to be more intense directly in front of the heater. Similarly, a strong magnifying glass can focus the energy from the sun onto a tiny spot, and if held long enough, can cause a leaf to smolder. The same principle applies to using a microwave or radar to focus and harness a beam of EM energy.

NSWCDD has been conducting RDT&E using directed EM energy and developing pulsed power systems that enable the technology since the 1970s, but for most of this time, the work was done in indoor laboratories. In recent years, the confluence of advances in directed-energy weapons technology and the Secretary of the Navy's decision to make future surface combat ships, such as the DDG-1000, all-electric with integrated power-supply systems, has spurred directed-energy RDT&E. This fundamental shift to electric propulsion opens the door for a new generation of electric weapons, including directed-energy weapons, lasers, and EM launchers described in the following sections.

Integrated power systems can dedicate most of the power onboard a ship to electric propulsion motors for high-speed operations, but when the tactical situation requires, the power can be shared with electric weapons and sensors. With an expected 80 MW of installed electrical power, future electric warships will have ample power to operate directed-energy weapons, lasers, and EM launchers, and will not need to carry or use chemical explosives.

As is the case with EM launchers, NSWCDD's RDT&E work with high-power lasers and directed energy is expected to advance the technologies, but full-scale testing of weapons based on the technology would take place at other military facilities.

Increases in directed-energy levels results in energy beams becoming more powerful and traveling farther. With sufficient power, radar can detect targets hundreds of miles away. When properly focused with the same amount of power, this radar can direct very intense EM energy at short range that can damage electronics, so that it becomes a weapon. One such use might be to defeat potential enemy electronics by detonating an improvised explosive device before it triggers explosives near passing troop vehicles. NSWCDD conducts this sort of RDT&E with the use of directed EM energy.

NSWCDD is in the process of moving directed energy from indoor laboratory science to outdoor development, test, and evaluation. The PRTR provides a unique test capability not found elsewhere within DoD: an instrumented maritime range with a high-power microwave propagation source close to the water, allowing study of the effects of maritime conditions on high-power microwave tests using non-lethal harbor scenarios, open-water boat swarms, and counter-drug interdictions. Directed-energy propagation-path outcomes are not well understood because laboratory conditions cannot capture the shifting humidity and wind conditions outdoors.

In 2009, NSWCDD constructed and began operating two structures to transmit directed energy (microwaves, RF, and lasers) outdoors across the waters of the Potomac River within the PRTR. The buildings accommodate NSWCDD's directed-energy warfare RDT&E mission: the Navy Directed Energy Center (NDEC) is located on the Machine Gun Range at the northern entrance to Upper Machodoc Creek, and the Counter Explosive Test Facility (CETFAC) is located on the EEA adjacent to the PRTR (Figure 1-7). The Directed Energy Warfare Office (DEWO) conducts directed-energy RDT&E to protect sailors and soldiers and enhance their capabilities. Testing includes RDT&E of pulsed-power sources, non-lethal directed energy, electronic attack technologies, improved detectors and diagnostics, associated effects testing and analysis, and modeling and simulation techniques. An EA for construction and operation of CETFAC and NDEC (NSF Dahlgren, 2006) covered eye-safe laser and non-lethal RF and microwave transmissions between the two facilities and a FONSI was signed on December 17, 2006 (DoN, 2006).

1.5.2.5 Electromagnetic (EM) Launchers

As mentioned under Ordnance (Section 1.5.1), NSWCDD is conducting RDT&E on EM launchers. An electric motor is normally thought of as using electricity to create an EM field that spins a rotor. The rotor is connected to something such as a gear or pulley to produce useful work. Such motors can be tiny fans cooling a laptop computer, or they can be the propulsion power of large ships, such as the Queen Elizabeth II. However if an electric motor is configured differently from the norm, the same EM field can produce thrust in a straight line instead of in a circle, and this is called a linear induction motor. Such a motor can accelerate extremely quickly and can push heavy objects. At Naval Air Engineering Station Lakehurst, New Jersey, the Navy has launched jet aircraft using this technology.

NSWCDD is focusing primarily on applying this technology to ordnance – to firing projectiles without using explosives. To a lesser degree, NSWCDD is testing the technology's capabilities to propel "launch packages" such as logistic supplies and other heavy objects over short distances or to launch small unmanned aircraft as described in Section 1.6.3.1. An example of an EM launcher that is being developed and tested for ordnance purposes by NSWCDD is the railgun.

1.5.3 Mission Activities Using Lasers

Lasers – Coherent Beams of Light

The word "laser" is an acronym for "light amplification by stimulated emission of radiation." A laser is a device that emits a coherent beam of light (EM energy). Most light is incoherent, meaning it is made up of many frequencies, which scatter and diffuse quickly, such as light from a flashlight. Lased light is light of a single wavelength, so it does not scatter and stays in a narrow, intense beam without dissipating quickly.

Lasers work by using electricity to excite the atoms or molecules of a gas, liquid, or other substance to a state in which more of the atoms or molecules are at higher energy levels than lower energy levels, which creates the laser beam of light.

Lasers, as a type of directed EM energy, have been the subject of RDT&E at NSWCDD since the 1970s. Today, NSWCDD's laser RDT&E program is recognized by the Navy and ONR as a center of excellence for laser RDT&E. Just as lasers have become ubiquitous in the daily lives of Americans – in laser pointers, scanners, leveling devices, printers, corrective eye surgery, and toys – they share an equally important, varied, and growing

role within the Navy, and therefore in NSWCDD's RDT&E programs. NSWCDD's expertise in laser safety and lasers includes RDT&E of sensors, rangefinders, target designators, guidance systems, simulators, communications equipment, and weapons.

NSWCDD is developing novel military applications of lasers and assessing potential hazards to materials and personnel from the use of lasers by enemy forces. Because of its coastal location and over-water range instrumentation, NSWCDD is a particularly valuable site for laser propagation studies that assess the environmental science for low-altitude, over-water laser beam propagation. Low atmospheric turbulence has been found to cause significant break-up in the energy of laser beams.

The lasers that NSWCDD tests fall within the range of frequencies from IR to UV light, which includes visible light (Figure 1-2). Lasers are categorized into four classes according to the power of the light they emit, expressed in watts (Table 1-1). NSWCDD tests all four classes of lasers outdoors.

Table 1-1
Laser Power

Laser Class	Description	Energy Emitted	Safety Issues	Examples
Class 1*	Low-powered devices considered safe from all potential hazards.	Minimal – cannot cause damage	No injury, regardless of exposure time, to eyes or skin. No safety measures necessary.	Laser printers, toys, CD players, CD ROM devices, laboratory analytical equipment.
Class 2*	Low-power, visible-light lasers that could possibly cause damage to a person's eyes.	< 1 milliwatt (mW)	Usually safe. Eye protection normally afforded by the aversion response (turning away from a bright light source or closing or blinking eyes). If directly viewed for long periods of time with no blinking or with binoculars, damage to eyes could result.	Pointers used in presentations, toys, range- finding equipment, aiming devices.
Class 3**	Medium Power	1 - 500 mW	May be hazardous to eyes under direct and specular reflection (almost perfect reflection, such as from a mirror) viewing conditions.	Laser scanners, military hand-held laser rangefinders, entertainment light shows, target illuminators.
Class 4	High power	> 500 mW	Direct beam or specular reflection is hazardous to eyes and skin. May pose a diffuse reflection (reflection off a rough surface) hazard or fire hazard.	Medical surgery, research, drilling, cutting, welding, aircraft target designator used for guided weapons, military laser weapons.

Source: ANSI, 2007.
*Class 1M and 2M categories also exist, which have the same parameters, except that direct viewing with an optical instrument such as a telescope could be potentially hazardous.
**Two subcategories exist under Class 3: Class 3R lasers are potentially hazardous if the eye is appropriately focused and stable, but the probability of injury is low. Class 3B may be hazardous under direct and specular reflection viewing conditions.

Diffuse reflection is laser energy reflected from a rough surface, which causes the laser beam to scatter in all directions (Figure 1-8a, Diffuse Reflections from Laser Beam's Striking a Rough Surface). Specular reflection is laser energy reflected from a mirror-like surface, such as still water on a pond (Figure 1-8b, Specular Reflections from Laser Beam's Striking a Mirror-like

Surface). Specular reflections retain more energy than diffuse reflections, and hence, are more hazardous to eyes and skin.

1.5.3.1 Laser Safety

NSWCDD has implemented a detailed RHA/SOP process for the use of Class 3 and Class 4 lasers – high-energy or HE lasers – outdoors, which identifies and implements controls to ensure the safety of installation personnel and the public. The SOP ensures that each outdoor laser operation complies with Chief of Naval Operations Instruction (OPNAVINST) 5100.27/Marine Corps Order 5104.1A *Navy Laser Hazards Control Program* (September 24, 2002), which incorporated the industry standard, American National Standards Institute (ANSI) Z136.1, *Safe Use of Lasers* (ANSI, 2007), into its requirements. SOPs are also prepared in accordance with DoD Instruction 6055.15, *DoD Laser Protection Program* (DoD, 2007). Each operation must be approved by NSWCDD's Laser System Safety Officer and the Navy's Laser Safety Review Board (LSRB) to ensure that adequate safety criteria are incorporated within the SOP and observed during the operation.

Like EM hazard zones, laser-hazard areas are determined for each outdoor HE laser test event based on the power of the laser being used, and personnel are either not allowed in these areas or must use protective eyewear. Because the focused energy of lasers can burn skin and injure eyes, many safety measures are in place to ensure that the range is clear of wildlife and people before and during the brief lasing events. Before an operation begins, laser operating corridors and adjacent areas are cleared of people and wildlife, barricades are erected, and in the river, range boats patrol the operating area. Tests are conducted to ensure that the laser is aligned with the target. When the laser is emitting – a period of time lasting from an instant to a few minutes – trained observers, electronic monitors, and cameras watch the corridor so that the test can be stopped if people or wildlife approach the laser corridor. Lasers are fixed almost horizontally and fire slightly downward at targets surrounded by backstops, which are made of rough, dark materials to absorb the energy of the laser and minimize diffuse and specular reflections. Sensors surround the target within the backstop area; if a preliminary, low-power laser beam strikes slightly to the side of the intended center of the target, the laser is refocused before higher-power tests are conducted. Safety measures are described in more detail in Section 3.8.4.

1.5.3.2 Current Laser Activities

NSWCDD's RDT&E of lasers is centered in two programs:

- As the Lead Technical Laboratory for Navy and Marine Corps laser safety, NSWCDD evaluates lasers and laser systems used on Navy and Marine Corps installations for hazards to personnel.
- DEWO conducts laser RDT&E of lethal and non-lethal directed-energy, electronic-attack technologies, improved detectors and diagnostics, associated effects testing and analysis, and modeling and simulation techniques.

Figure 1-8a Diffuse Reflections from Laser Beam's Striking a Rough Surface

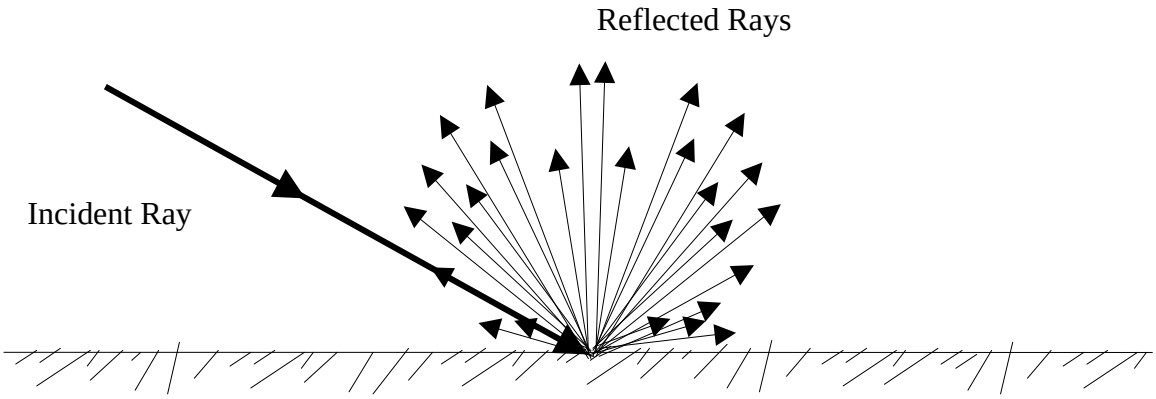
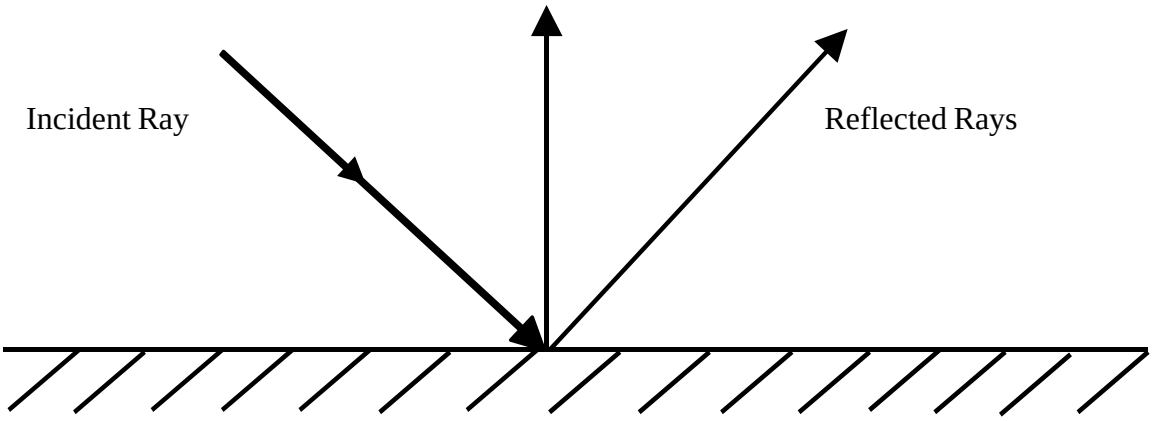


Figure 1-8b Specular Reflections from Laser Beam's Striking a Mirror-like Surface



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Existing HE lasers do not perform well in the marine environment, particularly during inclement weather such as fog and rain. In dry environments – such as the deserts where HE lasers have mainly been tested until now – laser beams remain coherent over longer distances. NSWCDD's RDT&E with lower-power lasers in maritime conditions indicates that in the maritime environment that prevails at NSWCDD, laser beams become less coherent and more diffuse, and more easily distorted by density and temperature variations, functioning differently than in dry conditions. The Navy is working to overcome these problems in order to use lasers in the maritime environment – the Navy's operational environment and the location of many of our nation's cities. Therefore, testing different types of lasers, using different frequencies and power levels, in various weather conditions, is necessary to ensure that they function properly and to make the necessary changes to them if they do not.

NSWCDD currently conducts approximately 60 outdoor HE laser events a year in a wavelength range from 500 nanometers (nm) (500 billionths of a meter) to 11 micrometers (μm) (11 millionths of a meter) and a power range from less than 500 milliwatts (mW) up to 100 kW.

HE laser activities take place outdoors in a variety of weather conditions, mainly during the day, but occasionally at dawn and dusk, and rarely at night. NSWCDD's outdoor HE laser program is conducted along five corridors (Figure 1-9, High-Energy Laser Current Operation Locations), which range from 1,650 ft to 12,000 ft in length. Two of the corridors – Shock Tube Area and Terminal Range-to-Missile Test Range – are on the PRTR's developed land ranges. Three of the corridors – Terminal Range-to-CETFAC, NDEC Area-to-CETFAC, and NDEC Area-to-EEA Dock Area – cross the waters of the PRTR from one land range to another. An EA addressed the impacts of increasing the power levels of outdoor HE laser activities up to 100 kW in these five corridors (NSWCDL, 2009b) and a FONSI was signed on October 7, 2009 (DoN, 2009).

Figure 1-10, 100 kW High-Energy Laser Eye-Hazard Zones, shows the eye-safety hazard zone calculated for a laser operating at 100 kW of power toward a target/backstop 100 ft from the Potomac River shoreline (such as CETFAC or the EEA Dock Area). The backscatter from directing a 100-kW HE laser beam from the Terminal Range or NDEC over the waters of the PRTR to a target within or near CETFAC or in the EEA dock area, either of which would be 100 ft from the shoreline, was calculated to be eye-hazardous within 80 ft of the target for both specular and diffuse reflections. Therefore, the area of eye-hazardous backscatter would be 20 ft from the shoreline. The eye-hazard area around the laser beam would be about 6 ft in diameter and at least 6 ft above mean water level. Test personnel near the target would be completely enclosed in a personnel shelter during eye-hazardous laser activities. ROC observers on land or on range control boats would be kept well away from the eye-hazardous zone around the laser beams.

For current operations, both the laser emitter and the target/backstop are fixed and the laser emits almost horizontally. The laser is pre-aimed at a fixed target slightly downgrade from the laser and is not able to move in either elevation or azimuth, except for minute corrections to the aim point. For over-water operations, the laser beam begins a minimum of 12 ft above mean water level on the Terminal Range, from NDEC, or from in front of NDEC, and terminates at a target in or near CETFAC or the EEA Dock Area at a minimum of 9 ft above mean water level. For overland operations, the laser beam is a minimum of 6 ft above ground level.

1.5.4 Mission Activities Involving Chem/Bio Simulants

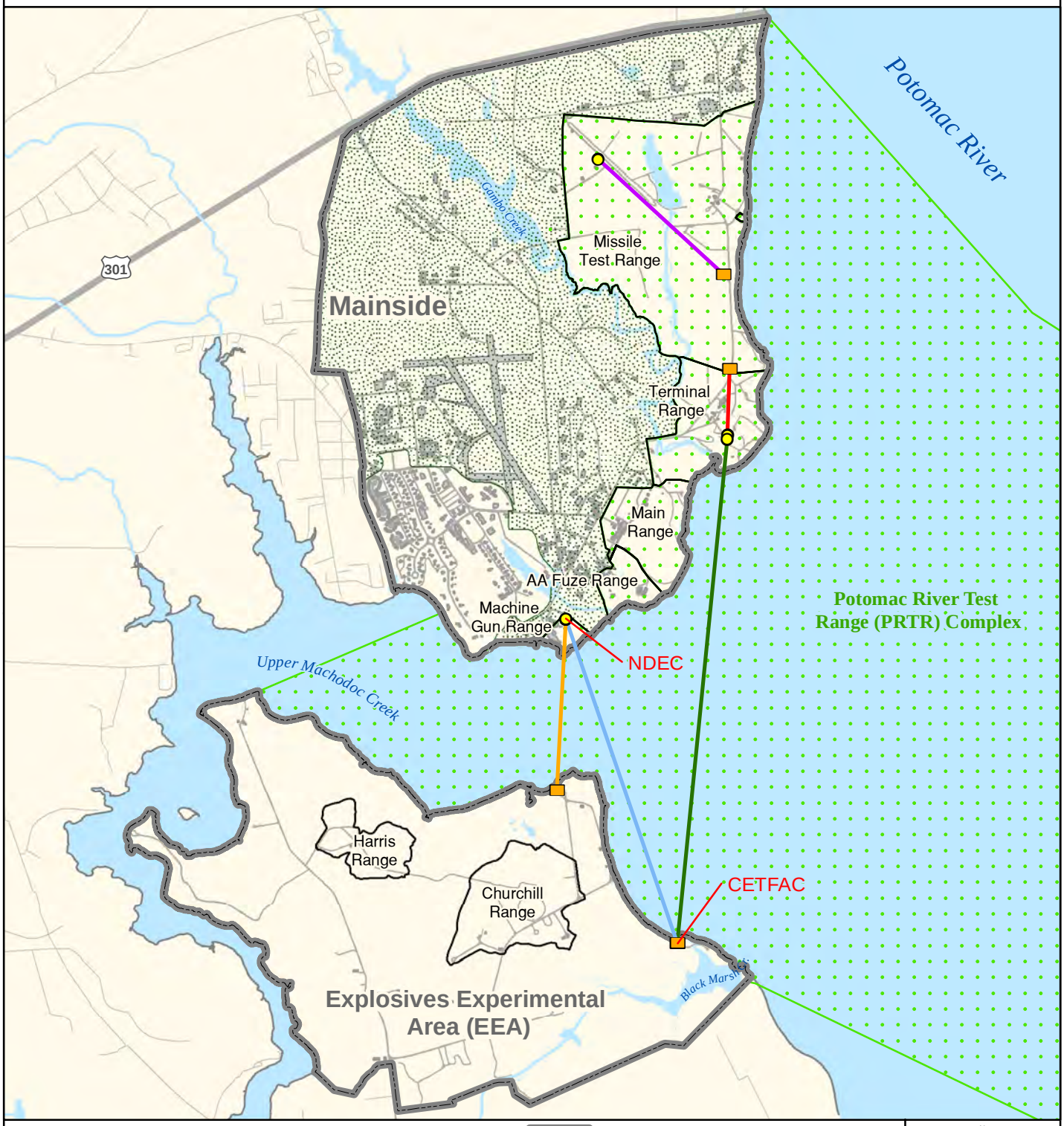
The increased threat of terrorist attacks on our nation, military personnel, embassies and bases overseas, and allies has prompted the DoD to step up RDT&E to counter chem/bio terrorism. Chem/bio agents are very difficult to detect, and the key to minimizing the effects of an attack is early detection and warning. The capability of the military to respond to such threats is greatly enhanced by RDT&E to characterize, predict, detect, and mitigate chem/bio threats. As the Navy's lead laboratory supporting the DoD's Chemical and Biological Defense Program (CBDP), NSWCDD has been working with other DoD agencies, the Department of Homeland Security (DHS), and civilian industry to develop rapid and accurate models and systems for detecting dangerous biological and chemical agents. NSWCDD is also developing methods to protect personnel from contact with these agents, such as protective clothing and equipment, as well as methods for decontaminating people and equipment exposed to these agents while minimizing danger to others.

The program-level impacts of work that DoD performs under the CBDP are addressed in the *Chemical and Biological Defense Program Final Programmatic Environmental Impact Statement* (US Army Medical Research and Materiel Command, 2004). The program-level (as distinct from operational-level) impacts of NSWCDD's chem/bio defense RDT&E program are evaluated in the CBDP Final EIS (FEIS), which found that with appropriate safeguards, there are no significant impacts resulting from continuing to implement the CBDP at any site, including at NSF Dahlgren.

The use of actual chemical and biological agents in open-air testing is prohibited in the US unless certain procedures (e.g., testing is necessary for national security and precautionary measures to protect public health and safety) are met (Public Law 91-121, Defense Appropriation Act of 1970, as extended under 50 U.S.C. § 1512). Instead of the actual agents, NSWCDD uses simulants in outdoor RDT&E activities to minimize hazards to workers, the public, and the environment. A simulant is a chemical or a biological organism that has at least one physical property similar to that of the biological or chemical agent under study but that is much less hazardous than the agent. Simulants are reasonably safe to handle and use without significant environmental or health effects. Examples of the simulants that have been used outdoors at NSWCDD include glacial acetic acid (GAA) (a strong form of the acid in vinegar), methyl salicylate (MeS) (oil of wintergreen, used as flavoring in foods), and polyethylene glycol (PEG) (used in laxatives, skin creams, and toothpaste).

Most of NSWCDD's chem/bio RDT&E takes place in indoor laboratories. At some point in the RDT&E process, chem/bio sensors must be tested outdoors in the types of environments in which they will be deployed – over water, on land, and in the air. Sunlight, wind, and weather affect how the sensors work and cannot be fully replicated in any laboratory. In addition to environmental factors, substances likely to occur or be released intentionally during a battle, such as smoke – an obscurant from weapons firing – or diesel emissions – an interferent – can impede sensor effectiveness and must be tested. Even items commonly found aboard ships, such as oil, fuel, bleach, ammonia, paint or floor cleaner, can interfere with the sensors' ability to detect an actual threat and therefore, must be included in testing. NSF Dahlgren provides a coastal environment that replicates the shipboard conditions under which detectors must function to

High-Energy Laser Current Operation Locations



Laser Operating Corridors:

- NDEC Area-to-CETFAC
- NDEC Area-to-EEA Dock Area
- Shock Tube Area
- Terminal Range-to-CETFAC
- Terminal Range-to-Missile Test Range

- Target/Backstop
- Laser Emitter
- Range
- Mission Area
- Potomac River Test Range (PRTR) Complex

- Naval Support Facility (NSF) Dahlgren

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 1-9

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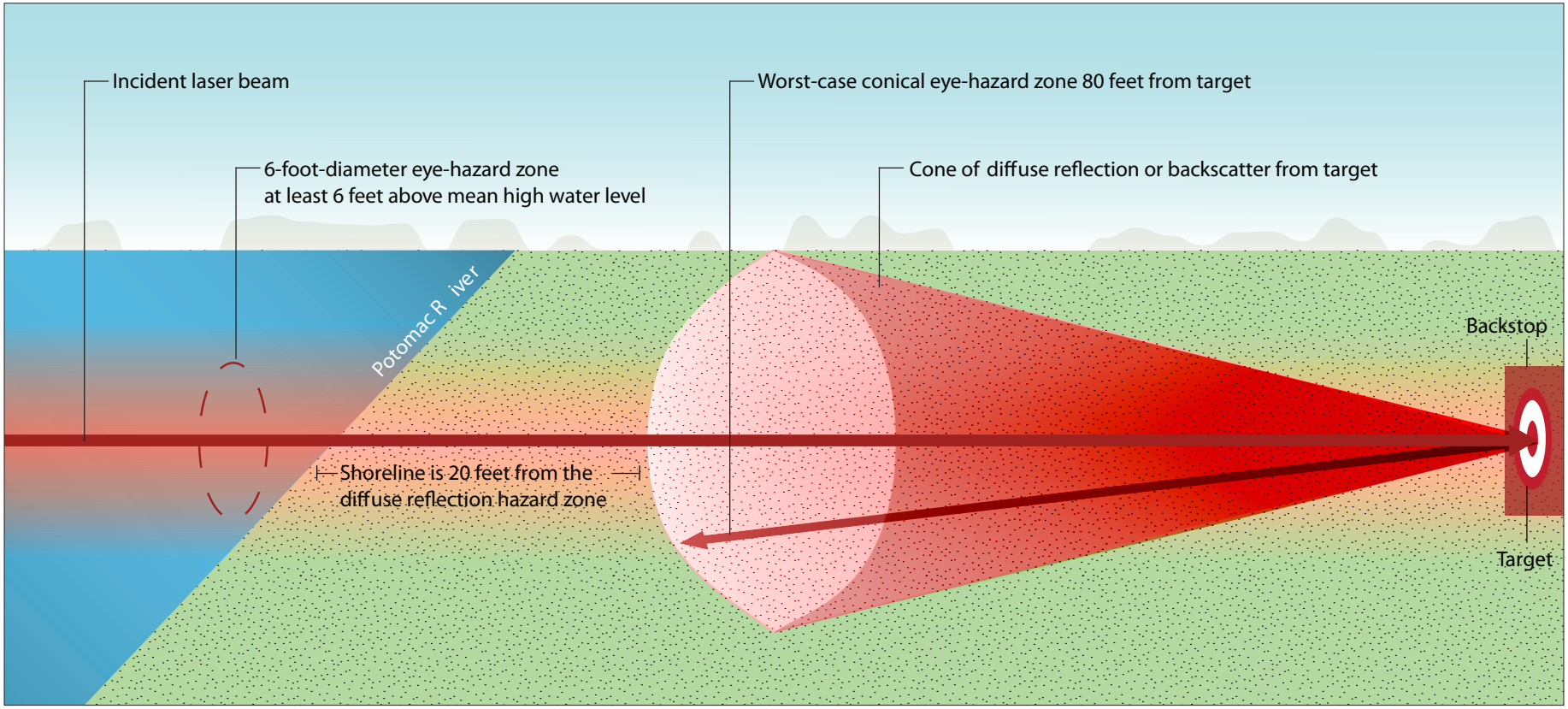
100 kW High-Energy Laser Eye-Hazard Zones



Eye-hazard zones were calculated for a 100 kW laser. In this scenario, a laser beam striking a target/backstop located 100 feet from the shoreline of the Potomac River would result in:

- An eye-hazard zone around the laser beam at least 6 feet above mean water level
- An eye-hazard zone extending 80 feet from the target in a cone shape. The eye-hazard cone would end 20 feet away from the river.

NSWCDD EIS

Figure 1-10

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protect our service men and women and has the equipment necessary to effectively perform the testing.

The DoD Joint Service Lightweight Stand-off Chemical Agent Detector (JSLSCAD) Test Integration Working Group, a joint effort of the Navy, Army, Air Force, and Marine Corps, has been conducting open-air testing of the effectiveness of the JSLSCAD and similar chemical stand-off detectors in various environments since 1995. This testing involves the release of a vapor of chemical "simulant" to challenge the instrument. These simulants absorb IR radiation at wavelengths similar to the wavelengths absorbed by chemical and biological agents. Therefore, use of simulants can determine the sensitivity of the JSLSCAD and future similar sensors to perceive actual chem/bio agents.

JSLSCAD Infrared Detector

NSWCDD conducted chemical simulant releases on the Churchill Range in 1986 (a precursor to JSLSCAD) and on the PRTR in 1996. For the 1986 operation, documented in a Preliminary EA, a combination of PEG 200 and MeS were sprayed from a helicopter over the Churchill Range to test the feasibility of using the CH-46 helicopter as a dispersal platform for chemical simulants (NSWC Dahlgren, 1986). The 1986 Preliminary EA concluded that the potential environmental impacts of the proposed operations were insignificant and uncontroversial, and that the action should be considered categorically excluded. The Record of Categorical Exclusion was signed on June 16, 1986. The operations in 1996 challenged early prototype hardware in support of the JSLSCAD program using sulfur hexafluoride (SF_6) as the chemical simulant (NSWCDL, 1996). [Because SF_6 is a potent greenhouse gas it was added to DoD's Emerging Contaminant Action List in 2009 (Yaroshak and Ransom, 2010). NSWCDD has been and will most likely continue to substitute the refrigerant gases R-134 and R-152a for future activities].

In 2003 and 2005, NSWCDD tested a fully-operational JSLSCAD IR chemical-agent sensor system on the PRTR using one chemical simulant to calibrate the system and two additional simulants to challenge the sensor. Figure 1-11, Chemical Simulant Operations Area in 2003, 2005, and 2009, shows the area of the PRTR that was used. Tests were designed to verify that the system would perform as expected in a coastal environment. In each year, approximately 55 events took place. An EA was prepared prior to testing (NSWCDD, 2003) and a FONSI was signed on June 17, 2003 (DoN, 2003). Field tests and modeling were conducted prior to testing on the PRTR to predict human and ecological health risks associated with the proposed release of the chemical simulants as a vapor. The chemical simulants used were SF_6 for calibration and triethyl phosphate (TEP) and GAA to challenge the sensor. A third simulant, para [p]-xylene, was approved by state authorities, but never used. The PRTR was cleared of vessel and air traffic during testing. The EA concluded that human and ecological health risks would be minimal, which was supported by actual field monitoring during the tests in 2003 and 2005.

In 2009, NSWCDD conducted chemical simulant tests on the PRTR similar to those conducted in 1996, 2003, and 2005. The 2009 test activities involved release of the liquids MeS, TEP, GAA,

and the gases R-134 and R-152a. MeS falls within the same range of deposition, vapor concentration, potential water concentration, toxicity, and environmental impacts as the previously-used liquid simulants TEP and GAA and has been used as a chemical simulant outdoors over the Cooper River at Naval Weapons Station Charleston, South Carolina (US Army, Dugway Proving Ground, 2003).

1.6 Range Operations

All RDT&E operations that take place outdoors on range complexes and the Mission Area have factors in common. They:

- Follow stringent safety procedures (specific to each test)
- Usually (but not always) take place within specified times on weekdays
- When needed, restrict SUA and PRTR access as a safety precaution
- Require that specific target areas be determined for each test
- May require the use of vessels and/or manned or unmanned aircraft
- Are announced to the public via the NSWCDD web site and telephone number if access may be restricted or if the effects may be noticeable off of the ranges and the Mission Area

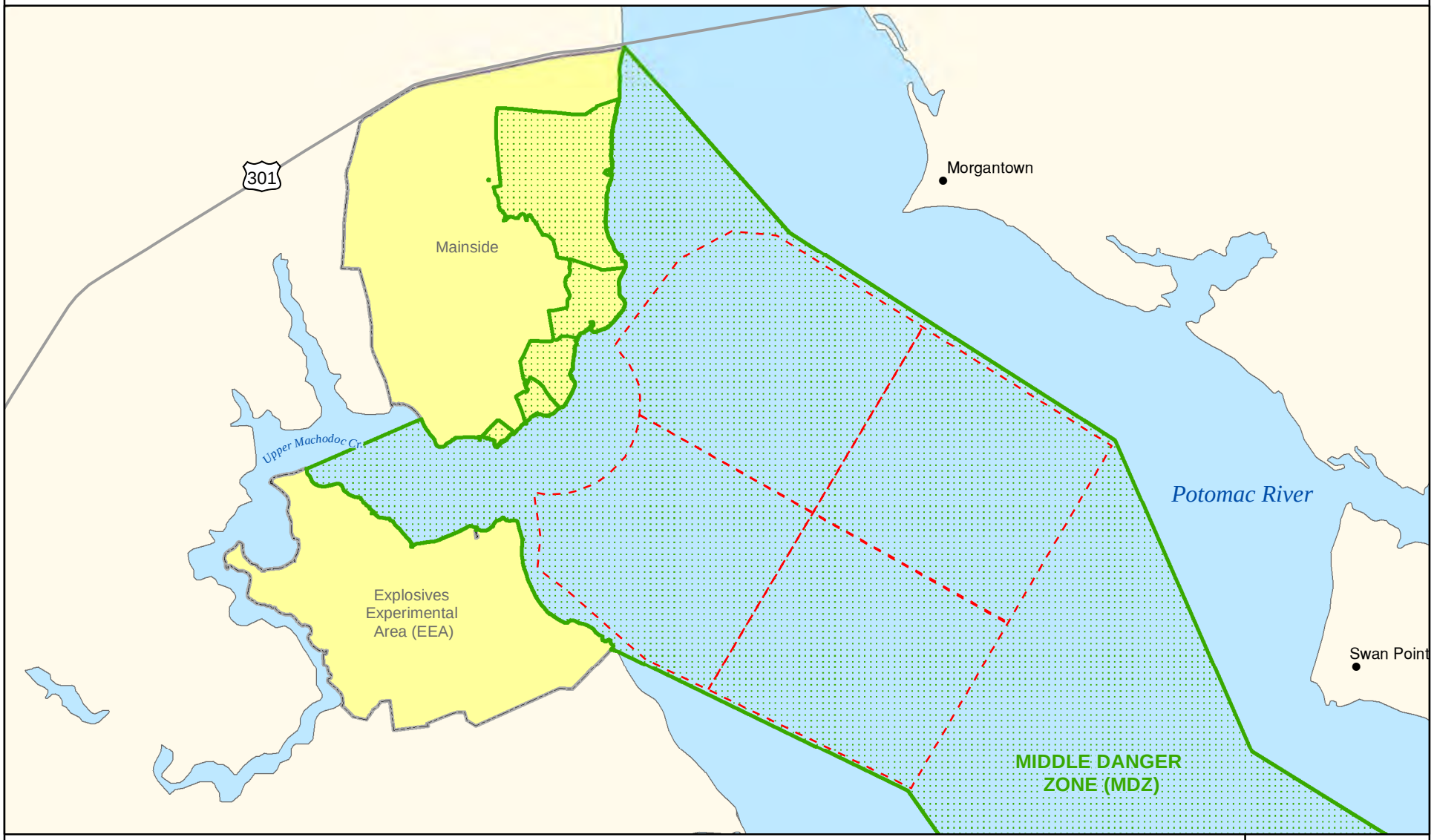
The processes common to all outdoor RDT&E activities are described below.

1.6.1 Frequency of Testing

NSWCDD conducts all ordnance activities Monday through Friday between 8 am and 5 pm. Set-up for testing may begin before 8 am. Outdoor RDT&E activities using lasers, EM energy, or chem/bio simulants may take place at dawn, dusk, or night and on weekends. Weekend activities, however, are rare. HE lasers are tested occasionally at dawn or dusk across the PRTR from land range to land range and rarely at night. The frequency of weekend and dawn and dusk activities is influenced by the progress of the particular RDT&E program and its findings, by surges in or changes in the types of global threats, by technological developments, and by budget constraints and is difficult to predict in advance.

The daily operations schedule is available in advance on NSWCDD's website or by calling the toll-free range telephone number. NSWCDD's ROC notifies the public through the website and toll-free number when activities will take place beyond normal range hours, for example after 5 pm or on a weekend.

Chemical Simulant Operations Area in 2003, 2005, and 2009



Test Area

Potomac River Test Range (PRTR) Complex

Navy Support Facility Dahlgren

Source: NSWCDD GIS (2008 - 2011)

1 0 1 Miles

1.5 0 1.5 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Figure 1-11

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1.6.2 Range Control and Safety

Before an outdoor RDT&E operation takes place, RHAs and SOPs are developed, reviewed, validated, approved, and implemented, as described in Section 1.5.1 and in more detail in 3.8.1. These measures ensure that tests are conducted safely and with a minimum of environmental impacts, following NSWCDD's Environmental Management System (EMS).

Range Operations Center (ROC)
Notifies Public of Upcoming Range Activities

In order to inform the public about upcoming range activities, ROC provides notification through:

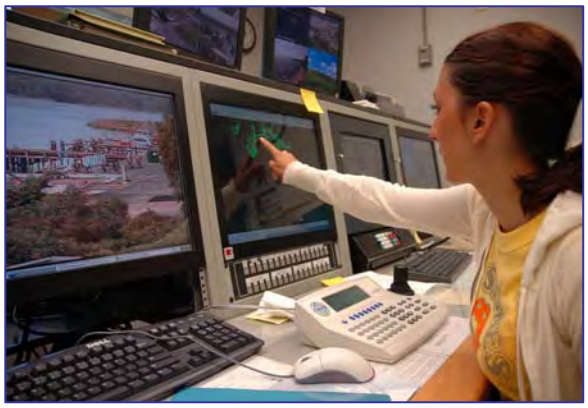
- The NSWCDD website: http://www.navsea.navy.mil/nswc/dahlgren/ RANGE/ rangeschedule.aspx
- A toll-free telephone recording (877-845-5656).

Daily range schedules, types of tests (such as firing single or multiple shots or detonations), the use of substances (such as smoke for smokescreens), hours of testing, where on the PRTR the tests will take place, whether tests are on schedule, whether noise will be made, and contact numbers to obtain more information are included on the website and in the recorded message.

As described in more detail in Section 3.8.1.1, NSWCDD danger zones are defined on nautical charts for the PRTR (Figure 1-3) to alert mariners that access to the areas may be restricted when tests are taking place, so as to ensure their safety. Access may be restricted either because activities are taking place on the river or because safety zones for activities taking place on the land ranges extend into the river. NSWCDD's ROC restricts access to the range(s) before testing begins and deploys range boats to clear the range of watercraft.

Current activities require that all or part of the PRTR MDZ be cleared for testing approximately 750 hours a year (based on the number of hours range control boats are deployed). While activities take place occasionally on the UDZ and LDZ, the types of activities conducted do not currently require access restrictions on either of these areas. Some types of tests – such as large gun firing – require that all or most of the MDZ be restricted. Other types of tests – such as the use of lasers across the entrance to Upper Machodoc Creek – require that only that part of the MDZ be restricted during testing.

ROC personnel take care to minimize delays to both commercial and recreational boat traffic. The ROC minimizes inconvenience to the public by restricting access only to the areas of the PRTR that are needed for tests and by taking advantage of frequent lulls in testing for equipment adjustments and the like to allow watercraft to move through the PRTR. Depending on the type of operation, river traffic frequently can be safely rerouted around the test area. The ROC monitors two marine ship-to-shore channels and responds to requests for information.



NSWCDD's Range Operations Center (ROC)

Even when access to most of the MDZ is restricted for testing, small watercraft can move up and down the river along the Maryland shoreline, just outside the PRTR boundary. They cannot move past NSF Dahlgren along the Virginia shoreline because the range restrictions extend up to the shoreline. Deep-draft vessels

that need to stay in the main channel, which runs through the range, may be advised to slow before reaching the range or may be delayed up to an hour near the range, though in practice the delays are usually less than 30 minutes. During breaks in the testing, ROC personnel work with smaller watercraft to allow them to cross the range from one side of the river to the other, and with deep-draft vessels to allow them to proceed up and down the river channel.

SUA zones (Figure 1-6) over the EEA and PRTR are in effect from 8 am to 5 pm daily, excluding weekends and holidays, to restrict civilian aircraft during gun testing, as well as during laser, EM energy, and chemical-sensor tests. The airspace is reserved for an average of 2,120 hours annually, and may be restricted at other times, in which cases a Notice to Airmen (NOTAM) is issued by the FAA. The zones extend from sea level to 40,000 ft and from 40,000 to 60,000 ft above the river surface over the PRTR, and from ground level to 7,000 ft over the EEA (Figure 1-6). However, the zones from 40,000 to 60,000 ft over the PRTR are only reserved on rare occasions. When activation of the SUA is not required, even though it is scheduled, NSWCDD turns control of the SUA back to the FAA for use by civilian aircraft.

1.6.3 Use of Aircraft and Vessels for Activities

Outdoor RDT&E activities may employ manned and unmanned watercraft, ground vehicles, and aircraft to:

- Serve as tracking objects to test sensors
- Tow targets or tracking objects
- Observe tests and measure outcomes
- Test active and passive sensors such as radar
- Carry new sensor systems for evaluation
- Disperse chem/bio simulants
- Serve as platforms for targets, weapons, or aerostats
- Act as links in tests of integrated systems
- Act as targets
- Act as reflectors

Military use of unmanned systems (UMSs) is increasing rapidly because they provide a way to gather intelligence, provide surveillance, perform reconnaissance, and target enemy activity while keeping personnel out of harm's way. Manned and unmanned vehicles not only participate in tests on the PRTR for the types of activities that are part of the Proposed Action in this EIS, but also for a broad range of other types of activities that generate little environmental impact. An example is the use of "go-fast" boats – high-performance, high-speed boats used by pirates, smugglers, and terrorists as well as by US agencies trying to stop them – in recent years to test various strategies to repel terrorists who, for example, might be trying to approach a US Navy or Coast Guard vessel in a foreign port, as was the case with the USS Cole in the Port of Aden in 2000. Equipment that can be rapidly deployed, such as gear-entanglement nets to ensnare the

propellers, are being tested. Similar types of RDT&E activities are also taking place at NSWCDD to counter drug runners.

1.6.3.1 Unmanned Systems (UMSs)

UMSs include unmanned, self-propelled aerial, terrestrial, sea-borne, or submersible platforms that operate without a human being positioned on or within the vehicle/platform. Instead, their operation is achieved through either autonomous or remote tele-operated control. Tele-operations are controlled by a human operator at a remote location via a communications link. The remote operator directs the vehicle either by visual observation or remote sensing. Autonomous operations are controlled by onboard pre-programmed auto-processors, and after a flight pattern is selected prior to the flight, vehicles can operate without human assistance. NSWCDD blends these two modes of control: they use tele-operations control during landings and takeoffs and autonomous control thereafter unless changes in weather or problems arise, in which case operators switch back to remote tele-operations control. NSWCDD operates all types of UMSs except submersible vehicles as part of RDT&E. UMSs used by NSWCDD include:

Soldier launching an RQ-11 Raven micro aerial vehicle

Unmanned Aerial Vehicles (UAVs)

With increasing frequency, NSWCDD is using UAVs – also called “drones” – for various aspects of RDT&E activities, as listed above. In particular, NSWCDD’s UAVs are used as platforms for weapons-system integration. To test that all systems are working together, UAVs variously carry payloads of sensors, lasers, radars, and ordnance. On battlefields, UAVs are used for targeting, reconnaissance, and surveillance, and as communications relays.

UAVs can range in size from wingspans of less than one foot to full-sized aircraft. However, the UAVs used by NSWCDD are on the smaller end of the size scale. NSWCDD’s UAVs range in size from micro aerial vehicles, which are small enough to be carried, assembled, and launched by a Marine or soldier on the battlefield (see figure of a serviceman launching a Raven, which weighs less than 5 lbs and has a wingspan of 5-6 ft) to UAVs such as the Tiger Shark, which, depending on the model, has a 17-21-ft wingspan and a maximum takeoff weight of 400 lbs.

Tiger Shark LR-3 UAVs take off and land on runways

Smaller, lighter UAVs can be launched by hand, from a hand-held or fixed launcher (see the figure of a 6-ft wingspan Scan Eagle being launched from Main Range), or from a fast-moving vehicle. NSWCDD's heavier UAVs, such as the Tiger Shark, require a runway to take off and land. NSF Dahlgren has two runways on the Terminal and Churchill ranges (Figure 1-12, Unmanned Aerial Vehicle Runways) dedicated to UAV use. Military UAVs must fly within military SUA, so NSWCDD's UAVs fly over the PRTR Complex and the EEA but cannot fly over the Mission Area or land on the airfield in the Mission Area.

Scan Eagle UAV being launched from Main Range

When operating, NSWCDD's UAVs fly at approximately 2,000 to 3,000 ft in altitude, but may occasionally ascend to 5,000 ft. In 2009, NSWCDD's UAVs logged approximately 200 hours of flight time (more than one may be aloft at a time).

NSWCDD also uses aerostats tethered to the ground or to a platform in the river, such as a barge. Aerostats are stationary, lighter-than-air objects, such as balloons or blimps. Aerostats can be used as platforms for radar and other sensors, or as targets. NSWCDD routinely uses weather balloons outfitted with sensors to collect weather information prior to performing tests.

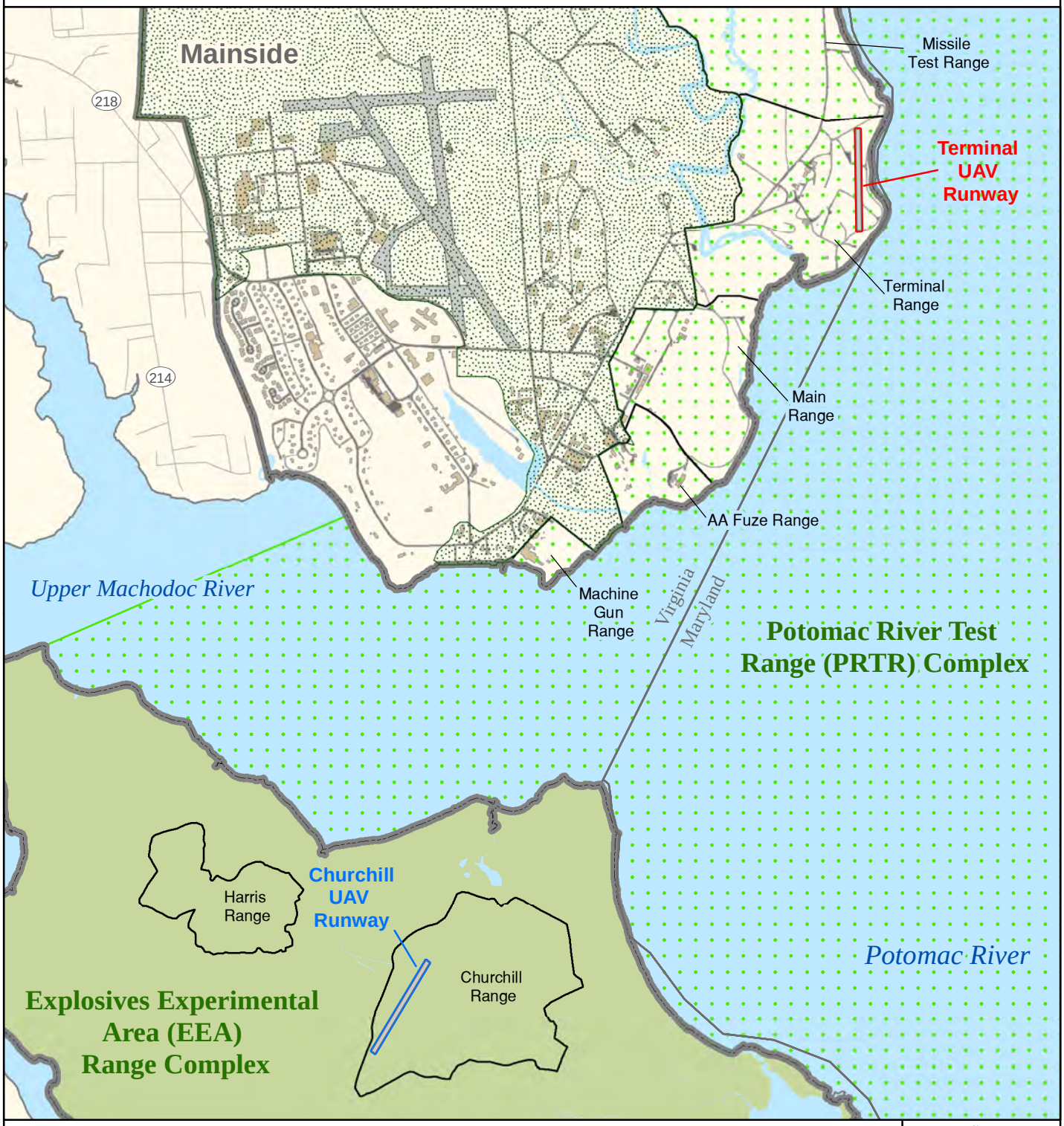
Unmanned Surface Vehicles (USVs)

Unmanned surface vehicles (USVs) are boats or amphibious craft that travel on the surface of the water. NSWCDD maintains a group of small watercraft in Upper Machodoc Creek, some of which can be used as USVs. For example, go-fast boats, Seadoos, and other small craft are used as USVs. They may be used to test the ability of radar to detect them and scan their contents, or for their reaction to counter-terrorism measures, or to disable their equipment, stop them, or destroy them. USVs may be used as one component in tests of integrated warfare systems.

Unmanned Ground Vehicles (UGVs)

Unmanned ground vehicles (UGVs) travel on the land surface. Like UAVs, UGVs range in size from small and toy-like to full-sized. They can operate autonomously or through remote tele-operation. NSWCDD uses UGVs as platforms for sensors and weapons on the land ranges and the Mission Area. Sensing UGVs can gain information about an area that may be dangerous for personnel and relay it back. Weapon-equipped UGVs can both detect people and other vehicles and fire upon them.

Unmanned Aerial Vehicle Runways



Airfield Surface

Terminal Unmanned Aerial Vehicle (UAV) Runway

Churchill UAV Runway

Naval Support Facility (NSF) Dahlgren

2,000 0 2,000 Feet

600 0 600 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 1-12

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Manned Vehicles

NSWCDD also uses manned ground, surface, and air vehicles in RDT&E activities. Surface vessels used include manned go-fast boats, inflatable Zodiac-type craft, landing craft, patrol boats, and barges. Sometimes larger Navy or Coast Guard vessels come up the river to participate in activities, but they are not based at NSF Dahlgren.

NSWCDD occasionally uses manned fixed-wing aircraft and helicopters for activities of the types listed above (but not as targets to be destroyed). In a typical test scenario, an aircraft makes passes, flying in the SUA, to test a sensor system either onboard the aircraft or helicopter or on the ground. Aircraft may fly from Naval Air Station (NAS) Patuxent River to participate in activities but may also originate at other bases or be rented commercially. Aircraft used in recent years include CA-8 and C182 Cessna-type small, fixed-wing airplanes and Baron N503W and Bell helicopters. Fixed-wing aircraft used in RDT&E activities do not land on NSF Dahlgren's airfield, which currently is closed for fixed-wing aircraft landings. NSWCDD does not maintain any manned aircraft. Helicopters use the airfield now and then to transport personnel, or – in one recent instance – for Marine aircraft landing and takeoff training.

1.6.4 Target Areas

1.6.4.1 Ordnance Target Areas

- **Potomac River Test Range** – Most large-caliber gunfire is directed at target areas in the MDZ. Figure 1-5 shows primary gun target areas in the MDZ. Most projectiles are fired into this area. The main target area for the 76 mm and 57 mm guns is typically between 5,000 and 9,000 yds from the Main Range. The main target area for the 5"/54 guns is between 9,000 and 13,000 yds from the Main Range. The main target area for small-caliber guns and fuze testing is typically between 2,000 and 6,000 yds from the Main Range. While NSWCDD fires occasionally at target areas 32,000 to 35,000 yds from the firing point, which is in the upper part of the LDZ, the main long-range target area, used in recent years for the 5"/62 gun, is short of this – in the vicinity of 27,000 to 28,000 yds. NSWCDD does not fire projectiles into the UDZ.

  Gunnery targets in the MDZ include primarily virtual targets but also floating targets. By design, some targets may be destroyed or damaged by gunfire, such as floating radar reflectors, fixed platforms in the river, UMSs, aerostats, vessels, towed sleds, and causeway sections. The environmental impacts of fragmenting these targets are minimized by removing hazardous materials such as batteries, oil, gasoline, and antifreeze to the extent possible prior to destroying or damaging them. After the target is impacted and the test completed, all visible remaining debris and waste is cleaned up. Tracking and calibration targets, which are not fired upon but rather used for taking bearings, may include UAVs, manned aircraft, aerostats, range control boats, diving tenders and other vessels, pilings in the river, land vehicles, and points of land.

- **Land Ranges** – Some large-caliber gunfire is directed at target areas on land within the Terminal Range. Gunnery targets on land may include armor plate or butts (impact areas designed to withstand and contain projectile impact and resulting fragmentation).

Examples of land tests include, but are not limited to, fuze impact tests and ballistic tests for target vulnerability, ordnance penetration, and projectile fragmentation, which take place on the Terminal and Missile Test Ranges. Small-caliber gunfire can take place on all of the ranges, but most commonly takes place on the Machine Gun Range, Main Range, and the AA Fuze Range. On the Machine Gun Range, guns are usually fired into butts.

1.6.4.2 EM Target/Operations Areas

- **Potomac River Test Range** – Targets used to test EM sensors can include many of the gunnery targets described above. Tests of EM sensors and directed-energy equipment mainly take place in the MDZ. Some types of tests can also take place in the UDZ and LDZ, such as a test of whether sensors could detect vessels or aircraft. Microwaves and RF waves are emitted from NDEC to CETFAC across the PRTR (Figure 1-9).
- **Land Ranges and Mission Area –** NOTES facility tests take place within the EEA. MOATS and ground-plane tests take place within the Mission Area.

1.6.4.3 Laser Operations Areas

- **Potomac River Test Range** – As shown on Figure 1-9, laser corridors crossing the waters of the PRTR include NDEC Area-to-CETFAC, Terminal Range-to-CETFAC, and NDEC Area-to-EEA Dock Area.
- **Land Ranges –** Laser corridors on the land ranges include the Shock Tube Area, and Terminal Range-to-Missile Test Range (Figure 1-9).

1.6.4.4 Chem/Bio Operations Areas

- **Potomac River Test Range –** Outdoor tests of chemical simulants in 2003, 2005, and 2009 took place in the MDZ within 2,000 to 6,000 yds of Main Range (Figure 1-11).
- **Land Ranges and Mission Area –** Outdoor tests of chemical simulants have taken place on Main Range in the past, but have not been used recently.

1.7 Authority, Relevant Statutes, and Regulations

This EIS has been prepared pursuant to the NEPA of 1969; the Council on Environmental Quality's (CEQ) implementing regulations at 40 Code of Federal Regulations (CFR) Parts 1500 to 1508; and Department of the Navy (DoN) regulations implementing NEPA (32 CFR Part 775).

This EIS is also intended to support other associated environmental reviews, including but not limited to:

- Compliance with the Clean Water Act (CWA) of 1977 as amended, 33 U.S.C. §§ 1251 *et seq*.
- Compliance with the Clean Air Act (CAA) of 1970 as amended, 42 U.S.C. §§ 7401 *et seq*.

- Compliance with the Resource Conservation and Recovery Act (RCRA) of 1976, 42 U.S.C. §§ 6901 *et seq*.
- Compliance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, 42 U.S.C. §§ 9601 *et seq*.
- Federal consistency determination under provisions of the Coastal Zone Management Act (CZMA), 15 U.S.C. §§ 1451-1456.
- Consultation under Section 106 of the National Historic Preservation Act (NHPA) of 1966, 16 U.S.C. §§ 470 *et seq*.
- Consultation under Section 7 of the Endangered Species Act (ESA), 16 U.S.C. §§ 1531-1544.
- Compliance with the Marine Mammal Protection Act (MMPA), 16 U.S.C. §§ 1361-1421.
- Performance of essential fish habitat (EFH) analysis under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), 16 U.S.C. §§ 1801-1882.
- Compliance with the Migratory Bird Treaty Act (MBTA) of 1918, as amended, 16 U.S.C. §§ 703 *et seq*.
- Compliance with the Bald and Golden Eagle Protection Act (BGEPA) of 1940, as amended, 16 U.S.C. § 668.

1.8 Scope of the EIS

The scope of this EIS encompasses all reasonably foreseeable environmental impacts to socioeconomic, physical, cultural, and biological resources that could potentially result from an expansion of NSWCDD's RDT&E activities using ordnance, EM energy, HE lasers, and chem/bio simulants on range complexes and the Mission Area. Consistent with CEQ's regulations, the scope of the impact analysis presented in this EIS was defined by the range of potential environmental effects that would result from implementation of the Proposed Action and alternatives.

The environmental impact analysis in this EIS (Chapter 4) addresses activities that take place outdoors on range complexes and in the Mission Area. The analysis does not encompass all of NSWCDD's work, much of which takes place indoors in laboratories. These indoor activities are addressed in other NEPA documents – environmental assessments or categorical exclusions, as appropriate. However, the cumulative impacts of NSWCDD's indoor activities when combined with outdoor activities taking place on range complexes and the Mission area are considered in the cumulative impact analysis (Chapter 5) in this EIS.

This EIS does not address activities that take place within the base's housing and community support area, or base-support activities that are not affected by the Proposed Action.

The EIS addresses enhancements to existing technologies now being used at NSWCDD that employ ordnance, EM energy, HE lasers, and chem/bio simulants, but it does not address new technologies. NEPA requires that only reasonably foreseeable impacts be considered in the EIS.

Evaluating the unforeseeable impacts of new technologies is beyond the scope of this EIS and would require additional NEPA documentation.

However, the impact analysis in this EIS will allow NSWCDD to determine whether new technology, variations on existing tests, and other new testing and evaluation activities fall within the effects limits established by the EIS. Tests involving new technology or variations on existing tests could proceed if they are found to be within the effects limits. Actions that fall outside the scope of this EIS (i.e., actions that might increase the effects or create new effects) would be assessed separately in other NEPA documents as they are proposed.

1.9 Public Involvement

1.9.1 EIS Public Involvement Process

Public involvement is an integral component of the NEPA process. Comments made by the public become part of the decision-making process with respect to the action being proposed. The Navy takes this seriously because it works hard at being a good neighbor. A large part of being a good neighbor involves keeping the public informed about what is being planned and listening to what our neighbors have to say.

NSWCDD developed a public-outreach program specifically for this EIS. The program began in 2003 with 96 interviews with various community leaders, business owners, on-base residents, and residents of the five counties bordering the PRTR about their concerns with respect to NSWCDD's current activities. These concerns were taken into consideration in developing the work plan for the EIS.

NSWCDD also established a Public Involvement Working Group (PIWG) comprised of representatives from the five counties surrounding the PRTR, of whom most were identified during the interviewing process. The participants provided feedback on the public involvement process and materials that described NSWCDD's mission and programs while they were being developed for NSWCDD's website, for community meetings, and for the EIS scoping meetings.

EIS public scoping meeting held in St. Mary's County

The next step in the program was notifying the public that NSWCDD was considering expanding certain RDT&E activities and was going to prepare an EIS to evaluate potential impacts. A notice of intent (NOI) to prepare an EIS was published in the *Federal Register* on June 18, 2007 (72 Federal Register 33456). Soon after, notices were placed in six newspapers in the counties around the PRTR Complex, advising readers of the EIS process and inviting them to come to one or more of five public scoping meetings to learn more about, and comment on, the proposed scope of the EIS. Letters were sent to public agencies to inform them of the process.

1.9.2 Scoping Meetings and Comments

The scoping meetings – one in each of the counties around the PRTR: King George, Westmoreland, and Northumberland counties in Virginia; and Charles and St. Mary's counties in Maryland – were held in the last two weeks of July 2007. Seventy-seven people attended. Comments were received from twenty individuals and three agencies (the Virginia Department of Environmental Quality [VDEQ], the Virginia Department of Game and Inland Fisheries [VDGIF], and the Maryland Transportation Authority [MdTA]). These comments were submitted at the meetings, via the project website, or by telephone, fax, e-mail, or US mail.

NSWCDD's overall mission garnered the most comments (13), with seven of these supporting NSWCDD's programs. Several of the supporters noted that they had lived along the river for decades and did not find operations to be a problem. People who were less accepting of NSWCDD's programs cited concerns that testing damages the environment and affects human and animal health and safety. Several people wanted NSWCDD to stop testing.

Eight of the 12 people who commented on noise and vibration (the second most common topic), reported that noise and/or vibration levels are high enough to be disturbing to them or to their property. The remaining four – all of whom indicated that they were long-time residents of the area – mentioned that NSWCDD makes noise, but that noise levels were higher in the past, and that they do not find current noise levels bothersome.

Nine people commented on the environment. Two said that NSWCDD protects the environment and minimizes impacts, while seven expressed concerns that NSWCDD's activities may be damaging the environment. The term "environment" included the Potomac River, water quality, and effects on organisms in the river and on the test ranges.

Other topics that generated one or more comments from the public included: aspects of the scoping meetings themselves; the positive effect of NSWCDD on jobs; negative effects on boating-related commerce during testing; negative effects of noise on quality of life and community; potential negative impacts to public safety from the effects of chemical, biological, and EM energy tests; potential negative effects on human and animal safety from noise and hazardous materials; effects on air quality; whether UAVs would be used in the airspace; and what the contents of the EIS would be.

VDEQ identified itself as responsible for the coordination of federal environmental documents in Virginia and also as the lead agency for coordinating Virginia's review of federal coastal determinations prepared under the Coastal Zone Management Act (CZMA) and provided a list of the agencies to whom they were sending NSWCDD's letter and the NOI. VDEQ recommended that the federal coastal consistency determination be included as part of the DEIS so that a single review, rather than two separate reviews, could take place and provided information on federal consistency under the CZMA.

VDGIF sent a list of wildlife resources known from sites associated with the PRTR, EEA, Mission Area, and SUA.

MdTA's concerns focused on the potential impacts of the proposed action on the adjacent Governor Harry W. Nice Bridge improvement project, which was just getting underway. MdTA asked for information on the extent of the UDZ (which is north of the bridge) and the types of activities conducted there. NSWCDD began coordination with MdTA and sent them a response to their letter discussing such issues as coordinating bridge reconstruction activities with RDT&E

activities and advising them that EM activities will not interfere with existing or expanding electronic toll collection activities.

The comments and concerns raised during the scoping process were considered in developing the EIS work plan and were addressed in the impact analysis of the Draft EIS (DEIS).

1.9.3 DEIS Public Hearings

When the DEIS was completed, a notice of availability was published in the *Federal Register* on August 17, 2012, beginning a 45-day public review period during which the DEIS was available for review in five local libraries, on the project website, or by mail, upon request. Letters indicating that the DEIS was available for review were sent to the distribution list in Chapter 8 of the Draft EIS accompanied by paper or compact disk copies of the DEIS. Notices of the DEIS' availability were published in local newspapers. Public hearings were held to describe the environmental impacts of the Proposed Action and alternatives and to receive comment on the impacts analysis. These comments have been taken into consideration in preparing this Final EIS (FEIS).

Public hearings for the DEIS were held in King George and Westmoreland counties, Virginia, and Charles County, Maryland the week of September 10, 2012. Twenty-nine people attended the hearings. By the end of the comment period, comments had been received from ten individuals, two non-governmental organizations (the Potomac River Association and the Swan Point Property Owners Association), and the following public agencies:

- US Environmental Protection Agency Region III
- US Department of the Interior
- Fort A.P. Hill
- Maryland Transportation Authority
- Maryland Department of the Environment
- Maryland Department of Planning
- Maryland Department of Natural Resources
- Maryland Historic Trust
- Virginia Department of Conservation and Recreation
- Virginia Department of Environmental Quality
- Virginia Department of Game and Inland Fisheries
- Virginia Department of Historic Resources
- Virginia Department of Health, Office of Drinking Water
- St. Mary's County
- Charles County

These comments were submitted orally or in writing at the meetings or by fax, e-mail, or US mail. Appendix A displays the comments in their original form and a matrix that includes each comment and a response to the comment, which may have resulted in revisions to the FEIS.

1.9.4 FEIS Process

A notice of availability was published in the *Federal Register* to inform the public that the Final EIS has been released. Publication of the notice of availability began the 30-day wait period. A notice that the Final EIS was ready for review was also sent to the distribution list in Chapter 8 and published in local newspapers. Comments received during the 30-day review period will be considered in reaching the final decision. Following the 30-day wait period, a Record of Decision (ROD) will be prepared. The ROD will state the decision, identify alternatives considered (including the environmentally preferable alternative), address substantive comments received on the Final EIS that were not previously addressed, discuss other considerations that influenced the final decision, and address mitigation, if needed. Following signing of the ROD, the Navy will publish a notice of availability of the ROD in the *Federal Register*.

1.10 Issues Eliminated from Further Analysis

Based on current projections, the Proposed Action would not result in significant personnel increases, new building construction, land acquisition, or expansion of the ranges and the Mission Area. Therefore, the following issues have been eliminated from evaluation in this EIS:

- Construction of new facilities.
- Acquisition of land.
- Significant personnel increases.

Because there would be little to no increase in personnel, the following topics also are eliminated from evaluation in this EIS:

- **Housing** – There would be no increase in demand for housing or housing construction in the region around NSF Dahlgren as a result of the Proposed Action.
- **Community Services** – There would be no increase in demand for community services such as schools, community centers, fire and rescue units, hospitals, clinics, police, or libraries.
- **Roadway Transportation System** – There would be no increase in traffic on the region's highways and roads, and therefore no need to build new roadways. However, the effects of the Proposed Action on river traffic and air traffic are considered.
- **Taxes** – The Proposed Action would not affect government tax revenues.
- **Prime or Unique Farmland** – No farmland, or land of any kind, would be required.

If in the future, new buildings, additional land, or more personnel are required beyond current projected needs, NEPA documents would be prepared to evaluate the impacts of these proposed changes.

2 PROPOSED ACTION AND ALTERNATIVES

The CEQ *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act* establish a number of policies for federal agencies, including using the NEPA process "…to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment" (40 CFR § 1500.2(e)). This chapter describes the Proposed Action, alternatives to meet the purpose of and need for the project, and the No Action Alternative, which provides a basis upon which a comparison of the potential impacts associated with the Proposed Action can be made. The chapter concludes with the Navy's determination of the Preferred Alternative.

2.1 The Proposed Action

The Proposed Action is to expand NSWCDD's RDT&E activities within the PRTR and EEA complexes, the Mission Area, and in the special-use airspace (SUA). These capabilities include outdoor activities that require the use of:

- Ordnance
- Electromagnetic (EM) energy
- Lasers
- Chemical and biological (chem/bio) simulants

In the future, because of the growing need to test EM equipment, lasers, and chem/bio sensors in foggy, rainy, or nighttime conditions, some testing would take place at dawn, at dusk, at night and on weekends. This would enable tests to be conducted when conditions match realistic operational requirements.

Under the Proposed Action, the number of firings, detonations, events, and hours of range use that would take place annually would increase above recent levels for all activities except large-caliber gun firing, as described in the following sections. Increases in activities would occur gradually; however, because of the nature of RDT&E, the rate of increase cannot be predicted. The alternatives being evaluated in this EIS – the No Action Alternative, Alternative 1, and Alternative 2 – reflect different numbers of annual firings, detonations, and events for each activity. The No Action Alternative includes the number of firings, detonations, and events typical of the years from 1993 (1995 for ordnance) through 2009. Alternative 1 includes annual increases of 325 percent in small arms firing, 5 percent in detonations, 20 percent in EM energy events, 108 percent in laser events, 400 percent in chem/bio events, and 16 percent in PRTR hours of use above recent levels. Alternative 2 includes annual increases of 400 percent in small arms firing, 21 percent in detonations, 39 percent in EM energy events, 142 percent in laser

events, 483 percent in chem/bio events, and 33 percent in PRTR hours of use above recent levels.

2.2 Alternatives Development Process

The process of developing alternatives began by establishing NSWCDD's RDT&E activities baseline. NSWCDD's programs are diverse and numerous. Over several years, the EIS team interviewed each of the managers of 75 NSWCDD programs at least once. The managers of programs that are expanding and that are likely to generate environmental impacts were interviewed several times. The kinds of information collected included:

- Program objectives, schedule and support requirements.
- Customer base.
- Typical test scenarios.
- Annual operations tempo and whether there were any night/weekend operations.
- Expected increase in operations tempo and changes in operations.
- Whether program was expanding or evolving.
- RDT&E facilities used.
- Expected increase in RDT&E facilities use or need for new or modified facilities.
- Whether installation infrastructure was sufficient to support program requirements.
- Whether operations take place indoors or outdoors.
- The kinds of materials released by and environmental impacts generated by operations.

With extensive knowledge of their field and of DoD requirements, customer needs, and future trends, the program managers helped to clarify which programs were growing, describe the ways in which the technology was evolving, and define future RDT&E needs and requirements. From these interviews and from reviewing range operations logs, the firing, detonation, and event baseline for each RDT&E activity was established. In most cases, because of the cyclical nature of RDT&E – which can vary considerably from year to year depending upon such factors as whether or not a new system is being tested – the baseline was generated by averaging data collected in the years from 1993 to 2009 (the years of data vary by activity) and then weighting the data for the highest-activity years in the RDT&E cycle to arrive at an average annual number of large-caliber guns and small arms firings; detonations; and EM energy, laser, and chem/bio sensor events. Table 2-1 documents the historical and current baseline, and future RDT&E mission requirements defined through this process.

From the interviews, it became clear that activities conducted in indoor laboratories with ample safeguards in place do not generate environmental impacts on the human environment. Therefore, activities that take place outdoors became the focus of the EIS. Those activities that had the potential to affect the environment – such as firing guns because of the noise produced, using lasers because of potential safety concerns, or using chem/bio simulants because of human and animal health concerns – were singled out. Further reviews established that lower-power EM energy operations, such as the use of Class 1 and 2 lasers, do not affect human health or the

environment. In this way, the types of activities to be included in the Proposed Action and evaluated in the EIS impact analysis became more clearly defined.

Table 2-1
RDT&E Mission Requirements

RDT&E Activity	Historical and Current Activity Magnitude	Historical and Current Baseline Average Annual Activity Levels	Known Future Average Annual Activity Levels	Future Average Annual Activity Levels with a Margin of Growth
Large-caliber Guns/ Projectiles	>20 mm to 8" caliber gun/ projectile	**4,700 projectiles**	**4,700 projectiles**	**4,700 projectiles**
Small Arms	≤20 mm caliber gun/bullet	**6,000 bullets**	**25,500 bullets**	**30,000 bullets**
Detonations	<0.01 lbs to 1,000 lbs NEW	**190 detonations**	**200 detonations**	**230 detonations**
EM Energy	300 kHz to 300 GHz frequency 10 W to 500 MW average power	**490 events**	**590 events**	**680 events**
Lasers	500 nm to 11 μm wavelength 1 mW to 100 kW maximum power	**60 events** 100 kW maximum power	**125 events** 500 kW maximum power	**145 events** 500 kW maximum power
Chemical & Biological Defense	≤20 gals of simulant/event	**12 events** Chemical simulants only	**60 events** Chemical and biological simulants used separately	**70 events** Chemical and biological simulants used separately and together
PRTR Use	750 hours annually	**750 hours**	**870 hours**	**1,000 hours**

For each of the components of the Proposed Action, potential alternatives were developed and evaluated based on the following criteria:

Criterion 1 – Accommodate historical and current, baseline RDT&E mission requirements for activities that have the potential to affect human health and/or the environment – namely, those involving ordnance, the use of EM energy, the use of high-energy (HE) lasers, the use of chemical simulants, and the use of the PRTR.

Criterion 2 – Accommodate known future requirements, which include the use of biological simulants alone.

Criterion 3 – Accommodate a margin of growth for those programs for which it is difficult to accurately forecast future needs. Mixtures of biological and chemical simulants would be included.

Criterion 4 – Minimize impacts to commercial and recreational use of the Potomac River.

The No Action Alternative constitutes the baseline for the portion of NSWCDD's outdoor activities that have the potential to affect human health and/or the environment and meets Criteria 1 and 4. Alternative 1 reflects the growth necessary to meet the minimum RDT&E mission requirements in the foreseeable future, without significantly increasing environmental impacts. Alternative 1 includes outdoor use of biological simulants. Alternative 1 meets Criteria 1, 2, and 4. Alternative 2 satisfies current requirements; includes the growth necessary to meet minimum requirements for the foreseeable future; includes the use of biological and chemical simulants together; and includes a margin of growth for the most actively evolving programs – those for which the number of future annual test events, firings, and hours of use is harder to predict because of the uncertainties inherent in carrying out RDT&E. Alternative 2 optimizes NSWCDD's outdoor RDT&E activities and meets all four criteria.

2.3 Alternatives Considered but Eliminated from Further Analysis

Alternatives that do not accommodate historical and current, baseline RDT&E mission requirements and known future requirements – and therefore do not meet Criteria 1 and 2 – do not satisfy the purpose and need for the Proposed Action and are considered unreasonable. Such alternatives were eliminated from further analysis, as were alternatives that substantially increase impact to commercial and recreational use of the Potomac River and therefore do not meet Criterion 4. The following potential alternatives other than no action, and Alternatives 1 and 2 were identified, but were eliminated from further analysis, as detailed in the following paragraphs.

2.3.1 Full Range Use Alternative

NSWCDD considered an alternative that would utilize the range complexes, SUA, and the Mission Area to the maximum extent possible in order to accommodate the maximum amount of growth in mission operations. Currently, activities are scheduled for about 750 hours a year. As NSWCDD normally conducts outdoor RDT&E activities Monday through Friday between 8 am and 5 pm, excluding weekends and holidays, the maximum potential availability of the PRTR and EEA complexes, the Mission Area, and the SUA is approximately 2,260 hours per year. Occasional use in early mornings, evenings and on weekends adds to the potential maximum annual hours of use. Also, some activities can be scheduled concurrently – for example, those using lasers or directed energy across Upper Machodoc Creek and those using chemical simulants farther out into the MDZ. However, weather conditions, such as storms, fog, and freezing weather that forms ice on the river, and the time required for pre- and post-test operations further reduce the maximum potential hours to approximately 1,800 hours annually.

While this maximum potential 1,800 hours would use the range complexes, SUA, and the Mission Area to the fullest feasible level, the alternative would require substantial increases in public access restrictions to the PRTR – more than doubling the number of hours when public access could be restricted, negatively affecting public commercial and recreational use of the

river well beyond the levels resulting from implementing either Alternative 1 (increase from 750 to 870 hours annually) or Alternative 2 (increase from 750 to 1,000 hours annually). For almost three-quarters of a century, the Navy and its community neighbors in Virginia's Northern Neck and Southern Maryland have prospered in a much-treasured partnership that was established and is secured by the common bonds of friendship, patriotism, national defense, and economics. NSWCDD actively engages with the local community to maintain this partnership.

Although this maximum range use alternative would meet Criteria 1 and 2 and would accommodate a margin of growth for programs for which it is difficult to accurately forecast future needs as specified by Criterion 3, increased range use would significantly restrict public access to the Potomac River for commercial and recreational uses; and the alternative, therefore, would not meet Criterion 4. For this reason, this alternative was dismissed from further consideration.

2.3.2 Locations other than NSF Dahlgren

As the Navy's leading surface warfare RDT&E center, with more than 3,000 highly-skilled scientists and engineers, operating ranges, and extensive infrastructure developed over 90 years specifically to support this kind of RDT&E, NSWCDD is unique. NSWCDD also is the Navy's primary center for proof-testing Navy guns, for safety and environmental testing for explosives, and for naval gun RDT&E. The laser program, which began in the 1970s, has been recognized by the Navy and the Office of Naval Research as a center of excellence for laser RDT&E. NSWCDD is the Navy's primary center for chem/bio research as part of DoD's Chemical and Biological Defense Program (CBDP). The 2005 Defense Base Closure and Realignment (BRAC) Commission, which reviewed the work of all DoD installations, identified NSWCDD as a center of excellence for weapon systems integration, which involves RDT&E for communications and sensors that use EM energy. NSWCDD is also the Navy's lead laboratory for the RDT&E of issues surrounding EM environmental effects (E3).

The activities that comprise the Proposed Action are not new technology, nor are they programs new to NSWCDD, but rather expansions of current programs based at NSWCDD. The development and implementation of specific safety procedures for these activities have resulted in an excellent health and safety record with no illnesses or injuries attributable to outdoor activities over the last 10 years. Safety programs and procedures are constantly reviewed and updated to ensure their continuing validity and appropriateness, as discussed in Section 3.8. For example, specific safety procedures will be developed and implemented for biological and chem/bio simulant testing. Relocation of these programs is neither desirable nor feasible. It would involve moving existing, active programs from NSWCDD to a new location, which would needlessly disrupt program operations, cause unnecessary delays, and generate substantial additional costs, all without any additional benefits. The 2005 BRAC Commission concurred with this thinking and recommended that NSWCDD's programs remain in place. Therefore, the Navy concluded that no other location for expanding these programs was a reasonable alternative.

2.4 Description of the No Action Alternative

Chapter 1 describes NSWCDD's current activities, which constitute existing baseline conditions and are the basis for the No Action Alternative. Implementing the No Action Alternative would not increase the average annual number of outdoor RDT&E firings, detonations, and events, or hours of PRTR use above recent levels – the numbers would remain at recent levels. Even though the Navy proposes to increase outdoor RDT&E activities, including the No Action Alternative in the evaluation of impacts provides a baseline against which to measure the impacts of the other two alternatives.

Table 2-2, which describes all three EIS alternatives, shows existing outdoor RDT&E activity levels on ranges and the Mission Area in the No Action Alternative column. The numbers of annual firings, detonations, events, and hours of PRTR use represent averages recorded for each RDT&E activity during the years from 1993 (1995 for ordnance) through 2009 weighted to take into account years with the highest activity levels. The No Action Alternative Activity Magnitude column of Table 2-2 indicates the magnitude of baseline activities, averaged from data collected for the years 1993 (1995 for ordnance) to 2009 inclusive. Magnitude indicates caliber, weight, frequency, power, wavelength, volume, or time duration.

Table 2-2
EIS Alternatives

RDT&E Activity	No Action Alternative Activity Magnitude	No Action Alternative Average Annual Activity Levels	Alternative 1 Average Annual Activity Levels	Alternative 2 Average Annual Activity Levels
Large-caliber Guns/ Projectiles	>20 mm to 8" caliber gun/ projectile	**4,700 projectiles**	**4,700 projectiles**	**4,700 projectiles**
Small Arms	≤20 mm caliber gun/bullet	**6,000 bullets**	**25,500 bullets**	**30,000 bullets**
Detonations	<0.01 lbs to 1,000 lbs NEW	**190 detonations**	**200 detonations**	**230 detonations**
EM Energy	300 kHz to 300 GHz frequency 10 W to 500 MW average power	**490 events**	**590 events**	**680 events**
Lasers	500 nm to 11 μm wavelength 1 mW to 100 kW maximum power	**60 events** 100 kW maximum power	**125 events** 500 kW maximum power	**145 events** 500 kW maximum power
Chemical & Biological Defense	≤20 gals of simulant/event	**12 events** Chemical simulants only	**60 events** Chemical and biological simulants used separately	**70 events** Chemical and biological simulants used separately and together
PRTR Use	750 hours annually	**750 hours**	**870 hours**	**1,000 hours**

2.4.1 Ordnance Activities

2.4.1.1 Large-caliber Guns/Projectiles

The guns included in the No Action Alternative are large-caliber weapons that can fire either live (explosive) or inert (non-explosive) projectiles. The guns range in size from more than 20 millimeters (mm) up to 8”-caliber, although the largest gun normally fired is the 155 mm howitzer (the 8” gun is only fired occasionally to launch non-explosive canisters of electronic components of new projectiles to test how well they can withstand high gravitational forces). In the years from 1995 to 2009, 74 percent of the projectiles fired from the PRTR land ranges into the Potomac River were inert, and 26 percent were live explosive projectiles. The gun fired most frequently is the 5” gun. ***Each projectile*** fired from a gun counts as one of the 4,700 projectiles fired annually on average in particularly active years. In most years, the average number of projectiles fired is considerably less than 4,700 projectiles; in some years, the number fired annually exceeds 4,700. Not all projectiles go into the river range. Some projectiles fired on the Missile Test Range and Terminal Range are aimed at gun butts on land rather than targets in the river. In this case, the river is used as a backstop.

2.4.1.2 Small Arms Activities

NSWCDD’s small arms tests usually employ machine guns firing mostly inert bullets with small propellant charges, and producing lower noise levels that affect a smaller area than the noise resulting from firing the large-caliber guns. Approximately ten percent of the bullets are fired into the river range. ***Each bullet*** fired counts as one of the 6,000 bullets fired annually, on average.

2.4.1.3 Detonations

Most ordnance detonations take place on the EEA’s Churchill and Harris Ranges but a few take place on the Explosive Ordnance Disposal training area of the Missile Test Range. Non-fragmenting ordnance detonated on the Explosive Ordnance Disposal training area includes detonators but no other explosives. The amount of explosives used in the ordnance that is detonated on the EEA can vary from less than 0.01 pounds (lbs) up to 1,000 lbs net explosive weight (NEW). ***Each detonation*** that takes place on the EEA is counted as one of the 190 total annual detonations.

2.4.2 Electromagnetic (EM) Energy Activities

The EM energy devices included under the No Action Alternative operate in the frequency range of 300 kilohertz (kHz) (or 300,000 cycles per second) to 300 gigahertz (GHz) (or 300 billion cycles per second) and at average powers ranging from 10 watts (W) up to 500 megawatts (MW), but with most events well below the maximum. Devices such as radios and range radars with power, frequency and exposure levels below established thresholds for hazards of EM radiation to personnel (HERP), ordnance (HERO), fuel (HERF), and the potential for EM interference (EMI) are not included in the Proposed Action. NSWCDD coordinates with the

Navy and Marine Corps Spectrum Center, which is responsible for ensuring access to and effective use of the EM spectrum in national security and military operations. As part of the SOP process for EM tests, NSWCDD uses power levels approved by and frequencies authorized by the Spectrum Center and HERO programs in order to mitigate interference with civilian devices.

An ***EM event*** consists of the tests that take place under one standard operating procedure (SOP) on one day. If similar tests under the same SOP occur the following day (or on multiple following days), this group of tests is considered a separate event (or multiple separate events). If two different tests are conducted on the same day under separate SOPs, then they would be counted as two separate events of the total 490 annual events. Power levels, frequencies, and safety parameters are all delineated, and must be approved in an SOP well before the event commences.

Events

For purposes of this EIS, an **event** consists of the operations that take place under one SOP on one day. If the same operation occurs the following day, it is considered a separate event. If two different operations are conducted on the same day under separate SOPs, then they are counted as two separate events.

2.4.3 Laser Activities

The HE lasers that are operated at NSWCDD included under the No Action Alternative emit focused (lased) light ranging in power from 1 milliwatt (mW) (Class 3) to 100 kilowatt (kW) (Class 4) in a wavelength range from 500 nanometers (nm) to 11 micrometers (μm). NSWCDD currently conducts approximately 60 outdoor HE laser events a year. Class 1 and Class 2 lasers, which are usually eye-safe (see Table 1-1), are not included in the Proposed Action because they have negligible environmental impacts.

For lasers and EM energy devices, effects are possible only as the device is emitting. The time of emission is usually brief – varying from less than a second to several minutes – and there are no residual effects. However, one event could entail several hundred instantaneous pulses while another event with a different device could be one single pulse of five minutes. To capture this range of options in a meaningful way that lends itself to analysis, a ***laser event*** is also defined as consisting of the tests that take place under one SOP on one day. If similar tests under the same SOP occur on the following day (or on multiple following days), this group of tests is considered a separate event (or multiple separate events). If two different tests are conducted on the same day under separate SOPs, then they would be counted as two separate events of the total 60 annual events. Power levels, frequencies, and safety parameters are all delineated, and must be approved in an SOP well before the event commences.

2.4.4 Chemical Defense Activities

A ***chemical defense event*** is defined the same way that EM and laser events are defined: as the tests that take place on one day under one SOP. The development and rigorous implementation of SOPs is a vital component of NSWCDD's health and safety approach as detailed in Section 3.8.1. If similar tests take place the following day under the same SOP, the group of tests is

regarded as a separate event. If two different tests are conducted on the same day but are based on separate SOPs, then they would be counted as two separate events. NSWCDD currently conducts approximately 12 outdoor chemical defense events a year.

The quantities of simulant used for an event may vary depending on the tests being conducted. Tests may include small quantities of a number of simulants or larger quantities of one or two simulants, consisting of no more than 20 gallons (gals) of simulant per test. There may be more than one test during one event.

Outdoor biological defense activities using simulants are not included in the No Action Alternative because such operations have not yet been conducted outdoors at NSWCDD and so are not existing conditions. Operations using chemical simulants are included because they have been conducted outdoors on NSF Dahlgren since the 1980s. The chemical and biological simulants that would be tested would be influenced by parameters such as global threats, homeland security, and technological developments. Therefore, it is not possible to provide exact specifications of future quantities, simulants, and potential mixtures.

2.4.5 PRTR Use

When NSWCDD is using the PRTR for mission activities, public access to the part of the range in use is restricted, as described in Section 1.6.2. Currently, only access to the part of the MDZ or upper LDZ in use is restricted. The types of activities conducted on the UDZ and mid-to-lower LDZ do not require that public access to these danger zones be restricted. Access to the MDZ or part of the MDZ or LDZ currently is restricted an average of 750 hours a year, based on the hours that range control boats are deployed.

2.5 Description of Alternative 1

Table 2-2 lists the proposed annual outdoor RDT&E activity levels under Alternative 1. The numbers shown in the Alternative 1 column represent average annual activity levels under Alternative 1 and were determined by combining:

1. An average of the annual number of bullets, events, or hours, as appropriate, for each RDT&E activity from 1993 (1995 for ordnance) to 2009, weighted to take into account years with the highest activity levels (No Action Alternative levels);
2. ***Plus*** growth above No Action Alternative levels necessary to meet known requirements in the near future.

The following sections describe in more depth the changes proposed for each type of activity – ordnance, EM energy, HE lasers, and chem/bio defense – under Alternative 1 and the reasons for the changes. A summary comparing the changes proposed under Alternative 1 with the No Action Alternative concludes each of these sections.

2.5.1 Alternative 1 Proposed Ordnance Activities

As noted in Chapter 1, the Navy established NSWCDD to test ordnance in 1918, and testing ordnance will remain a primary part of NSWCDD's mission into the future. Testing and improving ordnance reliability, safety, lethality, accuracy, fuzing, and distance for small-, medium-, and large-caliber guns up to 8", and assessing explosive compounds remains a basic Navy requirement. This is because these weapons remain core components of Navy ships or are used by the Marine Corps.

Ordnance technology has reached the point where fundamental changes in ordnance are now possible. The Navy's goals are to develop guns and projectiles that are more effective or lethal when they reach their target, can reach targets farther away, are integrated into warfare systems, and are safer to handle so that they don't explode inadvertently. NSWCDD has been and will continue to be a primary Navy RDT&E facility for existing and new types of ordnance. The use of reactive materials in projectiles is an example of such changes – projectiles carrying reactive materials will only be capable of exploding when hitting a target. When sufficiently developed, projectiles with reactive materials will begin to augment current explosive projectiles.

The Navy's goal to develop an all-electric ship within the next decade also is spurring development of weapons that use electricity rather than explosives. EM launchers, which when fully developed will use EM energy rather than explosives to fire an inert projectile at velocities more than seven times the speed of sound, are an example of a new type of motive force being developed at NSWCDD. Ultimately, when ready to be mounted on ships, EM launchers are expected to meet two of the Navy's other goals: they will be able to hit targets more than 200 nautical miles (NM) away and they will be very effective in destroying their targets.

2.5.1.1 Large-caliber Gun Activities

In the coming years, RDT&E to improve existing types of ordnance will decline, while RDT&E for newer types of ordnance will increase. As a result, the tempo of large-caliber gun testing is expected to remain relatively constant for the foreseeable future.

The use of computer modeling to predict certain aspects of ordnance testing has allowed much of the live firing to be replaced with virtual testing. Thus, modeling has played a substantial role in reducing the number of rounds fired into the PRTR. In the 1970s, approximately 15,000 to 18,000 large-caliber projectiles were fired in a year, compared to an average of 2,900 projectiles fired annually since 1995. However, as each new conflict demonstrates, no amount of modeling can completely replicate real-world environments; consequently, firing guns and projectiles will continue to be needed as a real-world test of what modeling has indicated will happen.

NSWCDD expects the number of large-caliber projectiles fired in the foreseeable future to remain at recent (last 15 years – 1995-2009) levels – an average of 2,900 projectiles fired annually ranging up to an average of 4,700 projectiles fired in particularly active years. Because of the cyclical nature of ordnance RDT&E, the actual number fired annually and the proportions fired from each type of gun will vary from year to year. In the last 15 years, annual firing has ranged from a low of 910 projectiles fired in 2005 to a high of 6,170 (all inert) fired in 2004. As is the case now, large guns would be fired typically from 8 am to 5 pm, Monday through Friday into the MDZ and rarely into the upper LDZ. The Range Operations Center (ROC) would issue a

notice to mariners in advance if firing were scheduled to take place in the evenings or on weekends.

The relative proportion of explosive and inert projectiles fired annually varies from year to year, depending on what is being tested, but the ratio prevailing from 1995 to 2009 of 74 percent inert and 26 percent live projectiles fired annually – approximately three inert projectiles for every live projectile – is expected to remain the average ratio in the future. By far, 5” projectiles would remain the most commonly fired large-gun projectile. The typical weight of explosives contained in most 5” projectiles would continue to be in the 6- to 10-lb range. The 155 mm howitzer would continue to be fired infrequently, and only rarely with live projectiles. For example, 11 inert projectiles were fired from the 155 mm gun in 2008, but none were fired in 2009. Live 155 mm projectiles typically contain 11 to 15 lbs of explosives. The use of NEWs above these ranges would be rare.

EM launchers, a type of large-caliber gun, would fire inert projectiles at conventional targets on the land and river ranges, rather than only into catchment facilities, as under the No Action Alternative. The EM launcher projectiles that would be fired are simple, shaped iron or aluminum “slugs” with fins for guidance. Projectiles would be fired at speeds no faster than the speeds of conventional large-gun projectiles.

To address the Navy’s goal of developing longer-range guns and projectiles, in the future large-caliber guns would fire into a target area from 32,000 to 35,000 yards in the upper LDZ up to 10 days a year, which represents an increase over recent firing levels in this target area. While NSWCDD currently can fire up to 40,000 yards (see Figure 1-5), it has only fired beyond 30,000 yards (approximately the downstream boundary of the MDZ – see Figure 1-5) occasionally in the last 15 years, such as during live-fire tests conducted in 2009.

2.5.1.2 Small Arms Activities

As is the case today, much of the future small arms firing would take place indoors, but some must be done outdoors. The number of bullets fired from small arms (defined as those having a projectile diameter of less than or equal to 20 mm) is expected to increase under Alternative 1 from the current 6,000 up to 25,500 per year to support projected Marine Corps requirements for small arms and related systems evaluation and development. The Marine Corps small-arms program bullets will be no larger than .50-caliber. All ammunition would be inert. NSWCDD has not used lead in bullets for more than 10 years, and there would be no lead contained in bullets fired from small arms. Estimates of the numbers of each type of bullet cannot be made at this time because of the nature of RDT&E where the program evolves as each set of test results is evaluated. Bullets will be fired at targets on land that will trap them and over the river at targets up to 4,000 yards from shore where the bullets will enter the river and not be recovered. When firing at targets in the river, the PRTR will be cleared to 6,000 yards, which is standard. Future firing would take place on and from the Machine Gun Range into the river range on weekdays.

2.5.1.3 Detonations

Fragmentation arena tests on the Churchill Range are expected to increase in the future, leading to an increase in annual detonations – from the current 190 detonations to 200 detonations under Alternative 1. Normally, detonations are and would continue to be scheduled for weekdays.

2.5.1.4 Summary Comparison of Alternative 1 with No Action Alternative

- There would be no change in large-caliber gun use, which would vary from year to year but would remain at the current level of approximately 4,700 projectiles on average fired in a particularly active year.
- EM launchers, a type of large-caliber gun, would fire inert, shaped metal projectiles at conventional targets on land and river ranges. Projectile speeds would be no higher than conventional large-caliber gun projectile speeds.
- Long-range guns would fire into a target area from 32,000 to 35,000 yards in the upper LDZ up to 10 days a year, which is more frequently than over the last 15 years.
- Outdoors small arms use would increase fourfold from 6,000 to 25,500 bullets fired annually.
- Detonations would increase by 10 detonations, or five percent annually.

2.5.2 Alternative 1 Proposed Activities Using Electromagnetic Energy

As described in Chapter 1, many types of EM energy emitters are present at NSWCDD, most of which operate at low powers and have negligible human health risks. Therefore, low-powered devices such as radios and range radars with power, frequency, and exposure levels well below established HERP, HERO, HERF, and EMI thresholds are not included in the Proposed Action because they pose little known hazard to humans or the environment. No special precautions are necessary in the vicinity of lower-power EM energy emitters such as radios, cell phones, remote controls, and radars because their operation generates negligible human health risks and environmental impacts. By contrast, the EM energy devices evaluated in this EIS operate in the frequency range of 300 kHz to 300 GHz and at average powers ranging from 10 W up to 500 MW, but with most events well below the maximum. Currently, an annual average of 490 events takes place at NSWCDD using EM energy fields in these ranges. More than three quarters of these events are ground plane operations, described in Section 1.5.2.3. Future activities using high-power EM energy are described in the following sections.

Because of the rapidly growing role of unmanned systems (UMSs) in modern warfare, NSWCDD anticipates that unmanned aerial vehicles (UAVs), unmanned ground vehicles (UGVs), and unmanned surface vehicles (USVs) would be used more frequently for outdoor RDT&E for weapons systems integration and as platforms for sensors and directed-energy sources, as sensor, laser, or directed-energy targets, and as communication relays. As the use of range patrol boats and other watercraft would increase with the increase in the number of operations and the use of the PRTR, so too would the use of USVs on the PRTR. Annual flight hours for UAVs are expected to increase in future years from 200 hours in calendar year 2009. However, the actual number of hours UAVs are in the SUA over the ranges would not rise as much as total flight hours because more than one UAV could be flying at the same time. They also could be flying concurrently with other range activities. If no other range activities are taking place, the PRTR surface would not need to be restricted while UAVs are flying. However,

the SUA would be reserved for military use while UAVs are flying. UAVs would be flown in all types of weather conditions and at night.

2.5.2.1 Electromagnetic Sensors

In the future, NSWCDD would continue to employ radio frequency (RF) radars, a form of directed energy, to ensure range safety and to test new or upgraded RF radar sensing systems. RDT&E for new and upgraded radar systems would focus on ensuring that they work well with – are integrated with – new and existing shipboard hardware and software. RF emissions would have the appropriate HERP, HERO, HERF, and EMI safety zones and restrictions when emitters are being operated.

2.5.2.2 Hazards of Electromagnetic Radiation to Ordnance (HERO) and Electromagnetic Environmental Effects (E3)

The number of HERO and E3 events that take place annually at the NOTES facility on the EEA and the MOATS and ground-plane facilities on Mainside would increase. Their operational power levels and frequency ranges would remain the same. Whenever these facilities are in operation, HERP, HERO, HERF, and EMI safety zones and restrictions are in effect.

2.5.2.3 Directed Energy

The number of outdoor events using directed energy, excluding EM sensors, would increase above current levels, as would the power of the emissions. Future directed-energy emissions being tested outdoors would include high-power microwave and radio frequency (RF) emissions. Future high-power directed-energy emitters might include the Navy Directed Energy Center (NDEC); a directed-energy mobile emitter on one of the land ranges; or a mobile emitter on a barge on the MDZ. Beams of directed energy might be directed at the Counter Explosive Test Facility (CETFAC), at targets on the land ranges, or at targets on the MDZ.

Increasingly, UMSs would be used as part of directed-energy RDT&E. UAVs, UGVs, and USVs may be used as mobile targets for beams of directed energy. The aim of targeting might be to electronically track, disable, or destroy a UMS, but UAVs would only be tracked – not disabled or destroyed.

An example of a target on the MDZ might be a USV such as an unmanned “go-fast” boat, to test whether directed energy could disable the vessel by overloading the circuits in the engine or other electrical equipment on board, such as radar or computers, or destroy it. High-power microwave energy might also be focused on explosive devices on land ranges or on vessels on the MDZ to test whether directed energy could disable fuzes or timing devices in order to render them harmless.

UAVs could also be used as platforms for directed-energy emitters. The constraint for this application for UAVs would be the current size and weight of the energy source required to power the directed-energy emitter versus the capacity of the UAVs used by NSWCDD, but the technology is changing quickly, and this may be less of an issue in the future. UAVs could be used as relay platforms to communicate from a land range or vessel on the PRTR to USVs or transmission targets on various platforms in the UDZ, MDZ, LDZ, or to targets on the land ranges.

USVs and UAVs could be used to "bounce" or reflect a beam emitted from a land range or a vessel on the PRTR to a UAV or similar airborne platform to a target located over the horizon on the land ranges or on a platform in the UDZ, MDZ, or LDZ. This would allow testing in over-the-horizon conditions, which would overcome a limitation in the use of directed energy (including lasers) as naval weapons: they fire straight beams that cannot arc over the horizon. Lower-power directed energy would be used for initial operations, with gradual increases in power levels as RDT&E progresses and as safety is assured through preparation of risk hazard assessments (RHAs).

For each type of operation proposed in the future, NSWCDD's Safety and Environmental Office in consultation with NSF Dahlgren personnel would consider the risks on a case-by-case basis. An RHA would be prepared to define the risks and the safety measures required to minimize risks. Using the RHA, the Range Safety Director would then make the final decision, and if he/she believes the operation can be done safely, the operation would proceed. If the Range Safety Director determines that the operation would be unsafe, it would not be conducted. For operations over the water, public access to the danger zones to be used and to the SUA would be controlled to ensure the safety of the public.

2.5.2.4 Summary Comparison of Alternative 1 with No Action Alternative

- Under Alternative 1, the number of annual events using EM energy would increase from No Action Alternative levels of 490 to 590. This represents a 20 percent increase in the number of tests annually using EM energy in the frequency range of 300 kHz to 300 GHz and at average powers ranging from 10 W up to 500 MW.
- Directed EM energy sensors and emitters may be mobile.
- EM energy may be directed at UAVs and USVs on the MDZ; USVs may be disabled or destroyed; UAVs would only be tracked.
- EM energy emitted from a land range or a vessel on the PRTR may be reflected off a UAV or similar airborne platform over the horizon to a target on the land ranges or a platform located in the UDZ, MDZ, or LDZ.
- Some EM energy operations would take place beyond the normal 8 am to 5 pm, Monday-to-Friday PRTR range schedule because of the increasing need to test systems in all kinds of weather conditions and at dawn, dusk, and at night.

2.5.3 Alternative 1 Proposed Activities Using Lasers

As described in Section 1.5.3.2, the Navy's use of lasers is expanding virtually as rapidly as technology allows. Therefore, NSWCDD's laser RDT&E program is growing. Laser RDT&E work in the foreseeable future would continue along the path of the work already being conducted. Research involving lasers would focus on uses ranging from communications and targeting to weapons and sensors – including detecting simulated weapons of mass destruction, such as chemical and biological simulants.

As described in 1.5.3, the EIS focuses on HE lasers because of their potential to be hazardous to the human environment. Under Alternative 1, NSWCDD's HE laser operating power levels,

currently a maximum of 100 kW, would increase up to 500 kW for some tests. The sizes of targets and types and thickness of backstop material would increase proportionally to absorb the increased energy.

Under Alternative 1, HE lasers would be directed from sources on land ranges (such as NDEC) over the waters of the PRTR to targets/backstops that would be located on the waters of the MDZ (likely on a barge) at varying distances from the source. Because the beam would become more diffuse and its diameter would expand as it gets farther from the laser emitter, the sizes of the targets/backstops that intercept the laser beam and absorb its energy would increase to contain the beam's width. Locations and scenarios for tests would be approved by the Navy's Laser Safety Review Board (LSRB) and NSWCDD's Laser System Safety Officer (LSSO) prior to testing.

Some HE laser operations under Alternative 1 would involve directing HE lasers at moving airborne targets, such as mortar shells and UAVs in flight, over the waters of the PRTR's MDZ. This would help to determine the value of employing the HE laser system for point defense against moving aerial targets and high-speed missiles. UAVs would be electronically tracked as targets but would not be destroyed; mortar shells would be destroyed. Currently, HE lasers used by NSWCDD are fixed and only emit on a slightly downward angle to fixed targets/backstops. In order to direct HE lasers above the horizon, NSWCDD would coordinate with the FAA and affected DoD components, such as the North American Defense Command, and, in this case, NAS Patuxent River, which coordinates the use of NSWCDD's SUA, in accordance with the joint Chief of Naval Operations Instruction/Marine Corps Order, OPNAVINST 5100.27/MCO 5104.1A

Some HE laser operations might involve directing lasers at an airborne platform, such as a UAV, but rather than trying to destroy the platform, the laser beam would be aimed at a mirror-like surface on the airborne platform to reflect the laser beam to a target over the horizon. Lasers may be emitted from a land range or a vessel on the PRTR to targets on various platforms in the UDZ, MDZ, or LDZ or the land ranges. The coordination and range controls described above for UAVs as targets would apply to this kind of test as well. Initially, laser emissions would be at eye-safe, lower-power levels. As RDT&E progresses, power levels would gradually increase.

As described for directed-energy activities, for each laser operation proposed in the future, NSWCDD's Safety and Environmental Office would consider the risks on a case-by-case basis. An RHA would be prepared to define the risks and the safety measures required to minimize risks. Using the RHA, the Range Safety Director would then make the final decision, and if he/she believes the operation can be done safely, the operation would proceed. If the Range Safety Director determines that the operation would be unsafe, it would not be conducted. For operations over the water, public access to the danger zones to be used and to the SUA would be controlled to ensure the safety of the public.

More events would take place at dawn and dusk, when the atmosphere is thermally stable. Also, because lasers must be operated at all times of the day in order to fully evaluate their capabilities, some laser operations would occur at night, after dark. To help in evaluation of their performance in inclement weather, lasers may also occasionally be operated when it is rainy or foggy.

2.5.3.1 Summary Comparison of Alternative 1 with No Action Alternative

- Under Alternative 1, the number of HE laser events would increase from current/No Action levels of 60 annually to 125 annually, which is a 108 percent increase.
- The maximum HE laser power levels would increase from the current/No Action Alternative level of 100 kW to 500 kW.
- HE lasers would be directed from land ranges to floating targets on the MDZ.
- HE lasers would target UAVs by tracking them and would disable/destroy mobile targets such as USVs on the water and mortar shells in the air.
- HE laser beams emitted from a land range or a vessel on the PRTR may be reflected off a UAV or similar airborne platform located over the horizon to a target on land ranges or on various types of platforms in the UDZ, MDZ, or LDZ.
- If lighter-weight power sources are developed, lasers may be fired from manned and unmanned aerial vehicles at targets on the MDZ water surface.
- Some laser operations would take place beyond the normal 8 am to 5 pm, Monday-to-Friday PRTR range schedule because of the increasing need to test systems in all kinds of weather conditions and at dawn, dusk, and at night.

2.5.4 Alternative 1 Proposed Activities Using Chemical and Biological Simulants

As new chem/bio detectors, decontaminants, and collective protection (COLPRO) systems are developed and existing ones upgraded under the DoD's CBDP, they will need to be operated in maritime conditions and aboard vessels over water. NSWCDD, as the primary Navy laboratory for the CBDP, is the most cost-effective site for such activities. Activities would also take place on land ranges and the Mission Area.

Testing detectors in an outdoor marine/estuarine environment is essential. Stand-off detectors such as the Joint Service Lightweight Stand-off Chemical Agent Detector (JSLSCAD) remotely detect chemical-agent vapors some distance from the source using a scanner, a detector, and an electronics module to process and communicate information. These sensors detect infrared (IR) radiation, recognized as temperature differences – such as the temperature difference between a vapor cloud and the surrounding air. When the background air being sensed includes the area where water and sky meet (the water-sky interface), the IR sensor may lose sensitivity, making it more difficult to distinguish a harmful vapor. Water vapor and fog from the marine/estuarine environment present a challenge for chemical sensors, which must be overcome. Passive IR sensors such as JSLSCAD do not emit IR radiation.

As compared to stand-off detectors that are designed to detect remotely, point detector sensors typically are tested by first attaching the sensor – a badge, a patch or a small unit – to a surface or to the inside or outside of a protective suit; then challenging the sensors with a cloud of simulant at various concentrations; and, finally, observing whether the sensors detect the simulant. Interferents could be added to further test the accuracy of the sensor or detector.

2.5.4.1 Increase in Activities

Future activities using chemical and biological simulants outdoors on the land and water range complexes and the Mission Area would increase from the current baseline of 12 events annually using chemical simulants and none using biological simulants. Under Alternative 1 there would be up to 60 events annually of either chemical or biological simulants released for each event, but chemical and biological simulants would not be mixed. The areas in which the activities may take place would expand from the areas used in the past shown in Figure 1-11 to include all the land ranges, the Mission Area, and the MDZ.

2.5.4.2 Likely Progression of Chem/Bio RDT&E

Based on the current state of the technology, the likely progression of chem/bio defense RDT&E for the foreseeable future would be:

1. More operational tests on the PRTR's MDZ and on land similar to those conducted in 2003, 2005 and 2009, using comparable chemical simulants, but representing a wider range of chemical agents, to test updated or new point and stand-off detector systems.
2. Biological point and/or stand-off sensor tests on the PRTR's MDZ and on land using biological simulants to challenge detectors.
3. Chemical and biological simulants used separately for stand-off or point sensor tests on the PRTR's MDZ to challenge detectors.
4. Tests of the effectiveness of point and stand-off sensor/detector systems to sense chemical and/or biological simulants in an environment with various interferents, smokes, and obscurants on the PRTR's MDZ and on land.
5. Decontamination operations on equipment and facilities, on land and on the PRTR's MDZ, using chemical or biological simulants representing known or expected chem/bio threats.
6. Outdoor COLPRO operations on land and on the PRTR's MDZ using chemical and/or biological simulants representing known or expected chem/bio threats. This would include clearing spaces exposed to simulants, as well as preventing exposure of spaces to simulants.

2.5.4.3 Outdoor Chemical Detector Operations

A typical future operational scenario for outdoor testing of a chemical-detector system using chemical simulants would be similar to the JSLSCAD testing that NSWCDD conducted in 2003, 2005, and 2009. Operations likely would be conducted several times a year, each lasting for approximately two weeks. Stand-off detectors like the JSLSCAD would be used, but point detectors could be tested as well. Testing could take place on any of the land ranges or the Mission Area, but most testing would be conducted on the PRTR's MDZ.

Chemical simulants are chosen for their low toxicity, low environmental impacts, and ability to closely simulate, or mimic, the actual agent the sensor is designed to detect. The toxicity of a chemical is defined by the extent of its adverse effects on a biological organism, as described further in Section 3.8.5.1. The chemical simulants that have been used in NSWCDD's past indoor or outdoor RDT&E operations include the following compounds:

- Polyethylene glycol (PEG 200)
- Methyl salicylate (MeS)
- Sulfur hexafluoride (SF_6)
- Triethyl phosphate (TEP)
- Glacial acetic acid (GAA)
- Dipropylene glycol methyl ether (DPGME)
- Dimethyl methylphosphonate (DMMP)
- Diethyl malonate (DEM)
- Diethyl phthalate (DEP)
- Dimethyl adipate (DMA)
- Diethyl ethyl phosphonate (DEEP)

PEG 200 and MeS were used in outdoor chemical simulant tests at NSWCDD in the 1980s. SF_6 was used as a simulant in the 1996 outdoor tests and to calibrate the JSLSCAD equipment for the 2003 and 2005 tests. TEP and GAA were used as chemical simulants for the tests on the PRTR in 2003 and 2005. The 2009 test activities involved release of the liquids MeS, TEP, GAA, and the gases R-134 and R-152a .To date, DPGME, DMMP, DEM, DEP, DMA, and DEEP have not been used as simulants outdoors at NSWCDD.

Future operations could use any of these simulants or other ones with similar or lesser toxicities. Prior to use, all simulants would be reviewed and approved by the NSWCDD Safety and Environmental Office in consultation with NSF Dahlgren personnel, as applicable, and would only be approved after considering toxicity data relative to the intended quantity and concentration of the simulant to be used. All operations would be conducted in accordance with local, state, and federal regulations.

Other materials and chemicals that have been used during chemical-detector operations include thickeners, flavorings, and ultraviolet (UV) dye indicators, as listed below:

- Polymethyl methacrylate (PMMA), Acryloid K-125 (a thickener; trademark Rohm and Haas)
- Isoamyl acetate (banana oil)
- Tinopal CBS-X (trademark Ciba-Geigy), which is a UV dye (used as a shirt whitener in laundry detergents)

These compounds are used to aid in dispersal and identification. Future testing could use similar auxiliary chemicals.

Operational tests over water would be conducted on the MDZ. Details of operational conditions and restrictions would be documented in SOPs approved by NSWCDD authorities. Prior to the operation, the Navy team would determine where, based on wind conditions, the operation should begin to release the vapor to attain the desired vapor concentration for a particular test. Vapor releases would take place well within the boundaries of the ranges and the Mission Area, so that vapor clouds would disperse before reaching their boundaries, as determined by modeling and by monitoring weather conditions just prior to the test. Over-water operations would involve

release of a vapor of chemical simulant in a variety of weather conditions from a vessel, helicopter, or UAV. Prior to releasing simulants, the MDZ would be cleared of non-participating boats and personnel by range control boats – both as a safety measure and to preclude non-background sources of IR radiation (i.e., other vessels) that could interfere with the test. Range boats would continue to patrol the MDZ during the tests and during cleanup, if required, afterwards.

Sensors mounted on and operated from vessels and/or on shore would be aimed upriver or downriver, to detect the simulant vapor against a sky/water background. The release for each operational test would take about two minutes, and the resulting vapor would dissipate in less than ten minutes. The PRTR's cameras, a global positioning system (GPS), meteorological stations, real-time surface radars, and a locational system would be used to detect and record in detail the release, dispersion, and ultimate dissipation of the simulant vapor.

Operational tests on land could be conducted on any of the land ranges or the Mission Area. Test methods would be similar to tests on the PRTR. Wind and storm conditions would be monitored prior to releasing the vapor to attain the desired vapor concentration and location for a particular test. Operations could occur in a variety of weather conditions. Releases of vapor could take several minutes, and the resulting vapor would dissipate quickly. Operations on land would be monitored using much the same equipment used on the river.

Operations on the PRTR or on land would be designed to determine not only whether stand-off detectors are working as designed, but also whether point detectors and protective gear are working as designed.

2.5.4.4 Quantity of Simulants

For both land and river range operations, repetitive tests would be conducted with each simulant or group of simulants. A typical test would involve the release of approximately 10 gallons (gals) of simulant, but the amount could vary from a few ounces up to 20 gals of simulant. The amount of simulant used would be the minimum amount needed to test the lowest level of simulant the sensor can detect (its threshold capacity). Thus, the concentrations produced within each vapor cloud would be extremely low.

Typically, for tests over water, a simulant would be released by boat at a height of approximately 40 ft. Simulants also would be released over land or water by a helicopter-mounted or UAV-mounted sprayer system at a height of about 300 ft. Some simulant coming from the helicopter or UAV spraying over water might enter the river, and cleanup of the test platform would result in some effluent with low concentrations of simulants entering the river.

SF_6 has been used in past tests to calibrate detectors but is unlikely to be used in the future because it has been identified as a greenhouse gas and is on the US Environmental Protection Agency's (USEPA's) Greenhouse Gas Watch List. Instead, R-134a and R-152a (common commercial refrigerant gases) or similar substances would be used in the future to calibrate detectors. Based on past experience, future tests could each use approximately 30 lbs to 150 lbs of these chemicals (averaging 125 lbs per test) to calibrate test equipment.

2.5.4.5 Dispersal of Simulants

In a typical scenario, the simulant would be pressurized with nitrogen gas and blown out as an aerosol or mist into the air using a high-velocity blower, or dispersed as a liquid or aerosol from the helicopter-mounted sprayer. The simulant could be dispersed from a boat, helicopter, or UAV at altitudes that would ensure test objectives are met while at the same time achieving the desired movement and dispersion of the simulant. Similar results could be obtained from similar exposure concentrations in a JSLSCAD-type test using either 10 gals of simulant released at a height of 40 ft or 1.5 gals of simulant released at 6 ft. The test objective in this example – to test the reliability of a JSLSCAD-type sensor some distance "x" downwind of the "attack" – would dictate the simulant scenario employed.

2.5.4.6 Outdoor Biological Sensor Tests

In many ways, outdoor testing of biological-agent sensors would be similar to chemical sensor tests using chemical simulants. These tests could be conducted on land ranges or within the Mission Area, but the PRTR's MDZ would be the most likely focus of the work because of DoD's – and particularly the Navy's – need to test biological sensors over water to observe how riverine/marine conditions affect them.

Biosafety Level (BSL)-1 Organisms

BSL-1 organisms are defined by the Centers for Disease Control and Prevention (CDC) (September 3, 2008) as "well-characterized strains of viable microorganisms not known to consistently cause disease in healthy adult humans and of minimal potential hazard to laboratory personnel and the environment."

Biological simulants are microorganisms that exhibit a quality similar to an actual biological threat agent. NSWCDD would only use Biosafety Level (BSL)-1 organisms as simulants. BSL-1 organisms are commonly used in high school and introductory college teaching laboratories. Examples of BSL-1 organisms are *Lactobacillus acidophilus*, which is used to turn milk into yogurt, and *Neurospora crassa*, a bread mold, which is used for genetic studies because its simple genome has been completely sequenced. Future test activities would use the simulants listed below or similar BSL-1 organisms. All simulants would be approved through the NSWCDD Safety and Environmental Office in consultation with NSF Dahlgren and would only be approved after considering biosafety-level data relative to the intended use of the simulant and the purpose of the test. All tests would be conducted in accordance with local, state and federal regulations.

Tests of biological detectors would use the following BSL-1 bio-simulants or BSL-1 organisms similar to them:

- Spore-forming bacteria: *Bacillus atrophaeus* (formerly known as *Bacillus globigii*), *Bacillus subtilis*, and *Bacillus thuringiensis*
- Non-spore-forming bacteria: *Pantoea agglomerans* (formerly known as *Erwinia herbicola*) and *Deinococcus radiodurans*
- The fungus *Aspergillus niger*
- The protein ovalbumin
- MS2 bacteriophages

These biological simulants are described in Section 3.8.5.2.

The amount of simulant used would be the minimum amount necessary to obtain the desired results. Operations would likely be conducted over a two-week period, with up to two tests per day, for a maximum of up to 20 tests in a two-week period.

In contrast to chemical simulants, biosimulants are typically dry and powdery rather than liquid. Therefore, the simulants could be released by a blower to form a small dry cloud rather than a vapor cloud. Aside from this, operational tests of both stand-off and point detectors would be similar to those described for tests of chemical simulants.

2.5.4.7 Outdoor Chemical and/or Biological Sensor Tests with Interferents, Smokes, and Obscurants

All of the sensor-testing described in the preceding sections could be repeated with the introduction of interferents, smokes, or obscurants to study how these substances interact with simulants to affect the capability of detectors. Examples of these include fog oil, PEG 200, poly alpha olephin, paints, fuels, and cleaners. All interferents, smokes, or obscurants must be approved through the NSWCDD Safety and Environmental Office in consultation with NSF Dahlgren and would only be approved after considering the intended quantity and concentration of the interferent, smoke, or obscurant to be used. All tests would be conducted in accordance with local, state and federal regulations.

2.5.4.8 Outdoor Collective Protection (COLPRO) Tests

Operational testing of COLPRO systems in an outdoor setting would be another RDT&E scenario that would use chemical and biological simulants. These tests could be performed on land or on the PRTR to measure the impacts of outdoor conditions on COLPRO systems.

2.5.4.9 Summary Comparison of Alternative 1 with No Action Alternative

- The annual number of outdoor chem/bio defense events would increase fivefold from 12 to 60.
- A wider range of chemical simulants would be used for outdoor chemical defense operations.
- Biological simulants would be used as well as chemical simulants outdoors, but they would not be tested together.
- Chemical and biological simulants may be tested on ranges previously used – the PRTR, EEA, and Main Range – as well as other land ranges, the Mission Area, and the MDZ, where they have not been tested in the past.
- Some chem/bio sensor activities would take place beyond the normal 8 am to 5 pm, Monday-to-Friday PRTR range schedule because of the increasing need to test systems in all kinds of weather conditions and at dawn, dusk, and at night.

2.5.5 Alternative 1 PRTR Use

The increase in activities and the requirement to test beyond normal range operations hours under Alternative 1 would result in:

- An overall increase in the number of hours that public access to some part of the PRTR would be restricted from 750 hours under the No Action Alternative to 870 hours annually under Alternative 1.
- Restricting public access to the PRTR UDZ and the LDZ approximately two times a year each to allow, for example, for weapon systems integration operations using vessels and aircraft, compared to no restrictions under the No Action Alternative.
- Restricting public access to the upper LDZ approximately 10 days a year for long-range, large-caliber gun firing, compared to only infrequent restrictions under the No Action Alternative.

2.6 Description of Alternative 2

In most respects, Alternative 2 would include the same types of activities described for Alternative 1, but the number of large-caliber gun and small arms firings, events, and hours would increase. Table 2-2 shows the proposed annual outdoor RDT&E activity levels under Alternative 2. The number of average annual activities under Alternative 2 represents:

1. An average of the annual number of large-caliber gun and small arms firings, detonations, and events for each RDT&E activity from 1993 (1995 for ordnance) to 2009, weighted to take into account years with the highest activity levels (No Action Alternative levels);
2. ***Plus*** the increase in average annual RDT&E activities under Alternative 1 above No Action Alternative levels;
3. ***Plus*** roughly 15 percent growth in the number of average annual RDT&E activities above Alternative 1 levels.

This alternative satisfies current requirements, known outdoor RDT&E scheduled for the coming years, and projected increases in tests in the foreseeable future based on current trends. It provides the flexibility required in RDT&E to accommodate future developments that may influence global threats, homeland security, and future missions. Alternative 2 includes the following increases above Alternative 1 levels:

- Small arms firing would activities would grow by about 4,500 bullets fired annually (18 percent) above Alternative 1 levels. The number of large-caliber projectiles fired would not increase (0 percent).
- Detonations on the EEA would increase by about 30 annually (15 percent) above Alternative 1 levels.

- RDT&E for operations using EM energy events would increase above Alternative 1 levels by 90 (15 percent) annually, HE laser events would increase by 20 (16 percent); and chem/bio simulant events would increase by 10 (17 percent).
- Biological simulants may be tested simultaneously with chemical simulants. Detectors capable of immediately recognizing a mixture of chemical and biological threats would be tested.
- NSWCDD's use of the PRTR would increase by 130 hours annually (15 percent above Alternative 1 levels). The number of days that the UDZ and LDZ would be restricted would be similar to Alternative 1, approximately two times a year, and the upper LDZ would be restricted approximately 10 days a year.

The one respect in which Alternative 2 would differ from Alternative 1 – other than annual numbers of firings, detonations, and events – is that outdoor tests would include mixtures of chemical and biological simulants. Alternative 1 would use both types of simulants, but separately. DoD's and Navy's goal is to develop detectors capable of immediately recognizing either a chemical or biological threat, or a mixture of both, which would only be addressed under Alternative 2. A mixture of chemical and biological simulants would be used for this type of operation. The chemical and biological simulants used would be the same ones approved for use in the individual chemical and biological operational tests under Alternative 1. Detector tests would be similar to those described for chemical simulants. The same protective and safety measures taken for chemical-simulant testing and biological-simulant testing would be used for the combined chemical and biological sensor testing.

2.7 Preferred Alternative

Alternative 2 is the Navy's Preferred Alternative because it would support an increased level of outdoor RDT&E activities in the foreseeable future, thus optimizing NSWCDD's activities on ranges and the Mission Area, without significantly increasing environmental impacts, such as noise. This alternative would improve NSWCDD's operational capability and flexibility to provide mission support to the Navy and to the other services and organizations now benefiting from NSWCDD's RDT&E programs.

2.8 Comparison of Environmental Impacts

Each alternative was evaluated for its potential to produce environmental impacts. The following defines the impact attributes that were used to assess potential impacts:

- **Context** – Context refers to the geographic, social, and environmental circumstances within which a proposed action may have effects on an environmental resource, as well as the size of the area affected by the action.
- **Intensity** – Intensity refers to the severity of the impacts. Intensity is rated as negligible, minor, moderate, or major, in accordance with the framework presented below.
- **Short-term or Long-term** – In general, short-term impacts are those that would occur only with respect to a particular discontinuous activity or for a finite period, or only

during the time required for installation activities. Long-term impacts are those that are more likely to be persistent and chronic.

- **Direct or Indirect** – A direct impact is caused by a proposed action and occurs contemporaneously at or near the location of the action. An indirect impact is caused by a proposed action but might occur later in time or be farther removed in distance but still be a reasonably foreseeable outcome of the action.
- **Positive or Negative** – A positive impact is one having beneficial outcomes on an environmental resource. A negative impact is one having adverse, unfavorable, or undesirable outcomes.

The following scale is the qualitative framework used in this EIS to evaluate the intensity of impacts:

- **No Impacts** – No change to the environmental resource.
- **Negligible Impacts** – Impacts either are non-detectable or, if detected, are well within natural or normal variability and do not appreciably affect the extent or value of the environmental resource. Adverse impacts are easily absorbed by the natural or human environment without mitigation or long-term consequences.
- **Minor Impacts** – Impacts are clearly detectable but they approximate natural or normal variability and do not appreciably affect the extent or value of the resource. If needed to offset adverse impacts, mitigation is simple and mitigation success is likely.
- **Moderate Impacts** – Impacts exceed natural or normal variability; impacts appreciably affect the value or extent of the resource, but do not affect its viability. Although mitigation typically would be needed for the environment to absorb adverse impacts without long-term deterioration, mitigation success is likely.
- **Major Impacts** – Impacts exceed natural or normal variability and likely affect the viability of the resource or, as the impacts are highly uncertain or involve unique or unknown risks, the future viability of the resource is in question. Full mitigation of adverse impacts may not be possible or mitigation success is not likely, and some long-term deterioration of the environment may be unavoidable.

Table 2-3 compares in summary form the environmental impacts of the No Action Alternative with Alternatives 1 and 2. Chapter 3 describes the existing conditions that set the stage for the analysis of impacts in Chapter 4. In Chapter 4, the impacts of each alternative on resources are evaluated in detail.

Table 2-3
Summary of Environmental Impacts

Resource	No Action Alternative	Alternative 1	Alternative 2
Land Use, Plans, & Coastal Zone Management			
NSF Dahlgren	No military construction proposed. Activities would continue to use existing facilities and corridors within operational ranges and the Mission Area. No direct or indirect impacts on NSF Dahlgren land use pattern. Negligible, short-term, direct, negative impacts and no indirect impacts on non-operational uses of ranges and the Mission Area on NSF Dahlgren. Consistent with Navy plans to guide development at NSF Dahlgren, except that alternative would not support regional plans to further promote district as an RDT&E center.	No military construction proposed. Activities would use existing facilities and existing plus some new areas within operational ranges and the Mission Area. Activities would take place more frequently than under No Action Alternative (Alt). No direct or indirect impacts on NSF Dahlgren land use pattern. Negligible, short-term, direct, negative impacts and no indirect impacts on non-operational uses of ranges and the Mission Area on NSF Dahlgren. Consistent with Navy plans for NSF Dahlgren. Would support regional plans to promote district as an RDT&E center and maximize existing facilities for highest and best use.	No military construction proposed. Activities would use existing facilities and existing plus some new areas within operational ranges and the Mission Area. Activities would take place more frequently than under other alternatives. No direct or indirect impacts on NSF Dahlgren land use pattern. Negligible, short-term, direct, negative impacts on non-operational uses of ranges and the Mission Area on NSF Dahlgren. Consistent with Navy plans for NSF Dahlgren. Would support, to a greater extent than Alt 1, regional plans to promote district as an RDT&E center and maximize existing facilities for highest and best use.
Dahlgren Area and Potomac River Shoreline	Master plans, market forces, and the presence of NSF Dahlgren have determined current land use pattern and development projects. Therefore, continuing RDT&E activities would have no direct or indirect impacts on land use near NSF Dahlgren or along the shoreline of the PRTR. Consistent with master plans and policies of counties and towns near the PRTR. No direct or indirect impacts on existing access to the Potomac River for commercial or recreational purposes.	PRTR use increase of 16% plus 20% increase in EM energy and 108% increase in HE laser events would have negligible, short-term, direct, negative impacts and no indirect impacts on river use. No direct impacts and negligible, long-term, indirect, negative impacts on the desirability of waterfront property based on the slight increase in noise levels in the upper LDZ. NSWCDD gives notice of restrictions in advance, boat traffic is allowed to pass during lulls in tests, and recreational boating mainly takes place on weekends when operations rarely are conducted. No direct impacts and negligible, long-term, indirect, negative impacts on land use, land use planning, and ongoing development projects.	PRTR use increase of 33% plus 39% increase in EM energy and 142% increase in HE laser events would have negligible, short-term, direct, negative impacts and no indirect impacts on river use. No direct impacts and negligible, long-term, indirect, negative impacts on the desirability of waterfront property for the reasons described under Alt 1. No direct impacts and negligible, long-term, indirect, negative impacts on land use, land use planning, and ongoing development projects
Special-Use Airspace	No change from existing conditions; no direct or indirect impacts on civilian air traffic.	Negligible, short-term, direct, negative impacts and no indirect impacts on civilian air traffic. No change in the hours that airspace is restricted annually. Although fewer hours	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
		would be turned back to FAA for civilian use, commercial and general aviation operators normally stay out of the special-use airspace at all times; many operators consider the special-use airspace to be off-limits at all times. It is expected that few aircraft would actually use the airspace during hours normally restricted.	
Coastal Zone	The Proposed Action is consistent to the maximum extent practicable with the enforceable policies of Virginia's and Maryland's coastal zone management (CZM) programs. The Virginia Department of Environmental Quality (VDEQ) concurred that the Proposed Action will be consistent with the Virginia Coastal Zone Management Program. The Maryland Department of the Environment (MDE) received a copy of the DEIS and the Federal Coastal Consistency Determination (Appendix I) but did not respond within 60 days to the Navy's consistency determination nor ask for an extension, so under the provisions of the Coastal Zone Management Act, the state has waived its consistency rights, stating neither that it concurs with nor objects to the Navy's consistency determination.	Same as No Action Alt.	Same as No Action Alt.
Socioeconomics			
Demographics	No significant increase in NSWCDD's outdoor RDT&E personnel anticipated; unlikely to affect population projections and would have no direct or indirect impacts on demographics.	No significant increase in NSWCDD's outdoor RDT&E personnel anticipated; unlikely to affect population projections and would have no direct impacts and negligible, long-term, indirect, negative impacts on demographics.	Same as Alt 1.
Economics	Current PRTR activities have not suppressed real estate development driven by proximity to Washington, DC and attractiveness of the Potomac River. Marine navigation (freight movement, commercial fishing, and recreational boating) coexists with range use; inconvenience of delays of up to 30 minutes (10 minutes typical) for small vessels and up	Based on No Action Alt experience, the 16% increase in PRTR use and no significant increase in noise, coupled with Range Operations Center measures to facilitate river traffic movement (as described under No Action Alt), are expected to have no direct and negligible, long-term, indirect, negative impacts on real estate development; and	Based on No Action Alt experience, the 33% increase in PRTR use and no significant increase in noise, coupled with Range Operations Center measures to facilitate river traffic movement (as described under No Action Alt.), are expected to have no direct and negligible, long-term, indirect, negative impacts on real estate development; and minor, short-

Resource	No Action Alternative	Alternative 1	Alternative 2
	to one hour (half-hour typical) for large vessels is mitigated by Range Operations Center's early notices of upcoming operations and working with vessel operators to allow them to pass during lulls in testing. No direct or indirect impacts on economic conditions in the study area because it would not change factors such as noise and river use, which are already incorporated into existing economic activities.	minor, short-term, direct and minor, long-term, indirect, negative impacts on marine commerce.	term, direct and minor, long-term, indirect, negative impacts on marine commerce.
Environmental Justice and Protection of Children	No disproportionately high and adverse human health or environmental effects on minority populations and low-income populations. No disproportionate environmental health or safety risks to children.	Same as No Action Alt.	Same as No Action Alt.
Utilities			
Utilities	NSWCDD's current power requirements are being adequately supplied by the power grid and NSF Dahlgren's auxiliary generators. RDT&E activities would have no direct or indirect impacts on utilities. The Dominion Virginia Power (DVP) application to build a new 230 kilovolt transmission source and substation at NSF Dahlgren has been approved and construction is scheduled to be completed in 2014. This would meet NSF Dahlgren's needs and King George County's growth and development.	Despite 20% increase in EM energy and 108% increase in HE laser events, RDT&E activities would have no direct and negligible, long-term, indirect impacts on the Virginia power grid. RDT&E activities would have no direct or indirect impacts on other utility systems, which are sufficient to support proposed activities.	Despite 39% increase in EM energy and 142% increase in HE laser events, RDT&E activities would have no direct and negligible, long-term, indirect impacts on the Virginia power grid. RDT&E activities would have no direct or indirect impacts on other utility systems, which are sufficient to support proposed activities.
Air Quality			
Stationary & Mobile Sources	No construction of any new major stationary sources is proposed. The land-based portion of NSF Dahlgren is in an attainment area and has a state operating permit for stationary air emissions. Annual emission levels do not exceed Title V major source thresholds. The emissions from the portion of the PRTR's MDZ located within an ozone nonattainment area would be unchanged. RDT&E activities would result in negligible, long-term, direct and	Same as No Action Alt.	Same as No Action Alt.

Resource	No Action Alternative	Alternative 1	Alternative 2
	indirect, negative impacts on air quality.		
Other Sources	Chemical simulants released have low toxicity and are rapidly dispersed to low concentrations. NSWCDD personnel exposed to simulants use personal protective equipment. Chemical defense activities would result in negligible, long-term, direct and indirect, negative impacts on air quality.	The 400% increase in chem/bio defense events and the addition of biological simulants would result in negligible, long-term, direct and indirect, negative air quality impacts comparable to impacts under the No Action Alt.	The 483% increase in chem/bio defense events and the addition of biological simulants, which may be mixed with chemical simulants, would result in negligible, long-term, direct and indirect, negative air quality impacts comparable to impacts under the No Action Alt.
Greenhouse Gases	NSWCDD RDT&E activities make an incremental contribution to greenhouse gas emissions, representing a very small percentage of total United States emissions. Based on an estimate of CO_2 equivalents generated, NSF Dahlgren's facility-wide total greenhouse gas emissions in 2008 represented approximately 0.0001% of the total emissions for the country as a whole. NSWCDD RDT&E activities when combined with other past, present, and reasonably foreseeable future actions would have the potential for negligible, long-term, indirect, negative impacts on climate.	Same as No Action Alt because increases in greenhouse gas emissions would be negligible.	Same as No Action Alt because increases in greenhouse gas emissions would be negligible.
Noise			
Noise	Noise levels resulting from firing large guns and small arms and from detonations would remain the same as at present. Ordnance activities would have minor, long-term, direct, negative weapons-testing noise impacts; negligible, long-term, direct, negative vibration impacts; and no indirect noise or vibration impacts. EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect noise or vibration impacts.	Although small-arms firing would increase by 325% and detonations by 5%, there would be no significant overall increase in noise levels. Ordnance activities would have minor, long-term, direct, negative weapons-testing noise impacts; negligible, long-term, direct, negative vibration impacts; and no indirect noise or vibration impacts. EM energy, HE laser, chemical and biological defense activities, and PRTR use would have no direct or indirect noise or vibration impacts.	Although small-arms firing would increase by 400% and detonations by 21%, there would be no significant overall increase in noise levels. Ordnance activities would have minor, long-term, direct, negative weapons-testing noise impacts; negligible, long-term, direct, negative vibration impacts; and no indirect noise or vibration impacts. EM energy, HE laser, chemical and biological defense activities, and PRTR use would have no direct or indirect noise or vibration impacts.
Cultural Resources			
Archaeolog-ical Resources	RDT&E activities would have no direct or indirect impacts on previously identified archaeological resources and are not expected to affect unknown resources within the Archaeological Area of Potential Effect	RDT&E activities would have no direct or indirect impacts on previously identified archaeological resources and are not expected to affect unknown resources within the Archaeological APE. In accordance with	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
	(APE) because no groundbreaking activities and no expansion of outdoor RDT&E activities are proposed. In accordance with Section 106 of the National Historic Preservation Act, the Virginia Department of Historic Resources (VDHR) and Maryland Historic Trust (MHT) concurred that this alternative would not have an adverse effect on archaeological resources within the archaeological APE.	Section 106 of the National Historic Preservation Act, the VDHR and MHT concurred that this alternative would not have an adverse effect on archaeological resources within the archaeological APE. No archaeological resources are known to occur in the heavily-disturbed range areas used for detonations so an increase in detonations would have no effect. There would be no increase in large-caliber gun firing.	
Historic Architectural Resources	In accordance with Section 106, ordnance noise and vibration modeling indicates no adverse effect to either the National Register-eligible Dahlgren Residential Historic District or the three proposed districts on NSF Dahlgren.The VDHR and MHT concurred that the Proposed Action would have no direct or indirect adverse effect on National Register of Historic Places-eligible or -listed properties within the Historic Architectural APE. In accordance with NEPA, the No Action Alternative would have minor direct impacts and no indirect negative impacts on historic architectural resources within the APE.	Same as the No Action Alt. Although there would be a 325% increase in small-arms use, the area affected is limited and would not include National Register-listed or -eligible resources. There would be no increase in large-caliber gun firing.	Same as the No Action Alt. Although there would be a 400% increase in small-arms use, the area affected is limited and would not include National Register-listed or -eligible resources. There would be no increase in large-caliber gun firing.
Hazardous Materials and Waste			
Hazardous Materials and Hazardous Waste	The numerous policies and programs in place to remediate and to safely use, store, transport, and dispose of hazardous materials and hazardous waste ensure that they are safely handled and do not enter the environment. The environmental restoration program is addressing past range use when environmental programs were less stringent. Ordnance activities would have minor, long-term, direct and indirect, negative impacts and EM energy, HE laser, and chemical defense activities would have negligible, long-term, direct and indirect, negative impacts.	The numerous policies and programs in place to remediate and to safely use, store, transport, and dispose of hazardous materials and hazardous waste would ensure that they are safely handled and do not enter the environment. The environmental restoration program is addressing past range use when environmental programs were less stringent. Comparable to the No Action Alt, ordnance activities would have minor, long-term, direct and indirect, negative impacts and EM energy, HE laser, and chem/bio defense activities would have negligible, long-term, direct and indirect, negative impacts.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
Health & Safety			
Health and Safety	Activities are conducted in accordance with Navy policies, carefully-conceived management controls, and operation-specific risk hazard assessments and standard operating procedures, which are implemented to ensure safety during the RDT&E activities. Input of munitions constituents (MCs) into the Potomac River from current and past ordnance use are well below concentrations that could cause adverse effects on human health. Ordnance, EM energy, HE laser, and chemical defense activities would have negligible, long-term, direct and indirect, negative impacts. PRTR use would have negligible, long-term, direct, negative impacts and no indirect impacts.	The 325% increase in small-arms firing and 5% increase in detonations would not increase releases of MCs on or off range or pose unacceptable risks to human health. Most bullets are fired into butts and those entering the PRTR are likely to be buried in sediments and be isolated from exposure pathways. The MC contribution of the additional number of bullets settling near the surface of the sediments is negligible (0.1% of duds and inert bullets or about 26 bullets). Treatment of explosive waste from the additional detonations would take place at NSWCDD, consistent with current operations. Biological simulants would be tested, but simulants proposed for use are common and found naturally in the environment. Ordnance, EM energy, HE laser, and chem/bio defense activities would have negligible, long-term, direct and indirect, negative impacts. PRTR use would have negligible, long-term, direct, negative impacts and no indirect impacts.	The 400% increase in small-arms firing and 21% increase in detonations would not increase releases of MCs on or off range or pose unacceptable risks to human health. Most bullets are fired into butts and those entering the PRTR are likely to be buried in sediments and be isolated from exposure pathways. The MC contribution of the additional number of bullets settling near the surface of the sediments is negligible (0.1% of duds and inert bullets or about 30 bullets). Treatment of explosive waste from the additional detonations would take place at NSWCDD, consistent with current operations. Biological simulants would be tested, but simulants proposed for use are common and found naturally in the environment. Biological simulants tests could be performed in combination with chemical simulants; there are no known synergistic interactions between the proposed types of biological organisms and low-toxicity chemical simulants. Ordnance, EM energy, HE laser, and chem/bio defense activities would have negligible, long-term, direct and indirect, negative impacts. PRTR use would have negligible, long-term, direct, negative impacts and no indirect impacts.
Geology, Topography, Soils & Sediments			
Geology, Topography, Soils and Sediments	Ordnance activities would have minor, long-term, direct, negative impacts on soils and sediments, based on localized disturbances to soil and sediments, and no direct or indirect impacts on geology or topography. EM energy, HE laser, and chemical defense activities would have negligible, short-term, direct impacts and no indirect impacts on geology, topography, soils, or sediments, as there would be minimal contact with these features. Use of boats during activities on the	Same as No Action Alt.	Same as No Action Alt.

Resource	No Action Alternative	Alternative 1	Alternative 2
	PRTR would have no direct impacts and negligible, long-term, indirect, negative impacts on geology, topography, soils, and sediments.		
Water Resources			
Surface Water	RDT&E activities would have little contact with surface water resources and minimal potential to affect them. Low concentrations of MCs and simulants enter surface water with predicted concentrations below standard detection levels. Ordnance activities and PRTR use would have negligible, long-term, direct and indirect, negative impacts on surface waters. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. Any incidental EM/laser energy would be quickly diminished by reflection, absorption, or scattering by water. Chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts. PRTR use would have negligible, long-term, direct and indirect, negative impacts on surface waters.	Same as No Action Alt. Naturally-occurring biosafety level (BSL)-1 organisms used in bio defense tests would not affect surface water.	Same as Alt 1.
Wetlands and Floodplains	Ordnance and PRTR use would have no direct impacts and negligible, long-term, indirect, negative impacts on wetlands and floodplains. EM energy, HE laser, and chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect wetlands and floodplains.	Same as Alt 1.
Groundwater	Ordnance activities would have no direct impacts and negligible, long-term, indirect, negative impacts on groundwater. EM energy, HE laser, chemical defense activities, and PRTR use do not contact groundwater and therefore would not directly or indirectly impact groundwater.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not enter the groundwater.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
Potomac River Biological Resources			
Submerged Aquatic Vegetation (SAV)	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on SAV communities. Exposure concentrations of MCs and simulants are below levels that could cause adverse effects in aquatic organisms. EM energy, HE laser, and PRTR use would have negligible, short-term, direct, negative impacts and no indirect impacts on SAV. Chemical defense activities would have no direct impacts and negligible, short-term, indirect, negative impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect SAV.	Same as Alt 1.
Plankton	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on plankton communities. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. Chemical defense and PRTR activities would have no direct impacts and negligible, short-term, indirect, negative impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect plankton communities.	Same as Alt 1.
Aquatic Invertebrates	Ordnance, activities would have negligible, long-term, direct and indirect, negative impacts on aquatic invertebrate communities. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. Chemical defense and PRTR activities would have no direct impacts and negligible, short-term, indirect, negative impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect aquatic invertebrate communities.	Same as Alt 1.
Fish	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on fish communities. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. Chemical defense activities would have no direct impacts and negligible, short-term, indirect, negative impacts. PRTR use would have negligible, short-term, direct	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect fish communities.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
	and indirect, negative impacts.		
Essential Fish Habitat (EFH)	The RDT&E activities conducted by NSWCDD on the PRTR may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The National Marine Fisheries Service (NMFS) concurred that the proposed action would not substantially adversely affect EFH or habitat areas of particular concern. In accordance with NEPA, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on EFH. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on EFH. Chemical defense activities would have no direct impacts and negligible, short-term, indirect, negative impacts. PRTR use would have negligible, short-term, direct and indirect, negative impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect EFH.	Same as Alt 1.
Potomac River Birds			
Potomac River Birds	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on Potomac River birds. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. Chemical defense activities would have no direct impacts and negligible, short-term, indirect, negative impacts. PRTR use would have negligible, short-term, direct and indirect, negative impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect birds.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
NSF Dahlgren's Biological Resources			
Ponds, Streams, and Creeks	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on biological resources associated with NSF Dahlgren's ponds, streams, and creeks. Large-caliber guns are mostly fired into the river rather than at land targets; 90% of small arms are fired at targets on land that trap the bullets, but 10% are fired at targets in the water up to 4,000 yds out and end up in the river. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts, as most activities occur well away from ponds, streams, and creeks. Chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect ponds, streams, and creeks.	Same as Alt 1.
Vegetation	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's vegetation. HE laser, EM energy, and chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect vegetation.	Same as Alt 1.
Wildlife	Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's wildlife. EM energy and HE laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts. EM and laser corridors are checked for presence of wildlife before and during tests. Chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect wildlife.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
Special Interest Areas (SIAs)	Ordnance, EM energy, HE laser, and chemical defense activities would have no direct or indirect impacts on biological resources associated with SIAs.	Same as No Action Alt. Biological defense activities would have no direct or indirect impacts on biological resources associated with SIAs.	Same as Alt 1.
Hunting and Fishing	Ordnance activities would have no direct impacts and negligible, long-term, indirect, negative impacts on hunting and fishing. EM energy, HE laser, and chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts. These activities have little or no spatial overlap with hunting and fishing areas.	Same as No Action Alt. Biological defense activities would have little or no spatial overlap with hunting and fishing areas.	Same as Alt 1.
Protected Species			
Fish	NMFS has provided concurrence in accordance with Section 7 of the Endangered Species Act (ESA) that existing RDT&E activities may affect, but are not likely to adversely affect the endangered shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, ordnance activities and PRTR use would have negligible, long-term, direct and indirect, negative impacts on the shortnose sturgeon and Atlantic sturgeon. EM energy, HE laser, and chemical defense activities would have no direct or indirect impacts.	Same as No Action Alt. Biological defense activities would have no direct or indirect impacts.	Same as Alt 1.
Sea Turtles	Ordnance use is more than 6.5 nautical miles above the lowest reach of the Potomac River where sea turtles (ESA-listed loggerhead, Kemp's ridley and green) are found seasonally. There is minimal spatial overlap between RDT&E activities conducted by NSWCDD on the PRTR and sea turtles using the lower Potomac River. NMFS has provided concurrence in accordance with Section 7 of the ESA that the baseline RDT&E activities impacts are considered to be insignificant or discountable and may affect, but are not likely to adversely affect sea turtles.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not change the conclusions.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
	In accordance with NEPA, ordnance activities would have no direct and negligible, short-term, indirect negative impacts on sea turtles. EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect impacts.		
Birds	Ordnance, EM energy, HE laser, chemical defense activities, and PRTR use would not affect the birds protected by the Bald and Golden Eagle Protection Action (BGEPA), Migratory Bird Treaty Act (MBTA), Lacey Act, or the ESA. In accordance with NEPA, ordnance, EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect impacts on the bald eagle or other protected bird species.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not change the conclusions.	Same as Alt 1.
Marine Mammals	There are no reasonably foreseeable takes of marine mammals associated with ordnance, EM energy, HE laser, chemical defense activities, and PRTR use in accordance with the MMPA. In accordance with NEPA, ordnance, EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect impacts on marine mammals.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not change the conclusions.	Same as Alt 1.
Insects	The ESA-listed threatened northeastern beach tiger beetle is found on sandy beaches in the lowest reach of the Potomac River, but no RDT&E activities, inclusive of ordnance, EM energy, HE laser, and chemical defense activities, would take place near the shoreline of the LDZ. In accordance with Section 7 of the ESA, RDT&E activities would have no effect on listed insect species. In accordance with NEPA, ordnance, EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect impacts on tiger beetles.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not affect the tiger beetle, and in any event, would not be released near the beaches on which they live.	Same as Alt 1.

Resource	No Action Alternative	Alternative 1	Alternative 2
Plants	A USFWS Virginia Field Office online project review of the Proposed Action determined that because suitable habitat exists for the ESA-listed sensitive joint-vetch in tidal wetlands within NSF Dahlgren, the Proposed Action may adversely affect the sensitive joint-vetch. However, based on site- and project-specific information, the No Action Alternative would have no effect on this species. Even if the species occurs in tidal wetlands on the installation, it is unlikely to be present in the parts of the range used for ground-disturbing activities, because there is no suitable habitat in these areas. Further, the No Action Alternative would not cause ground disturbance outside of existing target areas and other areas subject to recent and continuing disturbance. In accordance with NEPA, ordnance, EM energy, HE laser, chemical defense activities, and PRTR use would have no direct or indirect impacts on rare, threatened, or endangered plants.	Same as No Action Alt. Naturally-occurring BSL-1 organisms used in bio defense tests would not change the conclusions.	Same as Alt 1.
Cumulative Impacts			
Cumulative Impacts	The baseline RDT&E activities when combined with other past, present, and reasonably foreseeable future actions would have the potential for negligible or minor, but recoverable, negative impacts to the resources evaluated in this EIS.	Same as No Action Alt. The addition of biological defense activities would not change the conclusion.	Same as No Action Alt. The addition of biological defense activities alone or in combination with chemical defense activities would not change the conclusion.

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3 AFFECTED ENVIRONMENT

This chapter describes the environment of the area that may be affected by the Proposed Action, as required by the Council on Environmental Quality's (CEQ's) regulations implementing NEPA (40 CFR Part 1500). Depending on the resource considered, the potentially affected environment for this EIS includes:

1. NSF Dahlgren.
2. The Potomac River from the UDZ to the river's mouth at the Chesapeake Bay, which marks the limits of the PRTR.
3. The five counties surrounding the PRTR:
   - King George County, Virginia
   - Westmoreland County, Virginia
   - Northumberland County, Virginia
   - St. Mary's County, Maryland
   - Charles County, Maryland
4. The larger region, including the:
   - The Tri-County Council for Southern Maryland, which is the regional planning agency for Charles, St. Mary's, and Calvert counties.
   - Virginia's Northern Neck Planning District, which includes Westmoreland, Northumberland, Richmond, and Lancaster counties.
   - Virginia's RADCO Planning District, which includes Caroline, King George, Stafford, and Spotsylvania counties and the City of Fredericksburg.

For any given resource, the extent of the potentially affected area may be NSF Dahlgren, the PRTR, the surrounding counties, the larger region, or some combination thereof. For some resources (such as terrestrial wildlife), the affected environment mostly consists of NSF Dahlgren; for others (such as fish), it is the PRTR; for still others (such as socioeconomics and air quality), it is broader and encompasses the installation, the PRTR, the surrounding counties, and the larger region.

The impacts of implementing the alternatives are addressed in Chapter 4.

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3.1 Land Use, Plans, and Coastal Zone Management

3.1.1 NSF Dahlgren

This section characterizes existing land use at NSF Dahlgren, current land use plans and goals, and major projects presently under development.

3.1.1.1 Existing Land Use

NSF Dahlgren occupies approximately 4,320 acres (ac) in King George County, Virginia. The facility is home to several tenant agencies, the largest of which is NSWCDD. Other tenants include the Joint Warfare Analysis Center; the Aegis Training and Readiness Center; the Center for Surface Combat Systems; the AEGIS Ballistic Missile Defense Field Activity; the Navy Air and Missile Defense Command; and 20th Space Control Squadron Detachment One.

NSF Dahlgren consists of two discrete areas separated by Upper Machodoc Creek: the 2,680-ac Mainside to the north of the creek and the 1,640-ac EEA on Pumpkin Neck, to the south. Physical connection between the two areas is through off-base public roads and a barge across the creek.

The EEA complex, which contains the Harris and Churchill Ranges, is one of two range complexes at NSF Dahlgren. Development there is very limited and consists mostly of small support buildings, test facilities, and magazines. The other range complex is the PRTR Complex, which extends mostly over water but also has a land component along the eastern edge of Mainside that comprises five ranges. From north to south, these are the Missile Test Range, Terminal Range, Main Range, Anti-Aircraft (AA) Fuze Range, and Machine Gun Range. A detailed description of both range complexes and their components is provided in Chapter 1 of this EIS.

Almost all existing development at NSF Dahlgren is found on Mainside. Existing land use on Mainside is shown in Figure 3.1-1 (Land Use – Mainside). The land use designations depicted come from Naval District Washington's Regionally Integrated Master Program and are based on the prevailing land use. The land uses include:

- *Ordnance/RDT&E*, which is the primary land use on NSF Dahlgren. Operations within this land use may include the use of explosive ordnance, and explosive ordnance is stored there. All of the PRTR land ranges and some of the Mission Area are encompassed within the *Ordnance/RDT&E* land use. Existing development within these ranges is mostly industrial in character.
- *RDT&E* land use encompasses laboratory-based RDT&E; no explosives are used in this area. Part of the Mission Area is within this area. The type of development is mostly that typical of suburban office parks, with large administrative and research facilities surrounded by parking lots and landscape features.
- *Open Space* encompasses the northwestern part of the installation, where natural special interest areas (SIAs), such as Gambo Creek, are located (see Section 3.13).

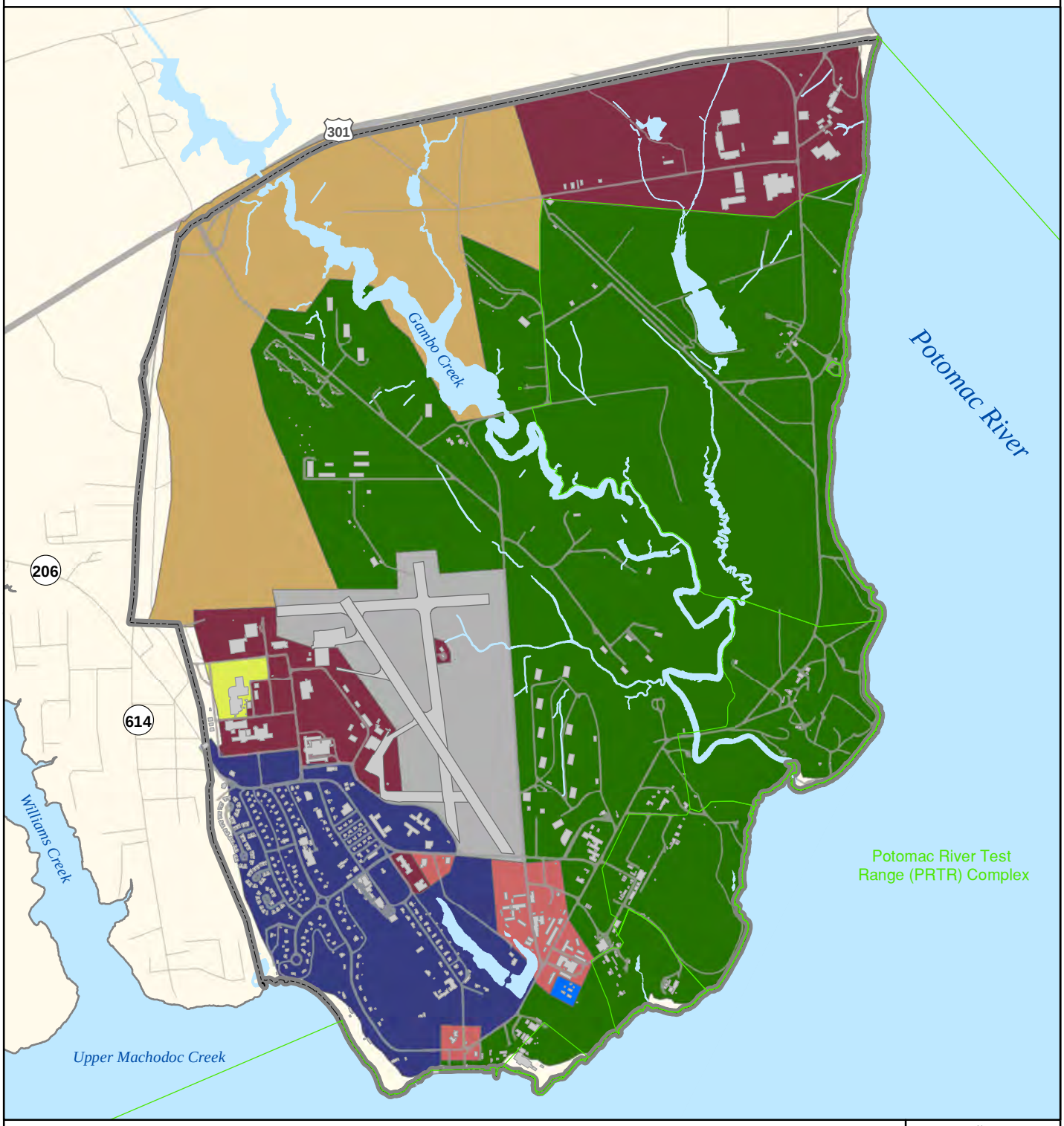
- *Airfield Operations* land use includes existing runways and taxiways, hard stand areas, and the designated Clear Zone to the northwest. This land use is part of the Mission Area. Of the airfield's three existing runways, one (16/34) is restricted to daytime visual-flight-rules helicopter use only; the other two are inactive. Landing strips have been built near the Potomac River's shore on the EEA's Churchill Range and on Mainside's Terminal Range (see Figure 1-11) to accommodate unmanned aerial vehicle (UAV) operations because the existing runways are outside the installation's special use airspace (SUA, see Section 3.1.3), and military UAVs can only operate within controlled SUA.
- *Sailor and Family Support* land use includes facilities that support military personnel and their dependents: family housing and unaccompanied housing, as well as an elementary school, health clinic, fitness center, and Morale, Welfare, and Recreation facilities.
- *Base Support* land use includes administrative facilities.
- *Training Support* land use includes facilities used to train Navy personnel.
- *Utilities* land use includes installation utility support facilities.

3.1.1.2 Planning Documents: 2001 Area Development Plans

Naval Surface Warfare Center Dahlgren Site Area Development Plans: Warfare Systems Complex, Weapons Development Complex, and Advanced Concepts Complex (NSWCDD, 2001) was prepared in 2001 for NSWCDD. This document provides a comprehensive vision for facilities that would support current and future mission requirements and allow NSF Dahlgren to make optimal use of its existing assets and development opportunities. The plan is not a comprehensive installation master plan but rather focuses on the three complexes listed in the title, for which it offers broad development concepts based on an analysis of present and future requirements, constraints, and opportunities. These concepts realize the plan's overall goals and objectives, which are to:

1. Improve quality of work-life and quality of service to attract and maintain highly-qualified personnel by creating a campus-like environment with amenities through:
    - Developing open-space areas that provide recreational opportunities while providing aesthetic value to the installation.
    - Enhancing views of prominent facilities and installation functions.
    - Screening undesirable views.
    - Enhancing pedestrian access and circulation within and between complexes.
    - Enhancing the visual quality of the installation by developing streetscape standards.
2. Project a strong, positive image and create a sense of orderly and rational facility development through:
    - Consolidating interrelated activities and functions to reduce the number of facilities and achieve greater efficiency and convenience.
    - Optimizing the physical siting of new core facilities.
    - Evaluating long-range requirements and determining adequate area for development.

Land Use - Mainside



Airfield Operations
Base Support
Open Space
Ordnance/RDT&E
RDT&E
Sailor & Family Support
Training Support
Utilities
Potomac River Test Range Complex
Naval Support Facility Dahlgren

2,000 0 2,000 Feet
600 0 600 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 3.1-1

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3. Reduce the impact of operational constraints through:
   - Avoiding, where possible, intrusion into existing operations.
   - Evaluating/analyzing existing operational constraints, identifying opportunities to reduce, eliminate, consolidate, or relocate functions that create constraints.
   - Identifying areas that are free of operational constraints.
   - Reducing ordnance magazine/operation/testing exclusion zones when possible.
4. Reduce impact of natural and man-made constraints through:
   - Identifying constraints and evaluating the impact of future development scenarios.
   - Identifying areas of development that are free of constraints.

3.1.1.3 Planning Documents: 2005 NDW Regional Shore Infrastructure Plan

Naval District Washington (NDW) is the regional provider of common operating support to naval installations within a 100-mile (mi) radius of the Pentagon. Services provided include public affairs; public works; public safety; community support; human resources; information technology; supply; air and port operations; ceremonial support; environmental and safety; and morale, welfare, and recreation. NDW encompasses more than 4,000 square miles (sq mi), including the District of Columbia; the Maryland counties of Anne Arundel, Calvert, Charles, Frederick, Montgomery, Prince George's, and St. Mary's; and the Virginia counties of Loudoun, Fauquier, Fairfax, Prince William, Stafford, King George, Westmoreland, and Arlington, as well as the incorporated cities within their boundaries (NDW, 2011). NSF Dahlgren is one of 17 Navy installations in the District that are covered by the *NDW Regional Shore Infrastructure Plan* (RSIP), completed in 2005 (NDW, 2005)

The RSIP was prepared in accordance with a directive from the Chief of Naval Operations (CNO) to establish a comprehensive approach to managing the Navy's resources, facilities, and infrastructure. The policy objectives of the RSIP are to: reduce footprints and costs; increase existing capabilities and sustainability; and maximize mission efficiencies.

Among the various recommendations included in the RSIP, two are particularly relevant to NSF Dahlgren and this EIS:

- Recognize NDW as an RTD&E center: "The high concentration of RDT&E missions and facilities in the region is a unique occurrence in the Navy and provides an opportunity for NDW to stand out among other regions." RDT&E is "a priority for the Navy because of the continuing requirement to test and evaluate many weapons and platforms that are procured."
- Maximize existing facilities for highest and best use: under this recommendation, the Dahlgren Airfield is called out as an under-utilized facility with potential for better use: "The UAV testing program is rapidly expanding and will reach limits within Naval Air Station Patuxent River and Webster Field air spaces. The Air Operations Program Director must evaluate the necessary resources and facilities to support UAV testing or another air operations mission at Dahlgren."

3.1.2 Dahlgren Area and Potomac River Shoreline

This section broadly describes existing land use around NSF Dahlgren and along the shoreline of the stretch of the Potomac River overlain by the PRTR. Three Virginia counties – King George, Westmoreland, and Northumberland – one incorporated town – Colonial Beach, Virginia – and two Maryland counties – Charles and St. Mary's – have land within this area. The current comprehensive plans and, where applicable, other planning documents designed to guide land use decisions in each of the five counties and in Colonial Beach are briefly characterized. Existing water-access points and county planning pertaining to water access are addressed in a separate subsection, as are the known large-scale projects currently being planned or implemented within the area under consideration and the several military installations present in or adjacent to the area.

3.1.2.1 Existing Land Use

All five counties within the area under consideration are predominantly rural in character, with agricultural and forested land comprising approximately 72 percent of the land in Charles County in 2009 (Charles County, 2012) and 77 percent of the land in St. Mary's County in 2002 (St. Mary's County, 2010). In King George County in 2007, about 31 percent of the land was in agricultural use and, in 2010, about 63 percent of the land was forested (King George County, 2012). In 2004, approximately 59 percent of the land area of Westmoreland County was forested; in 2007, about 42 percent of the county's land was agricultural (Westmoreland County, 2010). Finally, in Northumberland County in 2005, about 83 percent of the land was either in agricultural use or forested (Northumberland County, 2006).

In all five counties, however, the trend over the last decades has been toward a loss of farm and forest land to development – particularly residential, single-family home development – to accommodate a growing population. For instance, between 1997 and 2009, the amount of developed land in Charles County increased by almost 57 percent, from 46,878 ac to 73,419 ac; the amount of residential development increased by more than 67 percent, from 37,280 ac to 62,328 ac (Charles County, 2012). In St. Mary's County, the amount of developed land increased by 30 percent between 1997 and 2002 (St. Mary's County, 2010). As a further illustration of this trend, Table 3.1-1 shows the increase in the number of housing units for each of the five counties between 2000 and 2010.

Table 3.1-1
Housing Units – 2000 & 2010

County	Housing Units in 2000	Housing Units in 2010	Increase
Charles	43,903	54,963	25%
St. Mary's	34,081	41,282	21%
King George	6,820	9,477	39%
Westmoreland	9,286	10,618	14%
Northumberland	8,057	8,995	12%

Source: US Census Bureau, 2011a, Census 2000, QT-H4 Physical Housing Characteristics 2000; 2011b, Census 2010, QT-H1 General Housing Characteristics 2010.

In all five counties, development, especially residential development, is low-density and widely spread out. However, each county features clusters of relatively denser residential and commercial uses, generally located along the main highways or around employment centers.

These denser areas are more suburban in character and contrast with areas characterized by more diffuse, more obviously rural patterns of development. Both types are found along the shores of the Potomac River and adjacent bays and estuaries, which are particularly popular with retirees and second-home owners. There, forested land, fields, and parkland alternate with loosely-woven communities and denser villages or subdivisions. Colonial Beach is the only substantial town within the area. Throughout, shoreline development is primarily residential, with commercial uses mostly being water-dependent businesses, such as charter boat operations, marinas, or seafood eateries. However, there are a few exceptions, as noted below.

The following paragraphs provide a summary description of existing shoreline land uses within each county, down from Charles along the Maryland side and up from Northumberland along the Virginia side. Places and features mentioned in the text are shown on Figures 3.1-2a (Study Area Points of Interest – Upper and Middle Danger Zones) or 3.1-2b (Study Area Points of Interest – Lower Danger Zone).

Charles County

In Charles County, which is the most populated county of the five under consideration, areas of denser development are found mostly to the north and northwest, away from the waterfront. The major population centers are La Plata, Waldorf, and St. Charles. The presence of NSF Indian Head and the relative proximity to Washington, DC largely account for this distribution pattern. By contrast, the south and southeast of Charles County, including the shorelines of the Potomac River and its tributaries, are predominantly rural and undeveloped, particularly between Indian Head and the US Route 301 bridge (the Governor Harry W. Nice Memorial Bridge, henceforth the Harry Nice Bridge), where land use maps and aerial photography show widely spread-out areas of low-density waterside residential development. Many of the houses fronting the water have piers for recreational boating or fishing, a feature found throughout the study area.

Several recreational/natural and cultural resource areas are located along the western shore of the Nanjemoy peninsula, fronting the Potomac River: the Mallows Bay Natural Resources Management Area, the US Bureau of Land Management's Douglas Point property, the Douglas Point State Natural Resources Management Area, and Purse State Park comprise together about 1,900 ac of contiguous protected public land offering hunting, bird-watching, fishing, and fossil-hunting opportunities (Maryland Department of Natural Resources, 2011). On the eastern side of the peninsula, near the head of the estuary formed by Nanjemoy Creek, Friendship Farm Park occupies about 380 ac; the park features ball fields, a boat ramp, and allows for pier and shoreline fishing. Fronting the Port Tobacco River due north of NSF Dahlgren, lies Chapel Point State Park (approximately 820 ac in area) (Charles County, 2012).

Finally, two military installations front the Potomac River: NSF Indian Head, where Naval Surface Warfare Center Indian Head is based (about 20 mi to the northwest of NSF Dahlgren), and the Army's Blossom Point Field Test facility, which is approximately 7 mi north of NSF Dahlgren, at the tip of the small peninsula formed by Nanjemoy Creek and the Port Tobacco River (see Section 3.1.2.4 for brief descriptions of these facilities).

Farther south, the Charles County side of the Harry Nice Bridge is dominated by the smokestacks of the Morgantown generating station – the only heavy industrial land use within the area under consideration – and clusters of residential and commercial development to the north (Newburg) and south (Morgantown). The shoreline south of the bridge down to the county

line is again characterized by very low-density, spread-out residential uses with a few areas of greater concentration, including Morgantown, Issue, the Swan Point Yacht and Country Club, and Cobb Island, separated by fields and forest. Here too, most riverside houses feature piers for recreational boating or fishing. Southern Park, featuring a playground, picnic area, ball fields, tennis courts, and a fishing pier, is located on about 40 ac between Issue and Cobb Island (Charles County, 2012).

St. Mary's County

Existing land use along the southern shoreline of St. Mary's County shows a similar pattern of very-low-density residential development interspersed with fields and forest, with a few denser waterside communities, such as Mill Point, Longview Beach, River Springs, Coltons Point, and Piney Point/St. George Island. Leonardtown, the county seat, lies at the head of Breton Bay, one of several deep bays and estuaries along the southern coastline of the county. A concentration of residential developments is also found on the northern shore of Breton Bay (Society Hill) and on the eastern shore of the adjacent St. Clements Bay (St. Clements Shores).

Two state parks are located along the southern shore of St. Mary's County: St. Clements Island State Park (the site of arrival of the first English settlers in the state), which is accessible by boat only; and Point Lookout State Park (about 1,000 ac), which offers swimming, fishing, boating, and camping opportunities.

NAS Patuxent River Webster Field Annex is located on the eastern shore of the St. Mary's River estuary into the Potomac, to the northwest of Point Lookout Park, about 35 mi to the southeast of NSF Dahlgren. NAS Patuxent River lies approximately 34 mi east of NSF Dahlgren, at the confluence of the Patuxent River and the Chesapeake Bay (see Section 3.1.2.4 for a brief description of these facilities).

Northumberland County

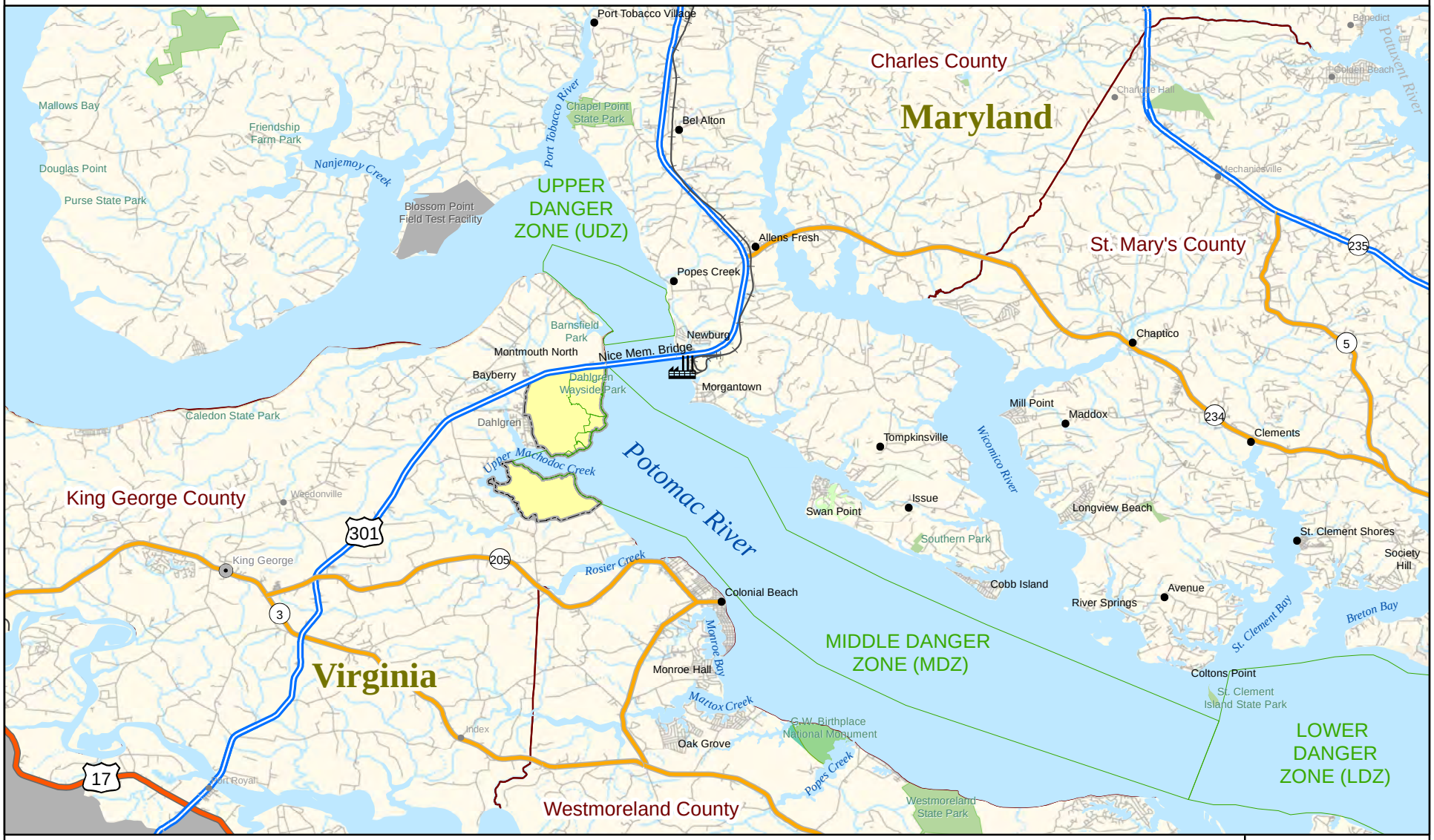
Across the river, in Northumberland County, development is typically concentrated along the main roadways (both residential and commercial development) and the waterfront (primarily residential). As elsewhere in the study area, along the shore low-density housing alternates with fields and forested parcels. Approximately 45 percent of the county shoreline is forested and 34 percent is in residential use, with other development accounting for a little over two percent of the shoreline. Moving westward from Smith Point along the river, the main residential clusters include Ophelia, Lake, and Lewisetta. Two major waterside subdivisions identified in the county's comprehensive plan are White Sand Harbour and Bay Quarter Shores (Northumberland County, 2006).

Westmoreland County and Colonial Beach

A similar pattern of development characterizes the shoreline in Westmoreland County, although waterside residential uses there appear less evenly distributed and more clustered than in Northumberland County, while longer continuous stretches of coast are completely undeveloped.

This is due, largely, to the presence of two large riverside park areas: Westmoreland State Park and the George Washington Birthplace National Monument, located east and west of Popes Creek, respectively. Westmoreland State Park, a 1,311-ac facility extending about 1.5 mi along

Study Area Points of Interest - Upper and Middle Danger Zones



Source: NSWCDD GIS (2008 - 2011)

Figure 3.1-2a

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Study Area Points of Interest - Lower Danger Zone

Source: NSWCDD GIS (2008 - 2011)

Figure 3.1-2b

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the river, offers opportunities for hiking, camping, fishing, boating, and swimming (Virginia Department of Conservation and Recreation, 2012). The 622-ac George Washington Birthplace National Monument, managed by the National Park Service, has approximately 1 mi of waterfront. Areas of waterside residential concentration include the Yeocomico estuary (Kinsale), Coles Point and Glebe Harbor on Lower Machodoc Creek, the Currioman Bay area, and the area around Mattox Creek and Monroe Bay, surrounding Colonial Beach (Monroe Hall, Oak Grove).

Colonial Beach is one of two incorporated towns in Westmoreland County and the only substantial town in the study area along the river. Founded as a waterside resort in the 19th century, Colonial Beach experienced a marked decline in the 1960s and 1970s. In more recent decades, it has regained popularity as a waterfront community and beach resort; its year-round population of about 3,250 swells to 10,000 in the summer (Colonial Beach, 2007). Colonial Beach extends along a four-mile stretch of the Potomac River, on a small peninsula separating the river from Monroe Bay. For this reason, potential future growth is mostly confined to the northwest. In 2008, approximately 70 percent of the town was developed and 30 percent was vacant. The predominant land use is single-family residential on small lots (0.25 ac or less), although more recent residences tend to be built on larger lots. The proportion of year-round residences relative to vacation homes has been rising. Commercial uses occur mainly in three locations: the downtown/beachfront area, Colonial Avenue, and Route 205. Community uses (e.g., schools, churches) are mostly found within the Central Area (just south of Colonial Avenue) (Colonial Beach, 2010).

King George County

Rosier Creek, north of Colonial Beach, separates Westmoreland County from King George County. Between the creek and the Harry Nice Bridge, most of the shoreline is occupied by NSF Dahlgren, with a few residential lots between the southern boundary of the installation and the county line. A designated Primary Settlement Area, the area immediately around NSF Dahlgren is the most intensely developed part of King George County, with 12 percent of the county's population and approximately 1,100 housing units. It includes the Dahlgren community, wedged between Williams Creek and NSF Dahlgren, which consists of a commercial core along Route 206 (Dahlgren Road) and Route 614 (Potomac Drive) surrounded by residential uses. Outside of the Dahlgren community, the area contains two large residential subdivisions – Bayberry and Monmouth North. It also has the largest office park in the county (the Dahlgren Technology Center) and the largest concentration of commercial development (including a strip shopping center, several fast food and other restaurants, and the majority of the county's gas stations) (King George County, 2012).

The county's shoreline north of NSF Dahlgren is characterized by widely spread-out residential lots, most with piers into the river, as is the case throughout the study area for waterfront properties. Barnesfield Park, a 154-ac facility, lies just north of the Harry Nice Bridge landing (King George County, 2012). It is King George County's primary active recreational resource (King George County Planning Commission, 2006) and features nature trails, picnic areas, a playground, and beach fishing. The adjacent 10-ac Dahlgren Wayside Park, at the foot of the bridge, is the location of the Potomac Gateway Welcome Center, which provides touring information to visitors who have just entered Virginia via the bridge. Farther along the shore, near the bottom of the bend the Potomac makes at this location, is Caledon State Park, which

extends over 2,579 ac and is a designated National Natural Landmark. Among other recreational options, it offers visitors the opportunity to view bald eagles, which are very numerous in this area. Preservation of eagle habitat is an important focus of the park as a natural resources area.

3.1.2.2 County and Town Plans

All five counties in the study area and the Town of Colonial Beach have current comprehensive plans. A comprehensive plan is a document that provides a framework for land use management policies and decisions based on a set of goals that express the planning jurisdiction's growth-management philosophy and vision for the future.

In Maryland, county comprehensive plans are prepared pursuant to the legislation and requirements contained in Article 66-B of the Annotated Code of Maryland, as amended by the Economic Growth, Resource Protection and Planning Act, which establishes seven land use visions for Maryland's future, complemented by an eighth vision added in 2000. Under the act, the land use visions must be implemented when a local comprehensive plan is prepared. The eight visions are as follows:

1. Development is concentrated in suitable areas.
2. Sensitive areas are protected.
3. In rural areas, growth is directed to existing population centers and resource areas are protected.
4. Stewardship of the Chesapeake Bay and the land is a universal ethic.
5. Conservation of resources, including a reduction in resource consumption, is practiced.
6. To assure the achievement of the above, economic growth is encouraged and regulatory mechanisms are streamlined.
7. Adequate public facilities and infrastructure under control of the county or municipal corporation are available or planned in areas where growth is to occur.
8. Funding mechanisms are addressed to achieve these visions.

Additionally, Maryland counties are required to prepare and submit to the state land preservation, parks, and recreation plans (LPPRPs) that are to be updated every six years as of 2005. LPPRPs support Maryland's planning visions and qualify local governments for State Program Open Space funds and other programs related to the plan's objectives for three land resource elements: recreation and parks, agricultural land preservation, and natural resource conservation. Upon final adoption by the county board, the LPPRP becomes an amendment to the county's comprehensive plan.

In Virginia, county and city comprehensive plans are prepared pursuant to § 15.2-2223 through § 15.2-2232 of the Code of Virginia. As stated in the Code of Virginia,

> In the preparation of a comprehensive plan the commission shall make careful and comprehensive surveys and studies of the existing conditions and trends of growth, and of the probable future requirements of its territory and inhabitants. The comprehensive plan shall be made with the purpose of guiding and accomplishing a coordinated, adjusted and harmonious development of the territory which will, in accordance with present and probable future needs and

resources, best promote the health, safety, morals, order, convenience, prosperity and general welfare of the inhabitants.

Both Maryland and Virginia have regional planning agencies whose role is to coordinate local planning efforts to promote effective social and economic growth in their respective areas of jurisdiction. In Maryland, the Tri-County Council for Southern Maryland is the regional planning agency for Charles, St. Mary's, and Calvert counties as well as for the incorporated towns of Chesapeake Beach and North Beach (Calvert County); Indian Head, La Plata, and Village of Port Tobacco (Charles County); and Leonardtown (St. Mary's County). In Virginia, the Northern Neck Planning District Commission coordinates regional planning for Lancaster, Richmond, Northumberland, and Westmoreland counties. King George County is within the purview of the George Washington Regional Commission, along with the counties of Caroline, Spotsylvania, and Stafford, and the City of Fredericksburg. However, the primary focus of these regional planning agencies is on coordinating regional economic development and transportation. Specific land use planning and decision-making rest with local jurisdictions.

Current planning documents applying within the study area are the following:

- Charles County's *Comprehensive Plan* (2006a)
- Charles County's *Land Preservation, Parks, and Recreation Plan* (2006b)
- St. Mary's County's *Comprehensive Plan: Quality of Life in St. Mary's County – A Strategy for the 21st Century* (2010)
- St. Mary's County's *Land Preservation, Parks, and Recreation Plan* (2005)
- Northumberland County's *Comprehensive Plan* (2006)
- Westmoreland County's *Comprehensive Plan: Vision 2030* (2010)
- The Town of Colonial Beach's *Comprehensive Plan, 2009-2029* (2010)
- King George County's *Comprehensive Plan* (2006)

Though each plan is different in its details and emphases, they all share a few common characteristics, as can be expected, given the many common features of the areas under consideration:

- All five counties and Colonial Beach have experienced substantial growth in the past decades and all expect substantial growth to continue over the next two decades.
- All five counties strive to accommodate the expected growth while preserving their rural character and quality of life. Similarly, Colonial Beach aims to accommodate growth while preserving its character as a small town and an attractive waterfront resort.
- All five counties aim to focus a majority of the expected future development in specific areas already developed and served by county services (growth areas) and to discourage sprawl and the unstructured development of rural areas in favor of rural villages. (The area around NSF Dahlgren is a designated growth area for King George County.)
- All six jurisdictions consider the Potomac River and its shoreline a major natural and recreational asset essential to the quality of life of their residents. All emphasize the importance of providing, enhancing, and maintaining public access to the river for

recreational and economic purposes while preserving the natural shoreline environment and water quality.

More detailed summaries of the goals and objectives of each plan, as they pertain to land use and the scope of this EIS, are provided in Appendix B.

3.1.2.3 Public Water Access

The Potomac River and the several tributaries that empty into it through the many bays and estuaries that characterize the study area offer opportunities for a wide range of water-based activities. As noted above, every jurisdiction recognizes the role of the river in enhancing quality of life in, and drawing new residents to, the area; therefore, all jurisdictions strive to promote better access to the water for recreational and economic purposes.

There are numerous boat ramps, car-top boat launches, marinas, mooring and fishing piers, and swimming or fishing beaches throughout the study area. The following paragraphs focus on existing and planned public boat ramps or launches and public beaches as described in the aforementioned LPPRPs (for Maryland) and comprehensive plans (for Virginia). Locations within the study area that are mentioned in the text are shown in Figure 3.1-3 (Public Access to Water).

According to its draft LPPRP (Charles County, 2012), Charles County has a total of 19 boat ramps that are available to the public, 6 of which are at Smallwood State Park, just south of Indian Head. Other public boat ramp locations within the study area for this EIS include Mattingly Park, Mallows Bay Park, Friendship Farm Park, and Hatton Creek. The public beaches in the county are maintained by the state at Smallwood State Park, adjacent to NSF Indian Head, Douglas Point State Natural Resource Management Area and Purse State Park, north of Maryland Point, and Chapel Point State Park, along the Port Tobacco River. Based on an analysis of existing and future demand, the county's draft LPPRP estimates that Charles County had a deficit of three boat ramps in 2010 and would have a deficit of nine ramps by 2022. Actions to remedy this deficit outlined in the draft plan include the construction of new boat ramps at Friendship Farm Park and Chapel Point State Park (Charles County, 2012). Noting similar deficits, the LPPRP adopted in 2006 likewise prescribed the construction of new boat ramps, although at Friendship Farm Park and Mallows Bay (Charles County, 2006b).

St. Mary's County's LPPRP identifies 22 state- and county-owned water-access points, 13 with boat ramps. Compared to estimated demand, this represents a deficit of four for 2005 and five by 2020. Water-access points within the study area include the Wicomico Shores Landing, Chaptico Wharf, Bushwood Wharf, Paul Ellis Landing, River Springs Landing, Leonardtown Landing, Camp Calvert, Abell's Wharf, Tall Timbers Landing, Piney Point Landing, Piney Point Lighthouse, St. George Island Landing, St. Inigoes Landing, Fox Harbor Landing, and Point Lookout State Park. Among the plan's stated priorities is the acquisition of 20 to 50 ac in the central part of the county's southern shoreline for construction of a Potomac waterfront park sometime between 2015 and 2020. There are also four public beaches in St. Mary's County, only one of which is within the study area for this EIS: Point Lookout State Park Beach (St. Mary's County, 2005).

Public Access to Water

Source: NSWCDD GIS (2008 - 2011)

Figure 3.1-3

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According to Northumberland County's comprehensive plan, public water access in the county is limited, though numerous private facilities are available. There are 14 public powerboat ramps, but few places for launching canoes or bank fishing. Ramps on the Potomac side of the county are found at the head of the Coan River estuary (Rowes Landing, Forest Landing) and the Yeocomico River (Lodge Landing). VirMar Beach is one of only two public beaches in the county (the other one, Hughlett Point, is outside the study area). Improving water access is one of the county's major goals, as stated in the comprehensive plan. Implementation of this goal will involve developing additional public boat ramps and fishing piers, identifying new public beach areas and improving existing ones, establishing waterfront parks, and creating a network of canoe/kayak landings allowing for one-way traveling on county waters. Specific projects delineated in the plan include improvements at Rowes Landing (such as the addition of a floating canoe/kayak launch platform) and reactivation of an abandoned public water-access site at Hampton Hall Creek near the border with Westmoreland County as a canoe/kayak launch site (Northumberland County, 2006).

Westmoreland County's comprehensive plan lists a total of 32 public and private waterfront access areas, including public boat ramps at Bonum Creek, Branson Cove, Currioman Bay, Monroe Creek, and Westmoreland State Park. The county also has three public beaches in Colonial Beach and one at Westmoreland State Park. The plan notes that additional public access locations could be considered, including the provision of water access at Virginia Department of Transportation bridge repair or replacement project sites (Westmoreland County, 2010).

Even more than for the other jurisdictions considered here, the waterfront, which stretches along two miles of river, is an essential element of Colonial Beach's identity and appeal. As noted in the 2010 comprehensive plan, residents and local leaders value the town's beach front as of prime importance to the economic vitality of the area. To make optimum use of this asset, the plan recommends that the town work with the US Army Corps of Engineers and the State Beach Board on replenishment projects and structural erosion control. The town is also pursuing the redevelopment of the entire boardwalk area. Another significant feature is the 200-ft municipal pier in the center of the main beach area, which creates a focal point for water-related activities. The town also has a public boat ramp near Castlewood Park in the Point area (south end of the peninsula), which is recommended for improvement (Colonial Beach, 2010).

Potomac River access in King George County is inherently limited because much of the shoreline is occupied by limited-access facilities, including NSF Dahlgren but also the Caledon Natural Area (due to sensitive bald eagle habitat). Access to the Potomac is available from three private marinas and one public site at Wayside Park. There also is a river-access point on Dahlgren, reserved for use by Navy personnel. Two of the county's goals for community services and facilities, as stated in its current (adopted) and draft comprehensive plans (King George County Planning Commission, 2006; King George County, 2012), are to provide and encourage adequate recreational access to state waters while ensuring continued protection of the natural environment, and to create public-access opportunities that offer varied waterfront experiences and can enhance economic opportunities. The plans recommend that the county seek to control or acquire a select few places for recreational water access, but due to the presence of bald eagle habitat, such access points must remain limited in size and number, with sensitive siting, access, and design, especially along the Potomac River.

3.1.2.4 Nearby Military Installations

In addition to NSF Dahlgren, there are several major military installations within and near the study area for this EIS. These installations are considered here because impacts from their activities may overlap or combine with the impacts of NSWCDD. The following paragraphs provide short descriptions of each installation and briefly characterize the activities at each. Figure 3.1-4 (Nearby Military Installations) shows where each installation is located in relation to NSF Dahlgren.

NSF Indian Head

NSF Indian Head (Indian Head), home to Naval Surface Warfare Center Indian Head, a sister organization to NSWCDD, occupies 3,500 ac on the eastern shore of the Potomac River in Charles County, approximately 20 mi northwest of NSF Dahlgren. The installation consists of two parcels: Cornwallis Neck on the peninsula formed by Mattawoman Creek and the Potomac River, and Stump Neck across the creek's mouth.

The land use on Cornwallis Neck includes an operational area and a restricted area in the southern part of the peninsula, where munitions explosive testing is performed. Stump Neck is the primary location for the Naval Explosive Ordnance Disposal Technology Division and Range 3, where the division performs open air detonations of foreign ordnance.

Marine Corps Base Quantico

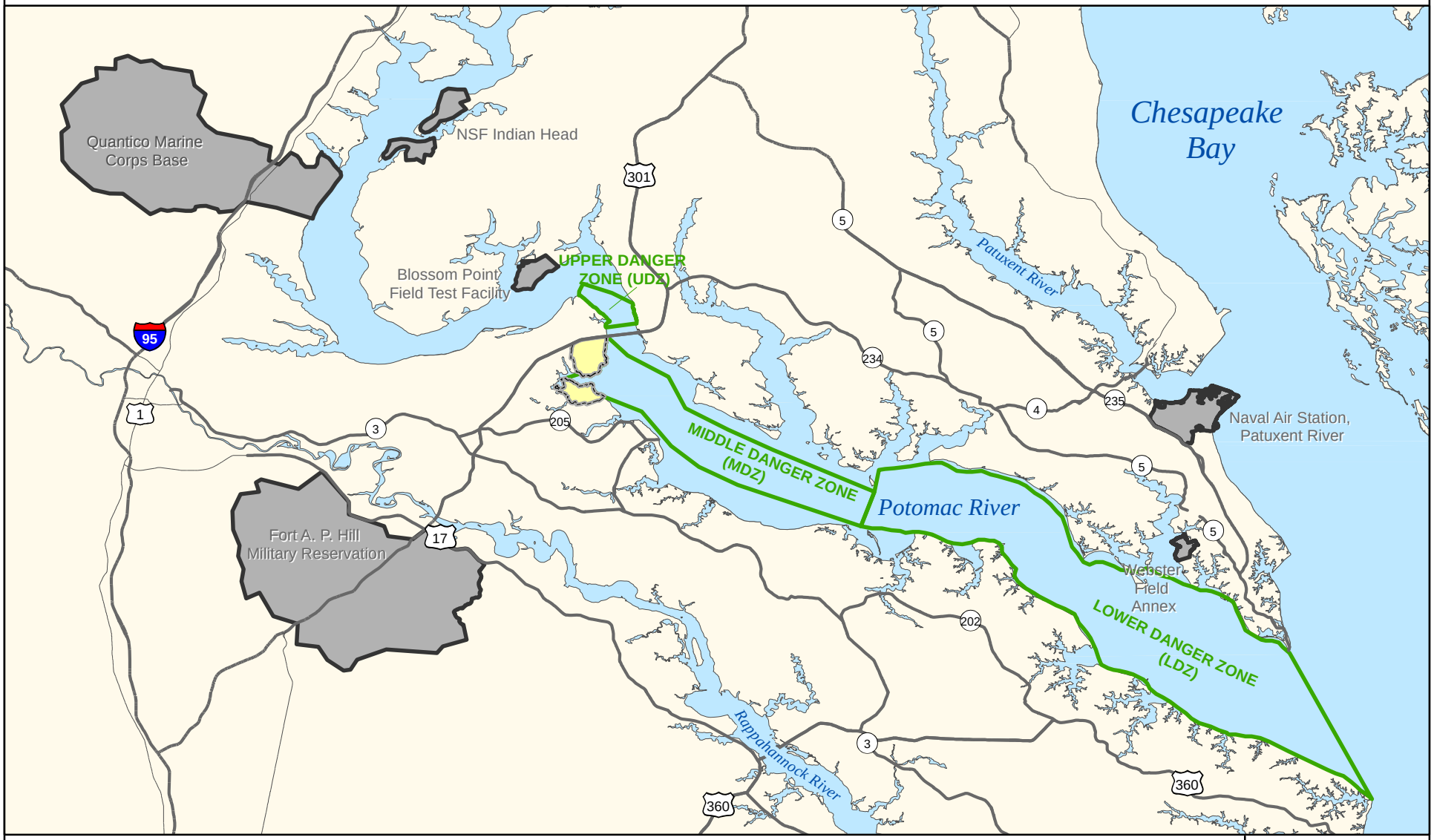
Just south of Indian Head, across the Potomac River, Marine Corps Base Quantico, known as the "Crossroads of the Marine Corps" is a major Marine Corps training base occupying about 59,000 ac in Prince William, Stafford, and Fauquier counties, Virginia, approximately 20 mi northwest of NSF Dahlgren. The base consists of two major areas on either side of Interstate 95: Mainside, east of the interstate, and Westside, west of it. Mainside is home to numerous administrative support functions, some training functions, and Marine Corps Air Facility Quantico. Westside is used primarily for military training. Largely undeveloped, it consists mostly of training areas and ranges used for a wide array of training activities, including small arms and artillery training, demolition training, and air-to-ground training.

Blossom Point Field Test Facility

The US Army's Blossom Point Field Test facility is a 1,600-ac installation located in Charles County about 7 mi northwest of NSF Dahlgren, on the peninsula formed by Nanjemoy Creek and the Potomac River. The site is an active testing range of the US Army Research Laboratory, Adelphi, Maryland. The Army Research Laboratory is the Army's corporate basic and applied research laboratory. The primary land use on the installation is research and development, with significantly smaller land uses comprising administration, storage and supply, and maintenance (US Army Garrison Adelphi Laboratory Center, 2009).

Under a permit from the Army, the Naval Research Laboratory (NRL) manages satellites through its Blossom Point Tracking Facility, which, at this location, enjoys horizon-to-horizon look angles and an interference-free, low-noise environment. Potential interference with the sensitive satellite antenna radio receivers is minimized by a 2,000-foot (ft) - radius buffer zone around the NRL site.

Nearby Military Installations



Naval Support Facility (NSF) Dahlgren
Other Military Installation
Potomac River Test Range (PRTR) Complex

10 0 10 Miles
16 0 16 Kilometers

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NSWCDD EIS
NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 3.1-4

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Fort A.P. Hill

Fort A.P. Hill is a US Army training facility located in Caroline County, Virginia, just north of the town of Bowling Green, approximately 20 mi southwest of NSF Dahlgren. The installation encompasses 75,794 contiguous ac and leases an additional 111 ac for specialized training along the Rappahannock River. The range complex is primarily for small arms, direct-fire weapons, anti-tank missiles, artillery, and aerial gunnery. In addition, ample tactical landing zones, parking areas, and refueling facilities for rotary-wing aircraft are available. The Fort A.P. Hill Airfield is located on the southeast side of US Route 301 and is used by rotary-wing aircraft. In addition, C-130 aircraft originating at other airfields train two or three times a year at the assault airstrip in the installation's drop zone (US Army, 2004).

Naval Air Station Patuxent River and Webster Field Annex

The 6,500-ac Patuxent River Naval Air Station Complex stretches across 25 mi of shoreline on the Patuxent River, near where the river enters the Chesapeake Bay, approximately 34 mi from NSF Dahlgren. The complex supports naval aviation operations by researching, developing, testing, and evaluating aircraft, aircraft components, and related products. Naval Air Warfare Center Patuxent River serves as the Navy's principal research, development, test, evaluation, engineering, and fleet support activity for naval aircraft, engines, avionics, aircraft support systems, and ship/shore/air operations. Webster Field Annex is an 850-ac dependence located on the eastern shore of the St. Mary's River (approximately 35 mi southeast of NSF Dahlgren) used primarily for UAV operations (GlobalSecurity, 2011).

3.1.2.5 Projects under Development

At any given time, in an area as large as the study area for this EIS, a number of private and public development and other projects of varying scale and scope are being planned, designed, or implemented. These projects can affect, or be affected by, the alternatives evaluated in this EIS. Therefore, this section briefly describes the most significant of these projects, based on publicly-available information.

Governor Harry W. Nice Bridge Replacement Project

The two-lane Harry Nice Bridge, which carries US Route 301 across the Potomac River and lands just north of NSF Dahlgren, is the only bridge across the Potomac south of the Woodrow Wilson Bridge, which carries the Washington, DC Beltway across the river. The Maryland Transportation Authority (MdTA) initiated planning for the Nice Memorial Bridge Improvement Project in 2006 to address the transportation conditions and capacity limitations at the bridge (MdTA, 2008). The purpose of the project includes providing sufficient capacity for future growth, improving traffic safety, and maintaining the traffic flow during adverse conditions.

In 2009, the MdTA released an Environmental Assessment (EA) (MdTA, 2009) that evaluated a total of seven alternatives: Alternate 1 is the no-build alternative and would include extensive rehabilitation of the existing bridge; Alternates 2 and 4 would rehabilitate the existing two-lane bridge and build a new two-lane span adjacent to it; Alternates 3 and 5 would replace the existing two-lane bridge and build a new two-lane span adjacent to it; and Alternates 6 and 7 would build a new four-lane bridge and take the existing structure out of service. The build

alternatives – Alternates 2 through 7 – provide reasonable tie-in points with the existing and planned highway network, capacity for 2030 traffic demand, the ability to maintain two-way traffic flow, improved safety on approach roadways and bridge, and the ability to comply with navigational channel guidelines. The build alternatives would require an alignment shift of the US Route 301 approach roadways to connect to the new bridge, and each includes a barrier-separated bicycle-pedestrian path (MdTA, 2009).

The EA did not identify a preferred alternative. However, in May 2010, the MdTA issued for review a draft Preferred Alternate/Conceptual Mitigation document (MdTA, 2010) that recommends Modified Alternate 7 – i.e., Alternate 7 with a modified bicycle/pedestrian option – as the preferred alternative. Modified Alternate 7 comprises the installation of a new four-lane bridge to the north of the existing bridge, with a single, barrier-separated, two-way bicycle/pedestrian path on the south side of the new bridge. The existing bridge would be removed under Modified Alternate 7.

The MdTA study team coordinated with regulatory agencies to develop the final environmental document, which was approved by the Federal Highway Administration on November 27, 2012. The Nice Memorial Bridge Improvement Project final environmental document comprises two components: a Finding of No Significant Impact (MdTA, 2012) and a Final Section 4(f) Evaluation (Federal Highway Administration and MdTA, 2012).

Dahlgren Wayside Park, at the foot of the existing Harry Nice Bridge, includes a sand beach along the Potomac River, boat access for small watercraft, and picnic tables, and provides the public opportunities for recreational activities including fishing and canoeing/kayaking. The Final Section 4(f) Evaluation (Federal Highway Administration and MdTA, 2012) found that Modified Alternate 7 would require approximately 2.2 acres of land from the park, including a portion of the park entrance road, a parking area, a portion of the picnic area, and a portion of the beach area. However, mitigation measures were incorporated into Modified Alternate 7 for Section 4(f) uses that cannot be avoided or further minimized and were documented in a memorandum of agreement, executed in September 2011. (Section 4(f) use is the use of land from any publicly-owned public park, recreation area, wildlife or waterfowl refuge, or any significant historic site as part of a federally funded or approved transportation project.) The memorandum of agreement specifies that the Dahlgren Wayside Park entrance and parking lot will be relocated, and that hardscape features such as picnic tables, barbeque grills, and a replacement boat landing will be installed.

Morgantown Generating Station Coal Barge Facility, Flue Gas Desulfurization System, Coal Blending and Gypsum Loadout Facilities, and Fly Ash Beneficiation Facility Projects

The Morgantown power generating station is located just south of the Harry Nice Bridge landing in Charles County, across from NSF Dahlgren. The owner of the plant, Mirant Corporation, has a number of projects that have recently been completed or that are under development. One of the recently completed projects is the new offloading facility that allows the power plant to import coal from overseas suppliers on large open barges that travel up the Potomac River and unload at this facility (Allen, pers. comm., February 19, 2009). Previously, the only option to transport coal to the plant was by train. In March 2007, Mirant began construction of the facility (Rucker, 2007). The new facility extends approximately 836 ft into the Potomac (Maryland Power Plant Research Program, 2007).

Another recent project at the Morgantown generating station was the installation of a flue gas desulfurization system and other associated facilities. The Mirant Corporation declared the desulfurization system operational on December 20, 2009 (Allen, pers. comm., June 3, 2010). The primary purpose of installing a flue gas desulfurization (FGD) system was to reduce sulfur dioxide (SO_2) emissions from the existing coal-fired steam-generating units in keeping with Maryland's Healthy Air Act (Mirant Mid-Atlantic, LLC, 2006).

Coal blending and gypsum loadout facilities were also recently completed at the Morgantown generating station. The coal blending facilities use different types of coals to match the specifications of the boilers and air quality control equipment of the station's coal-fired steam-generating units. The facilities enable optimizing fuel flexibility while meeting Mirant Corporation's system-wide SO_2 emission reduction compliance plan, designed to meet the requirements of state-mandated emission reductions. The gypsum loadout facility supports the beneficial use and efficient transportation of synthetic gypsum, a byproduct formed during the desulfurization process.

The Mirant Corporation is also proposing to modify its Morgantown generating station to install a coal fly ash beneficiation facility and associated truck loading and offloading equipment (Mirant Mid-Atlantic, LLC, 2010). The beneficiation facility would use staged turbulent air reactor thermal process technology to convert high-carbon fly ash that is otherwise unsuitable for commercial use into low-carbon mineral admixture material suitable for use as a Portland cement substitute, which avoids landfilling this fly ash. The proposed beneficiation facility and associated equipment would be constructed on previously-disturbed areas within the existing generating station property (Mirant Mid-Atlantic, LLC, 2010).

Villages at Swan Point Project

This project of US Steel Corporation and Brookfield Homes LLC, approximately 7 miles southeast of NSF Dahlgren along the river in Charles County, is the second phase of a development project initiated in the 1980s. The first phase built the existing Swan Point Yacht and Country Club community, which consists of 322 homes, a golf course, and a marina. The second phase would add 1,500 homes to the site, along with a hotel on the Weir Peninsula, a private beach, retail shops and restaurants along the Potomac shoreline, and a 150-slip marina on the Potomac River at Weir Creek (Degregorio, 2006; McConaty, 2007).

In 2006, Charles County approved a master plan and general development plan for the Villages at Swan Point (Dailey, pers. comm., June 3, 2010). Initiation of construction of all components of the development has been delayed because of the state of the economy and the housing market. Brookfield Homes anticipates that construction will begin in 2012 (Lannin, pers. comm., July 27, 2010).

Residential Development Projects in Colonial Beach

Over the last few years, the town of Colonial Beach has experienced substantial growth and several major residential development projects have been initiated, including: the construction at Monroe Point of about 330 units on 51 ac and a 12-ac commercial site; the construction of 751 homes along Route 205 west of the creek separating Colonial Beach from the unincorporated parts of the county (Northern Neck Subdivision); and, nearby, Potomac Crossing, with 913 residential units, 182,000 square feet of commercial space, a golf course, and a community recreation center (Colonial Beach Virginia Attractions, 2011; Delano, 2006 and 2007). However,

in October 2007, the developer of Potomac Crossing announced that the project was being put on hold due to unfavorable market conditions (Ficklin, 2007) and has remained on hold due to the economy (Colonial Beach Virginia Attractions, 2011).

3.1.3 Special-Use Airspace (SUA)

As explained in Sections 1.4.4 and 1.6.2, SUA areas have been established by the FAA to prevent hazards to aircraft from NSWCDD's RDT&E operations (see Figure 1-6 for the location of these areas). Over the PRTR, the maximum altitudes are 40,000 ft for R-6611A and R-6613A, and 60,000 ft for R-6611B and R-6613B. Over the EEA, the SUA (R-6612) extends up to 7,000 ft. R-6612, R-6611A, and R-6613A (surface to 7,000 or 40,000 ft) are automatically in effect (i.e., restricted to air traffic) from 8 am to 5 pm daily, excluding weekends and holidays. When NSWCDD does not plan to use the SUA during these hours, it turns it back to the FAA. Conversely, NSWCDD may need to use the airspace outside the normal hours (i.e., at night or on weekends), in which case a Notice to Airmen (NOTAM) is issued by the FAA 48 hours in advance. The same procedure is used for R-6611B and R-6613B (40,000 to 60,000 ft), which are not automatically in effect. When they are needed, the FAA, at the request of NSWCDD, issues a NOTAM 48 hours in advance. These higher altitude zones are used only on rare occasions.

Although the SUA around NSF Dahlgren is potentially accessible to civilian aircraft when it is not in effect, commercial and general aviation operators seldom take advantage of this accessibility for practical reasons. Commercial airlines prepare and file their flight plans well before any notice of the airspace status can be issued (Saulsberry, pers. comm., July 15, 2008) and would not benefit from last minute changes. Airliners flying in and out of Ronald Reagan-Washington National Airport, about 35 mi north of the installation, follow established arrival and departure routes that do not traverse the SUA. Only an emergency could prompt them to deviate from these routes, in which case protocols are in place to request and grant access to the restricted airspace if needed.

General aviation pilots have the option of verifying the status of the SUA when planning their flights by looking up NOTAMs or communicating with traffic control at NAS Patuxent River if they want to fly into the SUA. However, based on information provided by Maryland's Director of the Office of Regional Aviation assistance, they very rarely do so, being trained to assume as a matter of course that military restricted air space is off-limits at all times (Solanki, pers. comm., January 7, 2010).

3.1.4 Coastal Zone Management

The Coastal Zone Management Act (CZMA) of 1972 (16 U.S.C. § 1451, et seq., as amended) encourages states, in cooperation with federal and local agencies, to develop land and water use programs in coastal zones. The CZMA excludes from the coastal zone "…lands the use of which is by law subject solely to the discretion of … the Federal Government, its officers or agents" (16 U.S.C. § 1453 (1)). By this statutory definition, NSF Dahlgren is not within Virginia's coastal zone. However, if a proposed federal activity affects coastal resources or uses beyond the boundaries of the federal property – i.e., has spillover effects – Section 307 of CZMA applies. Section 307 stipulates that federal projects that affect land uses, water uses, or other coastal

resources of a state's coastal zone must be consistent to the maximum extent practicable with the enforceable policies of that state's federally-approved coastal management plan. Federal consistency with a state's coastal zone management program (CZMP) is demonstrated by means of a coastal consistency determination that is submitted to the state agency responsible for review and comments. Applying for and complying with state permits when required by federal law also achieves consistency.

King George, Westmoreland, and Northumberland counties are within Virginia's designated coastal zone. Virginia has developed and implemented a federally-approved coastal resources management program (CRMP) describing current coastal legislation and enforceable policies. The Virginia CRMP has nine enforceable policies: fisheries management, subaqueous lands management, wetlands management, dune management, non-point source pollution control, point source pollution control, shoreline sanitation, air pollution control, and coastal lands management (Chesapeake Bay Preservation Act). Federal consistency determinations in Virginia are reviewed by the Virginia Department of Environmental Quality (VDEQ), which coordinates reviews with other state agencies as well as county and regional planning agencies.

Charles and St. Mary's counties are within the designated coastal zone of Maryland. Maryland has developed and implemented a federally-approved CZMP based on existing state laws and regulations, particularly the Maryland Tidal Wetlands Law (Wetlands and Riparian Rights) and the Maryland Critical Areas Program. Federal consistency determinations in Maryland are reviewed by the Wetlands and Waterways Program of the Maryland Department of the Environment (MDE).

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3.2 Socioeconomics

For the purposes of this section, the study area consists of King George, Westmoreland, and Northumberland counties in Virginia; and Charles and St. Mary's counties in Maryland. Data for smaller (e.g., census tracts) or larger (i.e., the states of Virginia and Maryland) areas will also be provided for comparison, as appropriate.

The following paragraphs describe the population of the study area and its general demographic characteristics, including age and ethnicity; its economic characteristics, including income and employment; and housing conditions.

3.2.1 Demographic Profile

This demographic analysis characterizes the population of the study area and its evolution based on US Census Bureau data from the 1990 Census, the 2000 Census, and the 2010 Census, and Maryland Department of Planning and Virginia Employment Commission population projections.

3.2.1.1 General Demographic Trends

As shown in Table 3.2-1, between 1990 and 2010 the total population of the five-county study area went from 216,659 to 305,070, an increase of 88,411 or 40.8 percent. The combined growth rate of the five counties exceeded that of both Maryland and Virginia both between 1990 and 2000 and between 2000 and 2010.

Table 3.2-1
Population 1990-2010

Geography	Population			Change			
	1990	2000	2010	1990-2000	Percent	2000-2010	Percent
King George Co.	13,527	16,803	23,584	3,276	24.2	6,781	40.4
Northumberland Co.	10,524	12,259	12,330	1,735	16.5	71	0.6
Westmoreland Co.	15,480	16,718	17,454	1,238	8.0	736	4.4
Charles Co.	101,154	120,546	146,551	19,392	19.2	26,005	21.6
St. Mary's Co.	75,974	86,211	105,151	10,237	13.5	18,940	22.0
Study Area	216,659	252,537	305,070	35,878	16.6	52,533	20.8
Maryland	4,781,468	5,296,486	5,773,552	515,018	10.8	477,066	9.0
Virginia	6,187,358	7,078,515	8,001,024	891,157	14.4	922,509	13.0

Sources: US Census Bureau, 2011a, Census 1990, DP-1 General Population and Housing Characteristics 1990; 2011b, Census 2000, DP-1 Profile of General Demographic Characteristics 2000; 2011c, Census 2010, DP-1 Profile of General Population and Housing Characteristics 2010.

Among the five counties, King George County experienced the highest rate of growth: 40.4 percent (or 6,781 new residents) between 2000 and 2010, following a 24.2 percent increase between 1990 and 2000. However, its population remained relatively small compared to that of

Charles and St. Mary's counties, which are closer to Washington, DC and its suburban growth. These two counties together accounted for about 82 percent of the study area's population both in 2000 and 2010. St. Mary's County had the second highest growth rate between 2000 and 2010 (22.0 percent) and Charles County had the third highest growth rate (21.6 percent). Because of Charles County's large base population – it is the most populous county in the study area – Charles accounted for 51.3 percent of all the population growth in the area over the period 1990-2010. Charles and St. Mary's are the counties that gained the most residents during this period.

Table 3.2-2 shows available population projections to 2020 for each of the five counties and the states of Maryland and Virginia. As might be expected, the two Maryland counties account for the lion's share (85.3 percent) of the projected growth in the study area. In Virginia, King George is projected to experience the most growth, at a rate higher than that of the Maryland counties, but this projected growth rate is mostly because its base population is relatively small. In absolute terms, projected growth in all three Virginia counties remains substantially less than in the Maryland counties. Because of their proximity to Washington, DC, the Maryland counties will continue to account for a large majority of the population of the study area.

Table 3.2-2
Population Projections for 2020

Geography	Change			
	2000	2020	2000-2020	Percent
King George Co.	16,803	30,126	13,323	79.3
Northumberland Co.	12,259	14,587	2,328	19.0
Westmoreland Co.	16,718	18,336	1,618	9.7
Charles Co.	120,546	177,200	56,654	47.0
St. Mary's Co.	86,211	130,100	43,889	50.9
Study Area	252,537	370,349	117,812	46.7
Maryland	5,296,486	6,339,290	1,042,804	19.7
Virginia	7,078,515	8,917,396	1,838,881	26.0

Sources: US Census Bureau, 2011b, Census 2000, DP-1 Profile of General Demographic Characteristics 2000; Virginia Employment Commission, 2011; Maryland Department of Planning, 2008.

3.2.1.2 Age Distribution

Table 3.2-3 shows the age structure of the study area's population as of 2010. While the age distribution in the study area as a whole is similar to that of Virginia and Maryland, the proportion of persons 65 years and over in Northumberland and Westmoreland counties is noticeably higher than in King George, Charles and St. Mary's counties. Both Northumberland and Westmoreland counties have fewer members of their populations in the workforce years or younger. This reflects these counties' greater distance from the Washington, DC area and other major employment centers and possibly their attractiveness to retirees.

Median age data from the 2010 Census confirm Westmoreland and Northumberland counties' distinct age patterns: the median age is 37.4 in Charles County, 36.0 in St. Mary's, 36.6 in King George (all three comparable to Maryland – 38.0 – and Virginia – 37.5) but 53.6 in Northumberland County and 46.6 in Westmoreland.

Table 3.2-3
Age Distribution (2010)

Geography	Total 2010 Population	Percent			
		Under 5 years	5-19 years	20-64 years	65 and over
King George Co.	23,584	7.6	22.3	59.9	10.2
Northumberland Co.	12,330	4.3	14.1	51.5	30.1
Westmoreland Co.	17,454	5.3	16.9	57.0	20.9
Charles Co.	146,551	6.4	22.8	61.3	9.5
St. Mary's Co.	105,151	7.2	22.1	60.5	10.3
Study Area	305,070	6.6	21.8	60.2	11.3
Maryland	5,773,552	6.3	20.0	61.5	12.3
Virginia	8,001,024	6.4	19.7	61.7	12.2
Source: US Census Bureau, 2011c, Census 2010, DP-1 Profile of General Population and Housing Characteristics 2010.					

3.2.1.3 Households

Table 3.2-4 provides information on the number and type of households in the study area, based on Census 2010 data.

Table 3.2-4
Households (2010)

Geography	Households	Persons per Household
King George Co.	8,376	2.78
Northumberland Co.	5,540	2.23
Westmoreland Co.	7,310	2.38
Charles Co.	51,214	2.83
St. Mary's Co.	37,604	2.72
Study Area	110,044	2.73
Maryland	2,156,411	2.61
Virginia	3,056,058	2.54
Source: US Census Bureau, 2011c, Census 2010, DP-1 Profile of General Population and Housing Characteristics 2010.		

As shown in Table 3.2-4, household size varies across the area, with Charles County's higher number (2.83 persons per household) tilting the five counties' average (2.73). As might be expected based on age patterns, household size is smaller in Westmoreland and Northumberland counties than it is elsewhere in the study area and than in Maryland and Virginia statewide.

3.2.1.4 Race and Ethnicity

Table 3.2-5 shows the racial and ethnic composition of the study area's population based on 2010 Census Bureau estimates. White Alone is the largest racial category; the only other major

category is Black or African American Alone. Charles County has the largest proportion of African Americans (41.0 percent), followed by Westmoreland County (28.0 percent). Both counties have substantially more Black residents (as a percentage of the total population) than their respective states, as does Northumberland County. The opposite is true for St. Mary's County, which has less than half the proportion of African Americans than does the state of Maryland.

Table 3.2-5
Race and Ethnicity 2010

Geography	Percent							
	White Alone	Black or African American Alone	American Indian and Alaska Native Alone	Asian Alone	Native Hawaiian and Other Pacific Islander Alone	Two or more Races	Hispanic*	All Minorities Combined
King George Co.	76.7	17.9	0.5	1.2	0.1	2.9	3.3	25.4
Northumberland Co.	71.4	25.3	0.2	0.3	0.0	1.2	3.1	29.9
Westmoreland Co.	65.9	28.0	0.4	0.6	0.0	2.2	5.7	36.5
Charles Co.	50.3	41.0	0.7	3.0	0.1	3.7	4.3	51.6
St. Mary's Co.	78.6	14.3	0.4	2.5	0.1	3.2	3.8	23.5
Study Area	63.8	28.6	0.5	2.4	0.1	3.3	4.1	38.2
Maryland	58.2	29.4	0.4	5.5	0.1	2.9	8.2	45.3
Virginia	68.6	19.4	0.4	5.5	0.1	2.9	7.9	35.2

Note: * Hispanic or Latino ethnicity may be of any race and their percentages are already included among other racial categories.

Source: US Census, 2011c, Census 2010, DP-1 Profile of General Population and Housing Characteristics 2010.

Asians and Hispanics in the study area have smaller proportions than in the two states. Within the study area, the county with the largest proportion of Hispanics is Westmoreland County (5.7 percent), followed by Charles County (4.3 percent).

3.2.2 Economic Profile

3.2.2.1 NSWCDD

A limited set of economic data is available to characterize NSWCDD. Data provided by NSWCDD for fiscal year 2009 indicate that civilian employment at the agency was 3,055, with an additional 13 military, for total employment of 3,068. These numbers do not include approximately 2,700 NSWCDD contractors who work at the installation each day; including them brings the total number of NSWCDD employees to approximately 5,800 (NSWCDD, Public Affairs Office, 2009).

The annual payroll for the regular NSWCDD employees in fiscal year 2009 was $296.3 million; thus, with 3,068 employees, the average salary was $96,577. In addition, contractors working at NSF Dahlgren accounted for $399 million in expenditures. The total direct economic impact of

NSWCDD employment, therefore, was on the order of $695.3 million in fiscal year 2009 (NSWCDD, Public Affairs Office, 2009).

Approximately half of the employees of NSWCDD reside in the study area. Table 3.2-6 shows the residential distribution of the employees in fiscal year 2009. Approximately one-third reside in the greater Fredericksburg area (Fredericksburg plus Stafford and Spotsylvania counties), which is the nearest metropolitan center to NSF Dahlgren but is not included in the study area.

Table 3.2-6
NSWCDD Civilian Employment and Place of Residence (2009)

Residence Location	NSWCDD Civilian Employment	Percent
King George	1,079	35.3
Fredericksburg	163	5.3
Spotsylvania	588	19.2
Stafford	383	12.5
Caroline	74	2.4
Westmoreland	169	5.5
Other VA Counties	285	7.8
Maryland	236	9.3
Other States	78	2.5
Totals	3,055	100.0
Source: NSWCDD, Public Affairs Office, 2009.		

The workforce at NSWCDD is particularly well educated, with 3 percent (91 employees) holding doctoral degrees, 20 percent (611 employees) holding masters' degrees, and 59 percent (1,803 employees) holding bachelors' degrees. The distribution of the workforce by occupation is shown in Figure 3.2-1, NSWCDD Occupations (NSWCDD, Public Affairs Office, 2009). Computer scientists and a variety of other scientists and engineers dominate the occupation categories.

3.2.2.2 Income and Poverty

The 2000 Census provides data on income based on 1999 incomes; the 2006-2010 American Community Survey provides five-year income and poverty estimates. These data are shown in Table 3.2-7.

In 2006-2010, among the study-area counties, the highest median household income – $88,825 – was recorded in Charles County, the county closest to Washington, DC and its jobs. Median incomes in St. Mary's and King George counties were lower, but comparable. By contrast, Westmoreland and Northumberland counties had substantially lower median incomes.

Of particular interest is how increases in median household income between 1999 and 2006-2010 were highest in King George County, with a growth of 52.8 percent, higher than the rates in the other counties and much higher than the rates in the states. Other income data for families and per capita income in 2006-2010 generally follow the same distribution pattern for households in 2006-2010.

Table 3.2-7 also shows the distribution of persons below poverty in 1999, with Westmoreland County experiencing the highest proportion (14.7 percent) and with the next highest in Northumberland County (12.3 percent), both substantially higher than the other counties or among the two states. The 2006-2010 Census Bureau estimates show that King George County and the states increased the proportion of their population below the poverty level since 1999, whereas the other counties decreased the proportion of their population below the poverty level.

Figure 3.2-1
NSWCDD Occupations

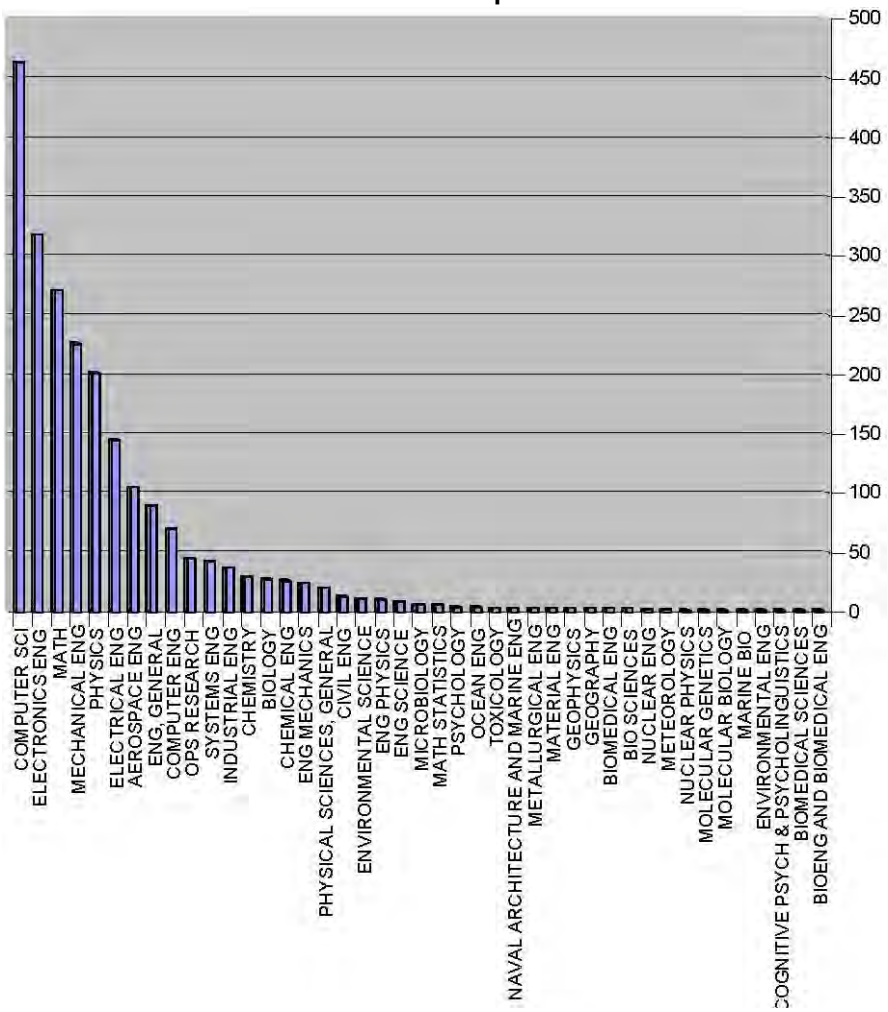


Table 3.2-7
Income and Poverty ($)

Geography	Median Household Income			Median Family Income 2006-2010	Per Capita Income 2006-2010	Percent Below Poverty	
	In 1999	2006-2010	Percent Change			In 1999	2006-2010
King George Co.	49,882	76,241	52.8	87,155	32,630	5.6	7.1
Northumberland Co.	38,129	51,944	36.2	60,872	28,646	12.3	10.9
Westmoreland Co.	35,797	52,990	48.0	59,613	27,501	14.7	9.7
Charles Co.	62,199	88,825	42.8	98,560	35,780	5.5	5.2
St. Mary's Co.	54,706	80,053	46.3	89,385	34,000	7.2	7.1
Study Area	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Maryland	52,868	70,647	33.6	85,098	34,849	8.5	8.6
Virginia	46,677	61,406	31.6	73,514	32,145	9.6	10.3

Note: 2006-2010 incomes are in 2010 inflation-adjusted dollars.
Sources: US Census Bureau, 2011b, Census 2000, DP-3 Profile of Selected Economic Characteristics 2000; 2012a, 2006-2010 American Community Survey 5-year estimates, DP03 Selected Economic Characteristics.

3.2.2.3 Employment

General

Data to profile the employment characteristics of the study area are compiled from several sources. Table 3.2-8 shows data from the US Bureau of Economic Analysis (USBEA) on employment trends between 2005 and 2009. During this period, employment in the study area grew by 4.7 percent, with the greater growth occurring in St. Mary's County, Maryland, and Westmoreland County, Virginia. With the exception of Northumberland County, Virginia, all five counties experienced growth rates that were higher than those of the two states.

Table 3.2-8
Employment 2005 and 2009

Geography	2005 Total Full- and Part-Time Employment	2009 Total Full- and Part-Time Employment	Percent Change 2005-2009
King George Co.	15,166	15,385	1.4
Northumberland Co.	4,710	4,655	-1.2
Westmoreland Co.	5,788	6,097	5.3
Charles Co.	58,160	59,184	1.8
St. Mary's Co.	56,786	61,870	9.0
Study Area	140,610	147,191	4.7
Maryland	3,308,776	3,356,112	1.4
Virginia	4,693,310	4,741,530	1.0

Source: USBEA, Regional Economic Accounts, 2011, CA25N.

Table 3.2-9 shows the most recent unemployment rates available from the US Bureau of Labor Statistics. Generally, unemployment in the study area is low, although the three Virginia counties have rates, equal to, or higher than their state's, whereas the two Maryland counties have rates lower than their state's.

Table 3.2-9
Unemployment Rates (August 2011)

Geography	Unemployment (percent)
King George Co.	7.5
Northumberland Co.	7.7
Westmoreland Co.	7.2
Charles Co.	6.5
St. Mary's Co.	6.5
Study Area	n/a
Maryland	7.4
Virginia	6.5
Source: US Bureau of Labor Statistics, Local Area Unemployment Statistics, 2011.	

USBEA provides information on the industries employing study area residents, as shown in Table 3.2-10. Data for the entire study area are not compiled because data suppression for confidentiality purposes among some industries would distort study-area totals. The USBEA suppresses certain industries' data because the numbers are either too small or would identify a specific employer; however, these data are included in totals for counties and states. Despite these limitations, useful employment information is discernable at the county level.

First, it may be noted that the five counties have higher rates of *proprietors employment* than do the two states; these are mostly *nonfarm proprietors*. King George and St. Mary's counties are distinct in having much higher rates of employment in *professional and technical* services (respectively 19.3 percent and 17.2 percent), and in *government* (respectively 33.7 percent and 24.1 percent), than do the other counties or the two states. For King George, in particular, this is largely attributable to employment at NSF Dahlgren. For St. Mary's, this is largely attributable to employment at NAS Patuxent River.

In King George County, *federal civilian* and *military* together account for 27.6 percent of employment (or 4,246 jobs); this is by far the largest proportion among counties in the study area and much higher than in Virginia as a whole, indicating the economic significance of NSF Dahlgren to the county. On the other hand, the county is underrepresented in traditional employment sectors such as manufacturing (1.0 percent, as opposed to 5.2 percent for Virginia) as well as in many trade and service sectors.

Table 3.2-10
Resident Employment by Industry (2009) (In Percentages, Except for Total Employment)

Industry	King George	Northumberland	Westmoreland	Charles	St. Mary's	Maryland	Virginia
Total employment	**15,385**	**4,655**	**6,097**	**59,184**	**61,870**	**3,356,112**	**4,741,530**
Wage and salary employment	70.0	62.8	65.1	74.5	73.5	78.7	81.9
Proprietors employment	30.0	37.2	34.9	25.5	26.5	21.3	18.1
Farm proprietors employment	1.0	2.1	2.1	0.6	0.9	0.3	0.9
Nonfarm proprietors	29.1	35.1	32.7	24.8	25.6	20.9	17.3
Farm employment	1.1	2.5	5.7	0.7	1.0	0.5	1.1
Nonfarm employment	98.9	97.5	94.3	99.3	99.0	99.5	98.9
Private employment	65.2	85.9	79.2	81.9	74.9	82.9	80.5
Forestry, fishing, related activities	0.7	(D)	3.1	(D)	0.5	0.2	0.3
Mining	0.6	(D)	0.2	(D)	0.1	0.1	0.3
Utilities	(D)	(L)	0.3	(D)	(D)	0.3	0.3
Construction	5.4	13.3	8.6	9.2	5.3	6.4	6.0
Manufacturing	1.0	11.7	11.3	1.7	1.1	3.7	5.2
Wholesale trade	(D)	2.6	1.3	(D)	(D)	2.9	2.6
Retail trade	5.2	9.9	9.5	16.4	9.1	9.9	10.0
Transport and warehousing	1.4	2.0	2.2	2.8	4.0	2.7	2.8
Information	2.1	0.8	0.3	1.1	0.9	1.8	2.0
Finance and insurance	2.6	3.6	3.4	3.3	2.3	4.8	4.0
Real estate & rental/leasing	5.7	7.3	6.3	5.5	5.7	5.0	4.3
Professional & tech services	19.3	6.4	(D)	6.3	17.2	9.9	10.6
Management of companies & enterprises	(D)	(D)	(D)	0.2	(D)	0.6	1.6
Administration and waste services	(D)	(D)	5.3	4.8	(D)	5.9	5.5
Educational services	(D)	(L)	(D)	1.1	1.9	2.7	1.9
Health care and social asst.	(D)	3.1	(D)	9.7	8.4	11.6	8.9
Arts, entertainment and recreation	1.7	2.7	3.4	1.9	1.9	2.3	2.0
Accommodation & food services	3.2	3.9	6.1	8.8	5.6	6.3	6.7
Other services (except pub admin)	4.6	9.0	7.8	6.4	5.2	5.6	5.6
Government	33.7	11.6	15.1	17.4	24.1	16.6	18.5
Federal, civilian	23.4	0.6	1.1	3.8	12.4	4.9	3.9
Military	4.2	0.9	1.0	1.8	4.2	1.4	3.3
State and local	6.1	10.0	13.0	11.9	7.5	10.4	11.3
State government	(D)	0.8	1.3	0.7	1.3	3.0	3.3
Local government	(D)	9.2	11.7	11.2	6.2	7.3	8.0

Note: (L) Less than 10 jobs, but estimates are included in totals.
(D) Not shown to avoid disclosure of confidential information, but estimates are included in totals.
Source: USBEA, Regional Economic Accounts, 2011, CA25N.

Marine-Related Economic Activity

The Navy shares the use of the Potomac River with others, including commercial and industrial vessels (e.g., fuel barges, gravel barges), commercial fishing, and recreational users.

Marine Freight

The Potomac River's navigation south of Washington, DC is limited by its relatively shallow draft at a number of locations – e.g., vessel draft limits are 19.8 feet (ft) at the Matawoman Bar and 18.5 ft at the Hunting Creek Shoal.

One new major commercial user is the Mirant Morgantown coal-fired power plant, on the Maryland shore immediately south of the Harry Nice Bridge and across the river from NSF Dahlgren. The plant has constructed facilities that allow it to supplement the importation of coal by rail to include barges that will unload from a new 500-ft dock, with a conveyor system extending into the river approximately 836 ft. The facility is expected to receive four to five 20,000-ton barges per week, with each taking about 16 hours to unload, during both day and night. (There are also seasonal use variations, with more in the summer and winter, and fewer in the spring and fall.)

The environmental review for the Mirant facility cites John Morgan, a Potomac River pilot, who notes commercial traffic on the river as being one or two vessels a week (Maryland Power Plant Research Program [MPPRP], 2007). This, however, does not fit with data cited in *Waterborne Commerce of the United States* (US Army Corps of Engineers [USACE], 2008). This data source indicates that the Potomac River below Washington, DC moved freight weighing 3.4 million tons in 2008, primarily composed of petroleum and petroleum products and sand and gravel. These freight movements were achieved with 3,176 vessel trips upbound and 3,156 vessel trips downbound in 2008. It is not clear from these data sources whether all these vessels would traverse the PRTR, but it does set an order-of-magnitude, which translates to approximately 122 vessels per week.

Commercial Fishing

USBEA data on the forestry and fishing industry in Northumberland and Charles counties are suppressed (see Table 3.2-10), but Westmoreland County shows relatively high numbers in that category (3.1 percent). Although notable in percentage terms, these data translate to 186 jobs in Westmoreland. The other counties where these data are not suppressed are King George, with 0.7 percent, translating to 107 jobs, and St. Mary's, with 0.5 percent, translating to 303 jobs. It should be noted that the data refer to both forestry *and* fishing; consequently, they set the high end for potential fishing employment in these counties. It is revealing that in the discussion of Agriculture and Fisheries and the Economy in the draft *King George County 2012 Comprehensive Plan*, only farming is actually discussed; the context is one in which the declines in farm acreage and returns are noted (King George County, 2012, page 60).

For those counties that have forestry and fishing data suppressed in the USBEA's 2009 statistics, 2006-2010 American Community Survey five-year estimates of employment by industry provide some indication of the scale of employment in the local fishing industry. These estimates, presented in Table 3.2-11, show that Northumberland County had 230 persons engaged in the broad economic category of *agriculture, forestry, fishing and hunting, and mining* and that

Charles County had 301 persons so employed. Thus, for the five-county study area, it appears that no more than approximately 1,130 persons are likely to be employed in forestry and fishing.

Table 3.2-11
Employment in Agriculture, Forestry, Fishing and Hunting, and Mining (2006-2010)

Geography	Employed Persons	Percentage of Locality Total
King George Co.	114	1.1
Northumberland Co.	230	4.2
Westmoreland Co.	432	5.4
Charles Co.	301	0.4
St. Mary's Co.	600	1.2
Study Area	1,677	1.1
Maryland	14,783	0.5
Virginia	42,834	1.1
Source: US Census Bureau, 2012a, DP03 Selected Economic Characteristics.		

Other data on the fishing industry are available from various sources. The draft *King George County 2012 Comprehensive Plan* notes that there were 36 commercially registered watermen in King George County in 1998 and 38 in 1999 (King George County, 2012). Fishing catches in the county have varied but were 718,907 pounds in 1998, with a value of $384,604. The value of fishing catches in King George County in 2005 was $259,000. The 2006 Northumberland County *Comprehensive Plan* cites the value of fishing catches as $3,648,604 in 2002, but this county has frontage on the Chesapeake Bay (Northumberland County, 2006).

Commercial fishing in the Potomac River involves fishing, crabbing, and less frequently, oystering. Data compiled by the Potomac River Fisheries Commission (PRFC) for commercial fish harvests provide catch volumes by species and reach of the river, but not the value of the catch. Table 3.2-12 summarizes the data for the years 2001 to 2010. Of particular interest is the degree to which Area 1 (extending from the mouth of the Potomac River to Hollins Marsh, Virginia/Colton's Point, Maryland and corresponding to the LDZ – shown on Figure 3.11-6) accounts for the great majority (86 percent) of finfish landed. The majority of hard crabs also are harvested in Area 1, but substantial quantities also are harvested in Area 2 (extending upriver from Area 1 to the Harry Nice Bridge and corresponding to the MDZ) and in Area 3. The upstream reaches of the Potomac correspond to Areas 3 and 4, and are north of the Harry Nice Bridge to Possum Point, Virginia/Moss Point, Maryland, and upstream to the Woodrow Wilson Bridge, respectively. These areas account for very small proportions of finfish and oysters, but Area 3 accounts for 29 percent of the hard crab catch.

Over the ten-year period, for Areas 1 through 4 combined, PRFC data indicate that menhaden account for 64 percent of the finfish landed, with croaker and striped bass accounting for 14 percent and 11 percent, respectively (Cosby, PRFC, pers. comm., March 1, 2011). All other species were caught in low volumes.

Table 3.2-12
Potomac River Fisheries Commission Harvest Reports for 2001-2010

Species	Area 1		Area 2		Area 3		Area 4		Total Catch All Areas
	Total Catch	Per-centage	Total Catch	Per-centage	Total Catch	Per-centage	Total Catch	Per-centage	
Finfish (thousand lbs)	51,567	86%	2,296	4%	4,163	7%	1,649	3%	59,674
Hard Crabs (thousand lbs)	14,457	50%	5,031	17%	8,278	29%	1,027	4%	28,794
Oysters* (bushels)	4,000	20%	16,189	79%	190	1%	0	0%	20,379

Note: *Oyster data are for the 2000-2001 through 2009-2010 seasons.
Source: Cosby, PRFC, pers. comm., March 1, 2011.

Recreational Activities

In addition to fishing, maritime employment along the Potomac River includes recreation-oriented employment. However, data sources have a major limitation: a broad industry class that includes all *Arts, Entertainment, and Recreation*. The USBEA, Regional Economic Accounts (2011, CA25N) reports a total of 255 jobs in this industry class for King George County, 127 for Northumberland County, 205 for Westmoreland County, 1,096 for Charles County, and 1,196 for St. Mary's County. Thus, employment numbers in *all* types of recreation, arts, and entertainment activities are relatively small in the Virginia counties and also quite modest in the Maryland counties. The percentages of employment in this industry category are 2.3 percent in Maryland and 2.0 percent in Virginia, a higher share than in three of the study area's counties but less than in Westmoreland (3.4 percent) and Northumberland (2.7 percent) counties; in these two counties, however, the number of jobs is small – 205 and 127, respectively.

Additional data that may point to the significance of recreational maritime activity along the Potomac are the number of charter boat companies and marinas. The Virginia Charter Boat Association (Virginia Charter Boat Association, Not Dated) lists 17 captains and boats operating from Potomac River ports (including some from the Maryland side). Marinersguide.com lists 31 Potomac River marinas, docks, and boat ramps and storage, including 18 marinas on the Virginia side of the Potomac and 10 marinas on the Maryland side (Marinersguide.com, 2011). The *Potomac River Guide* (Potomac River Guide, 2007) lists seven marinas on the Potomac side of the Northern Neck. A recent guidebook to cruising the lower Potomac River (Rhodes, 2003) lists 28 public and private marinas between Nanjemoy Creek and the Bay on the Maryland side of the river, and 28 such facilities south of the Caledon Natural Area on the Virginia side. A study by the Maryland Department of Labor, Licensing, and Regulation on Hospitality and Tourism notes that the industry category of *Scenic and Sightseeing Water Transportation* (including charter fishing) in the state included 301 employed persons with a payroll of $5,373,415 in 2004 (Maryland Department of Labor, Licensing, and Regulation, 2006). Additional economic activity, both directly and indirectly linked to marine recreation, is also important in the study area, and would encompass restaurants, accommodations, travel services, and entertainment-related activities.

3.2.3 Housing

Data on recent trends in housing in the study area are shown in Table 3.2-13. As a whole, the study area experienced an increase (17.1 percent) in housing units between 2000 and 2006, which was a much higher rate of growth than that experienced in the two states on a statewide basis (7.2 percent for Maryland and 11.2 percent for Virginia). With a 4.8 percent increase over the period 2006-2010, the study area continued to outpace the states (3.4 and 4.2 percent, respectively). Among individual counties, King George experienced the highest growth rate in both periods (28.9 and 7.8 percent), followed by St. Mary's and then Charles in 2000-2006, and by Charles and then Westmoreland in 2006-2010.

Table 3.2-13
Total Housing Units 2000, 2006, and 2010

Geography	2000	2006	2010	Percentage Change	
				2000-2006	2006-2010
King George Co.	6,820	8,789	9,477	28.9	7.8
Northumberland Co.	8,057	9,075	8,995	12.6	-0.9
Westmoreland Co.	9,286	10,241	10,618	10.3	3.7
Charles Co.	43,903	51,392	54,963	17.1	6.9
St. Mary's Co.	34,081	40,140	41,282	17.8	2.8
Study Area	102,147	119,637	125,335	17.1	4.8
Maryland	2,145,283	2,300,567	2,378,814	7.2	3.4
Virginia	2,904,192	3,230,803	3,364,939	11.2	4.2

Sources: US Census Bureau, 2011b, Census 2000, QT-H4 Physical Housing Characteristics 2000; 2012b, Population Estimates Program, T2 Housing Unit Estimates 2006; 2011c, Census 2010, QT-H1 General Housing Characteristics 2010.

The tenure status of occupied housing units is shown in Table 3.2-14. The percentage of owner-occupied units is higher in the study area (76.4 percent) than in the two states as a whole (67.5 percent in Maryland and 67.2 percent in Virginia). All five counties exceed the states in this respect, with Northumberland recording the highest rate (83.3 percent), followed by Charles (78.7 percent), and King George (78.4 percent).

Table 3.2-14
Housing Tenure (2010)

Geography	Total Occupied	Owner-occupied		Renter-occupied	
		Number	Percent	Number	Percent
King George Co.	8,376	6,568	78.4	1,808	21.6
Northumberland Co.	5,540	4,613	83.3	927	16.7
Westmoreland Co.	7,310	5,591	76.5	1,719	23.5
Charles Co.	51,214	40,317	78.7	10,897	21.3
St. Mary's Co.	37,604	26,966	71.7	10,638	28.3
Study Area	110,044	84,055	76.4	25,989	23.6
Maryland	2,156,411	1,455,775	67.5	700,636	32.5
Virginia	3,056,058	2,055,186	67.2	1,000,872	32.8

Source: US Census Bureau, 2011c, Census 2010, QT-H1 General Housing Characteristics 2010.

The occupancy status of all units in 2010 is shown in Table 3.2-15. In the two states, the percentage of occupied units exceeds 90 percent, but in the study area, it is 87.8 percent. This difference is largely accounted for by the high vacancy rates in Northumberland and Westmoreland counties. In turn, these high rates are attributable to the high percentage of seasonal or recreational homes in these two counties: such homes account for 29.0 percent of all housing in Northumberland and 20.2 percent of all housing in Westmoreland. The distribution of vacant units either for rent or for sale among the five counties is generally similar to that of the two states – again with the exception of Northumberland and Westmoreland counties, where vacant units for rent are fewer than those for sale.

Table 3.2-15
Housing Occupancy Status (2010)

Housing Occupancy Status	King George	Northumberland	Westmoreland	Charles	St. Mary's	Study Area	Maryland	Virginia
Total Housing Units (100 percent):	9,477	8,995	10,618	54,963	41,282	125,335	2,378,814	3,364,939
Occupied (percent)	88.4	61.6	68.8	93.2	91.1	87.8	90.7	90.8
Vacant (percent)	11.6	38.4	31.2	6.8	8.9	12.2	9.3	9.2
Vacant for rent (percent)	3.8	0.9	2.0	1.9	2.3	2.1	2.6	2.5
Vacant for sale (percent)	1.2	2.2	2.1	1.8	1.2	1.6	1.4	1.3
Rented or sold, not occupied (percent)	0.3	0.7	0.3	0.4	0.4	0.4	0.4	0.4
For seasonal, recreational, or occasional use (percent)	3.0	29.0	20.2	0.8	3.0	5.3	2.3	2.4
For migrant workers (percent)	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Other vacant (percent)	3.3	5.6	6.5	1.9	1.9	2.7	2.6	2.5

Source: US Census Bureau, 2011c, Census 2010, QT-H1 General Housing Characteristics 2010.

The estimated number of housing units per structure is shown in Table 3.2-16, based on American Community Survey five-year estimates for the years 2006 through 2010. By far the largest category is single-unit detached, which in the study area accounted for 75.0 percent of total units in 2010, with higher percentages recorded for King George, Northumberland, and Westmoreland counties. Multi-unit structures were very uncommon in the study area, much more so than in the two states as a whole. There were high proportions of mobile homes in the three Virginia counties.

Table 3.2-16
Housing Units in Structure (percent) (2006-2010)

Number of Units in Structure	King George	North-umberland	West-moreland	Charles	St. Mary's	Study Area	Maryland	Virginia
1, detached	76.3	83.8	86.6	71.8	73.9	75.0	51.6	62.6
1, attached	3.8	0.8	0.4	16.4	6.9	9.8	21.1	10.3
2	1.6	0.6	0.0	0.7	1.0	0.8	1.8	1.7
3 or 4	2.8	0.8	1.4	2.2	2.4	2.2	2.4	2.7
5 to 9	2.3	0.0	0.5	2.8	4.1	2.8	5.3	4.8
10 to 19	2.9	0.6	1.2	1.5	3.4	2.1	8.5	5.8
20 or more	0.4	0.2	0.3	2.6	2.7	2.1	7.7	6.4
Mobile home	9.8	13.2	9.5	1.9	5.5	5.2	1.7	5.7
Boat, RV, van, etc.	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Source: US Census Bureau, 2012a, DP04 Selected Housing Characteristics.								

Finally, Table 3.2-17 presents estimates of the median age of the housing structures, and median gross rents and median values for the years 2006 through 2010, for the counties and the two states (the study area median is not available). The two Maryland counties have a younger housing stock than the state as a whole, while in Virginia, King George has and Northumberland counties have a younger housing stock than the state. With respect to median gross rents, the two Maryland counties reveal median rents that are noticeably higher than that for the state as a whole: the highest rents are noted for Charles County ($1,307) and St. Mary's County ($1,123). In Virginia, state median rents are higher than those in two of the study-area counties ($772 in Northumberland and $888 in Westmoreland) and lower than those in the third ($982 in King George). For the Virginia counties, housing values follow a similar pattern, with the state exceeding the median value for owner-occupied housing for Northumberland and Westmoreland counties ($251,600 for Northumberland and $202,300 for Westmoreland, versus $255,100 for the state), and only King George County ($305,200) exceeding the median for Virginia.

Table 3.2-17
Median Year Housing Constructed, Median Gross Rent and Median Value (2006-2010)

Geography	Median Year Constructed	Median Gross Rent ($)	Median Value for Owner-Occupied Units ($)
King George County	1988	982	305,200
Northumberland County	1980	772	251,600
Westmoreland County	1975	888	202,300
Charles County	1986	1,307	355,800
St. Mary's County	1985	1,123	327,800
Maryland	1974	1,091	329,400
Virginia	1978	970	255,100
Source: US Census Bureau, 2012a, B25035 Median Year Structure Built; DP04 Selected Housing Characteristics.			

3.2.4 Environmental Justice

Executive Order (EO) 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, dated February 11, 1994, requires that federal agencies take appropriate and necessary steps, to the greatest extent practicable and permitted by law, to identify and address disproportionately high and adverse effects of federal projects on the health or environment of minority and low-income populations (EO 12898, 1994). Environmental justice (EJ) mandates that no minority or low-income population group shall bear a disproportionate share of potential adverse environmental impacts resulting from a major federal action, such as the Navy is proposing.

In order to determine whether a potentially affected EJ community is present within the study area, the CEQ in its *Environmental Justice: Guidance under the National Environmental Policy Act* (CEQ, 1997) offers the following guidelines:

1. Establish Study Area – Define the study area that could be affected by the project or proposal.
2. Identify Minority Populations – Using US Census data, identify minority communities or populations within the study area where either:
   a. Minority populations exceed 50 percent of the general population, or
   b. The minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population.
3. Identify Low-income Populations – Using annual statistical poverty thresholds from the US Bureau of Census's current Population Report, Series P-60, identify low-income populations in the affected area.
4. Evaluate Effects on Low-income and Minority Populations – Evaluate the effects of the Proposed Action on populations of concern to determine if the adverse impacts on these populations are disproportionately high or adverse when compared to the effects on the general population in the study area. (This is addressed in the Socioeconomic Impacts section of the Environmental Consequences chapter – 4. 2.)

Environmental Justice Study Area

For an analysis of EJ, the potential area of affect from the Proposed Action is defined as the five counties along the PRTR. These are: King George, Westmoreland, and Northumberland counties in Virginia, and Charles and St. Mary's counties on the north shore of the Potomac, in Maryland. This is the same study area used for the land use (Section 3.1) and socioeconomic (Section 3.2) analyses. This study area is where most project impacts would occur.

Population Characteristics of Study Area

Detailed social and economic characteristics of the study area and the respective counties are provided in EIS Sections 3.2.1 through 3.2.3, including demographic, housing, income, education, and employment data for the study area, the counties, and the two states. More-detailed data at the census tract level are provided for this EJ review, compiled from the US Census, and are displayed in a geographic information format using ESRI's ArcGIS software.

Populations of Concern

Definition of Communities of Concern

In an EJ analysis, populations or communities of concern (COCs) within the project impact area that may be adversely affected must be compared to a reference population. The reference populations in this case are those of the five counties in the study area and the populations of the states of Maryland and Virginia.

The present COC analysis begins by refining the geographic level of analysis to the census tracts. Those census tracts within the study area were examined. There are a total of 62 census tracts in the study area; of these, 49 census tracts are in Maryland and 13 census tracts are in Virginia. Two census tracts in Maryland and one in Virginia are not occupied by a resident population.

Definition of Minority Population

"Minority," as defined for EJ analysis purposes, is comprised of the following Census-defined populations:

- Native American and Alaskan Native
- Black or African American
- Hawaiian and Pacific Islander
- Asian
- Two or More Races
- Hispanic

In the Census, Hispanic origin is viewed as the heritage, nationality group, lineage, or country of birth of the person or the person's parents or ancestors before their arrival in the United States. People who identify their origin as Spanish, Hispanic, or Latino may be of any race. Consequently, for this analysis the minority population was compiled from Table P9 of Summary File 1 (SF 1) of the 2010 Census of Population and Housing, using the sum of the Hispanic population (of any race) plus the Non-Hispanic populations of Native Americans and Alaskan Natives, Black or African Americans, Hawaiian and Pacific Islanders, Asians, and Two or More Races – i.e., White Non-Hispanic populations are excluded from the minority count. For EJ analysis, the minority population is the aggregation of all minority persons.

Definition of Low-Income Population

The percentage of the population living below the Census-defined poverty level was used to define the low-income population in the study area. The percentage of the population for whom poverty was determined was identified from Table DP03 of the 2006-2010 American Community Survey five-year estimates at the census tract level.

Community of Concern Percent Thresholds

As noted, the CEQ approach is to identify the percentage of minorities and those in poverty at the appropriate unit of geographic analysis, such as the census tract level, and compare them to a reference population, with the five counties in the study area and the states of Maryland and Virginia adopted here as the references. Table 3.2-18 presents the minority population

percentages based on the 2010 Census for King George, Northumberland, Westmoreland, Charles, and St. Mary's counties. A notable concentration of minority populations assumes here a concentration that is a majority, i.e., 50.1 percent, or is 20 percent higher than that of the respective county. Thus, for the purpose of this EJ review, census tracts with minority population percentages that exceed the thresholds shown in Table 3.2-18 are classified as minority COCs.

Table 3.2-18
Community of Concern Thresholds (percent)

Geography	Minority Population		Low-Income Population	
	2010	Threshold	2006-2010	Threshold
King George Co.	25.4	30.4	7.1	8.5
Northumberland Co.	29.9	35.9	10.9	13.1
Westmoreland Co.	36.5	43.8	9.7	11.6
Charles Co.	51.6	50.1	5.2	6.2
St. Mary's Co.	23.5	28.2	7.1	8.5
Maryland	45.3	n/a	8.6	n/a
Virginia	35.2	n/a	10.3	n/a

Sources: US Census Bureau, 2012a, 2006-2010 American Community Survey 5-year estimates, DP03 Selected Economic Characteristics; 2012b, Census 2010, P9 Hispanic or Latino, and Not Hispanic or Latino by Race.

The estimated percentage of the population below the poverty level in the 2006-2010 American Community Survey in each of the counties in the study area is presented in Table 3.2-18. Applying the same criteria adopted for minorities (i.e., a majority or 20 percent higher than the percentage in the county) results in defining low-income population concentrations as those greater than the thresholds shown in the table.

Identification of Communities of Concern

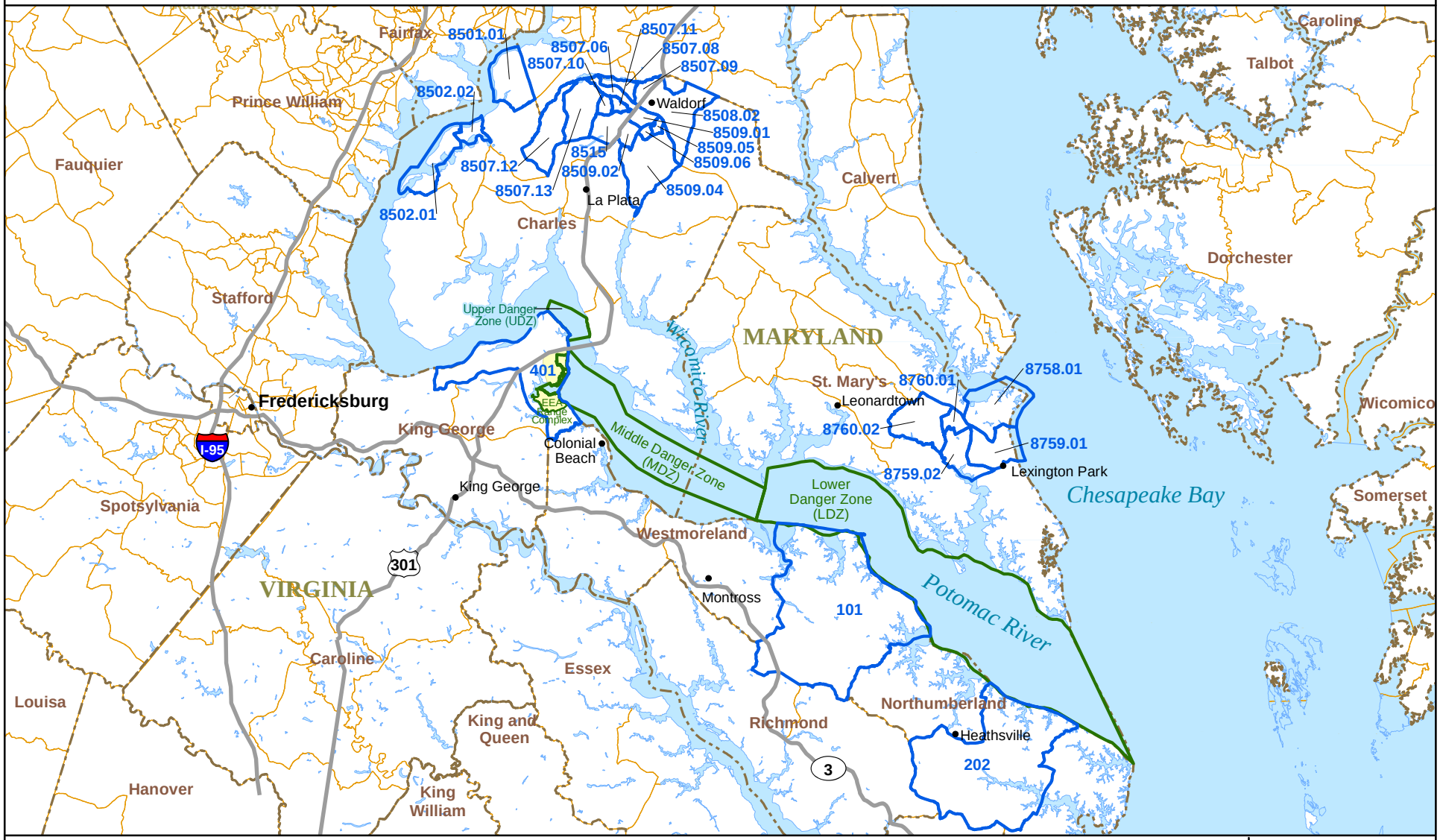
Table 3.2-19 presents the minority population percentages and low-income population percentages for the study area census tracts, and identifies the minority and low-income COCs. Of the 49 Maryland census tracts, 22 are defined as minority COCs. Of the 13 Virginia census tracts, 3 are defined as minority COCs. Fifteen of the census tracts in Maryland and 5 of those in Virginia are defined as low-income COCs. The following discussion reviews the locations of these communities.

Minority Populations

Applying the methodology noted above, the minority COCs in the study area were identified and mapped at the census tract level (Figure 3.2-2, Census Tracts with Environmental Justice Minority Populations).

In Maryland, of the 22 minority census tracts, 5 are in St. Mary's County and 17 are in Charles County. Only 3 of these are actually adjacent to the Potomac River – all in the northernmost part of Charles County, upriver from NSF Dahlgren and the UDZ. In Virginia, 1 minority census tract is in King George County, 1 is in Northumberland County, and 1 is in Westmoreland County.

Census Tracts with Environmental Justice Minority Populations



Census Tract
Minority Census Tract
County Boundary
Naval Support Facility Dahlgren
Potomac River Test Range (PRTR) Complex

4 0 4 Miles
6 0 6 Kilometers

N

NSWCDD EIS

Source: US Census Bureau, 2012b, P9 Hispanic or Latino, and Not Hispanic or Latino by Race 2010.

Figure 3.2-2

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Table 3.2-19
Minority and Low-Income Communities of Concern

Geography	Percent Minority	Percent Low Income	Geography	Percent Minority	Percent Low Income
King George Co.	25.4	7.1	Charles Co. (continued)		
Census Tract 401	**33.2**	4.7	Census Tract 8509.02	**54.8**	**6.8**
Census Tract 402	22.2	**9.1**	Census Tract 8509.04	**67.2**	3.4
Census Tract 403	22.0	**10.0**	Census Tract 8509.05	**60.8**	5.3
Census Tract 404	28.4	4.3	Census Tract 8509.06	**70.2**	**6.6**
Census Tract 405	21.5	3.3	Census Tract 8510.01	29.2	3.9
Northumberland Co.	29.9	10.9	Census Tract 8510.02	32.2	**6.9**
Census Tract 201	31.8	10.5	Census Tract 8511	21.4	1.7
Census Tract 202	**39.1**	**14.7**	Census Tract 8512	19.8	**7.6**
Census Tract 203	23.1	8.8	Census Tract 8513.01	13.6	2.0
Census Tract 9901	n/a	n/a	Census Tract 8513.02	25.8	2.3
Westmoreland Co.	36.5	9.7	Census Tract 8514	33.3	2.3
Census Tract 101	**51.9**	6.9	Census Tract 8515	**69.3**	1.1
Census Tract 102	39.9	8.1	Census Tract 9900	n/a	n/a
Census Tract 103	34.4	11.9	St. Mary's Co.	23.5	7.1
Census Tract 104	21.4	**11.7**	Census Tract 8750	11.0	2.8
Charles Co.	51.6	5.2	Census Tract 8751	14.3	4.6
Census Tract 8501.01	**70.4**	5.5	Census Tract 8752.01	11.1	6.1
Census Tract 8501.02	50.1	5.0	Census Tract 8752.02	13.6	3.8
Census Tract 8502.01	**55.1**	0.0	Census Tract 8753	17.6	8.0
Census Tract 8502.02	**50.6**	**9.5**	Census Tract 8754	14.6	5.5
Census Tract 8503	42.1	2.8	Census Tract 8755	19.9	6.0
Census Tract 8504	36.5	**10.3**	Census Tract 8756	18.2	2.9
Census Tract 8505	18.6	3.4	Census Tract 8757	9.3	7.2
Census Tract 8506	43.8	**7.3**	Census Tract 8758.01	**36.2**	**14.6**
Census Tract 8507.06	**69.2**	1.4	Census Tract 8758.02	15.0	1.3
Census Tract 8507.08	**67.2**	**7.4**	Census Tract 8759.01	**41.3**	**13.9**
Census Tract 8507.09	**79.9**	**8.4**	Census Tract 8759.02	**51.9**	**11.2**
Census Tract 8507.10	**63.5**	3.6	Census Tract 8760.01	**53.4**	**21.4**
Census Tract 8507.11	**74.5**	5.6	Census Tract 8760.02	**39.7**	4.9
Census Tract 8507.12	**58.1**	1.2	Census Tract 8761	16.4	6.4
Census Tract 8507.13	**55.3**	1.3	Census Tract 8762	17.8	8.0
Census Tract 8508.01	41.1	4.8	Census Tract 9900	n/a	n/a
Census Tract 8508.02	**55.3**	**8.9**	Maryland	45.3	8.6
Census Tract 8509.01	**68.6**	**12.9**	Virginia	35.2	10.3

Note: Bold text indicates population percentages of minority and low-income COCs.

Sources: US Census Bureau, 2012a, 2006-2010 American Community Survey 5-year estimates, DP03 Selected Economic Characteristics; 2012b, Census 2010, P9 Hispanic or Latino, and Not Hispanic or Latino by Race.

The minority census tract in King George County is the tract occupied by NSF Dahlgren, and is adjacent to the Potomac River and to the MDZ. The minority census tracts in Northumberland and Westmoreland counties also are adjacent to the Potomac River and are adjacent to the LDZ.

Low-Income Populations

Low-income COCs in the study area also were identified and mapped at the census tract level (Figure 3.2-3, Census Tracts with Environmental Justice Low-Income Populations).

Four of the 15 low-income census tracts in Maryland are in St. Mary's County and 11 are in Charles County. Three of the low-income census tracts in Maryland are adjacent to the Potomac River, in Charles County – 2 upriver from NSF Dahlgren and the UDZ, and 1 across the river from the facility and adjacent to the MDZ. In Virginia, 2 of the low-income census tracts are in King George County, 2 are in Westmoreland County, and 1 is in Northumberland County. Four of the low-income tracts are adjacent to the Potomac River – 1 upriver from NSF Dahlgren and the UDZ, 2 adjacent to the MDZ, and 1 adjacent to the lower LDZ. The fifth low-income census tract in Virginia, although not adjacent to the river, is immediately landward of the tract occupied by NSF Dahlgren.

3.2.5 Protection of Children

EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, was signed on April 21, 1997 (EO 13045, 1997). Because the scientific community recognized that children may suffer disproportionately from environmental health and safety risks, each federal agency is directed to identify and assess such risks, and consequently to ensure that its policies, programs, activities, and standards address effects on children. "Environmental health and safety risks" are defined as "risks to health or to safety that are attributable to products or substances that the child is likely to come in contact with or ingest." Covered regulatory actions that are affected by this EO are those substantive actions that concern an environmental health risk or safety risk that an agency has reason to believe may disproportionately affect children.

Children Under 18 Populations

Within the five-county study area, Census 2010 data on children under 18 were examined at the census tract level in order to identify any concentrations of minors. Table 3.2-20 presents the children under 18 population percentages based on the 2010 Census for King George, Northumberland, Westmoreland, Charles, and St. Mary's counties. On average, throughout the study area, such persons represented 25.7 percent of their respective tract populations (US Census Bureau, 2011c, DP-1 Profile of General Population and Housing Characteristics 2010).

An unusual concentration of children under 18 assumes here a concentration that is 10 percent higher than that of the respective county. Thus, census tracts with children under 18 population percentages that exceed the thresholds shown in Table 3.2-20 are classified as unusual concentrations of children.

Table 3.2-20
Concentration of Children Thresholds (percent)

Geography	Children Under 18 Population	
	2010	Threshold
King George Co.	27.7	30.5
Northumberland Co.	16.4	18.0
Westmoreland Co.	20.0	22.0
Charles Co.	26.5	29.2
St. Mary's Co.	26.2	28.9
Maryland	23.4	n/a
Virginia	23.2	n/a
Source: US Census Bureau, 2011c, Census 2010, DP-1 Profile of General Population and Housing Characteristics 2010.		

Table 3.2-21 presents the children under 18 population percentages for the study area census tracts and identifies the unusual concentrations. Of the 49 Maryland census tracts, 11 are defined as unusual concentrations of children. Of the 13 Virginia census tracts, 2 are defined as unusual concentrations. The locations of these census tracts are shown on Figure 3.2-4, Census Tracts with Concentrations of Children.

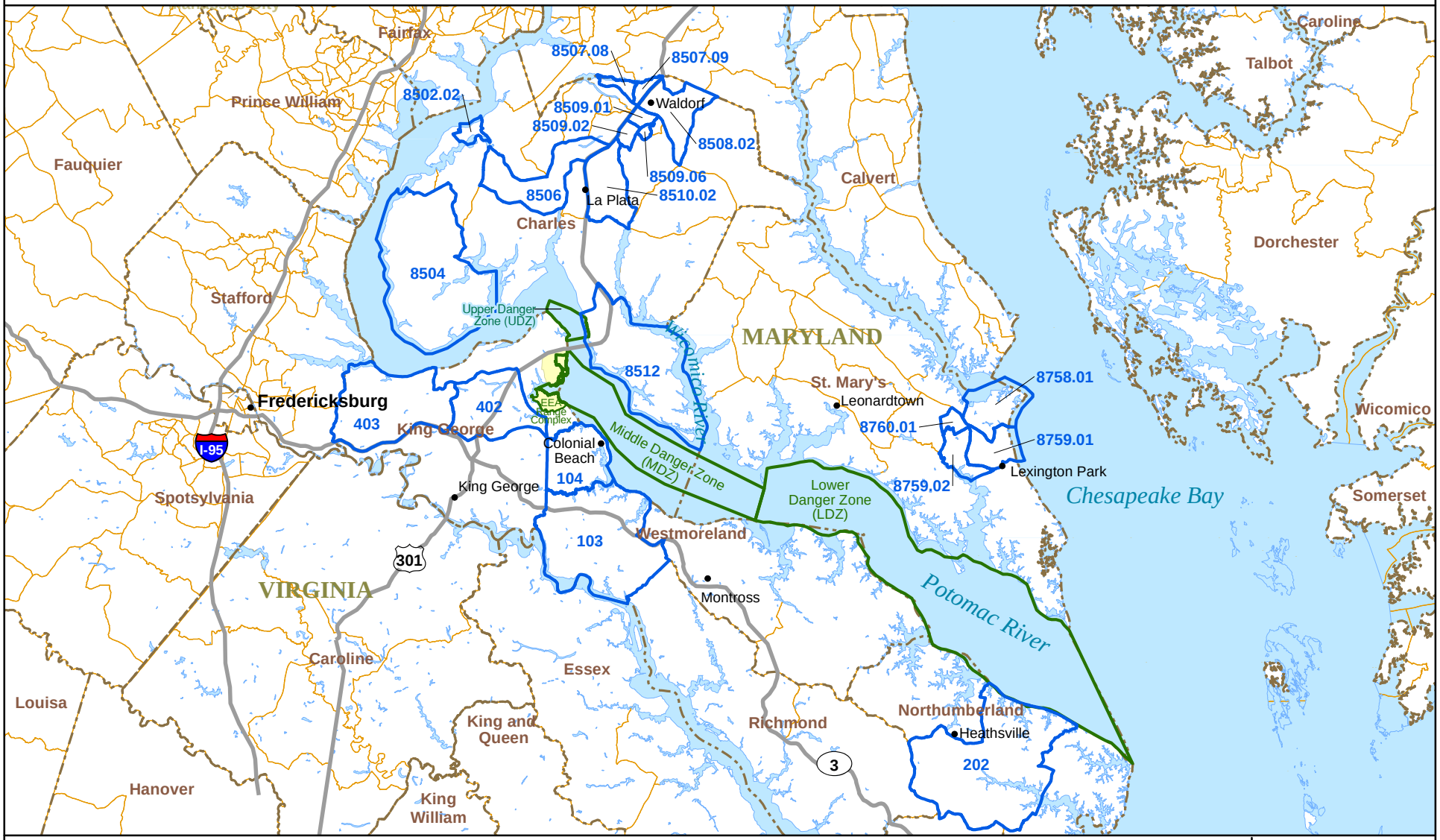
Table 3.2-21
Unusual Concentrations of Children

Geography	Percent Children	Geography	Percent Children
King George Co.	27.7	Charles Co. (continued)	
Census Tract 401	27.1	Census Tract 8509.02	25.4
Census Tract 402	26.4	Census Tract 8509.04	**29.6**
Census Tract 403	29.3	Census Tract 8509.05	28.1
Census Tract 404	28.9	Census Tract 8509.06	**29.2**
Census Tract 405	25.0	Census Tract 8510.01	18.2
Northumberland Co.	16.4	Census Tract 8510.02	25.2
Census Tract 201	**19.8**	Census Tract 8511	22.3
Census Tract 202	17.3	Census Tract 8512	21.7
Census Tract 203	13.3	Census Tract 8513.01	27.7
Census Tract 9901		Census Tract 8513.02	21.4
Westmoreland Co.	20.0	Census Tract 8514	24.3
Census Tract 101	18.4	Census Tract 8515	**29.4**
Census Tract 102	19.3	Census Tract 9900	
Census Tract 103	**23.6**	St. Mary's Co.	26.2
Census Tract 104	20.1	Census Tract 8750	26.4
Charles Co.	26.5	Census Tract 8751	25.1
Census Tract 8501.01	28.1	Census Tract 8752.01	27.6
Census Tract 8501.02	22.9	Census Tract 8752.02	26.8
Census Tract 8502.01	27.7	Census Tract 8753	19.7
Census Tract 8502.02	26.2	Census Tract 8754	27.6
Census Tract 8503	20.7	Census Tract 8755	**29.3**
Census Tract 8504	23.7	Census Tract 8756	26.4
Census Tract 8505	21.7	Census Tract 8757	24.3
Census Tract 8506	26.0	Census Tract 8758.01	**37.1**
Census Tract 8507.06	28.5	Census Tract 8758.02	24.4
Census Tract 8507.08	**29.3**	Census Tract 8759.01	27.9
Census Tract 8507.09	29.0	Census Tract 8759.02	**29.7**
Census Tract 8507.10	**30.7**	Census Tract 8760.01	**29.3**
Census Tract 8507.11	29.2	Census Tract 8760.02	28.0
Census Tract 8507.12	28.8	Census Tract 8761	23.8
Census Tract 8507.13	**29.2**	Census Tract 8762	17.6
Census Tract 8508.01	22.8	Census Tract 9900	
Census Tract 8508.02	24.4	Maryland	23.4
Census Tract 8509.01	**29.4**	Virginia	23.2

Note: Bold text indicates children under 18 population percentages of unusual concentrations of children.

Source: US Census Bureau, 2011c, Census 2010, DP-1 Profile of General Population and Housing Characteristics 2010.

Census Tracts with Environmental Justice Low-Income Populations



Census Tract

Low-Income Census Tract

County Boundary

Naval Support Facility Dahlgren

Potomac River Test Range (PRTR) Complex

4 0 4 Miles

6 0 6 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: US Census Bureau, 2012a, DP03 Selected Economic Characteristics 2010 5-year estimates.

Figure 3.2-3

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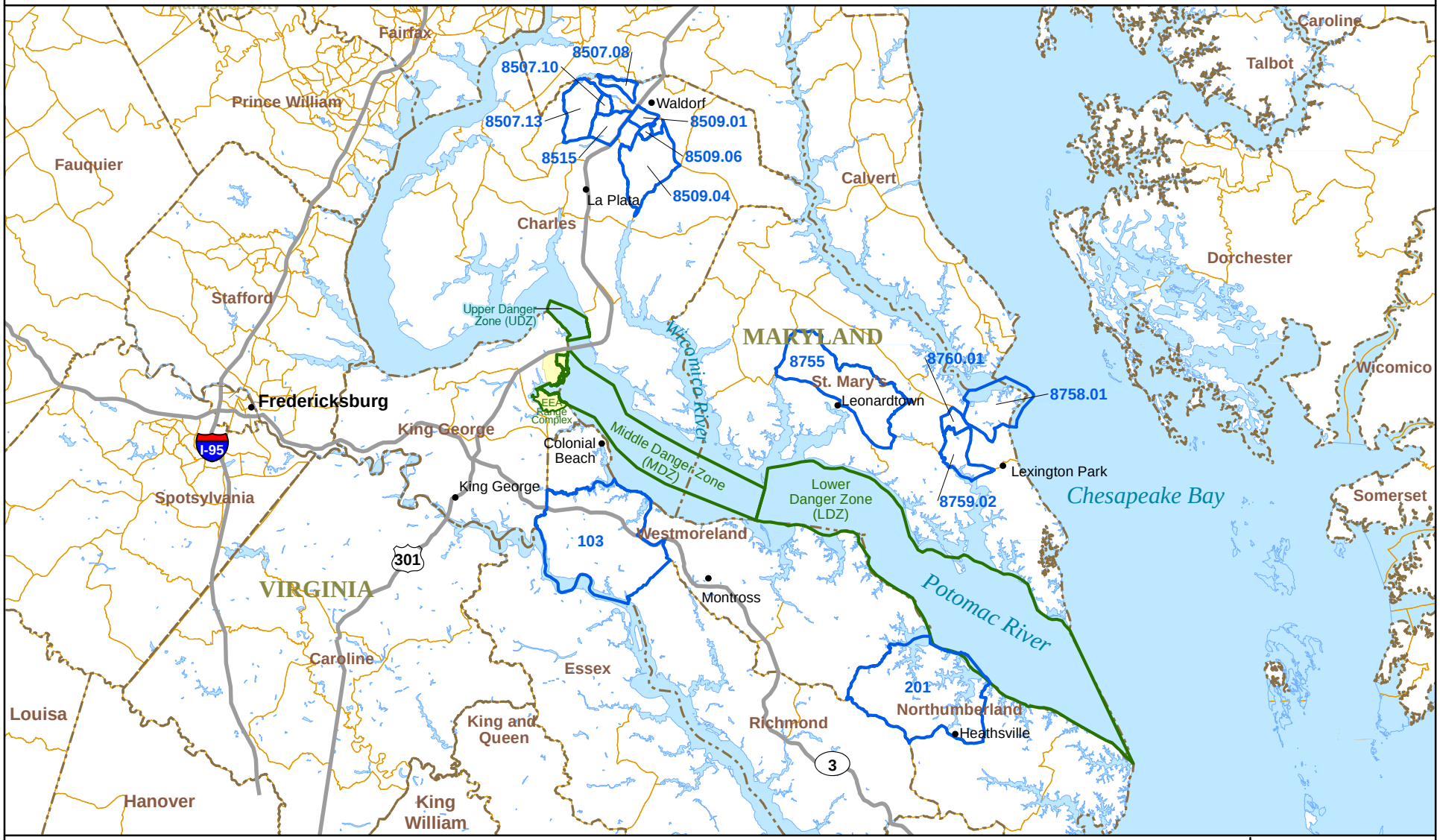
Census Tracts with Concentrations of Children



Census Tract

Unusual Concentration of Children Census Tract

County Boundary

Naval Support Facility Dahlgren

Potomac River Test Range (PRTR) Complex

4 0 4 Miles

6 0 6 Kilometers

N

NSWCDD EIS

Source: US Census Bureau, 2011c, DP-1 Profile of General Population and Housing Characteristics 2010.

Figure 3.2-4

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3.3 Utilities

NSF Dahlgren maintains and monitors the utility systems that support the installation and its tenants, including NSWCDD. In general, the current capacity of the utility systems is adequate to support the demand.

3.3.1 Electricity

Electrical power at NSF Dahlgren is provided by Dominion Virginia Power (DVP) via two 34.5-kilovolt (kV) feeders; the main substation is located near the Main Gate; from there, power is distributed through ten substations and switching stations. Four of the substations are 13.8-kV secondary, four substations are 4.16-kV secondary, and there are two 35-kV switching stations.

NSF Dahlgren's average annual electrical consumption for fiscal years 2005 through 2007 was approximately 110,500 megawatt-hours (MWH), with NSWCDD accounting for about 57,700 MWH, or 52 percent of the total (Prunty, pers. comm., March 5, 2008).

NSF Dahlgren, in conjunction with NSWCDD and its other tenants, conducted a study of electrical power needs and potential power supply alternatives to meet the growing demand for power on the installation (Naval Facilities Engineering Command [NAVFAC] Washington, 2010). The study concluded that the existing system is operating within its limits but is approaching the maximum rating.

DVP received approval on October 4, 2012 from the Virginia State Corporation Commission to build and operate a new 230 kV transmission line from DVP's 230 kV Birchwood-Northern Neck Line to a new substation at NSF Dahlgren (Dominion Virginia Power, 2011a, 2011b). This new infrastructure will meet long-term installation power demands and support the continued growth and economic development of King George County. The new infrastructure will also provide greater reliability and fewer service interruptions for the community. Construction is scheduled to begin in the spring of 2013 and finish in 2014.

3.3.2 Water and Wastewater

Three deep-water wells provide Mainside with drinking and domestic water. Dahlgren has a Community Permit for the Mainside water supply, issued by the Virginia Department of Health (VDH), with a maximum rated withdrawal capacity of 1.17 million gallons per day (gpd). The three wells can pump 385, 460, and 480 gallons per minute, respectively. Treatment consists of wellhead chlorination. Current storage capacity includes one 275,000-gallon (gal) ground-level storage tank with transfer pumps and four 100,000-gal elevated storage tanks (NSF Dahlgren and NAVFAC Washington, 2007).

The EEA water supply system is permitted as a Transient, Non-Community system by VDH. The maximum rated capacity is 31,200 gpd. Four service connections are tied to three storage tanks with a total capacity of 750 gals at the EEA (NSWCDL, 2006).

Wastewater on Mainside is collected and transported to a Navy-owned sewage treatment plant located at the southern end of Mainside via gravity sewers, force mains, lift stations, and pumping stations. There are approximately 50 miles of sewer distribution system lines and 40 pumping stations. The treatment plant discharges into Upper Machodoc Creek in accordance with a Virginia Pollutant Discharge Elimination System (VPDES) permit issued by VDEQ. NSF Dahlgren recently improved the treatment plant in compliance with VPDES General Permit requirements for total nitrogen and total phosphorus loading in treated effluent.

Domestic wastewater is treated using the following processes: dissolved-air flotation unit; first- and second-stage aeration basins set up for biological treatment removal; constructed wetland; ultraviolet-light disinfection system; re-aeration; and flow measurement. Under the permit, the wastewater effluent from the outfall at Upper Machodoc Creek is monitored periodically and the results are reported to VDEQ.

The treatment plant's permitted flow/average design flow is 0.72 million gpd. It can handle up to 1.4 million gpd on a short-term basis. However, highest average daily flows in the years from 2004 to 2006 were only 0.315 million gpd. Dewatered sludge is disposed of at the King George County landfill (NSWCDL, 2006 and NSF Dahlgren and NAVFAC Washington, 2007). Two buildings at the EEA – Buildings 9401 and 1105 – are served by septic systems.

Drinking and wastewater capacities are currently adequate to meet Dahlgren's needs. Between 2003 and 2007, average annual water usage at NSF Dahlgren was approximately 119 million gals, of which about 50 million gals, or 42 percent, were used by NSWCDD. Over the same period, an average of 124 million gals of wastewater was generated annually at NSF Dahlgren. Of these, about 52 million gals were produced by NSWCDD (Kelly, pers. comm., March 4, 2008).

3.3.3 Other Utilities

Dahlgren does not have a central heating plant (NSWCDL, 2006). There are separate fuel-fired heating systems that serve groups of buildings, while other buildings and on-base houses have their own boiler or electrical heat-pump heating and cooling systems.

Verizon provides telephone service. The network communication system is installed and maintained on-site.

Stormwater management is described in Section 3.7.3.4.

There is no natural gas service on the installation.

3.4 Air Quality

Air quality can be affected by air pollutants produced by: mobile sources, such as vehicular traffic, aircraft, and nonroad equipment; fixed or immobile facilities, referred to as stationary sources, such as industrial exhaust stacks and vents that are connected to boilers and generators; and other sources.

3.4.1 National Ambient Air Quality Standards

The US Environmental Protection Agency (USEPA), under the requirements of the 1970 Clean Air Act (CAA) as amended in 1977 and 1990, has established National Ambient Air Quality Standards (NAAQS) for six contaminants, referred to as criteria pollutants (40 CFR Part 50). These are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter with diameters up to 10 µm and up to 2.5 µm (PM_{10} and $PM_{2.5}$), lead (Pb), and sulfur dioxide (SO_2). The NAAQS include primary and secondary standards and are summarized in Table 3.4-1. The primary standards were established at levels sufficient to protect public health with an adequate margin of safety. The secondary standards were established to protect the public welfare from the adverse effects associated with pollutants in the ambient air, such as damage to plants and ecosystems.

Areas that meet the NAAQS for a criteria pollutant are designated as being "in attainment." Areas where the criteria pollutant level exceeds the NAAQS are designated as "nonattainment." Based on the severity of the pollution problem, O_3 nonattainment areas are further classified as basic (formerly attainment for the revoked 1-hour O_3 NAAQS), marginal, moderate, serious, severe, or extreme. CO and PM_{10} nonattainment areas are classified as either moderate or serious. A maintenance area is an area that has been redesignated as an attainment area from a former nonattainment area. However, during the maintenance period, most of the CAA rules for a nonattainment area are still applicable to a maintenance area.

NSF Dahlgren is located in King George County, an area currently designated as being in attainment for all criteria pollutants. A portion of the PRTR's MDZ is located within Charles County, Maryland, an area designated as an ozone nonattainment area. The USEPA has published final rules on General Conformity (40 CFR Parts 51 and 93) that require federal agencies to ensure that their actions conform to the State Implementation Plan (SIP) in a nonattainment area. The SIP is the document which sets forth the state's strategies for achieving air quality standards. Conformity to a SIP, as defined in the CAA, means conformity to a SIP's purpose of reducing the severity and number of violations of the NAAQS to achieve attainment of these standards. The federal agency responsible for an action is required to determine if its action conforms to the applicable SIP. Since NSF Dahlgren is located in an attainment area, the conformity rule does not apply to the Proposed Action, except for those activities with the potential to occur in the MDZ within the Charles County boundary, such as aircraft and/or vessel operations. As aircraft and/or vessel operations within the MDZ would essentially remain at the same level under the Proposed Action as compared to existing conditions, there would be no foreseeable increase in emissions from these activities in the Charles County ozone nonattainment area. Consequently, the general conformity rule does not apply to the Proposed Action within this nonattainment area since no change in emissions would occur.

Table 3.4-1
Virginia and National Ambient Air Quality Standards for Criteria Pollutants

Pollutant and Averaging Time	NAAQS	
	Primary Standard[1]	Secondary Standard[1]
Carbon Monoxide		
8-Hour Maximum	9 ppm[3]	none
1-Hour Maximum	35 ppm[3]	none
Nitrogen Dioxide		
Annual Arithmetic Mean	100[2]	100
Ozone		
8-Hour Average	0.075 ppm[4]	0.075 ppm
Particulate Matter[8]		
PM_{10}		
24-Hour Average	150[5]	150
$PM_{2.5}$		
Annual Arithmetic Mean (over 3 years)	15[2]	15
24-Hour Average	35[6]	35
Lead		
Quarterly Arithmetic Mean	1.5[7]	1.5
Sulfur Dioxide		
Annual Arithmetic Mean	80[2]	---
24-Hour Maximum	365[3]	---
3-Hour Maximum	---	1300[3]

Notes:
1. All concentrations in micrograms per cubic meter of air (µg/m3) or, except where noted, in parts per million (ppm).
2. Not to be exceeded during any calendar year.
3. Not to be exceeded more than once a year.
4. Standard attained when 3-year average of annual 4th-highest daily maximum 8-hour concentration is below the level.
5. Standard attained when exceedance occurred no more than once per year over 3 years.
6. Standard attained when the annual highest 98th percentile of 24-hour concentration over 3 years is below the level.
7. The quarterly lead standard is not to be exceeded during any calendar quarter.
8. PM_{10} - particulate matter diameter of 10 microns or less; $PM_{2.5}$ - particulate matter diameter of 2.5 microns or less.

Sources: 40 CFR 50 and 9 VAC 5 Chapter 30 (8/1/07).

3.4.2 Greenhouse Gas Emissions and Climate Change

In addition to the criteria pollutants discussed above, greenhouse gases are compounds that contribute to the greenhouse gas effect. The greenhouse gas effect is the process by which certain gases in the atmosphere allow long-wave radiation in, but also keep short-wave radiation from escaping, which then warms the planet's lower atmosphere and surface. Greenhouse gases are transparent to long-wave radiation from the sun; this radiation passes through the atmosphere without being absorbed or reflected, and warms the earth’s surface. Greenhouse gases trap short-wave (infrared) radiation emitted by the earth’s surface, however, preventing it from dissipating into space and causing it to re-radiate down to the surface of the earth.

The primary long-lived greenhouse gases directly emitted by human activities are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Human-induced increases in these gases are the primary cause of the global warming observed over the last 50 years (Karl et al., 2009). Predictions of long-term negative environmental impacts due to global warming include sea level rise; changes in ocean pH (potential of hydrogen, a measure of acidity or alkalinity) and salinity; changing weather patterns with increases in the severity of storms and droughts; changes to local and regional ecosystems (including the potential loss of species); shrinking glaciers and sea ice; thawing permafrost; a longer growing season; and shifts in plant and animal ranges. The USEPA Administrator has recognized potential risks to public health or welfare and signed an endangerment finding regarding greenhouse gases under Section 202(a) of the CAA (74 Federal Register 66496; USEPA, 2009a), which finds that the current and projected concentrations of the six key well-mixed greenhouse gases – CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 – in the atmosphere threaten the public health and welfare of current and future generations.

To estimate total greenhouse gas emissions, each greenhouse gas is assigned a global warming potential; that is, the ability of a gas or aerosol to trap heat in the atmosphere. The global warming potential rating system is standardized to CO_2, which is the dominant greenhouse gas both from natural processes and human activities, and is assigned a global warming potential equal to one. To simplify greenhouse gas analyses, total greenhouse gas emissions from a source are often expressed as equivalent emissions of CO_2, or CO_2 equivalents. The CO_2 equivalents is calculated by multiplying the emissions of each greenhouse gas by its global warming potential and adding the results together to produce a single, combined emission rate representing all greenhouse gases.

Federal agencies address greenhouse gases by reporting and meeting reductions mandated in federal laws, executive orders (EOs), and policies. Most recently, EO 13423, *Strengthening Federal Environmental, Energy, and Transportation Management* (72 Federal Register 3919), and EO 13514, *Federal Leadership in Environmental, Energy, and Economic Performance* (74 Federal Register 52117), were enacted to address greenhouse gases, including greenhouse gas inventory, reduction, and reporting. In October 2009, USEPA issued its final rule on mandatory reporting of greenhouse gases (74 Federal Register 56260; USEPA, 2009b) that requires reporting by all stationary facilities that release annual emissions of 25,000 metric tons CO_2 equivalents.

3.4.3 Stationary and Mobile Sources

Criteria Pollutants

The majority of federal and state air quality regulations apply to stationary emission sources, which in Virginia are regulated by the VDEQ Division of Air Quality. NSF Dahlgren has a number of stationary fuel tanks, boilers, and generators that are permitted emission sources. NSF Dahlgren also has a number of VDEQ-permitted mobile sources, including diesel and gasoline generators and mobile fuel tanks.

Based on the type of pollutants emitted – criteria pollutants or hazardous air pollutants (HAPs) – the CAA sets forth permit rules and emission standards for sources of certain sizes. The New

Source Performance Standards apply to sources emitting criteria pollutants, while the National Emission Standards for Hazardous Air Pollutants apply to sources emitting HAPs. The USEPA oversees programs for stationary-source operating permits (Title V) for new or modified major stationary-source construction and operation. NSF Dahlgren maintains a VDEQ synthetic minor operating permit. The air emissions inventory conducted in the early 1990s did not indicate a requirement for a Title V Permit or monitoring.

NSF Dahlgren is not a major source for any criteria or hazardous air pollutants. Because NSF Dahlgren's annual emissions levels do not exceed the Title V major source threshold of 100 tons per year of any criteria pollutants, the installation is operating under a state synthetic minor operating permit (Registration No. 40307) instead of a major-source Title V permit. As part of the state operating permit requirements, the installation updates the Emissions Statement on an annual basis. VDEQ reviews permitted sources on-site every two years. The most recent on-base annual emissions from stationary sources as reported in the 2011 Emissions Statement are summarized in Table 3.4-2, which also includes the emissions of nitrogen oxides (NO_x) and volatile organic compound (VOC) as ozone precursors.

Table 3.4-2
NSF Dahlgren 2011 Annual Emissions Statement

Installation Total Emissions (tons/year)					
SO_2	CO	PM_{10}	$PM_{2.5}$	NO_x	VOC
33.62	11.37	2.16	2.16	52.24	2.15

Source: NSF Dahlgren, 2012.

Greenhouse Gas Emissions

In accordance with the USEPA final rule on mandatory reporting of greenhouse gases, in 2009, NSF Dahlgren estimated the facility-wide total greenhouse gas emissions. Based on gasoline, fuel oil, and propane use, NSF Dahlgren estimated that in 2008 the facility generated a total of 9,702 metric tons of CO_2 equivalents, which is well below the reporting threshold of 25,000 metric tons CO_2 equivalents.

The potential effects of proposed greenhouse gas emissions are by nature global and may result in cumulative impacts, as individual sources of greenhouse gas emissions are not large enough to have any noticeable effect on climate change. Therefore, the impact of proposed greenhouse gas emissions to climate change is discussed in the context of cumulative impacts in Chapter 5.

3.4.4 Other Sources

NSWCDD's RDT&E operations have included releasing chemical simulants to test infrared-sensor chemical-agent detectors outdoors on the PRTR, as described in Chapters 1 and 2. Sensors have been tested by challenging them with a carefully-controlled cloud of chemical simulants released over the water. The simulants used absorb infrared radiation at wavelengths similar to the wavelengths absorbed by chemical warfare agents. Simulants used in operations in

2003, 2005, and 2009 included triethyl phosphate (TEP), glacial acetic acid (GAA), methyl salicylate (MeS), and 1,1,1,2-tetrafluoroethane (R-134) and 1,1-difluoroethane (R-152a), and/or SF_6 were used to calibrate the sensors. Because SF_6 is on USEPA's Greenhouse Gas Action List, its use is being phased out and NSWCDD is unlikely to use it in the future.

All chemical simulants previously used and proposed for future use are not considered criteria pollutants under the CAA and are not hazardous air pollutants. All simulants tested or proposed for use have low toxicity to humans and the environment. NSWCDD uses an air dispersion/deposition model to estimate the potential levels of downwind concentrations that would be generated, as well as the amount of each simulant that would be deposited on the water's surface prior to testing. The analysis uses the DoD-approved Vapor, Liquid, and Solid Tracking Model (VLSTRACK: Version 3.1.1) to calculate the concentration and deposition levels resulting from the testing under various release scenarios.

Since these chemicals have low toxicity and no established ambient air quality standards, the exposure guidelines established by the National Institute for Occupational Safety and Health (NIOSH) for protecting workers have been used as a basis for assessing effects (NSWCDL, 2002). Concentration levels modeled in 2002 for each simulant were within available NIOSH guidelines, and there were no potential air quality effects from releasing these chemicals during testing (NSWCDL, 2002).

Additional modeling and testing performed in 2003, 2005, and 2009 showed no significant impacts from the testing of chemical simulants. There were no observable environmental effects during or after testing (Bossart, letter, February 9, 2006; NSWCDL, 2004; NSWCDL, 2005; NSWCDL, 2009).

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3.5 Noise

3.5.1 Noise Fundamentals

Noise is definable as unwanted sound. Noise comes from numerous sources. Some noise is caused by activities essential to the health, safety, and welfare of a community (e.g., emergency vehicle sirens, garbage-collection operations, and construction and maintenance equipment). Other noise, such as traffic or aircraft noise, stems from the movement of people and goods. Although these and other similar activities are necessary to modern life, the noise they produce is sometimes undesirable and may detract from the quality of the living environment.

Noise can also be commonplace in areas near military installations. Military operations are often the sources of sounds (e.g., gunfire, detonations, aircraft flyovers, transport of heavy vehicles, etc.) that are experienced by the military community and the civilians who live and work around these installations.

The loudest sounds the human ear can hear comfortably have one trillion (1,000,000,000,000) times the acoustic energy of sounds the ear can barely detect. Because of this vast range, any attempt to represent the intensity of sound using a linear scale quickly becomes unwieldy. As a result, a logarithmic unit called the decibel (dB) is used to represent the intensity of sound.

In basic terms, sound as perceived by the ear is created by rapid changes in air pressure relative to ambient air pressure. For instance, an audio speaker in a car radio creates sounds by rapidly moving a speaker cone back and forth to create sound. The speaker cone moves back and forth rapidly to create high-frequency sounds, and more slowly to create low-frequency sounds. The ear drums of a person sitting in the car are also moving back and forth because of the higher and lower air pressure levels – or sound pressure levels – caused by the speaker cone relative to the ambient air pressure. This movement of the ear drum creates what is perceived as “sound.”

Turning up the speaker volume does not change the frequencies of the sound – the speaker cone is still moving back and forth fast or slow to create the same higher or lower sound frequencies – but the music is louder because the speaker cone moves farther back and farther forth each time it travels.

By moving farther out or in, the speaker cone exerts more energy, thereby creating greater differences in pressure to the ambient air. A “blown” speaker is caused by applying too much volume, forcing the speaker to push air with so much force that it ruptures. Sound pressure levels are greatest at the source and decrease as one gets farther from the source; they are also influenced by environmental conditions. When a person is too close to the source of loud sound – such as sitting in a car with the volume turned excessively high for long periods of time – damage to the ear can occur.

In more technical terms, air pressure is the force experienced by an object divided by the area on which the force acts. The typical unit of measurement used to evaluate air pressure, for instance when filling an automobile tire to proper pressure is pounds per square inch (psi). However, when dealing with sound pressure levels, an international unit is what is commonly used. This unit is the Pascal (Pa), named after Blaise Pascal, a 17th-century French mathematician and physicist. One (1) psi is equal to 6,890 Pa. To capture the intensity of sound levels meaningfully over such a large range as that which the human ear can experience, the logarithmic dB is used;

this unit expresses the ratio of sound pressure to a reference standard. Specifically, the sound pressure level in dB is defined as 20 times the common logarithm of the ratio of sound pressure in Pa to the reference pressure (0.00002 Pa). Some typical levels of sound in dB are shown in Table 3.5-1.

Table 3.5-1
Typical Sound Levels

Source of Sound	Sound Pressure Level dB re 20 μPa
M1 Garand Rifle being fired at 1 m	168 dB
Jet engine at 30 m	150 dB
Rifle being fired at 1 m	140 dB
Threshold of pain	130 dB
Jackhammer at 1 m	approx. 100 dB
Major road at 10 m	80-90 dB
Normal conversation at 1 m	40-60 dB
Very calm room	20-30 dB
Leaves rustling; calm breathing	10 dB
Auditory threshold at 1kHz	0 dB
Source: Wikipedia (2010)	

3.5.1.1 Noise Frequency and Time Weighting

A number of factors affect sound as the human ear perceives it. These include the actual level of noise, the frequencies involved, the period of exposure to the noise, and changes or fluctuations in noise levels during exposure. In order to correlate the frequency characteristics from typical noise sources to the perception of the human ear, several frequency networks (systems of measuring units) have been developed. The most common noise frequency-weighting networks include the following, with examples relevant to this EIS:

- **A-weighted Scale** – The human ear cannot perceive all pitches or frequencies equally well. Reflecting this fact, measures can be adjusted, or weighted, to compensate for the human lack of sensitivity to low-pitched and high-pitched sounds. This adjusted measurement unit is known as the A-weighted decibel, or dBA. The dBA is used to evaluate noise from transportation activities (traffic and aircraft) and from small-arms firing. It is commonly expressed as an A-weighted sound exposure level (SEL).
- **C-weighted Scale** – The C-weighted scale measures more of the low-frequency components of noise than does the A-weighted scale. This unit, symbolized as dBC, is used for evaluating impulse noise and vibrations generated by heavy weapons such as artillery, mortars, armor (20 millimeters [mm] or greater) and explosive charges. C-weighted noise levels are often expressed as a C-weighted SEL (CSEL).
- **Peak Sound Level** – The peak sound level (dBP) is a flat-weighted scale that can be used to measure noise from small-arms (less than or equal to 20 mm) firing, heavy artillery, and explosives.
- **Day-Night Sound Level** – The day-night average sound level (DNL) is useful to account for the difference in response to noises that occur during sleeping hours as compared to

waking hours. This indicator is defined as the average sound level in decibels during a 24-hour period, with a 10-dB weighting (penalty) applied to nighttime sound levels. The 10-dB nighttime weighting accounts for the fact that noises at night sound louder because there are usually fewer noises occurring at that time.

Note that noise levels in one scale cannot be added or compared mathematically to levels in another scale.

3.5.1.2 Noise Metrics

Another factor that is relevant to the characterization and analysis of noise is whether the noise is continuous or impulse. Sources of continuous noise include highways, construction sites, and urban environments with heavy traffic and large airports. Impulse noise consists of almost instantaneous (thus impulse-like) sharp sounds, such as clicks, pops, and bangs. Sources of impulse noise include ordnance explosions and gun firing. Ambient noise conditions around NSF Dahlgren are influenced by the impulse noise from detonations at the EEA Complex, gun firing in the PRTR Complex ranges, and, to some extent, by the noise of military aircraft both on and off the installation.

Continuous noise is fundamentally different from impulse noise and noise threshold criteria for the two types differ. For example, permanent damage to unprotected ears due to continuous noise occurs at approximately 85 dB with an eight-hour-per-day exposure while the threshold for permanent damage to unprotected ears due to impulse noise is approximately 140 dB peak noise, with 100 exposures per day (Pater, 1976).

Given the difference between continuous and impulse noise, the variations in frequency and period of noise exposure, and the fact that the human ear cannot perceive all pitches and frequencies equally well, noise from military activities is measured using two different noise metrics that reflect the different noise characteristics: the DNL and the dBP. The DNL metric is normally used for evaluating cumulative effects from both continuous (e.g., aircraft noise) and impulse (e.g., gun firing) noise sources. The dBP metric is used to assess peak event noise from impulse noise sources such as gun firing.

3.5.2 Department of Defense Guidelines on Noise

The Department of Defense (DoD), including the Navy and the Army, has developed guidelines to define, identify, and assess noise impacts. DoD uses a widely-accepted metric – DNL – to measure noise. The DNL metric is recommended by USEPA and is used by most federal agencies, including DoD, the US Department of Transportation (USDOT), and the US Department of Housing and Urban Development (USHUD). DNL is the primary descriptor for evaluating military noise.

In addition to the DNL metric, the Army has developed weapons-noise guidelines for DoD facilities to describe the type of single-event peak impulse noise generated by the large-caliber weapons and explosives it commonly uses (United States Army Center for Health Prevention and Preventive Medicine [USACHPPM], 2005). Historically, the Navy has used the Army's guidelines to assess impulse-noise impacts in NEPA documents.

Both DoD's DNL guidelines and the Army's peak noise guidelines have been used to evaluate the existing noise environment at and around NSF Dahlgren under existing conditions and the three alternatives evaluated in this EIS. They are described in more detail below.

3.5.2.1 DNL Guidelines

Navy

The Navy has established the Range Air Installations Compatible Use Zones program (US Navy, 2008) to protect public health, safety, and welfare, and prevent encroachment from degrading the operational capability of air-to-ground ranges. The Range Air Installations Compatible Use Zones program includes range safety and noise analyses, and provides land use recommendations that aim to ensure compatibility with range safety zones (i.e., areas of varying levels of safety concerns due to potential weapons impact) and noise levels associated with the range activities. The Navy has defined three noise zones based on the A-weighted DNL (ADNL) metric and provides general action to be considered with respect to land use compatibility within these noise zones (Table 3.5-2).

Table 3.5-2
Navy Land Use Compatible Guidelines

Noise Zone	ADNL (dBA)	Land Use Compatibility
I	< 65	An area of minimal impact where sound attenuation is not needed.
II	65 – 75	An area of moderate impact where some land use noise controls are needed.
III	75 or above	The most severely impacted area, where the greatest degree of land use noise controls is needed.
Source: US Navy, 2008, OPNAVINST 3550.1A.		

The Navy guidance also provides for the use of the DoD's Blast Noise Prediction (BNOISE) program to establish ordnance blast-noise contours. As discussed below, BNOISE has been used when preparing this EIS to predict the C-weighted DNLs (CDNLs) for large-caliber gun firing and explosive-detonation noise.

Army

As explained above, DNL measurements are "weighted" to reflect what people may actually hear (A-weighting). In a similar way, intense, low-frequency noise that can cause vibration is weighted to what people may actually feel (C-weighting). Relating CDNL values (in dBC) to ADNL values (in dBA) for similar annoyance responses makes it possible to correlate a high-energy impulse-noise CDNL environment with an "equivalent" ADNL environment. For example, a CDNL of 62 dBC can be equated to an ADNL of 65 dBA, and a CDNL of 70 dBC can be equated to an ADNL of 75 dBA. The CDNL metric is commonly used for evaluating heavy-weapon noise (20 mm gun and greater) and it is applicable to NSWCDD, given the type of weapons tests conducted.

Table 3.5-3 shows the Army's land use planning guidelines with respect to military noise, including the correlated CDNL guidelines for impulse noise. The table shows the permissible levels for three types of military noise within three land use planning noise zones that are used for assessing land use compatibility.

Table 3.5-3
Army Land Use Planning Guidelines

Noise Zone	Aviation ADNL (dBA)	Impulse CDNL (dBC)	Small Arms PK15 (dBP)
I	<65	<62	<87
II	65-75	62-70	87-104
III	>75	>70	>104

Notes: ADNL – A-weighted Day-Night Levels.
CDNL – C-weighted Day-Night Levels.
N/A – Not Applicable.
Source: USACHPPM, 2005.

Noise-sensitive land uses typically include residential areas, schools, hospitals, and churches. It should be noted that the potential for annoyance from noise does not equate to the potential for a significant noise impact.

In accordance with Army guidance applicable to a typical military installation, an average of 250 (not 365) annual operation days was assumed in NSWCDD's DNL existing conditions analyses.

3.5.2.2 Peak Impulse Noise (dBP) Metrics and Guidelines

There are many reasons why people complain about gun-firing noise. Some individuals seem to be more physiologically reactive to intrusive sounds than others. Another variable is the degree of buffering provided by a building. For example, somebody living in a solid brick house with sealed windows would not experience the rattling that someone living in a wood-frame house with loose sashes would experience. This interaction of personal variables and building construction complicates the prediction and minimization of gunfire-related complaints.

People who complain about gun sounds tend to mind the most intense events. A straightforward way to measure the most intense events is using the peak sound pressure level (PK). In 1976, NSWCDD engineers and scientists published a method to predict whether people would complain about weapons testing (Pater, 1976). How peak noise level and complaints are correlated under this method is shown in Table 3.5-4. The guidelines developed by NSWCDD have proved useful in predicting complaints at the Aberdeen Proving Ground in Aberdeen, Maryland. As documented by Luz and Eastridge (Luz and Eastridge, 2001, as cited in USCHPPM, 2005), most complaints at Aberdeen Proving Ground are associated with peak levels between 115 and 130 dBP. These same guidelines have since been used in weapon-noise impact studies at many installations.

The PK 50 metric can also be used to define noise contours. This metric indicates that a specific noise peak level may occur with a 50 percent probability, meaning that half of the time a particular noise-generating event (such as firing a gun) will create a peak noise above this level and half the time below this level; therefore, it is comparable to a mean peak noise level.

Table 3.5-4
Peak Impulse Noise Guidelines

Sound Level (dBP)	Risk of Complaints	Recommended Action
<115	Low	Fire all programs.
115-130	Moderate	Fire important tests; postpone non-critical testing, if feasible.
130-140	High, and possibility of damage	Only extremely important tests should be fired.
>140	Threshold for permanent physiological damage to unprotected ears - High risk of physiological and structural-damage claims	Postpone all tests.

Source: USACHPPM, 2005.

Based on a comparison with the maximum PK noise measurements conducted in 2007 as well as the most recent 2010 measurements at nine sites around NSF Dahlgren and along the PRTR MDZ that correlate to specific gun-firing events, the noise analysis in this EIS presents predicted (modeled) noise conditions – in the next section for existing conditions and in Section 4.5 for all alternatives – using the PK50 contours that best approximate the reception of PK noise conditions around NSF Dahlgren (see Section 3.5.4).

3.5.3 Existing Noise Conditions

Ambient background noise levels in the vicinity of NSF Dahlgren are typical of a rural or semi-rural environment. The area is relatively quiet, but aircraft flying overhead, boats traveling on the river, and vehicular traffic on US Route 301 add noise intermittently.

3.5.3.1 Noise Sources

NSWCDD generates two types of noise that add to ambient noise levels:

1. **Ordnance tests** – Impulse noise from small-arms firing, large-caliber-gun firing, and explosive detonations on the EEA and PRTR range complexes.
2. **Aircraft flights** – Continuous noise from helicopters using the NSF Dahlgren airfield, aircraft brought from other airfields to be used in tests, and unmanned aerial vehicles (UAVs) launched from the land ranges of the PRTR Complex and the EEA Complex and flown within the special-use airspace (SUA).

3.5.3.2 Continuous Noise from Aircraft/Helicopter Activities

Since NSF Dahlgren's active runway has been closed to fixed-wing aircraft activities since 2007, the airfield currently provides only helicopter flight services from and to nearby military bases.

As discussed previously, the DNL metric is the most frequently used metric for aircraft-related noise. It represents the total sound exposure averaged over a period of 24 hours in an average operational day, with a weighting reflecting the greater sensitivity to noise during night-time hours. While DNLs for ambient noise conditions have not been modeled around the airfield, the frequency of flight operations for helicopters is very low – at most, ten flights a month. Such a

small number of flights would not generate DNLs of 65 dBA or higher in residential areas either on or off the installation.

3.5.3.3 Noise from UAV Activities

UAVs are used for a number of different activities, as described in Section 1.6.3. They are launched manually from anywhere on the PRTR land ranges or take off from one of two UAV runways on the Terminal Range and the EEA's Churchill Range, respectively (see Figure 1-12). They must remain within the SUA and usually fly at an altitude of between 2,000 and 3,000 ft above the PRTR Complex. When they fly near the ground, such as during takeoff and landing, the largest size UAV NSWCDD uses generate noise levels of approximately 80 dBA, which is similar to the noise from a passing heavy-duty truck. Therefore, the noise from UAV flight events is considered negligible.

3.5.3.4 Impulse Noise from Range Test Activities

Impulse noise at NSF Dahlgren is generated by large-caliber-gun and small-arms firing on the PRTR Complex land ranges and explosive detonations on the EEA Complex ranges.

Bow Shock

A large-amplitude compression wave that occurs in front of an object that moves faster than sound.

Large-caliber firing includes both explosive (live) and non-explosive (inert, also known as blind load and plug) projectiles. When a large-caliber live projectile is fired, there is impulse noise both when the gun is fired and when the projectile explodes/detonates at the target area; there is also bow-shock noise from the projectile. The firing of an inert projectile does not create an explosion when the projectile hits the target; only the firing of the gun creates an impulse noise, with the addition of bow shock noise from the projectile.

To ensure conservative results, the analysis of existing noise conditions presented in this chapter was developed using the annual average numbers of events that occur during particularly active years (see Section 1.5.1) namely:

- 4,700 projectiles fired from large-caliber guns
- 190 detonation events at the EEA Range Complex
- 6,000 bullets fired from small-caliber guns

In late 2006, NSWCDD installed and began testing a new type of weapon – a 32-megajoule (MJ) electromagnetic (EM) launcher. Rather than using explosives to propel projectiles, the EM launcher uses EM energy. Ultimately, EM launchers will fire projectiles that can reach speeds of more than seven times the speed of sound (outdoor testing at high speeds would take place on other ranges than NSWCDD's). Since being installed, EM launchers, located on the Missile Test Range, have been firing at progressively higher muzzle energy levels into a backstop; since October 2008, they have been firing in an open-air trajectory control structure that guides inert projectiles into a terminal catch chamber. In February 2009, EM launchers were fired at levels of around 16 MJ of muzzle energy. As part of the Proposed Action, EM launchers would operate over land and over water. Over land impacts are addressed in a separate NEPA document (NSWCDL, 2009). EM launchers would not fire projectiles at speeds faster than other projectiles fired at Dahlgren either over land or over water. When firing at speeds equivalent to existing

guns, EM launchers are considered to have the same impacts as other guns used and are included as an additional component of the baseline activities in Chapter 2. Therefore, EM launcher noise is included in the existing baseline conditions presented here.

3.5.3.5 Noise Management Process

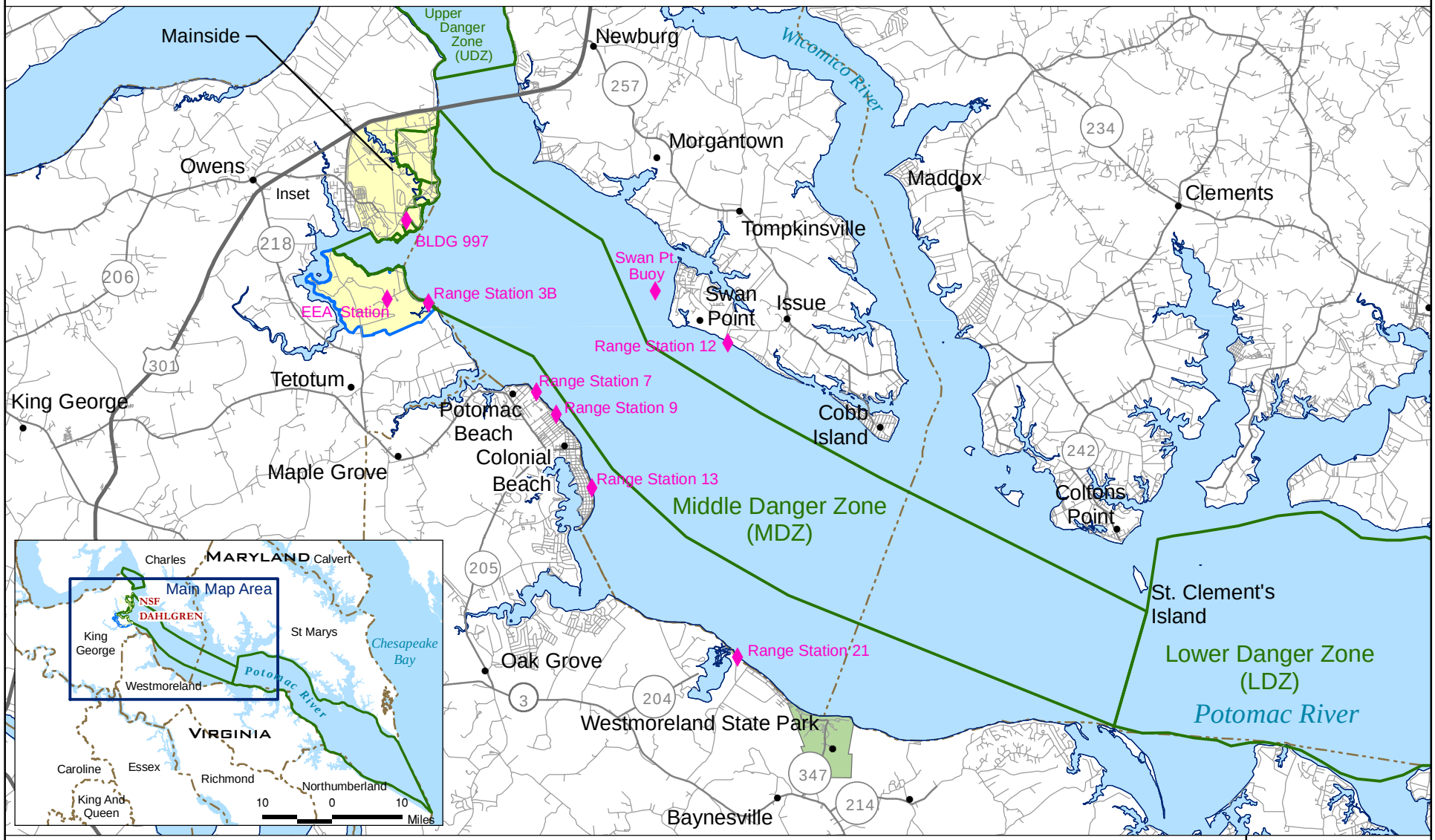
NSWCDD has developed and implemented a noise management process to monitor and control noise from its outdoor RDT&E activities (NSWCDL, 2011). As part of this process, NSWCDD uses a state-of-the-art Sound Intensity Prediction System (SIPS) to predict noise impacts to sensitive surface areas prior to gun firing and open detonation events. The SIPS computer model takes into account the amount of sound energy that would be released by the test, the landscape of the area, and current weather conditions, which strongly influence how sound is distributed over a particular area. SIPS, which has been used by NSWCDD since 1975, is recognized nationally as a valuable tool for the prediction of noise propagation, and has been deployed at other DoD heavy-weapons test sites.

In addition to using SIPS, procedures are in place to track, predict, and minimize noise effects, as follows:

- **Scheduling** – Whenever possible, gun-firing activities are conducted during normal business hours – Monday through Friday from 8 am to 5 pm. Because of the time it takes to set up tests in the morning, most gun firing gets underway around 9 to 10 am and then tails off after 3 to 4 pm.
- **Public Relations** – The Public Affairs Office (PAO) closely monitors and records any complaints involving noise and vibration. Naval Surface Warfare Center, Dahlgren Division maintains a website that provides: the Range Schedule; a toll-free Range/Weapons Testing hotline for daily information on range activities and test schedules; a toll-free number for noise comments and questions; and the local number for the NSWCDD PAO. In addition, the NSF Dahlgren PAO maintains a list of citizens who have requested notification when predicted noise levels will be greater than normal.
- **Ambient Peak-Noise Measurements –** Nine noise-measurement sites (Figure 3.5-1, Peak Noise Measurement Locations) are located around NSF Dahlgren and along the PRTR MDZ to monitor peak-noise levels during gun-firing and explosive-test events. Sound meters have been placed at these locations to monitor actual noise levels during ordnance events, provide feedback for improving the SIPS prediction model, and determine whether noise levels are acceptable at critical areas to continue the event. Handheld meters are also used to monitor noise when a potentially affected area does not have a previously-installed sound meter.

The NWSCDL noise management process manual (NSWCDL, 2011) includes an ordnance event decision process that determines whether or not an event may take place. This process is summarized in the text box on the following page.

Peak Noise Measurement Locations



Potomac River Test Range (PRTR) Complex

Explosives Experimental Area (EEA) Range Complex

Naval Support Facility (NSF) Dahlgren

County Boundary

Noise Monitoring Location

3 0 3 Miles

5 0 5 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS 2008

Figure 3.5-1

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Ordnance Event Decision Process

1. **Event Assessment**: To decide whether or not to proceed with an event given the potential noise impact, a SIPS analysis is required when one or more of the following conditions apply:
   - Gunfire:
     - Single shot (or single shots) from a 5" or larger gun
     - Live rounds with a caliber great than or equal to 57 mm
     - Rapid fire from a 76 mm or larger gun
   - Open detonation:
     - NEW of 30 or more (if the NEW for an Explosive Hazardous Waste [EHW] treatment exceeds 200 lbs, the ordnance will be earth-covered prior to treatment and SIPS is not required).

   Other noise-generating RDT&E will be evaluated on a case-by-case basis; for example, EM launcher operations do not require SIPS analysis. The event may proceed without SIPS analysis if the conditions provided above do not apply.

2. **SIPS Analysis:** If SIPS analysis is required, the decision to proceed with an event depends on the predicted sound intensity at critical surface areas:
   - If the sound intensity is predicted to be less than 130 dBP, then the event may proceed.
   - If the predicted sound intensity is greater than or equal to 130 dBP, then the event is postponed.

3. **Event Proceeds:** When proceeding with any ordnance event, actual noise levels will be monitored and recorded throughout the event:
   - For safety reasons, an open detonation will proceed to completion.
   - A gunfire event is dependent on actual sound meter data collected at critical surface areas for each shot or five rapid fire rounds:
     - If the actual measured noise level is less than 135 dBP, then the event will continue.
     - If the actual measured noise level is greater than or equal to 135 dBP and less than 140 dBP, the gun will fire one more round or 5 more rapid fire rounds, if necessary (the operation may be complete). Upon firing this round:
       - If the resulting actual noise level is greater than or equal to 135 dBP, the event will be postponed.
       - If the resulting actual noise level is less than 135 dBP, the event will continue.
     - If the actual noise level meets or exceeds 140 dBP, the event will either be cancelled or delayed until more favorable conditions—as demonstrated by SIPS predictions—are available.

   EM launcher RDT&E operations will continue if the actual measured noise level at the Montana shelter (on the installation) remains below 140 dBP and the actual measured noise level at the Swan Point buoy (see Figure 3.5-1) is less than or equal to 135 dBP. Otherwise, operations will be postponed for the remainder of the day. If the measured noise level at the Montana shelter exceeds 140 dBP, but the level at the Swan Point buoy does not exceed 135 dBP, a waiver may be granted, allowing the operation to continue.

   Other noise-generating RDT&E operations will continue if the actual measured noise level remains below 135 dBP. Otherwise, these operations will be postponed.

4. **Event Postponed:** When an event is postponed, additional SIPS analysis may be conducted until more favorable conditions are available. Otherwise, the Division Head is notified. The Division Head will either concur with the decision to postpone the event or will grant a waiver to allow the event to continue. Waivers may be granted when an event is critical; however, they cannot be applied if SIPS predictions or actual noise measurements at sensitive surface areas meet or exceed 140 dBP.

   In the event of a waiver, the following actions are taken:
   - The waiver is documented: the Division Head either drafts and signs the waiver or provides the waiver by email to Range Control, the Test Engineer, and the Safety and Environmental Office.
   - The event proceeds to completion—actual noise levels for each shot are monitored and recorded. If any measured noise meets or exceeds 140 dBP, the operation is again postponed and the postponement and the event postponement procedure starts over.

   If a waiver is not granted, the event will either be cancelled or delayed and the Test Engineer so notified. Unless cancelled, the event will be delayed until more favorable conditions are available, as verified by running SIPS again and following the noise guidelines.

3.5.3.6 Ambient Peak-Noise Measurements

Large-caliber Gun Firing

In 2007, noise monitors measured peak noise levels in one-second intervals for various gun-firing events, which included both inert- and live-firing events, at three on-installation and six off-installation locations. These peak-noise measurements for the largest guns in the events are summarized in Table 3.5-5. The overall worst-case recorded samples at off-installation sound-meter locations ranged from 122 dBP to 134 dBP. Based on further review of these samples, it was found that:

- One (1) sample from a total of 1,093 samples exceeded 130 dBP at the sound meter located at Range Station 7.
- Five (5) samples from a total of 1,706 samples exceeded 130 dBP at the sound meter located at Range Station 9.

Given such a low frequency of exceedances of 130 dBP, which is the threshold for high risk of noise complaints, the 2007 peak-noise measurements indicated that the off-installation sound-meter locations are within the area with moderate risk of noise complaints, as defined in Table 3.5-4.

Table 3.5-5
Range of Measured 2007 Peak Noise Levels (in dBP) during Large-Gun Firing Events

Measurement Location	Number of One-second Samples	Range of Recorded Peak Noise Levels (dBP)			
		5”/62 Gun	5”/54 Gun	76 mm Gun	Maximum
On-installation Locations					
#1 – Building 997	706	107 – 147	106 – 148	103 – 127	148
#2 –Range Station 3B	1,139	105 – 139	100 – 134	73 – 134	139
#3 – EEA Station 8	731	102 – 139	97 – 121	76 – 140	140
Off-installation Locations					
#4 – Swan Point Buoy	600	105 – 124	98 – 126	64 – 118	126
#5 – Range Station 7	1,093	101 – 129	100 – 132	81 – 121	132
#6 – Range Station 9	1,706	110 – 131	100 – 134	107 – 125	134
#7 – Range Station 12	1,113	90 – 125	92 – 129	109 – 122	129
#8 – Range Station 13	853	96 – 119	95 – 123	84 – 115	123
#9 – Range Station 21	1,121	101 – 119	79 – 118	65 – 122	122

Additional noise monitoring was performed in November 2009 to determine noise and vibration effects on historic structures when firing a large-caliber gun with explosive projectiles, as shown in Table 3.5-6. The historic structures were located at various distances from the gun firing point (see Appendix D, Figure 2). The noise and vibration measurement program took place during already-scheduled tests. Noise measurements were recorded during this particular group of tests because NSWCDD was firing the largest gun routinely fired on the PRTR – the 5”/62 caliber gun – with projectiles that contained the largest amount of detonation explosives typically used – approximately 9 pounds (lbs) net explosive weight (NEW).

Table 3.5-6
Airborne Peak Noise Levels from 5"/62 Live Firing Measured in 2009 at Historic Structures

Site	Firing Distance (yards)	Number of Shots Measured	Noise Level[2] (dBP)			Number of Events		
			Minimum	Mean	Maximum	< 115 dBP	115 – 130 dBP	> 130 dBP
Waverley House	5,300	15	115	117	120	0	15	0
	8,300	10	118	120	122	0	10	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	118	118	118	0	1	0
Christ Episcopal Church	5,300	9	73	86	96	9	0	0
	8,300	7	86	93	100	7	0	0
	16,700	7	82	86	92	7	0	0
	21,600[1]	-	-	-	-	-	-	-
	25,700	10	82	88	102	10	0	0
Newtown Manor House	5,300	15	97	102	106	15	0	0
	8,300	4	90	100	107	4	0	0
	16,700	2	103	105	108	2	0	0
	21,600[1]	-	-	-	-	-	-	-
	25,700	5	91	100	105	5	0	0
Stratford Hall	5,300	13	86	98	108	13	0	0
	8,300	8	89	100	108	8	0	0
	16,700	8	86	99	107	8	0	0
	21,600	5	110	112	114	5	0	0
	25,700	11	103	106	110	11	0	0
Bell House (Geosonics sound level meter)	5,300[1]	-	-	-	-	-	-	-
	8,300[1]	-	-	-	-	-	-	-
	16,700	9	103	114	122	4	5	0
	21,600	3	105	109	112	3	0	0
	25,700	11	101	106	116	10	1	0
Bell House (B&K 2250 sound level meter))	5,300	14	95	111	126	11	3	0
	8,300	10	103	115	125	5	5	0
	16,700	8	105	114	122	4	4	0
	21,600	5	108	111	115	4	1	0
	25,700	11	102	110	116	10	1	0
Greg House	5,300	15	116	124	129	0	15	0
	8,300	10	116	124	128	0	10	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	120	120	120	0	1	0

Notes:
1. No peak noise measurements were made.
2. Measurements were taken on November 16 and 17, 2009 at all locations except Waverley House and Newtown Manor, which were sampled only on November 16, 2009.

The overall worst-case recorded samples at off-installation sound-meter locations in 2009 ranged from 92 dBP to 129 dBP. There were no exceedances of 130 dBP, which is the threshold for high risk of noise complaints at off-installation historic structures from the 5”/62 caliber gun firings. The peak-noise measurements taken in 2009 indicated that the off-installation sound-meter locations are within the area with low or moderate risk of noise complaints, as defined in Table 3.5-4.

EM Launcher Firing

NSWCDD collected three sets of peak-noise measurements from operation of the existing 32-MJ EM launcher (railgun) system located in the Electromagnetic Launch Facility (EMLF) during the following three periods: from October 2006 to January 2007; from April 2007 to October 2008; and from December 2008 to January 2009. For all noise measurements, the system was operating at power levels considerably below 32 MJ because the pulse forming network (PFN) did not support higher power levels. Power levels increased from 0.8 MJ in the early tests to 16 MJ in the latest group of tests evaluated here.

These three sets of noise measurements, all recorded at on-installation receptors, were as follows:

- Between October 2006 and January 2007, peak noise levels were measured for 18 shots below the 8-MJ power level at an initial nine receptor locations (Figure 3.5-2, EM Launcher Firing Peak Noise Measurement Locations) with various combinations of the following:
  - Projectile weights of 5.3 lbs, 6.4 lbs, and 7.1 lbs.
  - Muzzle energy levels ranging from 0.8 MJ to 7.6 MJ.
- Between April 2007 and October 2008, peak noise levels were measured for more than 200 shots at various muzzle energy levels. During this round of sampling, measurements were taken at three of the original nine receptor locations – receptor locations #5, #6, and #8 – and three alternate measurement sites – Building 1425, the exterior of Building 1460, and the interior of Building 1460 – for a total of six locations (Figure 3.5-2). Muzzle energy levels for these measurements varied up to 12 MJ.
- Between December 2008 and January 2009, peak noise levels from additional tests were measured for 24 shots at receptor locations #5, #6, and #8 again, at two interior locations in Building 1425 (the office area and the warehouse area), at the exterior of Building 1460, and at two additional alternate locations – the fence line just south of US Route 301, and outside Dahlgren Elementary School – for a total of eight locations (Figure 3.5-2). Muzzle energy levels for these measurements varied up to 16 MJ.

The peak noise levels recorded during these three test rounds are summarized in Tables 3.5-7, 3.5-8, and 3.5-9, respectively. These data show patterns that are generally consistent with each other. They indicate that:

- There is no clear relationship between peak noise level and muzzle energy level, although the data suggest that there is a tendency for higher muzzle energy to generate slightly higher peaks.

EM Launcher Firing Peak Noise Measurement Locations

Noise Measurement Location
Additional Measurement Location
Electromagnetic Launch Facility (EMLF)

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

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Source: NSWCDD GIS 2008

Figure 3.5-2

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- For a given distance from the EMLF, sound propagation is generally not sensitive to the launch direction, except for receiving locations behind the EMLF and to the rear of the EM launcher's firing direction. The bulk of the high-bay EMLF building creates a shielding effect that attenuates launch noise. It is anticipated that the buildings behind the launch site as well as the surrounding forested area (Figure 3.5-2) effectively attenuate peak noise from EM launcher shots at off-installation locations beyond the northern boundary of the installation. This is supported by the relatively low peak-noise levels measured at Receptor #3 outside of the control van (Table 3.5-7), especially given its proximity to the noise source (only 302 ft north of the launch site, but with levels that are comparable to Receptor #5 levels 1,217 ft away), and at the fence-line receptor, near Route 301 (Table 3.5-9).
- Receptors #8 (EEA) and #9 represented off-base locations to the south and east, including potential receptors located on the Potomac River. Measured levels were either below 115 dBP (the majority of readings), indicating the likely low risk of generating complaints; or between 115 dBP and 130 dBP, indicating a moderate risk of generating complaints.
- All noise measurements at Dahlgren Elementary School show peak noise levels below 115 dBP, which indicates a low risk of generating noise complaints at both on-base school and housing areas.

Table 3.5-7
Measured Peak Noise Range from EM Launcher Shots (October 2006 – January 2007)

Receptor Location	Distance from EMLF (ft)	5.3-lb Projectile (6 Shots) Muzzle Energy – 0.8 – 5.4 MJ (dBP)	6.4-lb Projectile (2 Shots) Muzzle Energy - 6.2 – 6.3 MJ (dBP)	7.1-lb Projectile (10 Shots) Muzzle Energy - 3.7 – 7.6 MJ (dBP)
#1 Terminal Area	0	154 - 171	n/a	168 – 169
#2 Inside Bldg. 1410	33	152 – 154	n/a	164 – 169
#3 Outside Control Van	302	117 – 131	128 – 129	120 – 133
#4 Inside Control Van	302	100 – 113	114 – 115	104 – 117
#5 Bldg. 1180 Fence	1,217	121 – 129	131 – 131	130 – 139
#6 Bldg. 1400 Barricade	1,591	117 – 126	126 – 126	119 – 130
#7 Bldg. 1470 Intersection	3,425	106 – 118	118 – 125	112 – 123
#8 Line of Flight by Riverbank	5,302	102 – 115	106 – 111	93 – 123
#9 Terminal Range Barricade	6,998	99 – 109	112 – 115	103 – 120
Note: 1 mi = 5,280 ft.				

Table 3.5-8
Measured Peak Noise Range from EM Launcher Shots (April 2007 – October 2008)

Receptor Location	Number of Measure-ments	Peak Noise (dBP) under Lowest Muzzle Energy (0.84 MJ)	Peak Noise (dBP) under Highest Muzzle Energy (13.49 MJ)	Lowest Range		Highest Range	
				Peak Noise (dBP)	Muzzle Energy (MJ)	Peak Noise (dBP)	Muzzle Energy (MJ)
#5 Bldg. 1180 Fence	205	121	--	110	2.35	144	6.73
#6 Bldg. 1400 Barricade	172	117	134	114	3.30	139	11.95
#8 LOF by Riverbank	179	102	115	91	6.54	123	7.38
Additional Sites							
Bldg. 1425	170	--	142	111	3.39	147	3.99
Bldg. 1460 Exterior	100	--	--	113	4.01	134	3.99
Bldg. 1460 Interior	73	--	--	85	9.67	123	6.31
Note: -- indicates that no readings were taken, as readings were limited to a total of three sites during each test.							

Table 3.5-9
Measured Peak Noise Range from EM Launcher Shots (December 2008 – January 2009)

Receptor Location	Number of Measurements	Peak Noise Range Muzzle Energy ~ 16 MJ (dBP)
#5 Bldg. 1180 Fence	19	137 – 151
#6 Bldg. 1400 Barricade	17	130 – 138
#8 LOF by Riverbank	18	110 – 121
Additional Sites		
Bldg. 1425 Office Area (Interior)	15	122 – 131
Bldg. 1425 Warehouse Area (Interior)	9	129 – 137
Bldg. 1460 Exterior	21	123 – 138
Fence Line @ US Route 301	24	109 – 120
Dahlgren Elementary School	17	91 - 113

3.5.4 Existing Conditions Noise Modeling

Peak blast noise levels and DNL levels (C-weighted DNL levels for explosive detonations and large-caliber guns and A-weighted DNL levels for small arms) can be predicted (modeled) using the DoD's weapons-noise models: the BNOISE2 for explosive detonations and large-caliber guns; and the Small Arms Range Noise Assessment Model (SARNAM) for small arms (smaller than or equal to 20 mm guns). Since explosive detonations, large-caliber guns, and small arms are used by NSWCDD, both the BNOISE2 and SARNAM models were applied for the purposes of the present analysis.

It should be noted that the EM launcher system at the EMLF is still in the testing stage, with limited noise measurements available. As noted above, the measurements to date do not show a close correlation between increasing power and noise. The existing data are not sufficient to develop a noise-prediction model that can be used to predict both peak and DNL levels for EM launcher firings as is possible for large-caliber guns, explosive detonations, and small arms. Therefore, no EM launcher noise modeling was conducted.

Unlike the training exercises at most military installations, which follow fixed firing schedules using specified types of guns for a specified number of rounds fired, NSWCDD's RDT&E activities vary considerably. Therefore, given the wide range of possible test scenarios for RDT&E guns, DNL levels were predicted based on particularly active years. This ensures that the modeling yields a worst-case description. The dBP metric and gun firing-associated complaint risk thresholds were also considered in order to evaluate potential existing noise effects.

3.5.4.1 Impulse Noise from Large-Gun Firing and Explosive Detonations

Given the dominant low-frequency component of large-gun firing and explosive-detonation noise, the cumulative CDNLs (250-day average) and peak blast noise levels in dBP from large-gun firing were predicted using the DOD's large-caliber weapon-noise model – BNOISE2, Version 1.3.2003-07-03 (US Army, 2003). The number of rounds used in the modeling for large guns are shown in Table 3.5-10. The NSWCDD SIPS model was also used to predict the worst-case peak noise from a 200-lb open-field detonation at Churchill Range in the EEA Complex (200 lbs NEW was used because larger NEW detonations are buried 8 ft deep).

Table 3.5-10
Existing Baseline Large-caliber Projectiles Fired Annually

Firing Range	Gun								
	5"/54	5"/62	8"/55	155 mm	76 mm	120 mm Mortar	81 mm Mortar	30 mm	35 mm
Number of Inert Projectiles									
AAFR	91	--	--	75	553	--	24	--	--
Main	763	55	15	--	1,604	--	--	--	--
Terminal	11	13	--	--	--	--	--	--	--
Number of Live Projectiles Fired to MDZ Target Areas									
AAFR	--	404	--	--	444	36	--	--	--
Main	--	--	16	--	--	--	--	165	358
Terminal	50	--	--	--	--	21	--	--	--
Number of Live Projectiles Fired to Upper LDZ Target Area									
Main			25						

BNOISE2 is an Army-developed computer program that calculates and displays blast-noise exposure contours resulting from specified activities involving large guns and high-explosive charges. BNOISE2 considers the type of weapon and ammunition, the number and time (day/night) of rounds fired, range attributes, weather, assessment procedures, and various metrics. It accounts for the spectra and directivity of both muzzle blast and projectile bow shock, which facilitates accurate calculation of propagation and sound frequency weighting. The source-model parameter values are based on empirical data, while the propagation algorithms are based on sophisticated calculations and experimental data.

In predicting annual average cumulative CDNL contours, the BNOISE2 BN3.2 weather-emulation option, which reflects average weather and propagation conditions, was applied. Figure 3.5-3 (Existing C-Weighted Day-Night Average Noise Contours with 8"/55 Gun Firing in the Middle Danger Zone) shows the modeled CDNL noise contours for both typical large-gun firing noise (Table 3.5-10) and the noise from the 190 baseline detonation events on the EEA Complex. Figure 3.5-4 (Existing Baseline Weighted Day-Night Average Noise Contours with

8”/55 Gun Firing in the Middle and Lower Danger Zones) depicts CDNL contours associated with the atypical 8”/55 gun live firing that occurs infrequently (25 rounds annually) and is aimed at a long-range target area in the upper LDZ (Table 3.5-10).

In predicting the event peak-noise contours, the BNOISE2-defined conservative water-propagation surface condition was used to account for the different behavior of sound intensity as it propagates over land or over water: water surfaces reflect greater sound intensity. The typical worst-case composite noise contours, depicting the combined worst-case peak noise levels resulting from all existing large-gun firing and detonation events, are presented in Figure 3.5-5 (Existing Composite Peak Noise Contours with 8”/55 Gun Firing in the Middle Danger Zone). Although live gun firing to a target area in the upper LDZ is atypical and takes place infrequently, a peak noise contour using an 8”/55 gun was also predicted and is depicted in Figure 3.5-6 (Existing Composite Peak Noise Contours with 8”/55 Gun Firing in the Lower and Middle Danger Zones).

Among the guns available as part of the BNOISE2 model, the 8”/55 gun was selected to be the worst case for noise levels. The largest gun frequently fired by NSWCDD is the 5”/62 gun, with the larger 155 mm gun fired occasionally, but the model did not include the 5”/62 gun. Also, selecting a gun that fires projectiles with larger amounts of explosives than fired today by NSWCDD, leaves room for experimental guns/projectiles in the future. NSWCDD does fire an 8”/55 caliber gun, but it is only used to fire canisters filled with projectile electronic components to assess how well they withstand launch shock. No live projectiles are fired from the 8”/55 gun.

3.5.4.2 Day-Night Noise Contours (CDNL)

The CDNL noise contours shown on Figure 3.5-3 indicate that:

- DNL noise contours equal or greater than 70 dBC (Noise Zone III in Table 3.5-3) from all large-gun firing and detonations are confined entirely within the installation or within the PRTR MDZ.
- DNL noise contours between 62 dBC and 70 dBC (Noise Zone II) extend slightly over land to the south and southeast of NSF Dahlgren and to parts of the river beyond the MDZ near the EEA Complex.

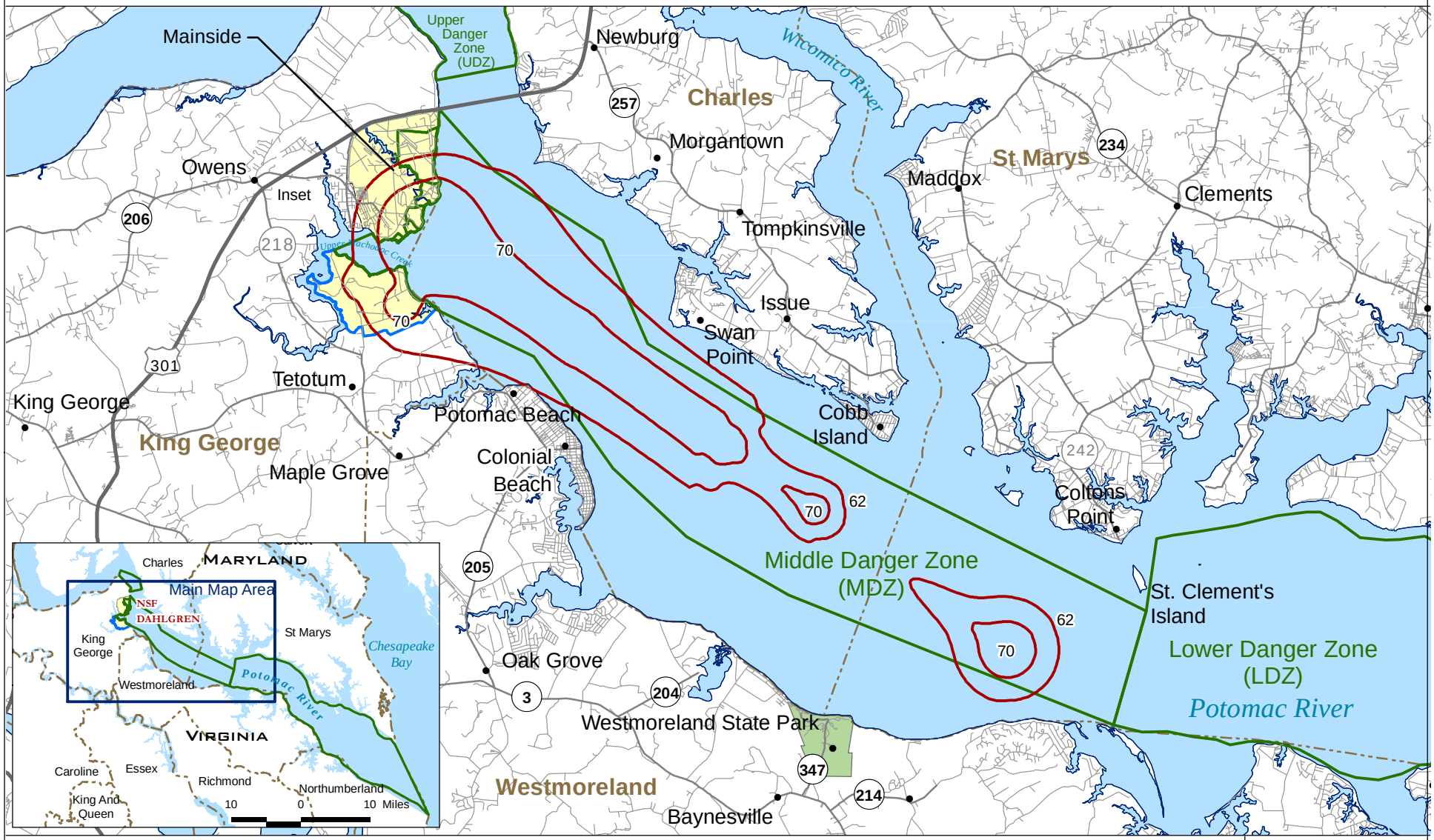
The presence of noise-sensitive land uses, such as housing, schools and medical facilities, is considered acceptable in Noise Zone I, but such land uses are not recommended in Noise Zone II. There are no schools or medical facilities within Noise Zone II, but there are approximately 70-80 residences in the area.

3.5.4.3 Peak-Noise Contours (dBP)

According to Army guidance, noise-sensitive land uses, such as housing, schools, and medical facilities, are discouraged in areas with noise levels between 115 and 130 dBP (moderate risk of noise complaints). Noise-sensitive land uses are strongly discouraged in areas with noise equal to or greater than 130 dBP (high risk of noise complaints).

Figure 3.5-5 shows the predicted existing composite PK50 noise levels generated by baseline large-gun firings and detonations including the 8”/55 gun, as shown in Table 3.5-10. Figure 3.5-7

Existing C-Weighted Day-Night Average Noise Contours with 8"/55 Gun Firing in Middle Danger Zone



Sources: NSWCDD 2008-2011 and BNOISE2 Model

Figure 3.5-3

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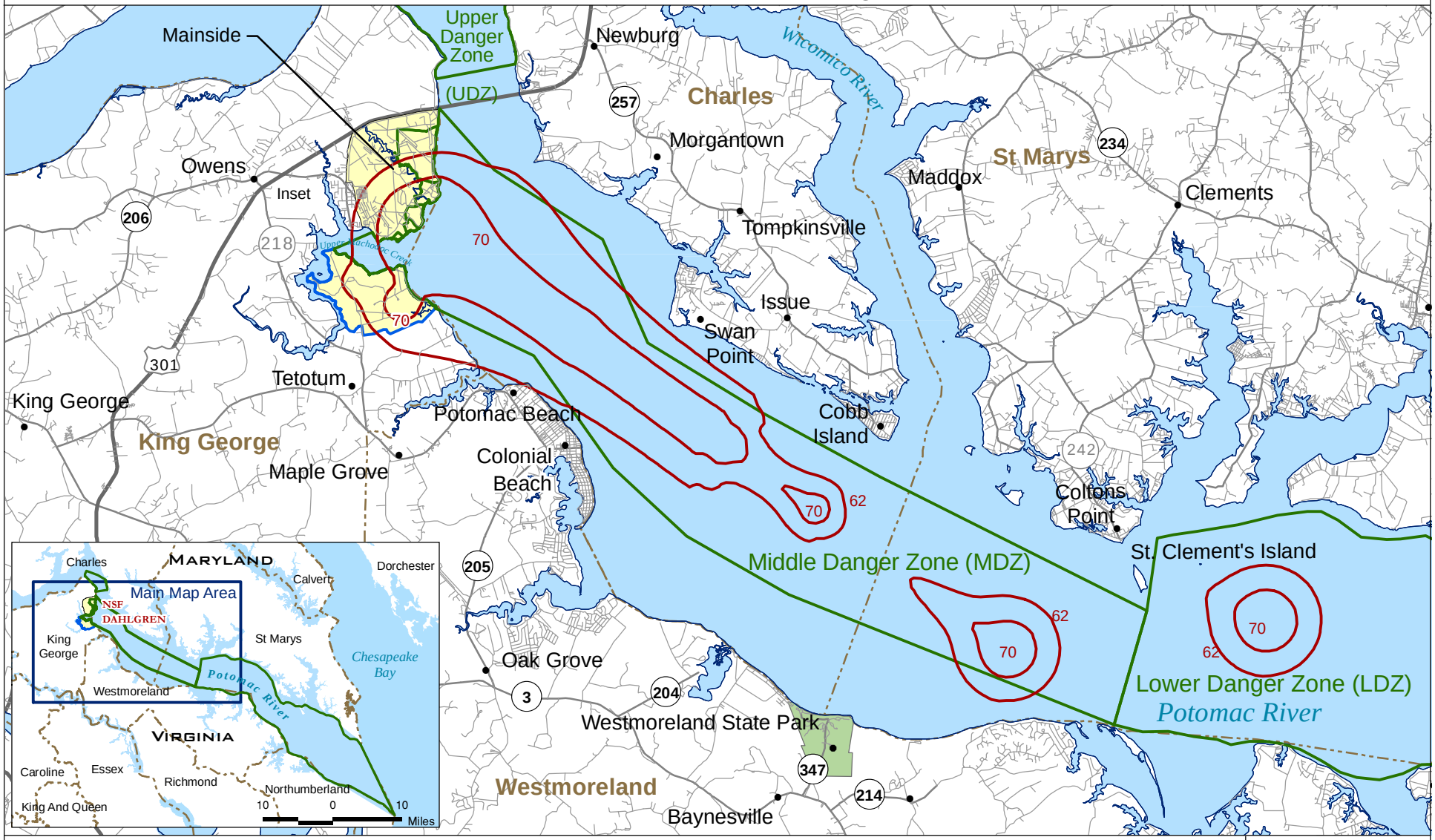
Existing Baseline Weighted Day-Night Average Noise Contours with 8”/55 Gun Firing in the Middle and Lower Danger Zones



C-Weighted Day-Night Average Noise Contours

Potomac River Test Range (PRTR) Complex

Explosives Experimental Area (EEA) Range Complex

County Boundary

Naval Support Facility (NSF) Dahlgren

3 0 3 Miles

5 0 5 Kilometers

N

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Sources: NSWCDD 2008-2011 and BNOISE2 Model

Figure 3.5-4

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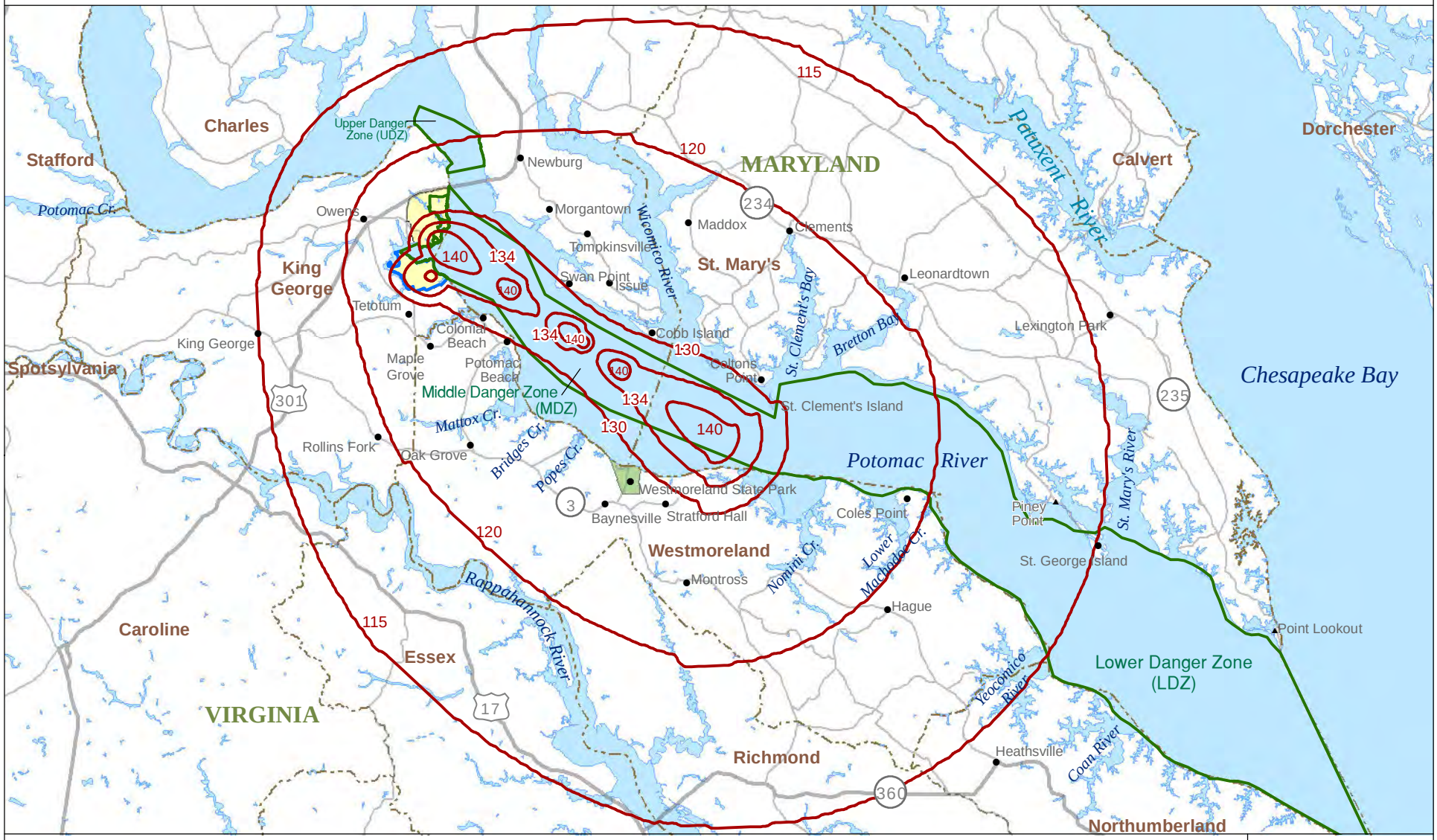
Existing Composite Peak Noise Contours with 8”/55 Gun Firing in Middle Danger Zone



Peak Noise Contours

Explosives Experimental Area (EEA) Range Complex

Potomac River Test Range (PRTR) Complex

County Boundaries

Naval Support Facility (NSF) Dahlgren

4 0 4 Miles

6 0 6 Kilometers

N

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NAVSEA WARFARE CENTERS DAHLGREN

Sources: NSWCDD 2008-2011 and BNOISE2 Model

Figure 3.5-5

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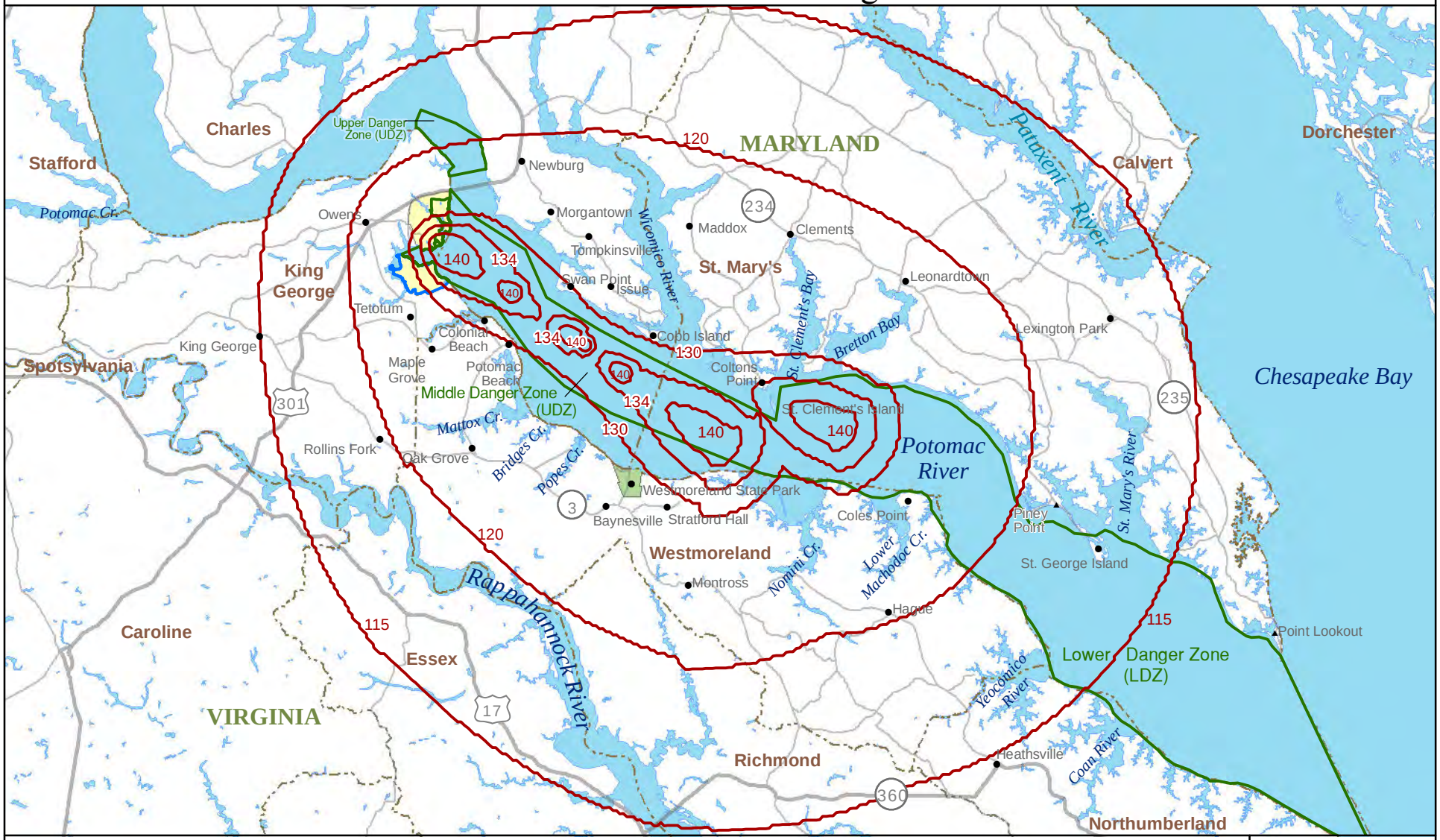
Existing Composite Peak Noise Contours with 8”/55 Gun Firing in the Lower and Middle Danger Zones



Sources: NSWCDD 2008-2011 and BNOISE2 Model

Figure 3.5-6

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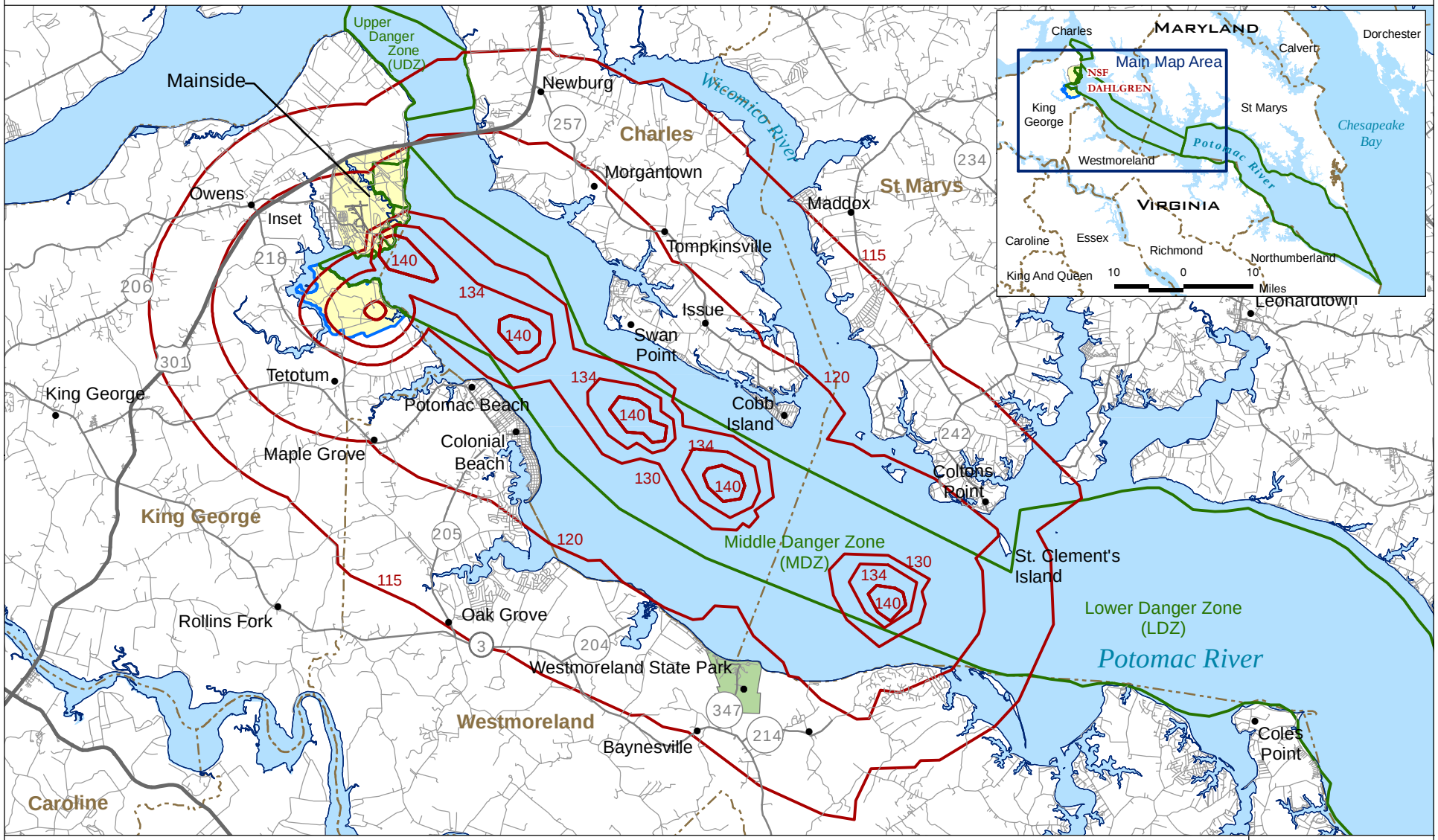
Existing Composite Peak Noise Contours without 8”/55 Gun Firing



Peak Noise Contours

Potomac River Test Range (PRTR) Complex

Explosives Experimental Area (EEA) Range Complex

County Boundary

Naval Support Facility (NSF) Dahlgren

3 0 3 Miles

5 0 5 Kilometers

N

Sources: NSWCDD 2008-2011 and BNOISE2 Model

Figure 3.5-7

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(Existing Composite Peak Noise Contours without 8”/55 Gun Firing) shows predicted PK50 contours based on the same firing data but without the 8”/55 gun. (As previously noted, the PK50 event contour represents the location where a stated noise value is exceeded 50 percent of the time with the remaining 50 percent being below the stated value.)

The validity of the peak noise contour modeling was verified by comparing the contours shown on Figure 3.5-6 with the 2007 measurements summarized in Table 3.5-5 (these measurements, like the Figure 3.5-5 contours, reflected the firing of large guns but not the 8”/55 gun). The comparison showed that the BNOISE2-predicted PK50 contours correlate well with the 2007 recorded maximum peak-noise levels. On this basis, the PK50 noise contours shown in Figures 3.5-5 and 3.5-7 can be considered to accurately reflect event peak-noise levels around NSF Dahlgren with and without 8”/55 gun events, respectively.

The greater extent of the composite peak-noise contour area in Figure 3.5-5 as compared to Figure 3.5-7 is essentially attributable to the noise generated by the 8”/55 gun, and, particularly, the live-firing events. The noise from firing the 8”/55 gun masks almost entirely all other gun-firing event noise. However, as indicated in Table 3.5-10, the worst-case existing baseline condition include only 15 inert and 16 live annual rounds for the 8”/55 gun, which is less than one percent of the entire annual number of large-gun rounds. This low frequency of tests shows that not only does Figure 3.5-5 represent the worst-case noise, but it also represents peak noise conditions that are unlikely to be experienced on most occasions when large-gun firing and explosive detonations occur. In the infrequent, atypical event that large guns are fired into a long-range target area in the upper LDZ, the contour area expands into the land areas along the PRTR LDZ as shown in Figure 3.5-6.

The composite contours of Figure 3.5-5 indicate that:

- Exterior noise levels of 140+ dBP essentially encompass the areas that are immediately adjacent to the firing and target points within the PRTR MDZ.
- The noise level area of 130 – 140 dBP (i.e., high risk of complaint) extends off-base over land immediately adjacent to the PRTR MDZ, such as Potomac Beach, Colonial Beach, Swan Point, Cobb Island, and Coltons Point.
- The 115 – 130 dBP exterior noise area encompasses almost all the areas along the Potomac River adjacent to the MDZ within approximately 10 miles of the river. Within this contour area, moderate noise complaints can be anticipated.

The composite contours of Figure 3.5-7 excluding 8”/55 gun noise contributions indicate that:

- Exterior noise levels of 140+ dBP essentially encompass the areas that are immediately adjacent to the firing and target points.
- The noise level area of 130 – 140 dBP (i.e., high risk of complaint) extends over some off-base land south of the EEA Complex, barely touching the shoreline of Potomac Beach.
- The 115 – 130 dBP exterior noise area encompasses almost all the areas along the Potomac River adjacent to the MDZ within approximately three miles of the river. Within this contour area, moderate noise complaints can be anticipated.

It should be noted that because the PK50 contours are tied to complaint risk rather than to a classified noise zone associated with average noise levels (e.g., CDNL), they should not be used as thresholds to determine potential noise-impact significance.

It should also be noted that, although the conservatively-predicted peak-noise contours show areas exposed to peak-noise levels above 140 dBP, NSWCDD's SIPS is an integral part of the noise-management procedures and would immediately stop a test, as needed, to ensure that no peak-noise level exceed 140 dBP when large-gun firing occurs.

3.5.4.4 Comparison of BNOISE-predictions with Measurements

The noise measurements collected during the November 2009 noise and vibration measurements taken at six historic structures provided data for a comparison of model-predicted noise levels to the maximum airborne noise levels recorded at each historic structure. The measured maximum peak noise level from the 5"/62 caliber gun and the BNOISE2-predicted noise levels are shown in Table 3.5-11. The results indicate that the BNOISE2 model-predicted average peak airborne noise levels were equal to or above the maximum recorded peak noise levels under normal weather conditions. Therefore, the BNOISE2 model, using average weather and propagation conditions, conservatively predicted, and sometimes slightly overestimated, the peak airborne noise levels on the PRTR from 5"/62 caliber gun firing under normal weather conditions.

Table 3.5-11
Comparison of BNOISE2-predicted Average Peak Noise Levels with Maximum Peak Noise Measurements for the 5"/62 Caliber Gun

Site	Measured Maximum Peak Noise (dBP)	BNOISE2-predicted Average Peak Noise (dBP)	Difference (BNOISE2 – Measurement) (dBP)
Waverley House	122	122	0
Stratford Hall	112	118	6
Newtown Manor House	108	114	6
Greg House	129	129	0
Bell House	126	127	1
Christ Episcopal Church	102	<115	N/A

3.5.4.5 Impulse Noise from Small-Arms Fire

Given the high-frequency characteristic of small-arms firing noise, the ADNL metric is the most appropriate metric to describe it. ADNLs were predicted using DoD's SARNAM (Version 2.6.2003-06-06). SARNAM is a computer model that provides the capability to calculate and display noise-level contours for firing operations at small-arms ranges. It considers the type of weapon and ammunition, number of rounds fired, time of day, range attributes such as size and barriers, etc. The model accounts for the spectra and directivity of both muzzle blast and projectile bow shock, and assumes a moderate downwind propagation condition. The source-model parameter values are based on empirical data. The modeling input data for each weapon type and annual rounds are presented in Table 3.5-12.

Table 3.5-12
Existing Baseline Small-Arms Rounds Fired Annually

Range	Machine Gun	
	.50 caliber (12.7 mm)	7.62 mm
Number of Inert (Blank) Rounds		
Machine Gun	2,565	285
Terminal	1,283	143
EEA – Churchill	641	71
EEA – Harris	641	71
Number of Live (Explosive) Rounds		
Machine Gun	135	15
Terminal	67	7
EEA – Churchill	34	4
EEA – Harris	34	4
Total Combined Small-Arms Rounds (.50 caliber + 7.62 mm)		
	6,000	

In predicting the annual average cumulative ADNL contours, a total of 6,000 rounds of firing were included:

- 90 percent were .50 caliber machine gun rounds.
- 10 percent were 7.62 mm caliber machine gun rounds.
- 95 percent of all rounds fired were inert (blank).
- 5 percent of all rounds fired were live.

These rounds are assumed to have been fired at three ranges:

- 50 percent at the Machine Gun Range.
- 25 percent at the Terminal Range.
- 25 percent at the EAA Churchill (12.5 percent) and Harris (12.5 percent) Ranges.

Figure 3.5-8 (Existing Small Arms A-Weighted Day-Night Average Noise Contours) displays the cumulative ADNL contours resulting from 6,000 annual rounds of small-arms firing. The contours indicate that:

- ADNLs at or greater than 75 dBA (Noise Zone III) and ADNLs between 65 dBA and 75 dBA (Noise Zone II) from small-arms firing remain entirely within individual firing ranges on the installation.

Figure 3.5-9 (Existing .50 CAL Peak Noise Contours) displays the estimated event peak noise contours resulting from small-arms firing from the Machine Gun Range. The contours indicate that:

- Noise Zone II (87 – 104 dBP) and III (>104 dBP) small-arms peak noise contours are essentially contained within the corresponding noise zones predicted from the baseline explosive detonations and large-gun firing CDNL noise contours shown in Figure 3.5-3.

3.5.5 Vibration Noise

In general, low-frequency impulse sound pressure generated by the detonation of explosive charges or large-caliber gun firing can cause structures to vibrate. Vibration consists of rapidly fluctuating motions with an average motion of zero. Residents of buildings exposed to vibration often perceive vibration as the rattling of loose windows and objects on shelves, and, sometimes, of the building itself.

There are two types of vibration – vibration transmitted through the ground and vibration transmitted through the air. Several different methods are used to quantify vibration amplitude. One method uses the peak particle velocity (PPV) in inches per second (in/sec) to describe the maximum instantaneous positive or negative peak of the vibration signal. PPV is often used in the monitoring of blasting vibration because it is related to the stresses experienced by buildings.

3.5.5.1 Ground-Borne Vibration

Ground-borne vibration originates from explosive detonations and other events, such as earthquakes, that radiate vibration energy into the soil. The face of the nearest foundation or underground building wall responds to the incident ground-borne vibration and propagates the waves throughout the building. The resulting ground-borne vibration is a function of the magnitude of the energy source, the distance from the source, the blasting-specific response characteristics of the transmitting media (rock/soil), and the response characteristics of the structural element (building). Vibration studies of coal mine detonations indicate that ground-borne vibration dominates in the near range while airborne vibration dominates at greater distances. For example, for a 100-lb charge, the ground-borne vibration is the dominant cause of building vibration if the building is located less than 500 ft from the detonation point. At distances greater than 500 ft, the airborne sound wave is the dominant cause of the vibration.

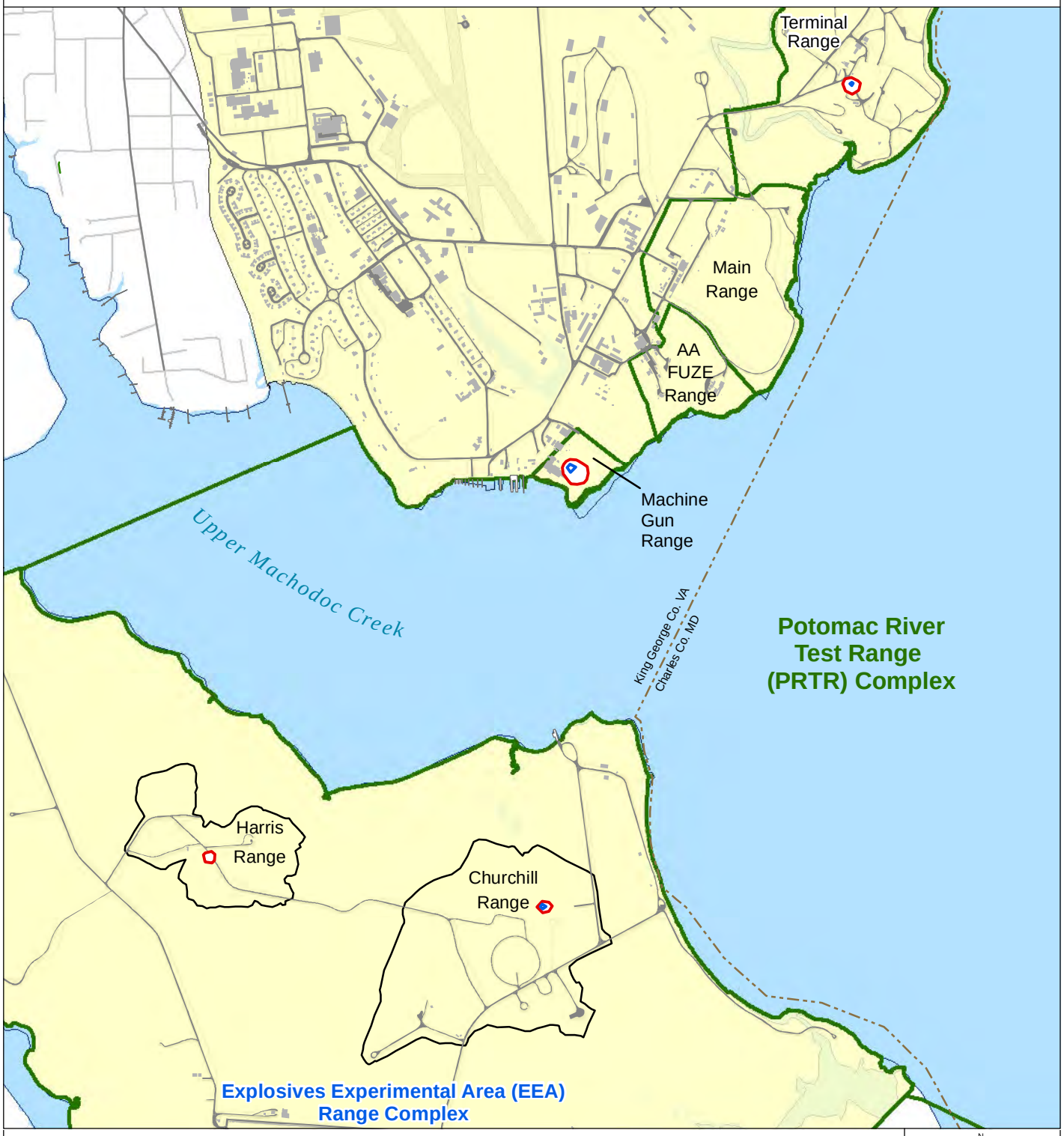
The US Bureau of Mines conducted an 18-month study at McAlester Army Ammunition Plant in 1988 (Siskind, 1989, as cited in USCHPPM, 2005) and found that:

- A PPV of 0.5 in/sec is the maximum ground-borne vibration threshold to prevent damage.
- A PPV of 2.0 in/sec is the threshold level at which minor structural damage may begin to occur in 0.01 percent of structures.

The NEW of EEA Range Complex detonations can vary from less than 1 lb to 1,000 lbs of explosives. The NEW can reach 200 lbs for an open detonation and 1,000 lbs for a buried detonation. For buried detonations, the depth will increase as the NEW increases. It is anticipated that, for the same amount of NEW and at the same measuring position, an open detonation would result in greater airborne vibration effects, while a buried detonation would generate greater ground-borne vibrations.

Ground-borne vibration data have been collected by NSWCDD for a buried 1,000-lb detonation to determine the worst-case vibration condition around the Churchill Range (Figure 3.5-10, Ground-borne Vibration Resulting from Buried 1,000-lb Detonation). Sensors were placed at radii of 75 ft, 225 ft, 675 ft, and 2,025 ft around the detonation point. Based on the

Existing Small Arms A-Weighted Day-Night Average Noise Contours



Contour Line 65 A-Weighted Decibel

Contour Line 75 A-Weighted Decibel

Naval Support Facility (NSF) Dahlgren

1,500 0 1,500 Feet

500 0 500 Meters

N

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Sources: NSWCDD 2008-2011 and BNOISE2 Model

Figure 3.5-8

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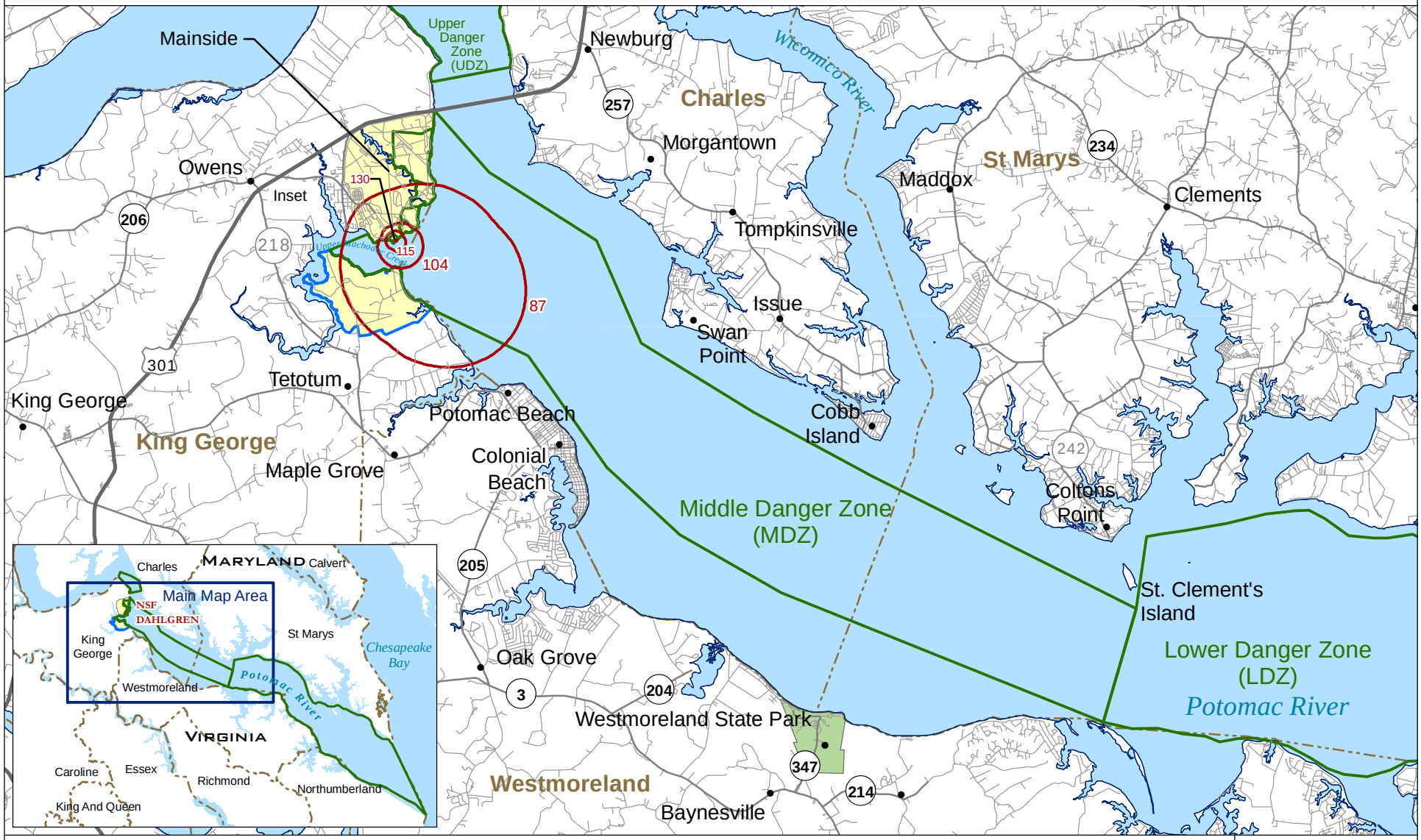
Existing .50 Caliber Peak Noise Contours



Peak Noise Contours

Potomac River Test Range (PRTR) Complex

Explosives Experimental Area (EEA) Range Complex

County Boundary

Naval Support Facility (NSF) Dahlgren

3 0 3 Miles

5 0 5 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Sources: NSWCDD 2008-2011 and BNOISE2 Model

Figure 3.5-9

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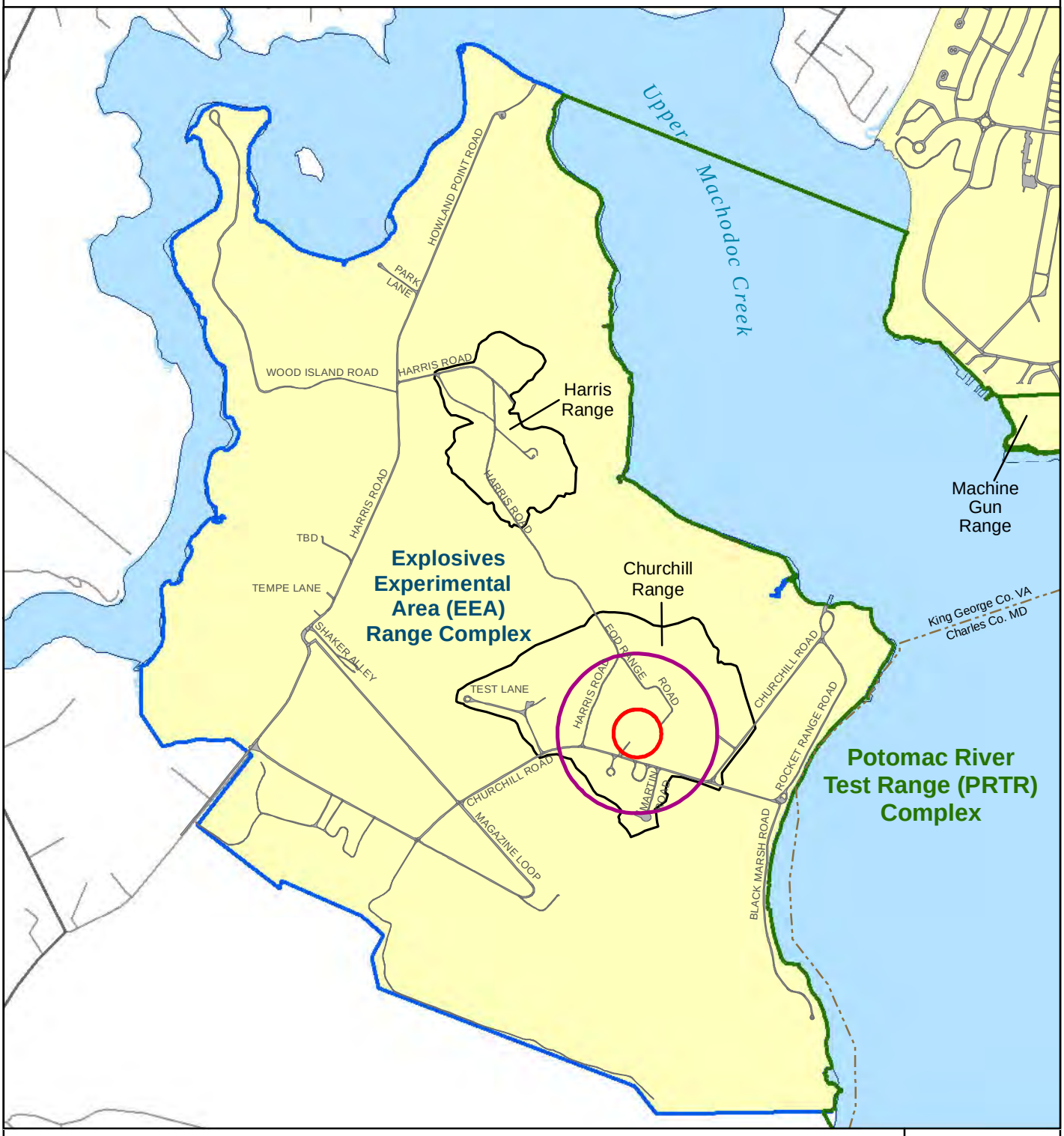
Ground-borne Vibration Resulting from Buried 1,000-lb Detonation



2.0 Inch/Second Structural-Damage Threshold at the 300-ft Radius

0.5 Inch/Second Vibration-Damage Threshold at the 1,000-ft Radius

Explosives Experimental Area (EEA) Range Complex

Potomac River Test Range (PRTR) Complex

Naval Support Facility (NSF) Dahlgren

1,800 0 1,800 Feet

600 0 600 Meters

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD 2008-2011

Figure 3.5-10

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measurements of both lateral and vertical displacement velocity at these sensors, it was calculated that:

- The 0.5-in/sec vibration-damage threshold occurred at the 1,000-ft radius
- The 2.0-in/sec structural-damage threshold occurred at the 300-ft radius

Therefore, the worst-case ground-borne vibration resulting from a 1,000-lb buried detonation at the EEA Range Complex would not be likely to cause any damage to off-installation properties.

As described earlier, noise and vibration measurements were taken at six off-installation historical structures along the PRTR in November 2009 (see complete report provided as Appendix D) during ballistic tests of explosive 5”/62 projectiles fired at different distances down the PRTR. This monitoring program was to confirm that no buildings beyond NSF Dahlgren or along the PRTR experience vibration levels that could result in structural damage.

Ground and/or foundation measurements are summarized in Table 3.5-13 (see Appendix D for details). All measurements were below 0.1 in/sec and well below the 0.5 in/sec threshold and were virtually non-detectable. These results indicate that any risk of structural damage to the historic structures along the PRTR from large-gun firing is minimal.

3.5.5.2 Airborne Vibration

Most of the studies of airborne vibration and the damage guidelines derived from these studies used sonic booms as the source. However, vibration from open-area explosive detonations and large-caliber gun firing is similar to vibration from sonic booms.

Structural shaking or window rattling by airborne vibration can annoy building occupants and may cause structural damage (e.g., broken glass and plaster cracks). The US Bureau of Mines study (Siskind, 1989, as cited in USCHPPM, 2005) correlated airborne vibration levels with peak sound pressure levels likely to cause potential structural damage (Table 3.5-14). As shown in the table, homeowners become concerned about structural damage at levels far below those actually capable of causing such damage.

Based on Figure 3.5-5, only three buildings beyond NSF Dahlgren or the PRTR boundaries are expected to experience peak noise levels of 134+ dBP, which is the threshold for potential property damage as shown in Table 3.5-14.

The noise and vibration monitoring was conducted at six historical properties along the PRTR in November 2009 (see Appendix D) and included wall vibration measurements. Maximum vibration levels measured at the six historical structures were found to be below 0.5 in/sec, the level at which minor structural damage may begin to occur (see Table 3.5-15), with one exception. The airborne vibration levels measured at the wall of the Bell House showed one exceedance (0.54 in/sec) of the 0.5 in/sec threshold. However, since the 0.5 in/sec threshold was conservatively set as a potential effect level for glass in poorly-fitted windows with loose glass or plaster cracks on stressed walls, vibrations slightly above this level would not be expected to cause any structural damage to the house. As indicated in Table 3.5-14, a vibration level of 2.0 in/sec is the threshold level at which minor structural damage may begin to occur in 0.01 percent of structures (one in ten thousand). The highest measured wall vibration level at Bell House is still well below this threshold.

These results indicated that the potential for structural damage impacts from the firing of the largest gun fired with any frequency by NSWCDD is minimal.

Table 3.5-13
Ground and/or Foundation Vibration Measurements

Site	Firing Distance (yards)	Number of Shots Measured	Vibration Level[3] (in/sec)			Number of Events (Vibration Levels)		
			Minimum	Mean	Maximum	<0.1 in/sec	0.1 – 0.5 in/sec	>0.5 in/sec
Ground Vibration								
Stratford Hall	5,300	12	0.005	0.005	0.005	10	0	0
	8,300	7	0.005	0.005	0.005	7	0	0
	16,700	8	0.003	0.003	0.005	8	0	0
	21,600	5	0.003	0.005	0.008	5	0	0
	25,700	11	0.003	0.003	0.003	11	0	0
Waverley House	5,300	8	0.005	0.005	0.008	8	0	0
	8,300	8	0.005	0.005	0.008	8	0	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	0.005	0.005	0.005	1	0	0
Bell House	5,300	-	-	-	-			
	8,300	-	-	-	-			
	16,700	1	0.005	0.005	0.005	1	0	0
	21,600[2]	-	-	-	-	-	-	-
	25,700[2]	-	-	-	-	-	-	-
Foundation Vibration								
Stratford Hall	5,300	12	0.0001	0.0003	0.0005	12	0	0
	8,300	8	0.0001	0.0002	0.0003	8	0	0
	16,700	9	0.0001	0.0005	0.0011	9	0	0
	21,600	5	0.0002	0.0010	0.0025	5	0	0
	25,700	12	0.0001	0.0002	0.0006	12	0	0
Waverley House	5,300	14	0.005	0.009	0.018	14	0	0
	8,300	10	0.004	0.006	0.008	10	0	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	0.005	0.005	0.005	1	0	0
Bell House	5,300[1]	-	-	-	-	-	-	-
	8,300[1]	-	-	-	-	-	-	-
	16,700	8	0.003	0.006	0.012	8	0	0
	21,600[2]	-	-	-	-	-	-	-
	25,700	1	0.002	0.002	0.002	1	0	0

Notes:
1. No vibration measurements were made.
2. Levels were too low to be detected.
3. Measurements were taken on November 16, 2009 at all locations but on November 17, 2009 at the Bell House only.

Table 3.5-14
Potential Building Damage and Airborne Vibration Levels

Response	Vibration Level in inches per second (in/sec)	Peak Sound Level (dBP)
Concern by homeowner about structural rattling and possible damage	0.1	120
Glass and plaster cracks (worst case*)	0.5	134
Gypsum wallboard (worst case*)	0.75	141**
Structural damage to lightweight superstructure	>2.0	175**

Note: * Worst case = Poorly fitted loose window glass and stressed walls.

** NSWCDD predicts noise levels before firing based on weather conditions and monitors them after firing; noise levels are equal to or exceeding 130 dBP trigger noise reduction procedures detailed in the text box in Section 3.5.3.5.

Source: Siskind, 1989, as cited in USCHPPM, 2005.

Table 3.5-15
Wall Vibration Measurements

Site	Firing Distance (yards)	Number of Shots Measured	Vibration Level[3] (in/sec)			Number of Events		
			Minimum	Mean	Maximum	<0.1 in/sec	0.1 – 0.5 in/sec	>0.5 in/sec
Waverley House (exterior brick wall)	5,300	14	0.039	0.139	0.298	4	10	0
	8300	10	0.059	0.113	0.180	5	5	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	0.059	0.059	0.059	1	0	0
Christ Episcopal Church (interior plaster)	5,300	8	0.001	0.003	0.006	8	0	0
	8,300	7	0.001	0.002	0.005	7	0	0
	16,700	7	0.001	0.003	0.005	7	0	0
	21,600	13	0.001	0.002	0.005	13	0	0
	25,700	10	0.000	0.002	0.006	10	0	0
Newtown Manor House (exterior brick wall)	5,300[2]	-	-	-	-	-	-	-
	8,300[2]	-	-	-	-	-	-	-
	16,700	1	0.00003	0.00003	0.00003	1	0	0
	21,600[2]	-	-	-	-	-	-	-
	25,700[2]	-	-	-	-	-	-	-
Stratford Hall (exterior brick wall)	5,300	13	0.004	0.012	0.020	13	0	0
	8,300	8	0.006	0.016	0.030	8	0	0
	16,700	9	0.004	0.015	0.037	9	0	0
	21,600	5	0.008	0.039	0.056	5	0	0
	25,700	12	0.001	0.016	0.024	12	0	0
Bell House (exterior front wall)	5,300[1]	-	-	-	-	-	-	-
	8,300[1]	-	-	-	-	-	-	-
	16,700	8	0.311	0.399	0.535	0	7	1
	21,600	3	0.086	0.245	0.480	1	2	0
	25,700	12	0.071	0.142	0.354	6	6	0
Bell House (exterior side wall)	5,300	13	0.005	0.037	0.225	12	1	0
	8,300	10	0.003	0.055	0.144	7	3	0
	16,700	7	0.001	0.058	0.144	6	1	0
	21,600	5	0.025	0.039	0.069	5	0	0
	25,700	9	0.017	0.027	0.043	9	0	0
Greg House (exterior front wall)	5,300	15	0.007	0.033	0.056	15	0	0
	8,300	10	0.018	0.030	0.046	10	0	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	0.021	0.021	0.021	1	0	0

Notes:
1. No vibration measurements were made.
2. Levels were too low to be detected.
3. Measurements were taken on November 16 and 17, 2009 at all locations except Waverley House and Newtown Manor House, which were only sampled on November 16, 2009.

3.6 Cultural Resources

3.6.1 Regulatory Framework

The following federal laws, executive orders, and regulations require that cultural resources listed in or meeting the eligibility criteria of the National Register of Historic Places (National Register) be identified, evaluated, and considered while planning federal actions:

- Sections 106 and 110 of the National Historic Preservation Act (NHPA) of 1966, as amended
- Executive Order 11593, Protection and Enhancement of the Cultural Environment
- The National Environmental Policy Act (NEPA) of 1969
- OPNAVINST 5090.1C, Environmental and Natural Resources Program Manual

This EIS is also intended to support cultural resources reviews:

- Consultation under Section 106 of the NHPA of 1966, 16 U.S.C. § 470 et seq.
- Compliance with the Archaeological and Historic Preservation Act of 1974, 16 U.S.C. §.469
- Compliance with the Archaeological Resources Protection Act of 1979, 16 U.S.C. § 470aa
- Compliance with the Abandoned Shipwreck Act of 1987, 43 U.S.C. § 2101
- Compliance with the Protection of Historic Properties Act, 36 CFR Part 800
- Compliance with the Antiquities Act of 1906, 16 U.S.C. § 431-433

In compliance with these requirements, NSF Dahlgren has undertaken multiple cultural resources surveys of its property. The objectives of previous archaeological surveys were to: characterize the archaeological potential of the property; perform testing in conjunction with proposed project actions and in compliance with Section 106; and recommend whether any identified archaeological sites were eligible for listing in the National Register. The objectives of previous architectural resources surveys were to provide the documentary and physical evidence necessary to permit recommendations of National Register eligibility. Eligibility recommendations are based on National Register criteria and National Park Service (NPS) guidance for architectural integrity (United States Department of the Interior, National Park Service, 2002).

This section describes the findings of the cultural resources surveys undertaken at NSF Dahlgren and at archaeological sites and National Register-listed historic properties in and near the PRTR MDZ that have the potential to be affected by NSWCDD's activities.

3.6.2 Areas of Potential Effect (APEs)

Section 106 requires federal agencies to define and document the Area of Potential Effect (APE) in consultation with state historic preservation officers (SHPOs). The Maryland Historic Trust

(MHT) – the SHPO for the State of Maryland – and the Virginia Department of Historic Resources (VDHR) – the SHPO for the Commonwealth of Virginia – were consulted on the APEs described below. Both SHPOs concurred with the APEs in correspondence prepared in 2008 (Appendix E). According to 36 CFR § 800.16(d), the APE is the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties and prehistoric sites, if such exist. The APE is influenced by the scale and nature of the undertaking and may be different for different kinds of effects caused by the undertaking.

The two APEs delineated for this project, the Archaeological APE and the Historic Architectural APE, are described below.

3.6.2.1 Archaeological APE

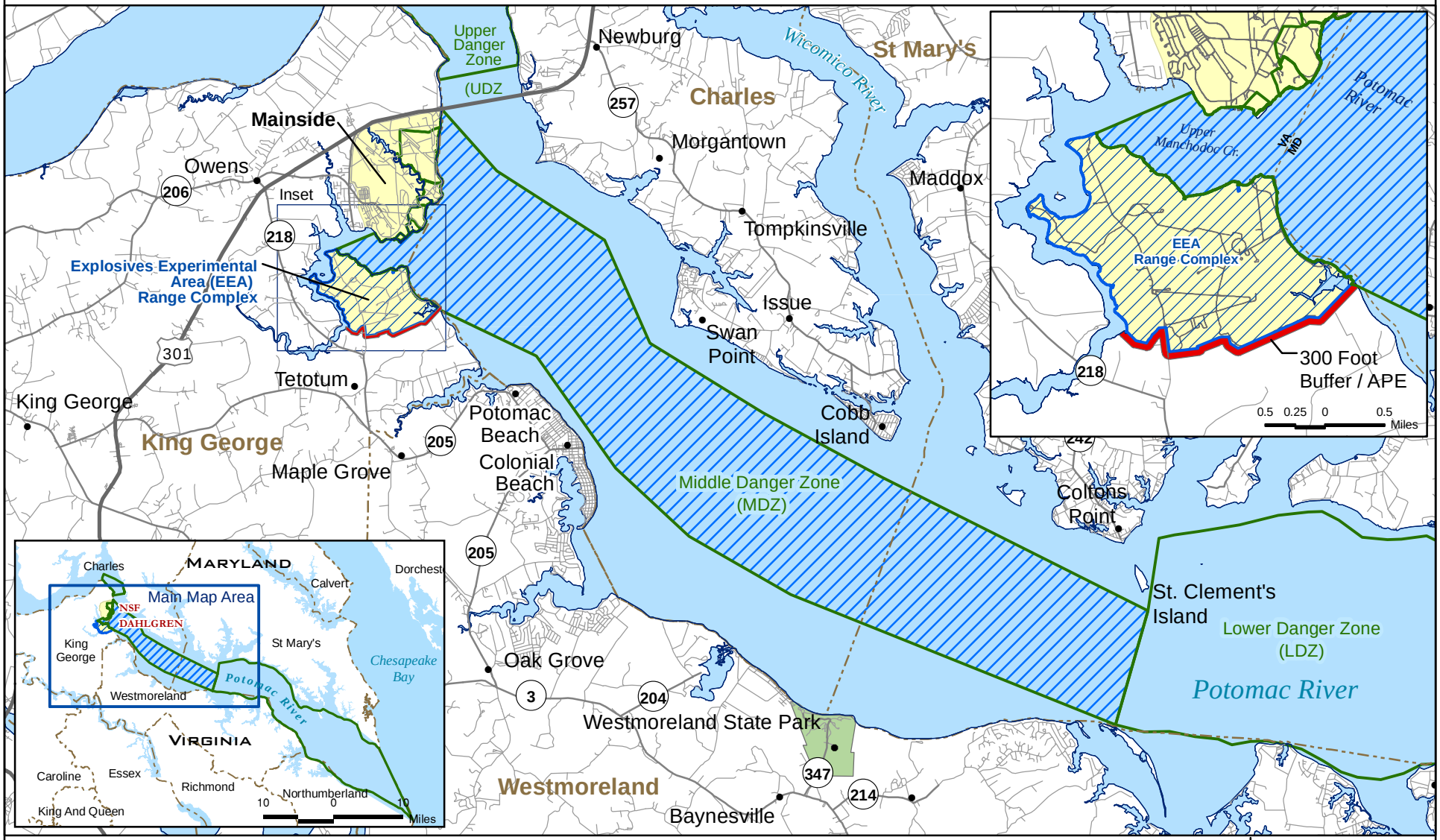
Traditionally, the Archaeological APE is concerned with direct effects and is defined by considering the areas of ground disturbance that would occur as a result of carrying out a proposed project action, such as building a new facility. In terms of the Proposed Action addressed in this EIS, the proposed activities would have little-to-no direct impact on archaeological resources within or near NSF Dahlgren, because no groundbreaking activities are proposed. However, indirect effects upon archaeological resources resulting from RDT&E activity-related noise are of potential concern, particularly with regard to shipwrecks in the Potomac River.

Therefore, the Archaeological APE is based on that portion of the PRTR that would be utilized during almost all RDT&E activities that generate noise, that is, the EEA from detonations and within the MDZ from large-caliber gun fire. In addition, the Archaeological APE includes a 300-ft-wide buffer zone along the southern boundary of the EEA from Upper Machodoc Creek to the Potomac River shoreline where indirect impacts resulting from activity-related noise may occur. The upper LDZ is used occasionally as a target area (the last time in 2009 when several rounds were fired into it), but the usage is so minimal that the APE boundary ends at the downriver MDZ boundary. Figure 3.6-1, Archaeological Area of Potential Effect, depicts the location of the Archaeological APE.

3.6.2.2 Historic Architectural APE

The Historic Architectural APE for this project was developed to account for potential direct and indirect effects of the worst-case scenario on previously identified and evaluated National Register-listed and National Register-eligible historic architectural resources in accordance with Section 106 of the NHPA. Therefore, the Historic Architectural APE includes areas where the Proposed Action may directly impact such resources, or may result in a change in character of their use or setting. In addition, the Historic Architectural APE also includes areas where the Proposed Action may indirectly cause the introduction of visual, atmospheric, or audible elements, such as vibrations, that might diminish significant features of such resources. As a result, the Historic Architectural APE encompasses portions of five counties, three in Virginia and two in Maryland. These include King George, Westmoreland, and Richmond counties in Virginia, and St. Mary’s and Charles counties in Maryland. Figure 3.6-2, Historic Architectural Area of Potential Effect, illustrates the APE.

Archaeological Area of Potential Effect



Archaeological Area of Potential Effect (APE)

300 Foot Buffer / APE

Potomac River Test Range (PRTR) Complex

Naval Support Facility (NSF) Dahlgren

County Boundary

3 0 3 Miles

5 0 5 Kilometers

N

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Source: NSF Dahlgren, 2008

Figure 3.6-1

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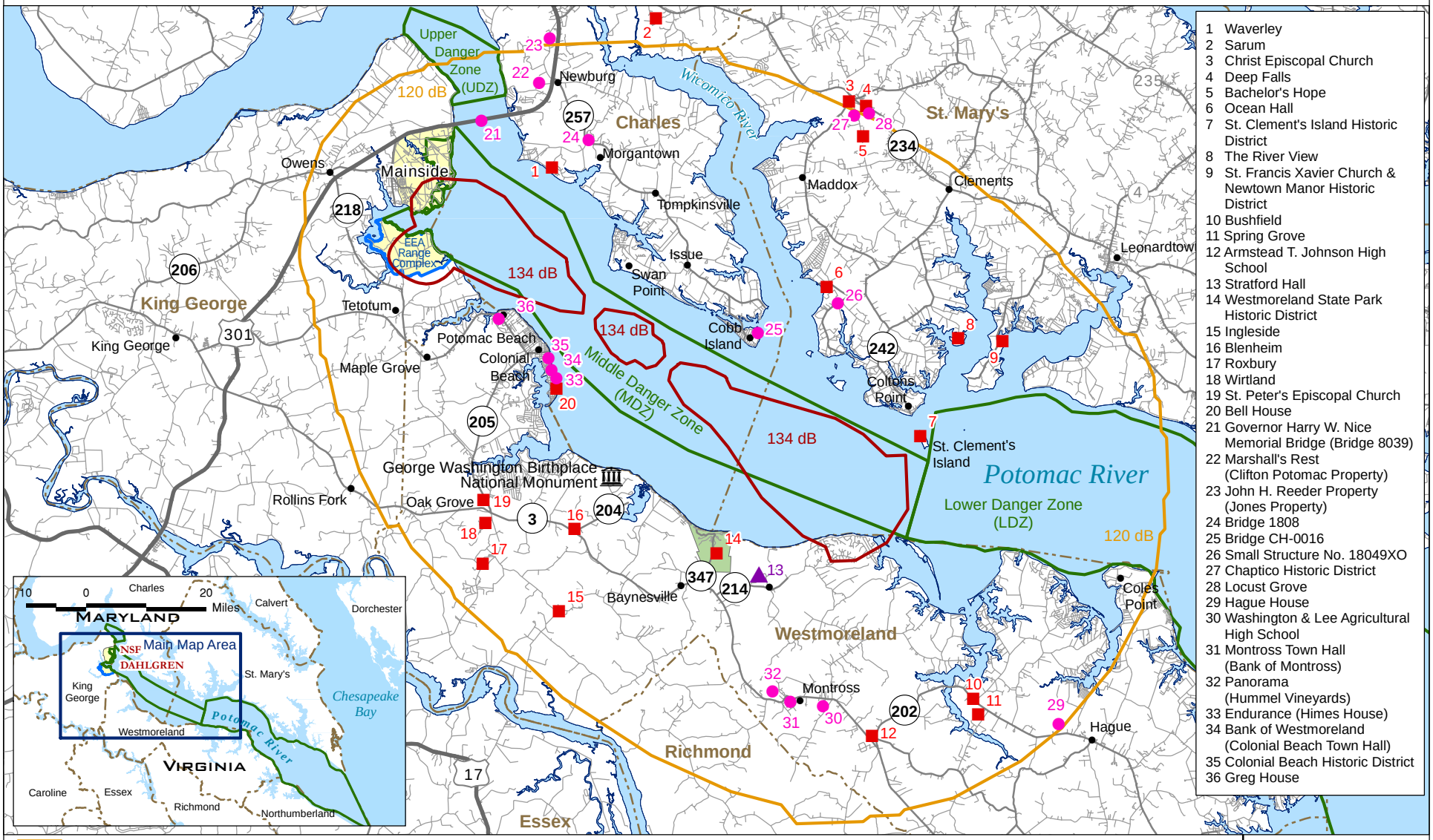
Historic Architectural Area of Potential Effect



1 Waverley
2 Sarum
3 Christ Episcopal Church
4 Deep Falls
5 Bachelor's Hope
6 Ocean Hall
7 St. Clement's Island Historic District
8 The River View
9 St. Francis Xavier Church & Newtown Manor Historic District
10 Bushfield
11 Spring Grove
12 Armstead T. Johnson High School
13 Stratford Hall
14 Westmoreland State Park Historic District
15 Ingleside
16 Blenheim
17 Roxbury
18 Wirtland
19 St. Peter's Episcopal Church
20 Bell House
21 Governor Harry W. Nice Memorial Bridge (Bridge 8039)
22 Marshall's Rest (Clifton Potomac Property)
23 John H. Reeder Property (Jones Property)
24 Bridge 1808
25 Bridge CH-0016
26 Small Structure No. 18049XO
27 Chaptico Historic District
28 Locust Grove
29 Hague House
30 Washington & Lee Agricultural High School
31 Montross Town Hall (Bank of Montross)
32 Panorama (Hummel Vineyards)
33 Endurance (Himes House)
34 Bank of Westmoreland (Colonial Beach Town Hall)
35 Colonial Beach Historic District
36 Greg House

Sources: BNOISE2 Model & NSWCDD SIPS Model

Figure 3.6-2

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Most RDT&E activities conducted at NSWCDD do not generate noise and vibration in the vicinity of the installation above ambient levels. However, activities associated with ordnance, particularly the firing of large-caliber guns on the PRTR, generate noise levels above ambient levels. The noise generated by ordnance is called impulse noise – each event can be singled out. This is different from continuous noise, such as that generated by a lawn mower.

According to research conducted by the US Bureau of Mines (Siskind, 1989, as cited in USCHPPM, 2005.), impulse noise resulting in potential vibration is typically noticed when noise levels reach 120 peak decibels (dBP). Similarly, low-frequency impulsive noise, such as large-gun firing and thunder, result in vibrations which can rattle loose window panes at levels starting at 120 dBP and may cause concern on the part of property owners. It is possible for window panes and plaster to crack in weak structures as a result of vibrations caused by sound pressure levels starting at 134 dBP. More extensive structural damage can occur at levels of 175 dBP or higher (see Section 3.5 for more information on noise and vibration).

To generate the noise contours shown in Figure 3.6-2, BNOISE2, a large-weapon noise-modeling software program developed by the US Army, was utilized (see Section 3.5 for more details). The model incorporates inputs such as types of weapons, weather, and sound-propagation surface conditions to predict peak-noise contours generated by ordnance used and expected to be used by NSWCDD.

The Historic Architectural APE is based upon peak-noise contours associated with multiple gun/projectile firings and detonations that would not occur simultaneously, but were combined in the noise modeling to form the worst-case scenario. The gun/projectile firings include the live and inert firing of multiple large-caliber guns at land-based ranges within the PRTR Complex. Detonations include the detonation of ordnance within the EEA Complex. Two key events help define the peak-noise contours which form the Historic Architectural APE featured in Figure 3.6-2. These events are:

- Live firing of 8” guns at a 27,500-yd distance from the Main Range of the PRTR Complex.
- Detonations of 200-lb NEW ordnance within Churchill Range at the EEA Complex and 1,000-lb NEW ordnance buried in the ground.

One 120-dBP noise contour and three 134-dBP noise contours depicted in Figure 3.6-2 represent locations where average peak-noise levels associated with these events are predicted to occur under a range of weather conditions.

Although the 120-dBP noise contour is below the property damage-causing threshold, it has the potential to concern affected property owners, as it has been determined that people begin to be concerned about damage at levels considerably below those actually capable of causing damage. Thus, it has been selected as the larger Historic Architectural APE for this project.

The three 134-dBP noise contours depicted in Figure 3.6-2 are situated within the 120-dBP noise contour. These include the westernmost, central and easternmost contours, and are described below:

- The westernmost contour reflects noise levels originating from guns fired from the Main Range of the PRTR Complex, and detonations within Churchill Range at the EEA Complex. The contour partially occurs on land within NSF Dahlgren and within the PRTR MDZ in the Potomac River.
- Two contours coincide with target areas in the river where live (explosive) projectiles and inert projectiles with live fuzes are fired from one of the land ranges into the MDZ. The central contour solely occurs within the PRTR MDZ. The majority of the easternmost contour occurs within the PRTR MDZ, while the southeast portion of the contour occurs in the Stratford Harbour development in Westmoreland County, Virginia.

When totally inert projectiles are fired, the only noise source is at the gun – there is no second noise source from an explosion at a target area down river. Consequently, the 120-dBP noise contour is much smaller when inert ordnance, which in the last fifteen years has been about three-quarters of the rounds fired, is used.

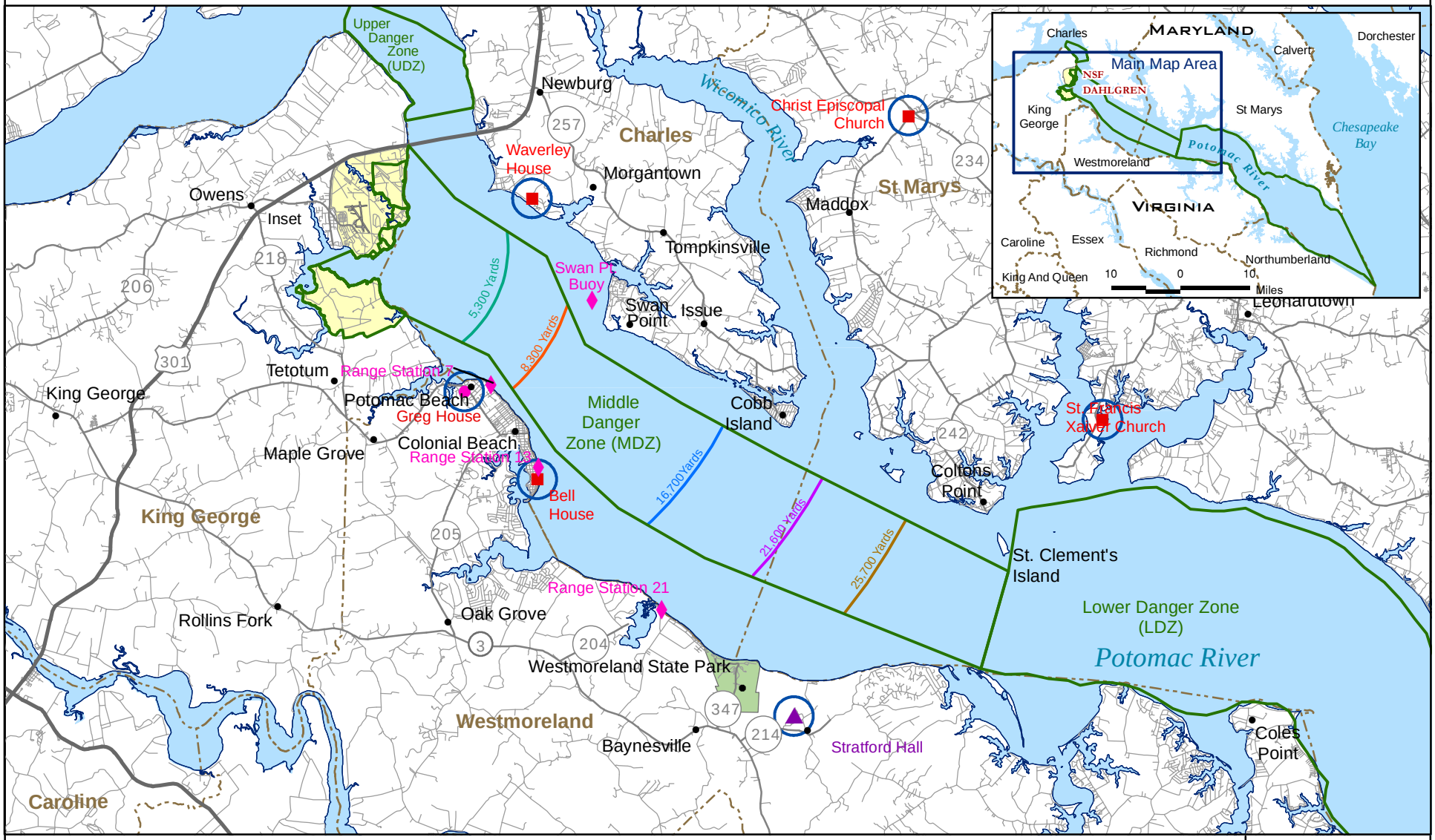
Although the Historic Architectural APE was delineated based on the live firing of the 8”/55 caliber gun, it should be noted that this gun has not been fired by NSWCDD with live projectiles since 2002, and contours are based on the BNOISE2 model assumptions for this gun. The gun was fired most recently in 2008 with a canister of electronic components of fuzes and projectiles as the payload to evaluate how well the components could withstand high gravitational forces during launching. When the 8” gun fires canisters, a reduced charge is used and the canisters contain no explosives. Even though the 8” gun today is used as a one-of-a-kind test fixture rather than to test the gun itself, noise modeling for the 8”/55 gun was used to help define the APE because it represents the future worst case for noise levels, making an allowance for future components – such as long-range projectiles – which may be noisier than current ones. The 5”/62 caliber gun is the largest gun fired frequently by NSWCDD, but it is not included in the BNOISE2 program and so could not be modeled. A somewhat larger-caliber gun, the 155 mm (6.1”) howitzer, is fired infrequently and normally not into the river. Figure 3.5-5’s noise contours are partially based on modeling of noise levels resulting from firing live projectiles from the 5”/54 and 155 mm guns but do not include the 8”/55 gun.

So few rounds are fired every now and then into the upper part of the LDZ compared to the thousands fired annually into the MDZ that the APE was based on targets in the MDZ only. Supporting this decision, noise and vibration measurements taken at the National Register-listed Newtown Manor House (St. Francis Xavier Church & Newtown Manor Historic District), which is located on the upper LDZ, during the firing of a few rounds into the LDZ in 2009, indicated no impact on the historic structure (see Figure 3.6-3, Selected Historic Structures, Measurement Sites, and Target Areas, and Appendix D).

3.6.3 Consulting Parties

In addition to notifying SHPOs and identifying historic properties within APEs that may be affected by the proposed undertaking, Section 106 requires federal agencies, such as NSF Dahlgren, to identify consulting parties with an interest in the effects of an undertaking on historic properties and seek ways to avoid, minimize, or mitigate any adverse effects on historic properties in collaboration with consulting parties. According to 36 CFR § 800.2(c), consulting parties include SHPOs (in this case, VDHR and MHT), representatives of local governments,

Selected Historic Structures, Measurement Sites, and Target Areas



Selected National Historic Landmark/National Register Listed
Selected National Register Listed
Selected National Register Eligible
Noise Monitoring Location
Vibration and Noise Monitoring Site

Target Areas
5,300 Yards
8,300 Yards
16,700 Yards
21,600 Yards
25,700 Yards

Potomac River Test Range (PRTR) Complex
Naval Support Facility (NSF) Dahlgren
County Boundary

Sources: BNOISE2 Model & NSWCDD SIPS Model

3 0 3 Miles
5 0 5 Kilometers
N

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Figure 3.6-3

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individuals or organizations with a demonstrated interest in the undertaking, Native American tribes, and the public.

In 2008, NSF Dahlgren began the process of identifying and engaging consulting parties in accordance with Section 106. Specifically, the Navy included a list of up to 32 proposed consulting parties in correspondence sent to VDHR and MHT which notified them about the project, the proposed APEs, and requested their participation in compliance with Section 106 (see Section 3.6.2 and Appendix E). Both VDHR and MHT generally concurred with the list of proposed consulting parties in 2008. The list included local government agencies, historic preservation organizations, historical societies, and administrators of publicly-accessible historic properties situated within and adjacent to the Archaeological and Historic Architectural APEs in Virginia and Maryland. In addition, both VDHR and MHT indicated that Native American tribes and tribal organizations in Virginia and Maryland should also be invited to participate as consulting parties. Correspondence from both agencies pertaining to consulting parties is included in Appendix E.

In 2009, NSF Dahlgren invited 43 local government agencies, historic preservation organizations, historical societies, administrators of publicly-accessible historic properties, and Native American tribes with an interest in the proposed undertaking to participate in the Section 106 process for this project. Correspondence is included in Appendix E.

Of the 43 invited entities, three within the Historic Architectural APE responded that they would like to be considered consulting parties as part of this project:

- Stratford Hall, Stratford, Virginia (National Historic Landmark [NHL]/National Register-listed)
- Charles County Historical Trust, Newburg, Maryland
- Charles County Government, Planning & Growth Management, La Plata, Maryland

Correspondence is included in Appendix E.

As the project progresses, it is anticipated that the Advisory Council on Historic Preservation (ACHP) will be notified about this project. The ACHP provides guidance and advice concerning the operation of the Section 106 process. According to 36 CFR Part 800, Appendix B, ACHP may choose to participate in the Section 106 process as a consulting party when an undertaking:

- Has substantial impacts (adverse effects) on important historic properties.
- Presents important questions of policy or interpretation.
- Has the potential for presenting procedural problems, including, but not limited to, disputes among or about consulting parties which ACHP's involvement could help resolve.
- Presents issues of concern to Native American tribes (36 CFR Part 800, Appendix B).

3.6.4 Noise and Vibration Monitoring

In 2009, Christ Episcopal Church, a National Register-listed resource just beyond the 120-dBP peak-noise contour of the Historic Architectural APE, submitted a letter to NSWCDD in

response to its request to participate in the Section 106 process as a consulting party. The church expressed concern regarding possible impacts that vibrations associated with outdoor RDT&E activities at NSF Dahlgren may have on the church, and noted that during test events, vibrations were felt and windows rattled. Furthermore, the church also expressed concern about the accuracy of noise models upon which the Historic Architectural APE is based, and whether structural damage may occur near the 120-dBP contour despite documentation to the contrary. Members of the church requested that noise and vibration monitoring take place at the church to determine whether outdoor RDT&E activities have the potential to cause damage to the church. The correspondence is included in Appendix E.

The noise models described in Sections 3.5 and 3.6.2.2 were employed to develop the Historic Architectural APE, and are conventional tools utilized by numerous military installations to conservatively forecast weapons noise. These models have been developed through stringent validation procedures based on a vast quantity of field measurements. However, in order to address concerns raised by Christ Episcopal Church, NSWCDD opted to monitor noise and vibration levels at six historic architectural resources within the 120-dBP contour of the Historic Architectural APE during large gun/projectile operations.

The six selected resources included National Register-listed and eligible resources in Virginia and Maryland. Three resources were selected in Virginia:

- Stratford Hall (NHL/National Register-listed)
- Bell House (National Register-listed)
- Greg House (National Register-eligible)

Three resources were selected in Maryland:

- Waverley (National Register-listed)
- Christ Episcopal Church (National Register-listed)
- Newtown Manor House (St. Francis Xavier Church & Newtown Manor Historic District) (National Register-listed)

The six resources are depicted on Figures 3.6-2 and 3.6-3, and described in Table 3.6-1 and Table 3.6-2.

Three of the six resources had been invited to participate in the Section 106 process because of their publicly accessible status. The resources included Christ Episcopal Church, as noted above, and Stratford Hall and the Bell House. Of these three resources, only Stratford Hall accepted the invitation to become a consulting party.

The six resources were selected to participate in the noise and vibration monitoring study based on several factors, including:

- Proximity to NSF Dahlgren and the PRTR
- Building type
- Construction materials
- Owner concern

Table 3.6-1
National Register-Listed Resources Outside NSF Dahlgren

Map Number	Resource Name	Location	Description	Status	Within APE	Outside APE
1	Waverley	Waverly Point Road Newburg Charles County, MD	Federal-style brick home built between 1782 and 1823	National Register-listed, 1987	X	
2	Sarum	Budds Creek Road (Maryland State Route 234) Newport Charles County, MD	"Virginia-style" home, built ca. 1680; oldest documented structure in Charles County.	National Register-listed, 1974		X
3	Christ Episcopal Church	**Church:** 25390 Maddox Road Chaptico St. Mary's County, MD **Parish Hall:** 37497 Zach Fowler Road Chaptico St. Mary's County, MD	Congregation was established in 1640; Colonial-style brick church was constructed in 1736 and is one of the oldest in continual use in the United States.	National Register-listed, 1994		X
4	Deep Falls	Deep Falls Road Chaptico St. Mary's County, MD	Built in 1745 by the Thomas family.	National Register-listed, 1975		X
5	Bachelor's Hope	Manor School Road Chaptico St. Mary's County, MD	Two-story, three-bay brick dwelling constructed in the 18th century.	National Register-listed, 2007	X	
6	Ocean Hall	Bushwood Road Bushwood St. Mary's County, MD	Built before 1670, Ocean Hall is the oldest surviving home in Maryland.	National Register-listed, 1973	X	
7	St. Clement's Island Historic District	St. Clement's Island St. Mary's County, MD	Small, deserted island in the Potomac River, which marks the location of the first landing of the English settlers of Maryland and the first Catholic mass held in the New World.	National Register-listed, 1972	X	
8	The River View	Burch Road St. Mary's County, MD	Built in the early 18th century by the Gardiner family, this property is notable for its smokehouse, shed, and log quarters – the largest grouping of such buildings in St. Mary's County.	National Register-listed, 1976	X	
9	St. Francis Xavier Church and Newtown Manor Historic District	Newtown Neck Road (Maryland State Route 243) Leonardtown St. Mary's County, MD	Part of the manor house is thought to date to the 1600s; otherwise constructed in 1767, these buildings, including a frame church, brick manor house, and the surrounding 700-ac farm comprise an example of a self-contained Jesuit community.	National Register-listed, 1972	X	

Table 3.6-1 (Continued)
National Register-Listed Resources Outside NSF Dahlgren

Map Number	Resource Name	Location	Description	Status	Within APE	Outside APE
10	Bushfield	367 Club House Loop Virginia State Route 708 Mount Holly Westmoreland County, VA	Early-18th-century home once owned by George Washington's brother; renovated in 1919 in the Colonial Revival style by architect Waddy Butler Wood.	National Register-listed, 2004	X	
11	Spring Grove	Virginia State Route 202 Mount Holly Westmoreland County, VA	Federal-style estate is an outstanding example of early-19th century architecture in rural Virginia.	National Register-listed, 1985	X	
12	Armstead T. Johnson High School	Virginia State Route 202 Montross Westmoreland County, VA	High school constructed in 1937 specifically for African-American students during the era of segregation; funded by Works Progress Administration (WPA) and donations from community.	National Register-listed, 1998	X	
13	Stratford Hall	Great House Road Stratford Westmoreland County, VA	Built in the 1730s by the Lee family, this H-shaped brick building is a notable example of an early Georgian-style home. It was the birthplace of General Robert E. Lee, Commander of the Confederate armies, as well as the home of two signers of the Declaration of Independence, Richard Henry and Francis Lightfoot Lee.	NHL/National Register-listed, 1966	X	
14	Westmoreland State Park Historic District	Westmoreland State Park, Westmoreland County, VA	One of six planned state parks conceived by the Commonwealth of Virginia during the 1920s and 1930s, the park was jointly developed between 1933 and 1943 by the Civilian Conservation Corps, NPS, and Virginia Commission on Conservation and Development. Park consists of a beach, cliffs, wetlands, ravines, and heavily forested areas; includes cabins, campgrounds and recreational areas.	National Register-listed, 2005	X	
15	Ingleside	Virginia State Route 638 Oak Grove Westmoreland County, VA	Built as Washington Academy in 1834; Classical Revival-style building was based on the Virginia Capitol in Richmond.	National Register-listed, 1977	X	
16	Blenheim	Virginia State Route 3 Oak Grove Westmoreland County, VA	Colonial-style home built by William Augustine Washington, George Washington's half-brother, in 1780.	National Register-listed, 1976	X	
17	Roxbury	Virginia State Route 638 Oak Grove Westmoreland County, VA	Built in 1861, this home's mid-Victorian style is more commonly found in the north.	National Register-listed, 1977	X	
18	Wirtland	Virginia State Route 638 Oak Grove Westmoreland County, VA	Built in 1850 by Dr. William Wirt, Jr., this home is one of the few examples of domestic Gothic Revival-style architecture in Westmoreland County.	National Register-listed, 1977	X	

Table 3.6-1 (Continued)
National Register-Listed Resources Outside NSF Dahlgren

Map Number	Resource Name	Location	Description	Status	Within APE	Outside APE
19	St. Peter's Episcopal Church	Virginia State Route 3 Oak Grove Westmoreland County, VA	Built in 1849, this church is a rare example of the Gothic Revival style; Washington, Monroe, and Lee families worshipped at the church.	National Register-listed, 2004	X	
20	Bell House	821 Irving Avenue Colonial Beach Westmoreland County, VA	Shingle-style frame house erected ca. 1883 when Colonial Beach emerged as a popular waterfront resort; acquired by family of Alexander Graham Bell in 1886.	National Register-listed, 1987	X	

Table 3.6-2
National Register-Eligible Resources Outside NSF Dahlgren

Map Number	Resource Name	Location	Description	Status	Within APE	Outside APE
21	Governor Harry W. Nice Memorial Bridge (Bridge 8039)	US Route 301 over the Potomac River Newburg Charles County, MD	This 1.7-mi-long bridge was built between 1939 and 1940 as part of Maryland's Primary Bridge Program which was initiated in the 1930s to provide access to previously isolated areas in Maryland; the only known example of a metal cantilever bridge in Maryland.	National Register-eligible, 2001	X	
22	Marshall's Rest (Clifton Potomac Property)	11985 Edgehill Road Newburg Charles County, MD	Built in 1847, this home is a representative example of a mid-19th-century farmhouse with Federal-style influences.	National Register-eligible, 1997	X	
23	John H. Reeder Property (Jones Property)	11450 Edgehill Road Newburg Charles County, MD	Built ca. 1865, this property is a good example of a mid-19th-century I-house with associated outbuildings, including barns, spring house, and smokehouse, all of which have retained integrity.	National Register-eligible, 1997		X
24	Bridge 1808	Maddox Road (Maryland State Route 238) over Burroughs Run Vicinity of Maddox St. Mary's County, MD	Bridge was built in 1929 by the State Roads Commission as part of the St. Mary's County road expansion; survives as a significant example of a single-span closed concrete-arch bridge with pierced concrete parapets.	National Register-eligible, 2001	X	
25	Bridge CH-0016	Rock Point Road over Ditchley Prong Vicinity of the Village of Wayside Charles County, MD	Built in the 1920s, this single concrete beam- span bridge with concrete parapets is a representative example of its type, and has retained a high degree of integrity.	National Register-eligible, 2001	X	

Table 3.6-2 (Continued)
National Register-Eligible Resources Outside NSF Dahlgren

Map Number	Resource Name	Location	Description	Status	Within APE	Outside APE
26	Small Structure No. 18049XO	Maryland State Route 520 over Branch of Whites Neck Creek Bushwood St. Mary's County, MD	Built in the 1930s-40s, bridge is an example of a concrete slab structure with concrete pier abutments, wing walls, and balustrade which has retained integrity.	National Register-eligible, 1997	X	
27	Chaptico Historic District	Chaptico St. Mary's County, MD	This cluster of 18th-, 19th-, and early-20th century religious, commercial, and residential buildings form a rare surviving village center which originated in the 18th century in St. Mary's County.	National Register-eligible, 2004	X	
28	Locust Grove	25434 Hurry Road Chaptico St. Mary's County, MD	Built ca. 1850, this home is a good example of well-preserved 19th-century domestic architecture. The interior features rare examples of Greek Revival-style woodwork and faux graining.	National Register-eligible, 2004		X
29	Hague House	Virginia State Route 202 Hague Westmoreland County, VA	Built during the late 18th century by John and Joseph Hague, this one-and-a-half story, four-bay wood-frame residence was transformed into the rear ell of a newly-constructed two-story residence around 1900.	National Register-eligible, 1996	X	
30	Washington & Lee Agricultural High School	16380 Kings Highway (Virginia State Route 3) Montross Westmoreland County, VA	Built ca. 1930, this is a one-and-a-half story, brick, Cape Cod-style school building.	National Register-eligible, 2000	X	
31	Montross Town Hall (Bank of Montross) ***DEMOLISHED IN 2001***[1]	100 Hawthorne Street Montross Westmoreland County, VA	Built in 1925 by Edward G. "Peck" Heflin, this one-and-a-half story brick, Classical Revival-style house had a flat roof and arched windows. It served as the second location of the Bank of Montross, established in 1908, and later the Montross Town Hall; demolished in 2001.	National Register-eligible, 2000	X	
32	Panorama (Hummel Vineyards)	1005 Panorama Road Montross Westmoreland County, VA	Built in 1932 in the Georgian style by the last private owners of Stratford Hall Plantation (home of Robert E. Lee), the bricks of this three-story house are thought to have been made at Stratford Hall.	National Register-eligible, 2004; nominated to the National Register in 2008; National Register listing pending	X	

Table 3.6-2 (Continued)
National Register-Eligible Resources Outside NSF Dahlgren

Map Number	Resource Name	Location	Description	Status	Within APE	Outside APE
33	Endurance (Himes House)	29 Irving Avenue South Colonial Beach Westmoreland County, VA	Built in 1906 in the Queen Anne style based upon a Sears, Roebuck, & Co. pattern, this two-story, three-bay, side-passage, double-pile house is located in an area known as "The Point," laid out around the turn of the 20th century by the Colonial Beach Improvement Company.	National Register-eligible, 2001; also located within the potentially National Register- eligible Colonial Beach Historic District.	X	
34	Bank of Westmoreland (Colonial Beach Town Hall)	18 Irving Avenue North Colonial Beach Westmoreland County, VA	Built in 1904 by the Mumford Company of Cape Charles, VA, this one-story, three-bay, side-passage commercial bank building is located in downtown Colonial Beach; converted to function as Bank of Westmoreland in 1907; currently functions as Town Hall of Colonial Beach.	National Register-eligible, 2001; also located within the potentially National Register- eligible Colonial Beach Historic District.	X	
35	Colonial Beach Historic District[2]	Colonial Beach Westmoreland County, VA	District encompasses a 56-acre portion of Colonial Beach, a resort town on the Potomac River; primarily includes vernacular residential and commercial buildings constructed between 1900 and 1920.	National Register-eligible, 2001	X	
36	Greg House	1763 McKinney Boulevard Colonial Beach, Westmoreland County, VA	Built ca. 1925, this one-and-a-half story, three-bay, center-passage, double-pile, frame, bungalow, sits atop a promontory overlooking the Potomac River.	National Register-eligible, 2008	X	

[1] Brenda Reamy, Town Manager, Montross, Virginia, pers. comm., October 14, 2009.

[2] *The Town of Colonial Beach Comprehensive Plan, 2009-2029* indicates that a preliminary historic district is proposed within the Point and older sections of the Central Area of Colonial Beach. The preliminary district encompasses the majority of the Colonial Beach peninsula, and includes the 56-acre Colonial Beach Historic District which was determined National Register eligible by VDHR in 2001. The 2009 plan indicates that research and documentation must occur within the preliminary historic district to develop precise district boundaries for a National Register nomination form. Upon completion, the form would be submitted to VDHR for review, approval, and eventual listing in the National Register. Following listing of the district in the National Register, the 2009 plan indicates that town officials should also consider its designation as a local historic district which would be subject to local zoning ordinances and design review procedures (Town of Colonial Beach, 2010).

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Letters were sent to owners of the six resources in June and October 2009 requesting their participation in the study, and all agreed to participate. VDHR, MHT, Charles County Historical Trust, and Charles County Government Planning and Growth Management were also notified of the study during the same period. Correspondence is included in Appendix E.

Gun/projectile activities at NSF Dahlgren were monitored by noise specialists at the six resources on November 16 and 17, 2009. These dates were selected because 5”/62 guns with live projectiles were being fired from the AA Fuze Range at multiple target areas in the PRTR. The 5”/62 gun is the largest and loudest gun fired frequently at NSF Dahlgren. Figure 3.6-3 shows the historic structures where noise and vibration levels were measured, range stations where noise levels were measured, and target areas used on the two days of firing.

Although the Historic Architectural APE was delineated based in large part on the live firing of projectiles from the 8”/55 caliber gun – which is larger and louder than the 5”62 caliber gun – firing the 8” gun for these tests was not possible because it is no longer used to fire live projectiles. The 155 mm howitzer (equivalent to a 6.1” caliber gun and hence louder than the 5”62 caliber gun) is fired infrequently, and in fact, was not fired in 2009 at all. If the 155 mm howitzer were scheduled for testing downrange on the PRTR in the future, the noise model would be used to predict noise contours prior to use. As the 5”/62 projectiles were the largest caliber rounds that had associated noise and vibration measurements, they were selected for the study.

To monitor the noise and vibration effects of the 5”/62 gun on the six resources, noise specialists affixed sensors to the buildings and grounds. Noise and vibration levels were recorded during the firing of the guns from the AA Fuze Range of the PRTR Complex, and also during detonation of the projectiles in target areas in the PRTR.

Detailed results of the noise and vibration measurements at six historic structures near NSF Dahlgren on November 16 and 17, 2009 are included in Appendix D. Peak noise levels (described in Section 3.5.4.3) ranged from 89 to 129 dBP. Vibration levels (described in Section 3.5.5) ranged from not detectable to slightly above 0.5 in/sec. The threshold level for minor structural damage caused by vibrations is 2.0 in/sec. Vibration levels measured at the six resources were well below the threshold level. Therefore, the results indicate that noise and vibration levels associated with live firing of the 5”/62 caliber gun did not result in structural damage to the six resources.

Furthermore, the peak noise levels measured during firing of the 5”/62 gun over the course of the two-day period are comparable, and in some cases lower – particularly at locations away from the PRTR shore line – than predicted noise contours depicted in Figure 3.5-5. Therefore, noise and vibration monitoring indicate that noise models utilized to develop noise contours depicted in Figure 3.5-5 appear to be accurate. The BNOISE2 model-predicted contours are conservative in nature, and thus ample enough to take into account certain physical and atmospheric conditions that may result in variable noise and vibration levels associated with gun/projectile operations. As a result, it is likely that the noise model utilized to develop the Historic Architectural APE is also accurate.

Results of the noise and vibration monitoring study have been used to assist in the assessment of the Proposed Action on historic architectural resources described in Section 4.6.2.

3.6.5 Prehistoric Context

The paleoenvironment and temporal divisions of the Prehistoric cultural sequence relevant to NSF Dahlgren and vicinity are discussed below.

3.6.5.1 Paleoenvironment

NSF Dahlgren is located on the western banks of the Potomac River in the Tidewater Region at the northern tip of Virginia's Northern Neck (the geographic name for the area between the Potomac and Rappahannock Rivers), in King George County, Virginia. This area is classified as the Coastal Plain Physiographic province of the Middle Atlantic Region. The tilted beds of the Coastal Plain extend offshore some 50 to 75 mi to the edge of the North American continent (the continental shelf). The continental shelf has not always been submerged. During the Pleistocene, sea levels lowered, exposing the shelf; streams then flowed across the shelf, carving valleys. As the Pleistocene waned about 10,000 years ago and the Holocene began, temperatures warmed, northern glaciers melted, and sea levels rose again, flooding the shelf and submerging these valleys. The Chesapeake Bay is one of these submerged Pleistocene valleys.

The stream-cutting of the Pleistocene that created Chesapeake Bay also led to the dissection of the Coastal Plain into several peninsulas. The northernmost of these, known as the Northern Neck, is bounded by the Potomac River to the north, the Chesapeake Bay to the east, and the Rappahannock River to the south.

The environment of the Coastal Plain in the Middle Atlantic region has generally remained relatively stable for the past 3,000 years. When the Pleistocene ended and the ice sheets retreated about 10,000 years ago, a gradual warming trend occurred and open tundra and boreal forest environments were replaced by mixed deciduous environments more typical of southern temperate zones. An essentially modern climate and environment had become established. Evidence for cultural adaptation to the changing environment is evident through artifact and settlement pattern variation. Major developments in cultural patterns recognized in the Virginia archaeological record are referred to by period and are described in the following section.

3.6.5.2 Prehistoric Cultural Sequence

The prehistoric cultural sequence for the Chesapeake Watershed and the Northern Neck region of Virginia closely follows the more general sequence defined for the Middle Atlantic Region. The following subsections provide summary information on this chronology, organized by the three major prehistoric adaptive trends (Paleo-Indian, Archaic, and Woodland) as they pertain to Virginia. The temporal divisions are based on technological advancements, the stylistic evolution of the lithic (stone) tool kit, and changes in subsistence strategies related to a changing environment and resource base.

Paleo-Indian Period – 12,000 BC to 8,000 BC

Near the end of the last ice age, about 12,000 years ago, the food supply of Paleo-Indian people increased and became more stable. With milder weather, more animals and plants survived and climatic conditions became more favorable. The Paleo-Indians of Virginia were "hunter-foragers," whose primary means of subsistence was hunting large mammals, supplemented by gathering wild plants and seeds. They lived in small family bands whose numbers would

increase or decrease through marriage, death, and other factors. These bands were widely scattered and "semi-nomadic," moving from place to place to take advantage of seasonal and ephemeral food resources.

The Flint Run Paleo-Indian Complex, located in the upper Shenandoah Valley, is one of Virginia's more important Paleo-Indian period resources (Gardner, 1974). This complex, excavated primarily in the early 1970s, is a series of sites generally located around a cluster of toolstone quarries that lead to a significant leap in the understanding of Paleo-Indian lithic procurement strategies. No Paleo-Indian sites have been recorded within the boundaries of NSF Dahlgren.

Archaic Period – 8,000 BC to 1,200 BC

Early Archaic Period

Early in the Archaic Period – from 8,000 to 6,000 BC – hunting remained the primary means of subsistence. Like the Paleo-Indian peoples before them, Early Archaic groups traveled in mobile bands, although it appears they did not travel quite so widely nor so frequently as their predecessors. Lithic technology advanced and stoneworking methods were adapted to better utilize higher-quality toolstones, such as chert and rhyolite, and to better exploit new and emerging faunal resources. Use of lower-quality toolstones obtained from local sources, such as quartz and quartzite, is also evident. As sea levels rose during this period and the Middle Archaic Period, coastal and lower riverine Paleo-Indian sites located along then-existing shorelines were submerged by rising sea levels.

As in the Paleo-Indian Period, Early Archaic Period groups lived in mobile bands. There is evidence that these bands moved across more tightly defined areas and traveled less frequently than did bands during the Paleo-Indian Period. In Virginia and throughout the Middle Atlantic region, Early Archaic sites frequently occur on large river terraces or upland surfaces (Johnson, 1986).

Within the boundaries of NSF Dahlgren, two archaeological sites have been recorded that contain artifacts diagnostic to the Early Archaic Period. Tests excavations at site 44KG168 yielded a LeCroy-type, bifurcate-base projectile point. The generally accepted date range for this point type is 8,000 to 5,000 BC. Investigations at site 44KG113 revealed the presence of a MacCorkle-type bifurcate-base projectile point. The general date range for this point type is 7,000 to 4,000 BC.

Middle Archaic Period

By the middle of the Archaic Period – from 6,000 to 3,000 BC – the climate had become warmer and drier. Lithic technology advanced further; techniques like pecking, grinding and polishing were being used to produce new kinds of tools that were used specifically for activities such as woodworking, seed grinding, and nut cracking.

As the food supply grew and more effective subsistence strategies were developed, populations began to rise. Middle Archaic sites are larger and more numerous. Many coastal and lower riverine bands began to establish semi-permanent fishing camps along the shores of the rivers and bays. During this period sites also began to appear in locations that had not previously been exploited, such as upland swamps and interior ridge tops.

Within NSF Dahlgren, one site has been recorded with temporally diagnostic artifacts indicating a Middle Archaic Period occupation. Shovel-test excavations at site 44KG218 yielded a Halifax-type side-notched projectile point. This point type, referred to alternately as a Brewerton type point, dates from 4,000 to 2,000 BC.

Late Archaic Period

By the end of the Archaic Period – from 3,000 to 1,200 BC – lithic technology had again advanced. Archaeological evidence indicates production of more advanced ground stone tools, such as axes and adzes and the first use of heavy stone bowls, called soapstone bowls, made from steatite. It has been suggested that soapstone bowls may indicate the use of direct-heat cooking, while others suggest a more symbolic function for these items (Maryland Department of General Services [DGS] and MHT, 1998).

Sea-level rise began to slow during this period, leading to the stabilization of riverine and estuarine environments and the growth of significant populations of shellfish and anadromous fish (fish that breed in fresh water but live their adult lives in more saline waters). Evidence from Late Archaic sites excavated in the Piedmont region of Central Virginia indicates that seasonal camp sites were located within or adjacent to forests containing nut-bearing trees. Exploitation of permanent food resources such as nuts led to the eventual increase of the more sedentary lifeways that come to fruition during the Woodland Period.

By the end of the Archaic Period and the beginning of the Woodland Period, a dramatic increase in the number of sites had occurred, suggesting both an increase in overall population and a movement into new environmental zones.

Multiple Late Archaic Period sites have been identified at NSF Dahlgren. Investigations at site 44KG112 revealed the presence of a Koens-Crispen-type broadspear point. This point type dates from 2,000 to 1,200 BC and is emblematic of Late Archaic Period stone-tool technology. Site 44KG157, a shell midden site that ranges in date from the Late Archaic through the Woodland Periods, has been determined eligible for listing in the National Register. Site 44KG217, also known as Black Marsh 1, was recommended National Register-eligible but has not yet been evaluated by VDHR (NSF Dahlgren and Engineering Field Activity Chesapeake, 2006).

Woodland Period – 1,200 BC to 1607 AD

The Woodland Period is most notably characterized by the introduction of pottery. The earliest recognized ceramic pottery type in the region is the Marcey Creek Type, a steatite tempered ceramic that dates to between 1,200 and 800 BC (Maryland DGS and MHT, 1998). The shell-tempered and net-impressed Mockely-Type pottery is characteristic of the middle part of the Woodland Period, and the cord-marked Potomac Creek Type typifies later woodland pottery styles. The appearance of pottery indicates changes in the social and political organization of production (Maryland DGS and MHT, 1998). This shift could either represent a move toward intensive harvesting of wild plant resources or the early foundations of domestication.

Other technological innovations include the development of the bow and arrow and associated stone-tool refinements, which took place during the early part of the Woodland Period. Also, a shift from curated biface tool forms – often produced using hard-to-procure high-quality lithic material – to a more expedient form produced using local quartz and quartzite, is evident during the Woodland Period.

The size and complexity of villages and settlement clusters increased as the Woodland Period advanced. Groups in the Middle Atlantic began to develop fortified villages, inter-tribal alliances, specialized societal roles, and more-refined religious and socio-political complexity.

Several sites recorded at NSF Dahlgren have yielded temporally diagnostic artifacts from the Woodland Period. At site 44KG105 test excavations yielded Popes Creek-type pottery fragments. The Popes Creek pottery type is typically thick-walled, net-impressed, sand-tempered pottery that dates from 500 BC to 300 AD. Excavations at site 44KG170 also yielded Popes Creek-type pottery fragments, and Carbon 14 dating of a sample from a pit feature at this site yielded a calibrated date range of 405 to 20 BC. A number of other Woodland Period sites have also been identified at NSF Dahlgren, according to records on file at the VDHR.

Evidence of prehistoric-period occupation on islands in the Potomac River within the vicinity of NSF Dahlgren was identified on St. Clement's Island. Several archaeological sites interpreted as prehistoric shell middens have been identified on the island. One shell midden was comprised of culturally distinct strata dating to the Middle and Late Woodland and Contact Periods (Site 18ST686, St. Clement's Island Midden [West Area I]) while another was dated to the Late Woodland Period (Site 18ST441, Borrow Pit [Field #3]). Two additional shell midden sites identified on the island did not contain culturally diagnostic artifacts (Site 18ST440 [Field #2] and Site 18ST439 [Field #1]), and their cultural affiliation is unknown.

In addition to the above-mentioned sites, an archaeological investigation in the 1960s identified a shell midden containing a burial on the eastern shore of the island (Site 18ST18, Blackistone Island [St. Clement's Island]) (MHT, 2003). This site was dated to the Woodland Period based on the presence of pottery. During the investigation, the site was excavated and the remains reportedly donated to the Smithsonian Institution. Recent investigations of the area by the MHT noted that the shoreline in the vicinity of this site has been extensively disturbed by rip-rap constructed for erosion control, as well as by hurricane activity. It was noted that the site has likely been completely destroyed by erosion and/or construction of rip-rap.

Contact Period

During the middle and late 16th century, Spanish, French, and English expeditions visited the Chesapeake Bay and its tributaries. While not specifically documented, it is likely that initial contact between Europeans and native groups in the vicinity of NSF Dahlgren occurred at this time. In 1607 the construction of a fort at Jamestown, Virginia by the English ushered in a period of more sustained contact and, ultimately, signaled the demise of existing native lifeways.

A 1648 treaty opened the Northern Neck, including the present-day NSF Dahlgren vicinity, to settlement. At this time, it is believed that the Machoatick band may still have inhabited the portion of the Northern Neck that includes NSF Dahlgren (NSF Dahlgren and Engineering Field Activity Chesapeake, 2006). Continued occupation from the Late Woodland Period into the 17th century is evidenced in the archaeological record at NSF Dahlgren (site 44KG137).

3.6.6 Historic Context

The following sections portray the historic context of the Archaeological and Historic Architectural APEs, including a historic overview of the Potomac River and the five counties within and adjacent to the Historic Architectural APE. A brief history of the installation property prior to construction of NSF Dahlgren is also provided in the King George County, Virginia overview. The historic context concludes with a brief history of NSF Dahlgren.

3.6.6.1 Potomac River in Vicinity of NSF Dahlgren

The Potomac River has served as a major transportation route over time. From its headwaters in Fairfax Stone, West Virginia, the river travels through four states before flowing into Chesapeake Bay approximately 45 mi southeast of NSF Dahlgren. Tributaries in the vicinity of NSF Dahlgren include the Port Tobacco and Wicomico Rivers and Nanjemoy and Rosier Creeks in Maryland; within NSF Dahlgren, Gambo Creek crosses through the northern portion of the installation (Mainside), Upper Machodoc Creek separates the northern and southern portions of the installation (Mainside and the EEA Complex, respectively), and Black Marsh Creek flows from the southeastern end of the installation (on the EEA complex). Several bays are located farther south along the east and west banks of the river, including Nomini, St. Clement's, and Breton.

European explorers first visited the Potomac River during the middle and late 16th century. Settlement along the Potomac River Tidewater Region began in the middle of the 17th century and prompted the need for river crossings. Due to the river's wide expanse, ferry crossings provided the only practical solution, and by the early 18th century, Virginia began to establish service to Maryland (Wilstach, 1921). Hooes Ferry, established in the vicinity of present-day NSF Dahlgren, was one of the earliest river crossings in the Northern Neck (circa. 1720) (King George County, 2008; Wilstach, 1921). Crossings on smaller, surrounding creeks and rivers would also have been necessary as settlement expanded.

Other vessels plying the waters during this period included merchant ships carrying cargo between ports. The closest major port to present-day NSF Dahlgren was in the town of Dumfries, Virginia, several miles upriver. The need for navigation along the river led to the use of lightships, and, later, the construction of lighthouses in the Potomac River. During the 19th century, several existed within the vicinity of present-day NSF Dahlgren, including at Mathias Point to the north and on St. Clement's Island to the south (Payette, 1999).

Downed row galley ships in the Wicomico River attest to maritime activity in the area during the American Revolution (1776-83) (MHT, 1997; NSF Dahlgren and Engineering Field Activity Chesapeake, 2006). Over the course of the 19th century, activity on the river between the newly established Washington Navy Yard in Washington, DC and the Chesapeake Bay increased greatly, starting with the War of 1812 (1812-14) and heightening through the Civil War (1861-65). During this time, ships of the British, United States, and Confederate States armies and navies traversed the river (NSWCDL, Not Dated).

Major batteries were constructed along the river during the Civil War to control movement on the waterway, including one at Mathias Point, north of present-day NSF Dahlgren, where the

river curves. A number of Confederate ships and fewer United States ships were sunk, burned, or otherwise lost in the river during the war (MHT, 1997; Naval Historical Center [NHC], 2008).

The 19th and 20th centuries saw the establishment of gun-proving grounds along the river by the Navy, first at the Washington Navy Yard, then at Indian Head, Maryland, and then at what was initially the "Lower Proving Ground," at Dahlgren, Virginia. Mine-testing conducted approximately 30 mi downriver from present-day NSF Dahlgren off Piney Point, Maryland utilized the U-1105, or Black Panther, a German submarine acquired by the United States as a war prize after World War II. The wreckage of the ship was designated as Maryland's first historic shipwreck preserve in 1994. Portions of the lower Potomac River continue to be utilized for testing by the Navy today.

3.6.6.2 County Histories

King George County, Virginia

King George County, Virginia, home of present-day NSF Dahlgren, was formed by the Virginia colonial legislature in 1720 out of the upper portion of what was then Richmond County. In 1776, the county expanded to include Potomac River frontage. Throughout the 17th and 18th centuries, Virginia's agricultural economy was rooted in the plantation/slave tobacco-farming system. Within the area later developed as the Dahlgren Naval Proving Ground, several plantations were present during this period. Plantations of the Hooes and Dade families occupied much of the land north of Upper Machodoc Creek (Barnesfield Plantation; Potomac View; Berry Plain; "The Cottage;" Plentiful Farm; Monmouth; and Bethany plantations) (NSWCDD, 1998; NSF Dahlgren and Engineering Field Activity Chesapeake, 2006). Tetotum Plantation was located to the south of Upper Machodoc Creek, in an area historically known as Pumpkin Neck. The plantation is believed to have been established by members of the Hooe [sic] family (NSWCDD, 1998).

The area surrounding the future location of the town of Dahlgren remained sparsely settled until the mid-19th century. By the 1860s, small settlements were concentrated along the Potomac River shoreline. During the Civil War, large portions of King George County were occupied by Union soldiers. A number of Confederate networks were also established in the county because of its riverfront location and proximity to Maryland. Within the present location of Dahlgren, suspected Confederate activities resulted in the burning of the Hooes' 18th-century home on Barnesfield Plantation by Union forces (NSWCDL, 1992; Haynes, Not Dated; Wilstach, 1921).

After the Civil War, King George County remained rural, consisting primarily of small farms. Of the plantations that once occupied present-day NSF Dahlgren, Barnesfield Plantation remained and functioned both as a plantation and dairy, which was established in the 1920s (VDHR, 1998; Naval Facilities Engineering Command [NAVFAC], Chesapeake Division, 1991; NSF Dahlgren and Engineering Field Activity Chesapeake, 2006). Other plantations developed into small communities, including an African-American community on the lands of Plentiful Farm. Dahlgren Naval Proving Ground was established on the grounds of "The Cottage" plantation in 1918 (NSWCDD, 1998; NSF Dahlgren and Engineering Field Activity Chesapeake, 2006).

Westmoreland County, Virginia

In 1651, what was the original Northumberland County, Virginia was divided into four new counties – Northumberland, Lancaster, Richmond and Westmoreland counties. The boundaries of Westmoreland County were redrawn a number of times, with the final adjustments made in 1778 (Norris, 1983). During the Colonial era, cheap land, established Protestantism, friendly Indians, and a distant government were all powerful draws for settlers to this area. By 1660, nearly all the waterfront property and much of the interior of the Northern Neck of Virginia had been settled (Norris, 1983).

In the 18th and 19th centuries, Westmoreland County was the birthplace of several prominent Americans, including George Washington in 1732; James Monroe, the fifth President of the United States, in 1758; and Robert E. Lee, Commander of the Confederate armies during the Civil War, in 1807. Their birthplaces are located along the Potomac River southeast of NSF Dahlgren. Plans are afoot to reconstruct Monroe's birthplace. Lee's birthplace, Stratford Hall, is on the National Register and is a National Monument. Washington's birthplace at Pope's Creek, with buildings reconstructed in 1931, is a National Monument.

Another connection to early American history in Westmoreland County is Leedstown, located just south of the Historic Architectural APE on the shores of the Potomac River. On February 27, 1766, Thomas Ludwell Lee and Richard Henry Lee brought together 115 patriots, who drew up and signed the Leedstown Resolutions, a Declaration of Independence that preceded Thomas Jefferson's by more than ten years (Norris, 1983).

During the 19th century, Westmoreland County's economy was (and still remains) primarily based in agriculture. However, one major economic generator for the county is the tourist destination of Colonial Beach. It began its existence as a bathing and fishing resort in the 19th century, with visitors arriving by boat from Washington, DC. Recreation activities included bathing at the mile-long sandy beach, fishing, and boating. In the latter part of the 19th century, Colonial Beach became known as "the playground on the Potomac." The area prospered as a resort destination during the late 19th and early 20th centuries, and the lure of beaches and waterfront property started a building boom of Victorian-style homes, summer cottages and large hotels. During the mid-to-late 20th century, Colonial Beach declined as vacationers' preferences changed in favor of ocean beach resorts rather than riverfront resorts. Legalized gambling and destructive fires contributed to the area's deterioration. In more recent times, however, Colonial Beach has rebounded, based on its proximity to Washington, DC and Richmond, Virginia (Colonial Beach, 2006).

Currently, farming (particularly dairy farming), fishing, and forestry remain vital parts of the Westmoreland County economy. However, the county is working to diversify, bringing in new, small manufacturing businesses, and strengthening its ties with NSF Dahlgren. Historical tourism also provides a strong economic base for the county (Westmoreland County, Virginia, Not Dated).

Richmond County, Virginia

Captain John Smith, who led the first European colonization at Jamestown, Virginia, was the first Englishman to set foot in present-day Richmond County. He came first in 1607 as a prisoner

of Native American Chief Powhatan, and returned in 1608 with a group from Jamestown to explore the Rappahannock River (Harper, 1992).

The county was established in 1692. Its county seat is the Town of Warsaw, located southeast of the Historic Architectural APE. Tobacco, specifically of the sweet-scented Oranco variety, was the major cash crop of Richmond County during the Colonial era. At that time, tobacco was so valued in Virginia that it was used as a means of monetary exchange, since coinage from other parts of the world was rare in the colonies (Harper, 1992).

Throughout this primarily rural county's history, farming, fishing, and forestry have been its main sources of income. In the 20th and 21st centuries, natural resources and government have defined Richmond County's economy, employing over half the working population. Tourism also comprises a large part of the local economic base (Virginia Economic Development Partnership, 2007).

St. Mary's County, Maryland

The first settlers of Maryland came to present-day St. Mary's County in 1634. They sailed from the Isle of Wight, England on two ships – the *Ark* and the *Dove*. They landed at St. Clement's Island, located in the Potomac River at the southwestern edge of the MDZ. They chose this as their first landing site because of its strategic location at a distance from the possibly hostile Native Americans. Upon landing, they celebrated the first known Catholic mass within the thirteen colonies (Hammett, 1977). Soon after landing, the colonists established friendly relations with the Native Yeocomico tribe. Governor Leonard Calvert traded axes, hoes, hatchets, and cloth with the tribe within a 30-mi area that was roughly contiguous with present-day St. Mary's County (Hammett, 1977).

The first settlement in Maryland was established at St. Mary's City, located east of the Historic Architectural APE. Until the first decade of the 18th century, the citizens of St. Mary's County were almost entirely immigrants (Hammett, 1977). Although St. Mary's County was a Catholic colony, settlers of any religion were welcome. However, Protestants took control in 1689 and forbade Catholics from holding office, serving on juries, or bearing arms (Reno, 2004). By 1695, there were 1,049 taxable settlers in St. Mary's County, and Protestants succeeded in transferring the capital of Maryland from St. Mary's City to Annapolis, which remains the seat of Maryland's state government today (Hammett, 1977).

Like many of the surrounding counties, St. Mary's County was heavily dependent upon tobacco cultivation and the fishing industry. During the Civil War, Maryland was a Union state. However, because of its dependence upon the tobacco/slave farming system, St. Mary's County heavily supported the Confederacy. In 1977, historian Regina Combs Hammett wrote that, in some parts of St. Mary's County, the Civil War was referred to as "the War of Northern Invasion." Many St. Mary's County residents participated by smuggling food and supplies across the Potomac River into Confederate Virginia. Until the Draft Act was passed in 1862, only four St. Mary's County residents had enlisted in the Union Army (Hammett, 1977).

During World War II (1939-1945), St. Mary's County's focus began to shift from agriculture and fishing to include a major military facility, Naval Air Station Patuxent River. "Pax River" (as it is commonly known) now covers 6,500 acres along the Patuxent River waterfront well east of the Historic Architectural APE, and is home to the Navy's principal Naval aircraft RDT&E and fleet-support facilities. Pax River has had a dramatic effect on the local economy, and now

employs approximately 22,400 military and civilian personnel, and defense contractors (Maryland Department of Business and Economic Development, 2011).

Despite the influx of new residents and technology, present-day St. Mary's County has a strong historical consciousness. St. Mary's City is now an 800-acre archaeology and living history museum. The museum has over 5 million artifacts from St. Mary's City, and visitors can experience a reconstructed historic town, including a tobacco plantation, a farm, and the State House (Historic St. Mary's City, 2011).

Charles County, Maryland

Charles County originally comprised an area much larger than its current boundaries. It was created by Cecil Calvert, the second Lord Baltimore, in 1650. It included all of present-day Charles County, as well as parts of present-day Calvert, St. Mary's, and Prince George's counties. During this time, southern Maryland was plagued by political struggle and hostility between the area's Puritan settlers and Roman Catholic England. George Calvert, the Catholic third Lord Baltimore, wanted to establish a colony free of religious persecution. In 1658, with this goal in mind, and to honor the first Lord Baltimore, Charles Calvert brokered the county's rededication with its current boundaries (Brown, 1976).

Early settlers of Charles County benefited from prime farming conditions, and focused their efforts on the cultivation of tobacco, which was grown in the area to the almost complete exclusion of other crops (Brown, 1976). The major settlement of colonial Charles County was Port Tobacco. Due to the popularity of agriculture and the fact that easy access to the Potomac River made major seaports unnecessary, Charles County was very rural. The only town in the county within the Historic Architectural APE that appeared upon a list of Maryland towns published in 1871 was Newburg, which was described as "a small post office" (Brown, 1976).

Between the 1600s and the Civil War, Charles County residents experienced stability, interrupted briefly by the War of 1812, during which the British Navy maintained fleets in the Potomac River. After the War of 1812, as the economy began to diversify, fishing was a major industry in the area. By 1832, there were 150 fisheries on the Potomac River, which employed 6,500 people (Charles County Historic Preservation Advisory Council, 2004).

During the Civil War, Charles County also primarily sympathized with the Confederacy, largely due to its tobacco/slave-dependent economy. As a result, and because of its location on the Union-Confederate border, the area was occupied by Union troops. Many Charles County men joined the Confederate Army (Charles County Historic Preservation Advisory Council, 2004).

After slavery was banned in Maryland in 1864, tobacco farming began to decline. By the end of the 19th century, producing tobacco without slave labor was so expensive that farmers could barely cover the cost of production. As a result, many farmers diversified their production. Aided by new railroads, farmers could take a variety of goods to market, and many even turned to canning. The first cannery in Charles County opened in La Plata in April 1883, and many others followed. Fisheries also regained their prominence in the area during this time (Brown, 1976).

In the 20th and early-21st centuries, military installations and legalized gambling have brought new economic bases to Charles County (Brown, 1976). Now considered part of the Washington-Arlington-Alexandria Metropolitan Area, the county has struggled to balance suburban development with the preservation of forest and agricultural lands. The county's managed-

growth strategy, outlined in its 2006 Comprehensive Plan, is to direct 75 percent of its growth to the Development District, encompassing the towns of Waldorf and Bryans Road and the area in between, located approximately 20 mi north of the Historic Architectural APE (Charles County, 2007).

3.6.6.3 History of NSF Dahlgren and NSWCDD

Pre-Installation History (1840s-1918)

The origins of the NSF Dahlgren site and NSWCDD – the Navy's RDT&E center – can be traced to the 1840s, when efforts began to improve Naval ordnance. In 1842, Congress authorized the creation of the US Navy Bureau of Ordnance and Hydrography as part of the modernization of the Navy. The purpose of the new bureau was to develop and construct shipboard weapons and projectiles, and conduct hydrographic studies for navigation purposes (Rife and Carlisle, 2006).

Two years later, federal government and Navy officials, including the Secretary of State and Secretary of the Navy, were killed by a test firing of the "Peacemaker," a 12" gun aboard the *USS Princeton*. Following this tragedy, an investigation led to multiple recommendations for Navy operations, including establishment of quality-control review for guns, and an onshore practice battery to test and range guns prior to their installation aboard ships (Rife and Carlisle, 2006).

In 1847, Lt. John A. Dahlgren (1809-70) was assigned to the Washington Navy Yard. He was an experienced oceanographer, a professor of gunnery, and had an interest in Naval technology. He was charged with transforming the Washington Navy Yard into an ordnance establishment. One of Lt. Dahlgren's top concerns was gun ranging. When produced, each new gun had slightly different characteristics, requiring that it be test-fired repeatedly to determine its range so that it could accurately hit its target when used in battle. Lt. Dahlgren established an "Experimental Battery," mounted on a gun deck overlooking the Anacostia River, with a range of five miles. It had a clear line of sight across the Potomac River to a target area just upriver from the City of Alexandria, where Reagan National Airport is situated on fill today. Lt. Dahlgren also designed special instruments, including a gunner's quadrant for measuring distances, and an alidade for recording the impacts of shots. The Anacostia battery became the prototype for shore-based Naval gun testing (Rife and Carlisle, 2006).

American Civil War and the Turn of the 20th Century (1860s-1900s)

In 1862, during the Civil War, Congress created the US Navy Bureau of Navigation. This action resulted in a reorganized Bureau of Ordnance (BUORD), led by Dahlgren, who was promoted to Rear Admiral that year. The BUORD's sole purpose was to focus on the development of US Naval guns and ordnance (Rife and Carlisle, 2006).

A decade later, naval gun ranges had increased to the point that the Navy shifted the Experimental Battery to the Severn River, across from the US Naval Academy in Annapolis, Maryland. In 1890, the advent of all-steel ships and even longer-range guns prompted a move to a new 13,000-yd testing facility on the Potomac River at Indian Head, Maryland. Still, by the turn of the 20th century, the Indian Head proving ground was quickly becoming obsolete due to the creation of longer guns with greater power. For example, stray shots, flying pieces of armor,

and bands from shells would occasionally fly into nearby civilian and military residences (Rife and Carlisle, 2006).

Indian Head as a proving ground reached the breaking point when the demands of World War I (1917-18) lead to exponential increases in gun testing. Also, full-elevation testing and accurate ranging of the powerful 16" battleship gun developed in 1914 could not be achieved within the confines of Indian Head. As a result, the US Navy began to consider a more isolated location for its proving ground (Rife and Carlisle, 2006).

Establishment of Dahlgren Naval Proving Ground (1918)

A new proving ground had several requirements. It had to be close to the Washington Navy Yard's Navy BUORD and gun factory and Indian Head's powder factory. It also had to be undeveloped, and able to accommodate a long range. During the height of US involvement in World War I, Congress authorized the acquisition by the Navy of a tract of land that included 994 acres between Machodoc Creek and the Lower Cedar Point Lighthouse on Mainside. The isolated site provided a straight, almost unimpeded, over-water range of nearly 90,000 yds toward Chesapeake Bay. Guns could efficiently be shipped by barge from the Washington Navy Yard foundry. Money was appropriated for a new long-range proving ground at Machodoc Creek on April 26, 1918. Breaking with Navy tradition, in which bases were named after the place in which they were located, the site was named after Rear Admiral Dahlgren. As an afterthought, the local post office was renamed "Dahlgren," and Navy tradition was preserved (Rife and Carlisle, 2006).

Dahlgren Naval Proving Ground, 1918-30s (Inter-war Period)

By August 1, 1921, BUORD had transferred almost all of its ordnance work from Indian Head to Dahlgren Naval Proving Ground, and subsequent development followed. Because of its isolated location, the Navy provided both residential and community-support facilities for its officers and personnel. By December 1921, construction was completed on the Commandant's Quarters, the Administration Building, a Recreation Hall, a machine shop, and shell storage and loading buildings (Rife and Carlisle, 2006).

The conclusion of World War I in November 1918 led to a sharp decrease in ordnance testing, but by 1923, Dahlgren Naval Proving Ground's developmental and experimental work was increasing as budgets were slashed. The rigor of RDT&E work increased when Dr. Louis Thompson became the civilian director in April 1923. Thompson's work was experimental and based in the Navy's post-war interest in physics and high-level mathematics.

Some of the most notable studies and projects accomplished during the decade included:

- Thermodynamics of guns
- Fuel oil ignition by projectile bursts
- Tracer shells
- Mechanically timed fuzes
- Illuminating and marker projectiles

- Anti-submarine ordnance fuzes
- Aerial bomb tests

Prescient and decades ahead of their time were studies conducted from 1919-25 of automatically piloted and radio-controlled aircraft, or flying bombs, much like today's unmanned aerial vehicles or drones. Carl L. Norden worked with Dahlgren Naval Proving Ground's scientists and engineers on these projects as well as improving bombsights. As Naval research funds dwindled, these projects were put aside in 1925 in favor of Norden's bombsight program.

As work increased at Dahlgren Naval Proving Ground, so did development of infrastructure. The Navy's Bureau of Yards and Docks was responsible for housing design and layout at Mainside. The bureau opted to adopt the newest theories of suburban planning in its vision for the installation, including the incorporation of main thoroughfares, curving streets, parks and open spaces. The military increasingly adopted these community-planning concepts after World War I to create cohesive installations. Residences constructed during this era were primarily built in the Colonial Revival and Craftsman styles, both popular domestic building modes in the US during the early 20th century. Other developments during this era included the construction of a golf course on reclaimed marshland in the central part of the officer housing area in 1927 (NAVFAC, 1994b).

A general store was also constructed at the installation. However, over time, it became apparent that it could not support the shopping needs of those living there, and therefore, every week an individual would drive to Fredericksburg for supplies. Eventually, the military and civilian population constructed a larger store, thereby decreasing the need to navigate the dirt roads to Fredericksburg, which could be especially treacherous in winter before they were paved in the 1930s (McCollum, 1976).

Industrial development also occurred at Dahlgren Naval Proving Ground in the 1920s and 30s. The Main Battery was established at Mainside during this era near the confluence of the Potomac River and Upper Machodoc Creek. The battery was comprised of laboratories, munitions-storage facilities, watch towers, firing batteries, weapons-testing structures, and other features. In the 1920s, many key facilities were erected, including the Lab & Air Compressor House (Building 249) and material-storage structures, magazines, batteries, gun racks and gun emplacements, to name a few. In 1923, the lab served as the Ballistic Measurement and Instrument Lab for preliminary ballistics and metallurgical research, and played an important role in the improvement of Naval gunnery accuracy (NAVFAC, 1994a).

The wharf area was also developed at Mainside during the inter-war period. Situated downrange from the Main Battery on the northern banks of Upper Machodoc Creek, the wharf played a role in the transportation of general supplies, heavy machines and gun barrels. In 1919 and 1920, multiple structures were erected in the wharf area, including a dock, coal pier and wharf house (NAVFAC, 1994a).

Aviation played an important role at Mainside. In 1919, the US Marine Corps built a ramp and hangar for seaplanes. In 1921, Building 110B, a land plane hangar, was built. Land-based aircraft used a grass field, although stumps in the field remained a hazard until 1925. In 1935, the grass field was replaced with a paved runway. In early aviation testing, pilots did not have radios to communicate with the base, and would instead transmit messages via carrier pigeon (McCollum, 1976).

Aviation supported the proof-firing tests. Measurements of temperatures at altitudes above 20,000 ft were also taken. These data was necessary for computing air density at high altitudes, which affected a round's performance in flight. Aircraft also supplemented watercraft in spotting artillery and patrolling the range area.

Aircraft were also used for testing all types of aviation ordnance and equipment, including bombsights, bomb racks and shackles, and weapons. In 1931, Dahlgren Naval Proving Ground began flight tests of Norden's Mark XV bombsight, a vast improvement over earlier models, and considered one of the most effective weapon systems of World War II (1941-45). Dr. Thompson worked with Norden to perfect the design over the next few years. The installation's role in the development of the Norden Mark XV bombsight, a form of analog computer, rooted it firmly within the field of mechanical computational technology, or computers (Rife and Carlisle, 2006). Aviators practiced both horizontal and dive bombing, and often experimented with high-altitude horizontal bombing. The increased number of high-altitude bombing experiments prompted the Secretary of the Navy to restrict air space north and south of the installation in the early 1940s.

A ten-year post-World War I "holiday" in capital ship building came to an end in 1932 with the election of Franklin D. Roosevelt, former Assistant Secretary of the Navy, as President of the United States. Roosevelt's New Deal extended to the Navy. By the end of 1934, 150 new ships were under construction or in planning. The installation's proving work boomed. The pace of experimental research also quickened. Projects included:

- Determination of ballistic qualities of all types of guns and shells
- Research to improve armor plate
- Development of improved 8" armor-piercing projectiles
- Development of new fuzes (Rife and Carlisle, 2006).
- Knowledge gained from the studies was applied during World War II.

Dahlgren Naval Proving Ground, World War II (1941-45)

Beginning with mobilization in 1940 and escalating when the United States entered World War II in December 1941, Dahlgren Naval Proving Ground underwent a massive expansion. Increased proof-testing requirements for surface guns and aviation ordnance triggered a transformation at the installation. In terms of size, the installation expanded by 3,500 ac in 1944, including the acquisition of the Pumpkin Neck test area at the mouth of Upper Machodoc Creek, the site of the present-day EEA. In addition, five range stations were added to the Potomac River range in Virginia.

The installation underwent dramatic industrial expansion. A 23-mi rail spur was constructed between Dahlgren and Fredericksburg to facilitate movement of heavy goods. The Main Battery at Mainside expanded as well, and the testing regime expanded tenfold, with millions of rounds fired from guns of every caliber and millions of pounds of powder expended. As the Navy's principal proving ground, all types of Navy ordnance, including guns, fuzes, and lot samples of projectiles, ammunition, and aerial bombs, were proof-tested prior to being deployed to fighting ships at sea. The airfield was expanded, and an Aviation Experimental Laboratory was established to develop and test rocket-propelled armor-piercing bombs, incendiary bomb clusters, and experimental target-identification bombs (Rife and Carlisle, 2006).

New laboratories and range facilities were built to perfect existing ordnance and develop new types, such as rockets and the variable time (radio proximity) fuze – a major advance that allowed a projectile or bomb to sense and explode near a target rather than needing to make direct contact. Within the Main Battery, boiler houses, 14 new magazines, armament facilities such as ten major-caliber gun emplacements, 17 small-caliber gun emplacements, offices, towers, and huts were erected to assist in the war effort. The wharf area at Mainside also expanded. For example, crane runways were erected for gantry cranes used to load and unload ships. A power house, boat-parts building, office, and rocket-assembly building were constructed at this time.

To accommodate new workers, 30 buildings were constructed in the officer housing area at Mainside. These included simplified Colonial Revival-style buildings and community support structures such as a dispensary, barracks, chapel, theater, library, and school (NAVFAC, 1994b; Rife and Carlisle, 2006).

Major achievements during World War II included the development of the Mark XV Norden bombsight and radio proximity fuze. Both these instruments improved the accuracy of aerial bombing campaigns. Furthermore, scientists played a tangential role in the Manhattan Project by developing and testing the ballistic qualities of gun-assembly bombs (Rife and Carlisle, 2006).

Cold War and Post-Cold War Eras (1946-Present)

After World War II, Dahlgren Naval Proving Ground continued testing gun components, projectiles, and fuzes. However, this role gradually became a smaller portion of its work as it built upon its early use of simple computers in developing new technologies and evolved into one of the Navy's primary research centers.

During the 1950s, the United States was in the height of the Cold War (1946-89) with the Soviet Union. The Cold War was essentially a conflict between American democracy and Soviet communism that led to an ongoing threat of nuclear war between the two nations. As a result, the US military focused on developing new technologies that would put the United States at an advantage. In 1953, the Navy sponsored development of the Naval Ordnance Research Calculator and selected Dahlgren Naval Proving Ground as its installation site. the Naval Ordnance Research Calculator was designed to perform the large calculations related to ordnance development, and was used to compute trajectories for the first US Army ballistic missile system, known as Jupiter (Rife and Carlisle, 2006).

In 1955, Rear Admiral Frederic S. Withington designated Dahlgren Naval Proving Ground as the prime BUORD agency for computation, exterior/rigid and body/terminal ballistics, and warhead characteristics. To better handle this new responsibility, Withington authorized the creation of three new laboratories: Computation and Exterior Ballistics (K); Warhead and Terminal Ballistics (T); and Weapons Development and Evaluation (W). The following year, Withington again expanded the installation's responsibilities by assigning the HERO program to the W Laboratory, beginning its extensive work in the area of EM technology and safety (Rife and Carlisle, 2006).

The Cold War escalated in the mid-1950s, and in 1957, the Soviet Union launched the Sputnik I satellite, causing panic in the United States. Two years later, the Naval Space Surveillance Operations Center was established at the installation's Computation and Analysis Laboratory, part of the K Laboratory, to monitor foreign satellites passing over the United States. (This facility was

re-designated the Naval Space Surveillance System in 1961.) Also in 1959, the Navy officially recognized the change in the installation's mission from traditional proving ground to research and development facility by changing its name from the Naval Proving Ground to the Naval Weapons Laboratory (Rife and Carlisle, 2006).

During the beginning and height of the Vietnam War (1960-1973), the installation became involved with a number of new projects, including:

- Satellite geodesy
- Projectile and warhead development
- Development and testing of armor materials
- Vulnerability studies of air and ground targets
- Weapons-systems aiming data
- Computation models for surface warfare exercises
- Computer simulation of ship-loading programs for POLARIS submarines
- Testing and evaluation of gun systems
- Operation and study of lasers

In 1964, a new Computation and Analysis building was constructed for K Laboratory, ushering the installation into a new era of technology. This was followed in 1968 by a restructuring of the Naval Weapons Laboratory, which eliminated the three-laboratory system, replacing it with five main technical departments and a number of support departments (Rife and Carlisle, 2006).

At the beginning of the 1970s, with the Vietnam War still underway, the installation was once again awarded more responsibilities. The Navy designated it as its lead laboratory for biological, chemical, and surface weapons, with a particular focus on surface gunnery systems. In 1972, new computing technology, in the form of a 6700 mainframe computer, replaced NORC (Rife and Carlisle, 2006). Two years later, after the Vietnam War – though not yet the Cold War – had ended, the Navy consolidated the Dahlgren Naval Weapons Laboratory with the White Oak Naval Ordnance Laboratory, located in Silver Spring, Maryland. This created the Naval Surface Weapons Center (NSWC), "the Navy's largest RDT&E center" (Finch, 2003). The two sites were identified as the Dahlgren Laboratory (NSWCDL) and White Oak, respectively (Rife and Carlisle, 2006).

In 1976, the Navy chose the NSWC to develop the proposed Aegis Combat System, designed to use powerful computers and radars to track and destroy enemy targets and to defend against air, surface, and subsurface threats. This brought NSWC into the emerging field of systems engineering. Other technological advances created during the late 1970s and early 1980s included targeting software for Tomahawk sea-launched cruise missiles, the Phalanx close-in anti-ship missile system, and improvements to the Aegis system. As a result of NSWC's work on the Tomahawk program, the Cruise Missile Weapons Systems Division was established in 1984, and two years later NSWC became the lead laboratory for the standard surface-to-air missile. Recognition of the expanded areas of interest at NSWC resulted in a name change in 1989 to the Naval Surface Warfare Center (NSWC) (Rife and Carlisle, 2006).

As the Cold War began to draw to a close later that year, the US military's – and therefore the installation's – focus shifted toward conflicts in the Middle East. NSWC played a large role in the early-1990s Operations Desert Storm and Desert Shield. Among the contributions from NSWC to these conflicts were upgrading threat libraries for Saudi Arabian ships; developing chemical/biological/radiation defense systems; and creating an Identification Friend-or-Foe device to help distinguish types of ground vehicles in order to prevent friendly-fire incidents (Rife and Carlisle, 2006).

In 1991, President George H.W. Bush announced a downsizing of the US military. In January 1992, under the Defense Base Closure and Realignment (BRAC) Commission, the Navy combined three entities: Dahlgren, White Oak, and Panama City, Florida Coastal Systems Station into the new Dahlgren Division of the Naval Surface Warfare Center (NSWCDD). In the early-to-mid 1990s, new programs at NSWCDD included the Naval Warfare Analysis Center and the DoD's Counterdrug Technology Development Program. In the late 1990s, as the US military's focus shifted away from traditional warfare and toward counter-terrorism measures, Admiral Jay L. Johnson established the Naval Operations Other Than War Technology Center at the installation (Rife and Carlisle, 2006).

As a result of the 1992 BRAC action, White Oak Laboratory closed in 1997. Personnel and functions from that facility were reassigned to Naval Surface Warfare Centers at Dahlgren; Panama City, Florida; Carderock, Maryland; and Indian Head, Maryland. In 1999, as part of the DoD's chemical and biological defense program, work began at the installation on a new chemical-biological laboratory. In 2003, major reorganizations began to more effectively address new threats to security and to counter terrorism (Finch, 2003). The mission of the center, presently known as NSWCDD, is described in Section 1.3.

3.6.7 Archaeological Resources

As discussed in Section 3.6.2, the Archaeological APE for this EIS includes the EEA, a 300-ft buffer south of the EEA between Upper Machodoc Creek and the Potomac River, and the PRTR MDZ in the Potomac River (Figure 3.6-1). This Archaeological APE is concerned with *indirect effects* upon archaeological resources resulting from testing-related noise, particularly with regard to shipwrecks in the Potomac River.

3.6.7.1 Archaeological Study Area

For comparative purposes, a broader study area that incorporates land and water areas outside of the Archaeological APE was developed. This study area includes the Mission Area and Ranges on Mainside on NSF Dahlgren; Upper Machodoc Creek and its banks in the vicinity of NSF Dahlgren; the width of the Potomac River from NSF Dahlgren to within roughly one mile east St. Clement's Island; and islands within the Potomac River in the vicinity of the Archaeological APE. This study area provides a broader context within which to interpret previously identified sites within the Archaeological APE, as well as to evaluate the potential for additional, as-yet-unidentified sites to be present.

3.6.7.2 Previously Identified Archaeological Resources

Archaeological data were collected for previously identified sites and resources within the Archaeological APE and the broader study area. Information was gathered from several repositories as well as through Internet searches. NSF Dahlgren provided archaeological survey reports and geographic information system (GIS) mapping noting previously identified sites and existing conditions on the installation. Archaeological site file forms from VDHR provided further information on archaeological sites identified across the study area. In addition, reports and site forms on file at MHT and the Naval History and Heritage Command (NHHC) provided information on maritime sites, including shipwrecks and other submerged resources, in the study area.

The archaeological data collected were reviewed, and the following categories of information were noted:

- Previous archaeological surveys
- National Register-listed resources
- National Register-eligible resources
- Previously identified resources determined not eligible
- Previously identified but unevaluated resources

As the Archaeological APE includes land and water areas, the discussion of collected information is presented in three subsections: Terrestrial Resources, Resources on Islands in the Potomac River, and Maritime Resources. A summary of all sites identified within the Archaeological APE follows a more detailed discussion of resources within the larger study area.

Previous Terrestrial Archaeological Surveys

Numerous archaeological studies conducted at NSF Dahlgren during the past few decades, as well as earlier regional studies along the Potomac River, have identified terrestrial archaeological sites within the study area. A large percentage of the studies on base were conducted in the 1990s and identified sites throughout the installation. Ongoing studies continue to produce new information about archaeological resources at NSF Dahlgren.

William Dinwiddie of the Smithsonian Institution conducted studies in the Northern Neck of Virginia along the Potomac River in 1891 and 1892, naming many sites for the small tributaries along which they were discovered (Holmes et al., 1891). Within the boundaries of NSF Dahlgren, he identified the sites Black Marsh 1 and 2, which are on the EEA (associated with Sites 44KG117 and 44KG118).

In 1979, American University conducted the Potomac River Archaeology Survey. This work included a preliminary reconnaissance of the EEA, which identified 16 potential archaeological sites based on the presence of artifacts and/or shell concentrations (14 prehistoric; one historic; and one with both prehistoric and historic components) (NSWCDL, 1992; NSF Dahlgren and Engineering Field Activity Chesapeake, 2006). The majority of the potential sites were noted to be located in the southern portion of the EEA; however, the potential sites have not been registered with the VDHR and their exact locations are unclear from the documentation reviewed for this report.

During the 1990s, the Mary Washington College (MWC) Center for Historic Preservation conducted surveys throughout NSF Dahlgren. In 1995, a walkover of the EEA was conducted by staff of MWC and Ms. Patricia Albert of NSF Dahlgren. Another walkover conducted in 1997 by MWC revisited sites identified by American University and identified four new domestic sites; these additional four sites have not been registered with the VDHR (NSWCDD, 1998; NSF Dahlgren and Engineering Field Activity Chesapeake, 2006).

Beginning in the 1990s, a number of environmental assessments (EAs) were conducted at NSF Dahlgren in response to proposed improvements at the facility. The EAs were prepared by several consulting groups including Greenhorne & O'Mara; Malcolm Pirnie, Inc.; Geo-Marine, Inc.; Geophex; TAMS/Earth Tech; and The Louis Berger Group. As part of these EAs, the proposed locations of project-specific impacts were reviewed for their potential archaeological sensitivity. While most of these assessments did not recommend additional archaeological work, a few did recommend that archaeological surveys be undertaken (NSWCDL, 1992 and NSF Dahlgren, 2006).

As part of the proposed construction, installation, and operation of the Naval Ordnance Transient Electromagnetic Simulator (NOTES) facility, a Phase 1 archaeological survey was conducted by Malcolm Pirnie, Inc. (NSWCDL, 1992). The archaeological survey investigated a proposed location on the EEA, one of four alternative locations for the facility (three on Mainside and one on the EEA). This survey did not identify any archaeological resources within the proposed project area on the EEA.

The EA to build and operate the Electromagnetic Research and Engineering Facility (EMREF) and Counter Explosive Test Facility (CETFAC) structures included an archaeological survey conducted by the Louis Berger Group (NSF Dahlgren and Engineering Field Activity Chesapeake, 2006). The survey was conducted at the two alternative locations proposed for CETFAC on the EEA and identified two prehistoric archaeological sites (Sites 44KG117 and 44KG118) (NSF Dahlgren and Engineering Field Activity Chesapeake, 2006).

Most recently, proposed activities associated with shoreline-stabilization projects at NSF Dahlgren were determined to have an adverse effect on previously identified National Register-eligible archaeological sites at the facility (Sites 44KG105 and 44KG157) (NDW, 2007). A Memorandum of Agreement between the VDHR and NSF Dahlgren was prepared in order to mitigate impacts to these resources. Mitigation actions were to include "documentation, systematic surface collections, onsite monitoring during construction, use of logging mats, post-construction site assessments, revision to sites forms, artifact analysis, and production of a technical report detailing these actions" (NDW, 2007). A report is not yet on file with the VDHR for this project.

Installation-wide documentation of the NSF Dahlgren facility has included an Historic and Archaeological Resource Protection (HARP) Plan prepared in 1992 (NAVFAC, 1992). In addition, NSF Dahlgren is currently preparing an Integrated Cultural Resources Management Plan (ICRMP) that will provide a comprehensive view of existing conditions on the installation (Albert, pers. comm., April 29, 2009).

Previously Identified Terrestrial Archaeological Resources

Because NSF Dahlgren is located on the banks of the Potomac River and has multiple tidal tributaries throughout the property, it has both prehistoric and historic archaeological potential.

Previous studies have identified dozens of terrestrial archaeological sites within the archaeological study area, largely in the vicinity of these waterways. Approximately 40 of these sites are registered with the VDHR; an additional 18 unconfirmed sites on file with NSF Dahlgren are not yet registered with the VDHR. Figure 3.6-4, Terrestrial Archaeological Resources Within or in the Vicinity of APE, notes the general location of sites registered with the VDHR and four of the unconfirmed sites on file with NSF Dahlgren; the locations of the four unconfirmed sites are based on GIS mapping provided by NSF Dahlgren in 2008. Of the sites registered with the VDHR and the four unconfirmed sites noted from mapping provided by NSF Dahlgren, six are within the Archaeological APE on the EEA. No archaeological sites have been identified within the 300-ft buffer south of the EEA, which is part of the Archaeological APE.

Of the sites registered with the VDHR, approximately one fourth date solely to the prehistoric period. Prehistoric activities identified include lithic and shell processing as well as domestic camp sites occupied from the Early Archaic through the Late Woodland Periods. Another quarter of the sites date solely to the historic period and represent domestic trash scatter and structural remains dating from the 17th century through the first half of the 20th century. Half of the sites identified components from both the prehistoric and historic periods, showing continual occupation of the study area for thousands of years.

National Register-Listed Terrestrial Resources

No previously identified sites within the study area are listed in the National Register.

National Register-Eligible Terrestrial Resources

Two of the previously identified sites within the study area were evaluated by VDHR and determined eligible for listing in the National Register (VDHR, 2008a). These sites – Site 44KG105 - Payne Site and Site 44KG157 – were identified as lithic-manufacturing and shell-processing sites dating from the Archaic and Woodland Periods; these sites are situated along the Potomac River and along Gambo Creek where it flows into the river, respectively.

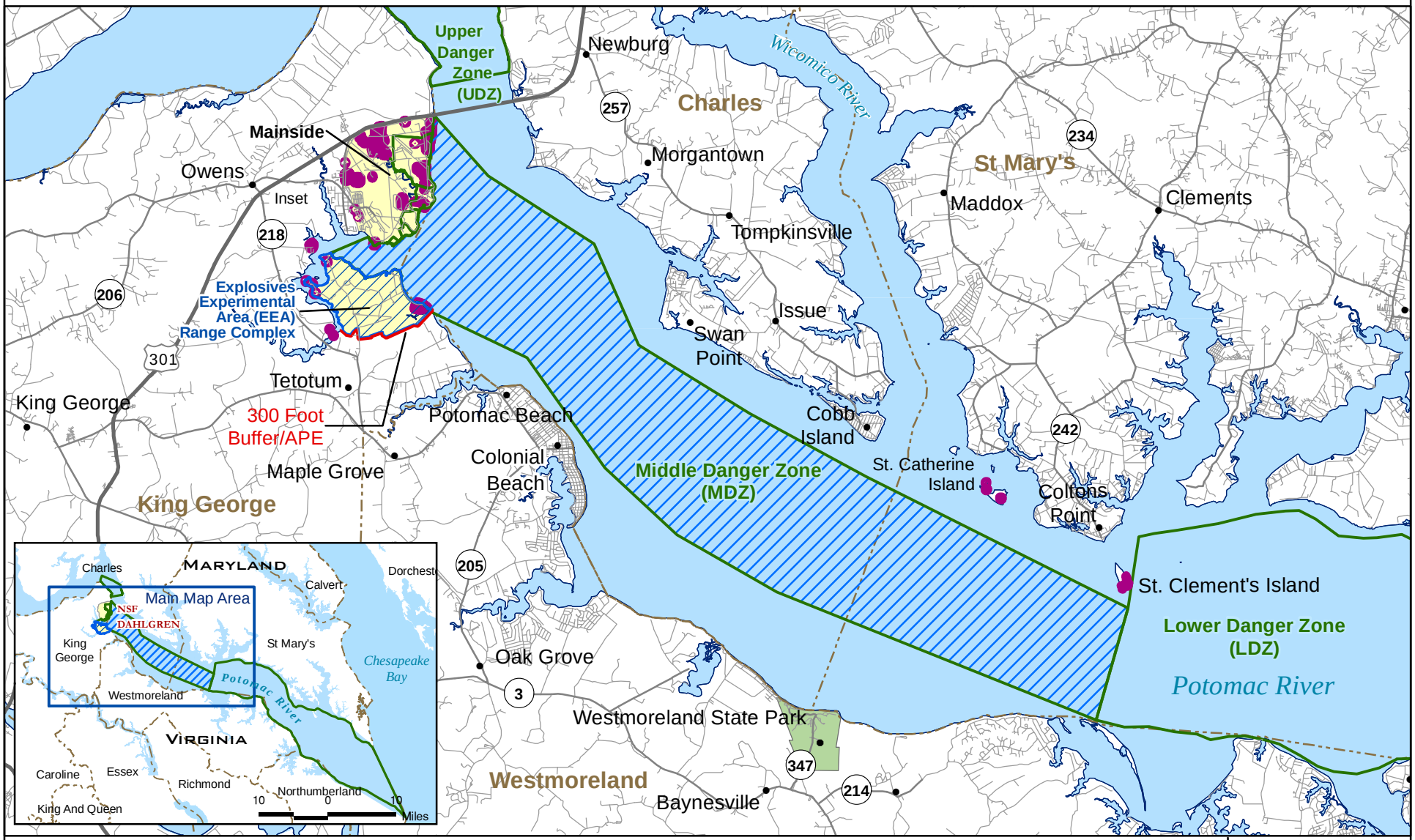
Previously Identified Terrestrial Resources Determined Not Eligible

Three sites at NSF Dahlgren in the vicinity of the study area were determined not eligible for listing in the National Register due to a lack of integrity from previous disturbances, such as agricultural or other development activities (Sites 44KG112, 44KG113, and 44KG152).

Previously Identified, Unevaluated Terrestrial Resources

The majority of previously-identified terrestrial archaeological sites within the study area, including the six located within the Archaeological APE, remain unevaluated by the VDHR, and their National Register-eligibility status is uncertain at this time. Through previous archaeological surveys, some of these sites have been recommended as potentially eligible for listing in the National Register, while others were noted as disturbed or destroyed and were not recommended as eligible for listing due to a lack of site integrity.

Terrestrial Archaeological Resources Within or in the Vicinity of Area of Potential Effect



Sources: NSF Dahlgren, 2008 (archeological resources within NSF Dahlgren property)
VDHR, 2008 (archaeological resources in Virginia, outside of Dahlgren Property)
MHT, 2008 (archaeological resources in Maryland)

Figure 3.6-4

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Documentation for these sites was limited. Prehistoric sites include shell middens and lithic scatter from which diagnostic projectile points and pottery fragments were also recovered. Many of these historic sites represent domestic trash scatter associated with plantations/farmsteads as well as with the period of establishment of the installation. A small number of foundations and possible outbuilding depressions, including the possible Barnesfield Dairy operation (Site 44KG165), were recorded. Pier remains, designated a terrestrial archaeological site with VDHR, were identified along Upper Machodoc Creek several hundred feet south of the Archaeological APE (Site 44KG38).

Of the six terrestrial archaeological resources within the Archaeological APE, one was recommended as potentially eligible for listing in the National Register following an archaeological survey. This site – Site 44KG117 – Black Marsh 1 – is a Late Archaic/ Transitional Period lithic and shell-processing camp situated between Black Marsh and the Potomac River in the southeast portion of the EEA (NSF Dahlgren and Engineering Field Activity Chesapeake, April 2006). A nearby site – Site 44KG118 – Black Marsh 2 – containing lithic scatter dating to the Middle Archaic Period, was not recommended as eligible for listing in the National Register due to a lack of integrity (NSF Dahlgren, 2006). As noted above, the VDHR has not yet evaluated the eligibility of these sites and their status remains unknown to date. The remaining four sites are on-file with NSF Dahlgren and have not been registered with the VDHR (MWC 17, MWC18, MWC 19, and MWC 34). These sites are situated in the northwest portion of the EEA near Upper Machodoc Creek, and may represent historic domestic deposits identified on the EEA by MWC in the 1990s; however, the exact nature of their cultural affiliation and their level of integrity is not clear from available information.

Previous Archaeological Surveys on Islands within the Potomac River

During the later part of the 20th century, a number of archaeological surveys were conducted on islands in the Potomac River in association with planned erosion-control projects. In particular, surveys were conducted on St. Catherine Island, near the mouth of the Wicomico River, and on St. Clement's Island near Coltons Point, Maryland.

Surveys were conducted on St. Catherine Island in the 1980s by staff of Historic St. Mary's City Research Lab. These non-systematic surface surveys identified a small number of prehistoric- and historic-period sites across the island.

In the late 1990s, surveys were conducted on St. Clement's Island by the Center for Historic Preservation at MWC, under subcontract to Dames & Moore. A Phase I survey on the southwestern end of the island identified a prehistoric site, which a Phase II evaluation determined eligible for inclusion in the Maryland Register of Historic Properties (Maryland DGS and MHT, 1998). An archaeological investigation on the island in the 1960s also identified a prehistoric-period site, discussed below.

National/State Register-Listed Resources

No previously identified sites situated on islands within the Potomac River study area are listed in the National Register.

National/State Register-Eligible Resources

One previously identified site situated on an island within the Potomac River study area has been evaluated by the MHT and determined eligible for inclusion in the Maryland Register of Historic Properties. Located on the southwestern edge of St. Clement's Island, this site was identified and evaluated in the late 1990s by MWC (Maryland DGS and MHT, 1998). The site was interpreted as a prehistoric shell midden with culturally distinct strata dating to the Middle and Late Woodland and Contact Periods (Site 18ST686, St. Clement's Island Midden [West Area I]). Archaeological analysis of the site revealed the central portion of the midden to be intact; the northern and southern extents were disturbed and the southeastern limit was eroding into the Potomac River.

Previously Identified Resources on Islands Determined Not Eligible

No previously identified sites situated on islands within the Potomac River study area have been evaluated and determined ineligible for listing in the National Register.

Previously Identified, Unevaluated Resources on Islands

Four previously identified, unevaluated archaeological sites on islands within the Potomac River study area are on file with the MHT. These sites are located on St. Catherine and St. Clement's Islands.

Three of the sites were identified on St. Catherine Island in the 1980s by MWC. One site was interpreted as a Late Woodland Period shell midden located along high ground at the southeastern end of the island (Site 18ST441, Borrow Pit [Field #3]). The other two sites were identified at the northern end of the island and included a historic house site and shell midden situated on the northern peninsula of the island (Site 18ST440, Field #2), and a scattering of 18th century artifacts and shell (Site 18ST439, Field #1).

One previously identified, unevaluated archaeological site is located on St. Clement's Island, along its southeastern shore. This site, identified in 1963 by Commander G. Braley and B. Bruce Powell, was interpreted as a prehistoric burial within a shell pit, or possible shell midden (Site 18ST18, Blackistone Island [St. Clement's Island]). The burial was excavated by Braley and Powell, and the skeleton was eventually donated to the Smithsonian Institution in Washington, D.C. The precise location of the burial site, however, was not recorded and remains unknown.

The 1963 National Register Nomination Form for the St. Clement's Island Historic District noted the potential for additional burials to be present in the vicinity of Site 18ST18. A field visit by the MHT in 2003 noted extensive disturbance in the area due to erosion and construction of riprap which had likely completely destroyed the site. An examination of the eroded bank at that time showed no evidence of archaeological resources.

Previous Maritime Archaeological Surveys

A number of surveys of the Lower Potomac River found in the MHT and the NHHC repositories identified shipwrecks and other submerged archaeological resources within the vicinity of the archaeological study area, which includes the Potomac River from NSF Dahlgren to St. Clement's Island. Shipwrecks and other submerged archaeological resources within the Potomac River are within the purview of the state of Maryland, and the MHT's Maryland Maritime

Archaeology Program (MMAP) in Crownsville, Maryland houses their archives. The Navy, however, retains jurisdiction over all naval wrecks within the river, and has information specific to these vessels in its repository at the Washington Navy Yard in Washington, D.C.

Research in the 1980s for the newly established MMAP notes a *Phase I Underwater Archaeological Project* in the "quad file notes" of the MHT. This project is associated with submerged and partially submerged maritime features, such as an existing lighthouse, pier, and bridge within the vicinity of the Archaeological APE. However, the project appears to have been limited to the notation of maritime sites based on cartographic research and did not include underwater field investigation (Langley, pers. comm., October 16, 2008).

In 1997, the *United States Navy Shipwrecks in Maryland Inventory and Assessment* was prepared for the MHT; this report deals with vessels located in Maryland waters that fall under the jurisdiction of the NHHC (MHT, 1997). The study created a database of naval shipwrecks through documentary research at various national, state, and maritime archives as well as from private collections; field work was not conducted as part of this survey. The purpose of the study was to develop a system for assessing and evaluating naval shipwrecks and to serve as a "reference and planning document to manage naval wrecks" (MHT, 1997).

In the 1970s, Steve Wilkie and Gail Thompson conducted shoreline surveys of the Potomac River (De Sarran, pers. comm., October 14, 2008). More recent studies, noted below, utilized remote-sensing techniques to identify submerged sites in Maryland and Virginia waters.

The Institute of Maritime History conducted a Phase I reconnaissance survey of the Potomac River in St. Mary's County, from the mouth of the Wicomico River to Piney Point, Maryland (MHT, 2007). The survey conducted background research and utilized side-scan sonars to identify shipwrecks and other submerged historic resources for entry into an ongoing database of submerged sites in Maryland waters.

A Phase I survey of Navy shipwrecks and other submerged archaeological resources in the Lower Potomac River was conducted between 2003 and 2005 by staff of the Maryland's Office of Archaeology and volunteers (NHC, Friends of St. Clements Island-Potomac River Museum, and MHT, 2007). The survey area extended from around the Wicomico River southeast to St. Mary's River and included tributaries on both sides of the Potomac River. The project aimed to locate and catalogue submerged maritime archaeological resources through side-scan sonar and magnetometer surveys. An in-depth historic context against which to evaluate the significance of resources identified was also developed for this project.

Previously Identified Maritime Archaeological Resources

The Archaeological APE for the current EIS includes the portion of the Potomac River that corresponds with the boundaries of the PRTR MDZ from below the Nice Bridge south to St. Clement's Island. Research was conducted to identify submerged archaeological resources within the Archaeological APE as well as within the wider archaeological study area, which includes the river from NSF Dahlgren south to just east of St. Clement's Island, beyond the bounds of the MDZ. Archaeological resources identified consist primarily of shipwrecks but include submerged refuse dumps, pier remains, lighthouses, anchors, and the ruins of a tidewater mill. Due to the sensitive nature of Navy shipwrecks, and for consistency, none of the maritime resources identified within the study area are presented in a figure for this report.

The 1997 MHT survey of Navy shipwrecks identifies 66 naval shipwrecks in Maryland waters (MHT, 1997). A partial list of foundered Navy shipwrecks and aircraft wrecks in the lower Potomac River, which includes the river from Washington D.C. to the Chesapeake Bay, identifies 13 shipwrecks and 4 aircraft wrecks (NHC, 2008). The majority of the shipwrecks date to the Civil War period; a smaller number date to the mid-to-late 18th century; the remainder date to the first half of the 20th century. The aircraft wrecks noted in the database date to the first half of the 20th century. Some of the shipwrecks identified are within the archaeological study area and potentially within the Archaeological APE; these are discussed below. None of the aircraft identified in the NHHC database are within the archaeological study area (NHC, 2008).

Due to its historical significance and relative proximity to the Archaeological APE and study area, it is also worth noting the shipwreck of the USS *Tulip*, situated in the Potomac River. The *Tulip* was lost in 1864 when a boiler exploded, taking the lives of 49 people on board (MHT, 1997). An approximate location of this site was identified through the historic record (MHT, 1997), and more recently, the shipwreck site was identified through a remote sensing survey (MHT, 2007). The USS *Tulip* is located approximately seven miles southeast of the Archaeological APE and archaeological study area.

National Register-Listed Maritime Archaeological Resources

None of the previously identified maritime sites within the study area are listed in the National Register.

National Register-Eligible Maritime Archaeological Resources

None of the previously identified maritime archaeological sites within the study area have been determined eligible for listing in the National Register.

Previously Identified, Maritime Archaeological Unevaluated Resources

A number of previously identified maritime archaeological resources have been identified within the study area; however, to date the National Register-eligibility of these resources has not been evaluated by the MHT.

A survey utilizing historical records identified four maritime resources, comprised of six naval shipwrecks from the Civil War era, within or adjacent to the archaeological study area (MHT, 1997). They include two Confederate schooners – the *Somerset* and the *Christiana Keen* – and a US army transport – the *Frances Elmor*. Historic records note that all three vessels were captured and burned during Civil War fighting. The remaining three naval shipwrecks, identified as a single resource under the name *Three Boats*, were utilized as transport vessels during the Civil War when they were captured and destroyed by the US; the names of these three boats are unknown (MHT, 1997).

The exact locations of these six naval vessels have not been verified through the use of underwater survey methods; only their "general locations" within the Potomac River are noted in the MHT's *Inventory and Assessment* (MHT, 1997). Their general locations are noted as being in the vicinities of Nomini Bay, Upper Machodoc Creek, Bluff Point, and Swan Point. The general location depicted for the *Somerset* is close to, but outside of the Archaeological APE. Whether the remaining five naval shipwrecks lie within the PRTR MDZ portion of the Archaeological APE is unknown, as only their general locations are depicted.

In addition to the naval vessels identified with the NHHC, a number of other previously identified sites have been recorded with the MHT within or adjacent to the Archaeological APE. Some of these resources have been issued national Smithsonian site numbers by the MHT, while others were issued only "quad file note" numbers in the MHT's internal files. Two of these sites, discussed in more detail below, have been identified within the Archaeological APE.

Within the study area, a small number of side-scan sonar anomalies that may represent sunken vessels have been identified in the vicinity of St. Clement's Island (NHC, Friends of St. Clements Island-Potomac River Museum, and MHT, 2007). One of these sites known via an anomaly – Stratford Hall-QF05 (or STRATF QF05) – is located within the Archaeological APE. In addition, to the north and west of this, in the vicinity of Colonial Beach, Virginia, an 18th-century anchor known as the Dahlgren Anchor Site was identified within the Archaeological APE; the anchor has since been recovered by the US Coast Guard.

Pier remnants have also been noted within the study area on the Potomac River and on Upper Machodoc Creek, all outside of the Archaeological APE. Remains were identified in the Potomac River near St. Clement's Island (or Blackistone Island) in St. Mary's County, Maryland and along Lower Cedar Point in Charles County, Maryland, across from NSF Dahlgren. The MHT designated the pier remains as St. Clement's-QF04 and Colonial Beach North-QF15. Within Virginia, pier remains associated with an 18th-century or possibly earlier crossing of Upper Machodoc Creek called "Little Ferry" were identified southwest of the Archaeological APE in King George County; the VDHR designated the pier remains as terrestrial Site 44KG38.

The remains of a tidewater mill have been recorded by the MHT as Site 18ST539 in the waters off of Westmoreland State Park, Virginia. The site is usually submerged, but portions of the remains are exposed during low tide. A lighthouse located northeast of the Archaeological APE near Lower Cedar Point was also identified by the MHT.

Summary of Previously Identified Resources within Archaeological APE

No National Register-listed or -eligible archaeological resources have been identified within the Archaeological APE at NSF Dahlgren. However, eleven unevaluated archaeological sites have been recorded within or potentially within the Archaeological APE, and are on file with various agencies, including the VDHR, the MHT, NSF Dahlgren and the NHHC. These sites include six terrestrial archaeological sites and five maritime archaeological resources; the exact location of three of the unevaluated maritime archaeological resources (comprised of five Navy shipwrecks) is unknown, but a recent study depicts them potentially within the Archaeological APE (MHT, 1997).

Conditions of some of these resources are known based on previous archaeological and historic architectural surveys, and in some cases archaeologists have made recommendations regarding their National Register eligibility based on National Register criteria. As noted in the prior subsection on terrestrial resources, one of the sites in the Archaeological APE was recommended as eligible for listing in the National Register (44KG217-Black Marsh 1), while a second was recommended as ineligible (44KG218-Black Marsh 2) (NSF Dahlgren, 2006). Another site identified within the Potomac River portion of the Archaeological APE, an 18th-century anchor, has since been removed to a pier; however, the possibility that an associated shipwreck may be present in the vicinity of the anchor site should be noted. Historic records of the Navy

shipwrecks indicate that shipwrecks within the Archaeological APE were burned and/or destroyed when lost during the Civil War.

Table 3.6-3 identifies eleven archaeological resources within or potentially within the Archaeological APE. As noted above, the VDHR and the MHT have not yet evaluated these sites and therefore their National Register-eligibility status remains undetermined.

Table 3.6-3
Archaeological Resources Within or Potentially Within the Archaeological APE

Resource Name	Resource Type	Recommendation and/or Condition of Resource	On File
44KG217 (Black Marsh 1)	Terrestrial	Recommended NRE[2]	VDHR and NSF Dahlgren
44KG218 (Black Marsh 2)	Terrestrial	Not recommended NRE[2]	VDHR and NSF Dahlgren
MWC17	Terrestrial	Unknown[3]	NSF Dahlgren
MWC18	Terrestrial	Unknown[3]	NSF Dahlgren
MWC19	Terrestrial	Unknown[3]	NSF Dahlgren
MWC34	Terrestrial	Unknown[3]	NSF Dahlgren
Colonial Beach South QF04 (Dahlgren Anchor Site)	Maritime	Anchor recovered from site by US Coast Guard in 1990[4]	MHT
STRATF QF05 [side-scan sonar anomaly]	Maritime	Unknown[4]	MHT
Christiana Keen[1]	Maritime	Burned and sunk[5]	NHHC
Frances Elmor[1]	Maritime	Burned and sunk[5]	NHHC
Three Boats[1]	Maritime	"Destroyed" and sunk[5]	NHHC

[1] Resource located within or potentially within the Archaeological APE (MHT, 1997).
[2] NSF Dahlgren and Engineering Field Activity Chesapeake, 2006.
[3] GIS data from NSF Dahlgren, 2008.
[4] Site file forms at MHT.
[5] MHT, 1997.

3.6.8 Historic Architectural Resources

3.6.8.1 Resources outside NSF Dahlgren

Multiple historic architectural resources have been surveyed within or immediately adjacent to the Historic Architectural APE outside NSF Dahlgren in Virginia and Maryland. In Virginia, approximately 335 resources have been surveyed according to the VDHR (Williams, pers. comm., December 8, 2008). Approximately 330 of the 335 resources are located within the 120-dBP noise contour, and five are located in the vicinity of the 134-dBP noise contour. In Maryland, approximately 320 resources have been surveyed according to MHT (MHT, 2008). All the resources in Maryland are located within or close to the 120-dBP noise contour.

Impacts of the Proposed Action on previously identified National Register-listed and National Register-eligible historic architectural resources within the Historic Architectural APE will be evaluated in this document. Twenty National Register-listed resources are located within or immediately adjacent to the 120-dBP noise contour, as depicted on Figure 3.6-2 and indicated in Table 3.6-1. Of these 20 resources, eleven are located in Virginia and nine in Maryland. Sixteen National Register-eligible resources are located within or immediately adjacent to the 120-dBP noise contour, as depicted on Figure 3.6-2 and indicated in Table 3.6-2. Of these 16 resources, eight are located in Virginia and eight in Maryland.

3.6.8.2 Resources within NSF Dahlgren

In the 1990s, several historic architectural resources surveys were conducted at NSF Dahlgren. The two most conclusive surveys included:

- Inventory of Standing Structures Within the Operations and Industries Area at The Dahlgren Laboratory of the Dahlgren Division, Naval Surface Warfare Center (NAVFAC, 1994a);
- Architectural Investigations Undertaken in the Dahlgren Residential Area, Naval Surface Warfare Center, Dahlgren Laboratory, Dahlgren, Virginia (NAVFAC, 1994b).

These surveys concluded that four proposed historic districts are located at Mainside:

- Residential Historic District within the Community Support Area
- Main Battery Historic District within the PRTR and Mission Area
- Wharf Area District within the Mission Area
- Airfield Historic District within the Mission Area

In 1994, VDHR issued an opinion that NSF Dahlgren constitutes a single National Register-eligible historic district known as Naval Surface Warfare Center, Dahlgren Laboratory. VDHR indicated that the single district should consist of several discontiguous areas, including the industrial testing area, the airfield area, and the residential area (Miller, letter, April 25, 1994). VDHR, NSF Dahlgren, and NSWCDD have not concurred on the boundary (VDHR, 2008b). Therefore, for the purposes of this EIS, impacts of the Proposed Action on the four districts will be evaluated.

The four districts are shown in Figure 3.6-5, Historic District Locations. It should be noted that the proposed Main Battery and Wharf Area Districts, as well as the southern portion of the proposed Residential District and most of the Airfield District, fall within the 134-dBP noise contour.

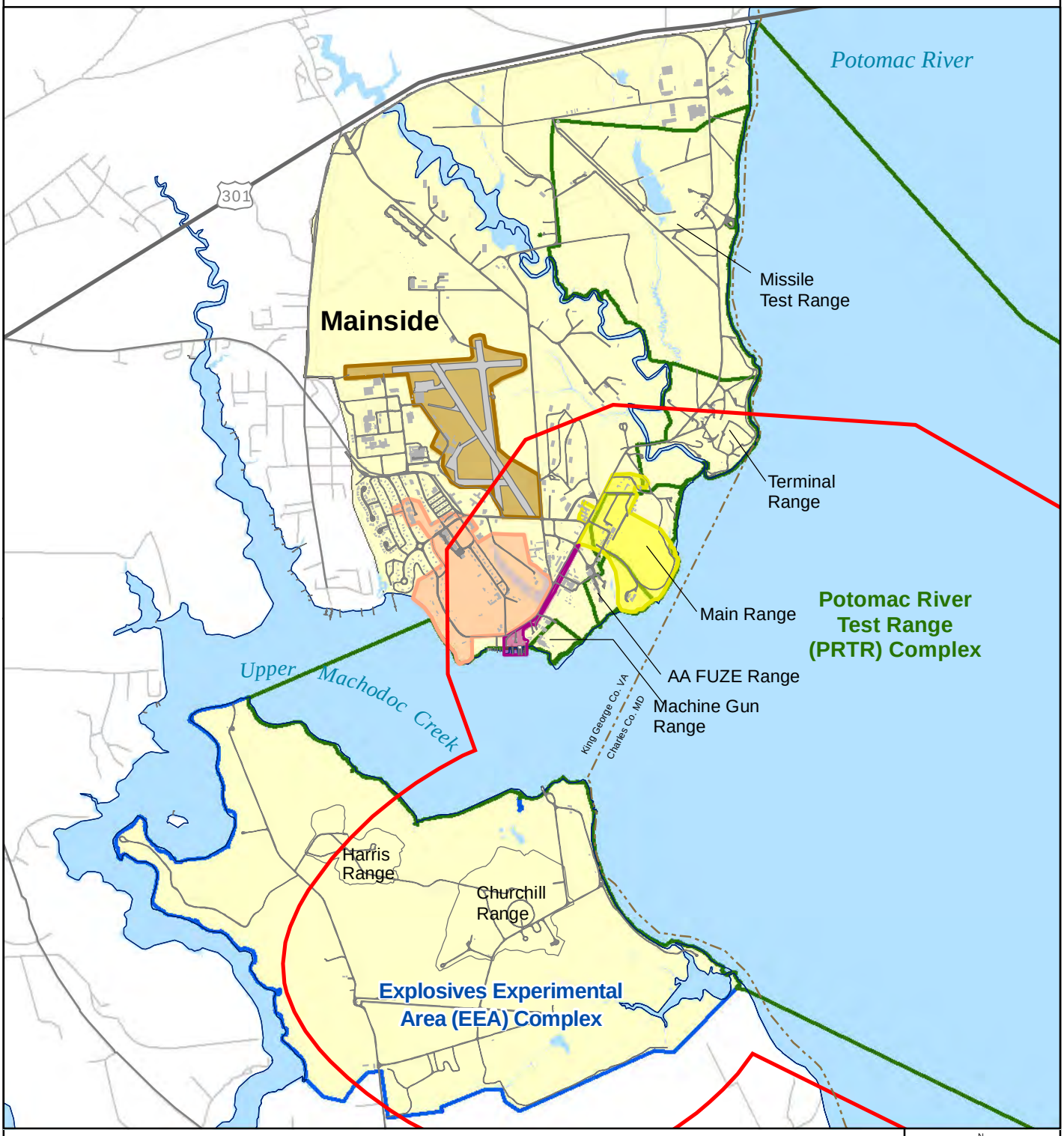
Tables 3.6-4 through 3.6-7 identify contributing and non-contributing resources within the four districts delineated in 1994. NPS defines contributing resources as components within an historic district that add to its historic character and possess architectural integrity. NPS defines non-contributing resources as components within historic districts that do not contribute to its significance, and usually consist of resources which post-date the period of significance of the district (United States Department of the Interior, National Park Service, 2002).

In 2004, based on the 1994 installation-wide survey and a survey of the residential area (David, Sadler &Whitehead, 2003) prepared for a Navy/Private Venture action to privatize housing, VDHR determined the Residential Historic District eligible for listing in the National Register under Criteria A and C for its historic and architectural significance (VDHR, 2004). The district

is eligible under Criterion A for its role as the residential support area for personnel involved in the primary mission of weapons testing. The district is also eligible under Criterion C because it represents the Navy's adaption of suburban planning trends and architectural styles popular between the 1920s and 1940s. Its planned community reflects the suburban planning ideal through curvilinear streets, open vistas, and landscape features that create a pastoral, rural setting (NAVFAC, 1994b).

NSF Dahlgren recently resurveyed the installation, including the four historic districts. When finalized and reviewed by VDHR, this survey may result in changes to the definition of the historic districts. For the time being, the 1994 survey of the installation supplemented by the 2003 survey of the residential area form the basis for Section 106 determinations.

Historic District Locations



Proposed Airfield Historic District (1994)
Proposed Main Battery Historic District (1994)
Proposed Residential Historic District (1994)
Proposed Wharf Area Historic District (1994)
EEA Complex
PRTR Complex
Historic Architectural APE/
134 Decibel Peak Noise Contour
Naval Support Facility (NSF) Dahlgren

3,000 0 3,000 Feet
1,000 0 1,000 Meters

N

NSWCDD EIS

Source: NSWCDD, 2008-2011

Figure 3.6-5

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Table 3.6-4
Proposed Residential Historic District (1994)

Building No.	Original Use	Date	Contributing	Non-Contributing
Not Applicable (N/A)	Joy Park	c. 1945	X	
N/A	Parade Ground	c, 1919	X	
60	Tool Shed	1920	X	
64	Canteen Garage	1921		X
101	Administration Building	1920	X	
105	Dormitory	1920		X
106	Dormitory	1920		X
112[1]	Mess Hall	1920		X
117	Assembly Hall	1921	X	
119	School	1921	X	
132	Water Tower	1920	X	
183	Barracks	1942	X	
184	Sewer Pump House	1942	X	
192	Dispensary	1942	X	
193	School	1942	X	
193A/B	School	1951		X
193E	School	1990		X
193F	Gymnasium	1993		X
195[2]	Gate House	1942	X	
215	BOQ	1942		X
216	Officers' Club	1942		X
217	BOQ	1942		X
220	Boiler House	1942	X	
222	BOQ	1918	X	
222A	Wood House	1919	X	
222B/C	Garage	1934	X	
240	Community Storage	1986		X
243	Community House	1940		X
246	Dispensary	1919	X	
267	Laundry	1944	X	
322	Railroad Station	1943	X	
431	Chapel	1945	X	
431A	Boiler House	1945	X	
501	Inspector's Quarters	1921	X	
501A	Garage	1921	X	
503	Housing	1921	X	
503A	Garage	1921	X	
506	Housing	1921	X	

Table 3.6-4 (Continued)
Proposed Residential Historic District (1994)

Building No.	Original Use	Date	Contributing	Non-Contributing
506A	Garage	1921	X	
507	Housing	1921	X	
507A	Garage	1921	X	
508	Housing	1921	X	
508A	Garage	1921	X	
509	Housing	1921	X	
509A	Garage	1921	X	
510	Housing	1939	X	
512	Housing	1939	X	
513	Housing	1939	X	
514	Housing	1939	X	
516	Housing	1939	X	
518	Housing	1951		X
518A	Garage	1951		X
600	Housing	1921	X	
600B	Garage	1920	X	
601	Housing	1921	X	
601B	Garage	1920	X	
800	Housing	1939	X	
801	Housing	1939	X	
802	Housing	1919	X	
802B	Garage	1920	X	
803	Housing	1941	X	
804	Housing	1919	X	
805	Housing	1941	X	
806	Housing	1919	X	
806B	Garage	1920	X	
807	Housing	1941	X	
808	Housing	1919	X	
808A	Hen House	1919	X	
809	Housing	1941	X	
810	Housing	1919	X	
810B	Garage	1919	X	
811	Housing	1942	X	
812	Housing	1919	X	
812A	Garage	1919	X	
813	Housing	1942	X	
814	Housing	1919	X	

Table 3.6-4 (Continued)
Proposed Residential Historic District (1994)

Building No.	Original Use	Date	Contributing	Non-Contributing
814B	Garage	1919	X	
816	Housing	1919	X	
816A	Hen House	1919	X	
818	Housing	1941	X	
820	Housing	1941	X	
822	Housing	1941	X	
824	Housing	1941	X	
909	Colored Dormitory	c. 1918	X	
1130	Storage Building	1952		X
1164	Tennis Courts	1943	X	
1166	Tennis Courts	1941	X	
1271	Golf Course	1927	X	
1278	Golf Clubhouse	1964		X
1282	Gas Station	1965		X
1294	Locker Room	1968		X
1384[3]	Gardeners Storage Building	1921		

[1]Building demolished according to NSF Dahlgren GIS data prepared in 2008.
[2]Located outside boundary of proposed district.
[3]Located within boundary of proposed district but not documented in the 1994 survey report.

Table 3.6-5
Proposed Main Battery Historic District (1994)

Building No.	Original Use	Date	Contributing	Non-Contributing
102	Bombproof	1920	X	
111	Tech Library	1920	X	
143	Toilet	1942	X	
160	Emplacements	1942	X	
161	Bombproof	1942	X	
181	Shell House	1942	X	
186	Office	1942	X	
207	Loaded Projectile Magazine	1942	X	
210	Boiler House	1942	X	
218	RDT&E Laboratory	1942		X
234	Boiler House	1920	X	
235	Shell House	1941		X
236	Case Packing House	1943	X	
239	Oil House	1920	X	
249	Lab & Air Compressor House	1920	X	

Table 3.6-5 (Continued)
Proposed Main Battery Historic District (1994)

Building No.	Original Use	Date	Contributing	Non-Contributing
252	Ordnance Shed	1920	X	
253	Gun Emplacements	1920	X	
254[1]	Broadside Battery	1921	X	
260	High Explosive Magazine	1920	X	
270	Gun Parking Platform	1927	X	
276	Black Powder Loading House	1942	X	
277	Women's Restroom	1942	X	
306	Lookout Tower	1942	X	
310[2]	Bomb Spotting Station	1975		X
312[2]	Case Storage	1943	X	
316	Magazine	1942	X	
326	Lookout Tower	1943	X	
339	Boiler House	1960		X
364[1]	Weapons Factory	1975		X
406	Boiler House	1950		X
415	Velocity Instrument Building	1951		X
440	Oil Storage	1945	X	
441[2]	Inert Storage	1945	X	
445	Kerosene Storage	1943	X	
460	Static Loading Tower	1946		X
463	Quonset Hut	1949		X
930	Armco Hut	1952		X
931	Armco Hut	1952		X
932	Armco Hut Case Storage	1952		X
940	Armco Hut	1952		X
941	Armco Hut	1948		X
942	Fuze Conditioning Building	1951		X
943	Ammunition Assembly	1952		X
948	Black Powder Loading House	1952		X
991	Heating Plant	1952		X
998	Case Storage	1953		X
1112	Personnel Shelter	No date available		X
1113	Case Storage	1953		X
1114	Locker/Lunchroom	1953		X
1157	Tunnel-Steel Plate	1953		X
1279	Gun Racks	1953		X

[1]Building demolished according to NSF Dahlgren GIS data prepared in 2008.
[2]Building slated for demolition according to NSF Dahlgren.

Table 3.6-6
Proposed Wharf Area Historic District (1994)

Building No.	Original Use	Date	Contributing	Non-Contributing
100	Yardcraft Admin.	1991		X
107	Wharf House	1920	X	
177[1]	Dock	1919	X	
178[1]	Coal Pier	1919	X	
288	Yardcraft Office	1943		X
318[1]	Crane Runway	1944	X	
319	Power House	1943	X	
347	Boat Parts Building	1945	X	
430[1]	Rocket Assembly Building	1945	X	
453	Rigging Loft	1945	X	
1175[1]	Crane Runway	1943	X	
1299[1]	Engine & Parts Storage	1968		X

[1] Building demolished according to NSF Dahlgren GIS data prepared in 2008.

Table 3.6-7
Proposed Airfield District (1994)

Building No.*	Original Use	Date	Contributing	Non-Contributing
110B	Land Plane Hangar	1921	X	
150	Land Plane Hangar 1	1941	X	
185	Garage Hangar 1	1943	X	
185T	Office	ca. 1970		X
194	Hangar 2	1942	X	
423	Acceleration Building	1945	X	
458	Machine Gun Bulk Hangar	1946		X
1174	Ground Plane and Turntable # 1	1959		X
1177	C.A.D. Firing Pads	1959		X
1277	Electric Com/Fac	1964		X
1280	Control House/Turntable #2	1964		X
1331	Misc Open Storage	1971		X

*Although not shown in the table, the airfield landing strip or runway is considered to be a contributing resource to the historic district because it was designed for conducting experimental tests of aviation weapons and equipment during World War II (NAVFAC, 1994a).

3.6.9 American Heritage Rivers

In addition to archaeological and historic architectural resources, American Heritage Rivers are also located within the Archaeological and Historic Architectural APEs. In 1998, the Potomac River was designated an American Heritage River under the authority of President Clinton's EO 13061, Federal Support of Community Efforts along American Heritage Rivers, which was enacted in 1997. The Potomac American Heritage River covers the entire 14,670-square-mile Potomac watershed, including major tributaries such as the South Branch, North Branch, Shenandoah, Monocacy, Anacostia, and Occoquan Rivers. This watershed extends through four states (Virginia, West Virginia, Maryland, and Pennsylvania) and Washington, DC (USEPA, 2009).

As an American Heritage River, the Potomac's unique place in American history and culture has been officially recognized. To devise plans to benefit the river and surrounding communities, an acting River Navigator has been appointed under the auspices of the lead agency, NPS-National Capital Region. The role of the River Navigator is to facilitate the application of existing federal programs and resources to the needs of the river, including natural resource and environmental protection, economic revitalization, and historic preservation.

Key stakeholders and partners of the Potomac River American Heritage River initiative are represented by the Friends of the Potomac River, a non-profit corporation which helps communities throughout the watershed in their efforts to conserve natural resources and create new business opportunities while retaining their distinctive local character and traditions. Key federal partners include:

- USEPA (Office of Water, Region 3, and Chesapeake Bay Program Office)
- US Fish and Wildlife Service
- US Department of Agriculture-Natural Resources Conservation Service
- US Department of Agriculture-Forest Service
- US Army Corps of Engineers
- US Department of Housing and Urban Development
- US Department of the Interior, Office of Surface Mining
- Chesapeake Bay Program's Federal Agencies Committee

Although the Potomac River is not a National/State Register-listed resource, the American Heritage River program acknowledges the important role that the river has played in the historic development of its watershed and the nation.

3.7 Hazardous Materials and Waste Management

This section describes:

- The hazardous material (HM) NSWCDD uses in RDT&E operations and how such materials are handled and disposed of as part of the HM and hazardous waste (HW) management program at NSF Dahlgren.
- The process NSF Dahlgren is conducting to clean up old disposal areas and spills under the Navy's Environmental Restoration Program (ERP).
- The management of munitions, environmental compliance, and the assessment of potential munitions constituents (MCs) on the PRTR and EEA operational range complexes.

The terms "hazardous material," "hazardous waste," and "hazardous substance" have specific legal definitions in various federal regulations. The term "hazardous material" as used in this document identifies those contaminants (chemicals, substances, or compounds) that have been determined to present potential risks to health, safety, or the environment when they occur at certain concentrations, and that are managed under one or more applicable regulatory programs.

3.7.1 Legal Framework

NSF Dahlgren and NSWCDD adhere to USEPA and other federal and state laws and regulations governing HM and HW. The following federal and state statutes and their implementing regulations are relevant to the management and control of HM and HW at Dahlgren:

- Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
- Superfund Amendments and Reauthorization Act (SARA) of 1986 to CERCLA
- Resource Conservation and Recovery Act of 1976 (RCRA)
- Hazardous and Solid Waste Amendments (HSWA) to RCRA, 1984
- Toxic Substances Control Act of 1978 (TSCA)
- Clean Water Act (CWA)
- Occupational Safety and Health Administration (OSHA) Regulations
- US Department of Transportation (USDOT) Hazardous Materials Regulations
- Virginia Hazardous Waste Regulations
- Maryland Hazardous Waste Regulations (Potomac River only)
- Military Munitions Rule (MR) of 1997

Through CERCLA, SARA, RCRA, and TSCA, USEPA promulgates and enforces regulations regarding past and present HM and HW management. These regulations establish the mandatory procedures and requirements for compliance and must be followed by federal facilities that use, accumulate, transport, treat, store, or dispose of hazardous wastes or materials. RCRA allows for

each state to establish and enforce its own HW management program, provided that the state's requirements are no less stringent than USEPA's. The USEPA will grant primacy – the authority to implement and enforce regulations – to each state that can demonstrate to USEPA that it can statutorily implement and fund a program equivalent in scope and coverage to the RCRA regulations. The Commonwealth of Virginia (implemented by the Virginia Department of Environmental Quality [VDEQ]) and the State of Maryland (implemented by the Maryland Department of the Environment [MDE]) have been granted such primacy.

CERCLA – commonly known as Superfund – as amended by SARA, establishes requirements for identifying and cleaning up unused, closed, and abandoned hazardous waste sites. In response to CERCLA and to RCRA, DoD instituted an ERP to identify, assess, characterize, and clean up or control contamination from past HW or explosive hazardous waste (EHW) disposal operations and hazardous-materials spills at DoD facilities. The Navy implements the ERP at NSF Dahlgren, with USEPA and VDEQ providing regulatory oversight. The ERP is described in Section 3.7.4.

Because RCRA-defined HW is also considered USDOT HM, HM, and HW must be handled, prepared, and transported in accordance with USDOT HM regulations. These regulations have been developed by the USDOT to provide for the safe transport of HM in commerce. The USDOT HM regulations are contained in CFR Title 49 §§ 100-185.

OSHA regulates the safety and health of workers in the US by establishing worker-protection standards that employers must follow. OSHA has promulgated standards to protect workers engaged in HW operations and emergency-response activities. These standards are found in CFR Title 29 § 1910.

The CWA, further described in Section 3.10, is the cornerstone of surface water quality protection in the US. Its broad goal is to restore and maintain the chemical, physical, and biological integrity of the nation's waters so that they can provide for "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water." The CWA addresses both "point source" facilities, such as wastewater treatment plants and industrial facilities, and "non-point source" stormwater runoff. Stormwater discharged into streams and rivers through conveyances such as storm sewers, which, if deemed point sources under the CWA, are subject to regulation. The discharge of treated effluent from wastewater treatment plants is also subject to regulation.

USEPA's MR defines when munitions (ordnance) become waste and are subject to RCRA regulations, and how these waste munitions will be managed, including safe storage and transportation. The Navy implements the MR through its Munitions Rule Implementation Policy, which defines when used or unused munitions (ordnance) are considered EHW. Under the MR, military munitions are not considered EHW when the intended use is for training or for RDT&E activities, or if materials are recovered and destroyed on-range during range clearance operations, repaired, or otherwise subjected to materials recovery. Under the MR definition of wastes, spent ordnance remaining on NSWCDD's land and water ranges is considered to have been used for the intended purpose of RDT&E activities, and therefore, is not subject to HW regulations.

3.7.2 Hazardous Materials and Waste at Dahlgren

NSF Dahlgren is a large-quantity HW generator, with NSWCDD being one of the largest contributors of HW. In the course of conducting RDT&E activities, NSWCDD uses and disposes of a variety of materials that may be considered hazardous by USEPA:

- Corrosive solutions
- Waste paint-related materials
- Lead-contaminated floor mats and rags
- Spent halogenated and non-halogenated solvents
- Waste photographic process chemicals
- Solvents
- Petroleum products, such as used lubricating oils
- Ordnance and explosive materials
- Ash from open burning of ordnance materials
- Contaminated soil
- Spent and expired laboratory chemicals

3.7.3 Hazardous Material and Waste Management Program

NSF Dahlgren and NSWCDD have in place a number of programs, plans, and processes to safely use, transport, handle, store, and dispose of HM and HW, as described below.

3.7.3.1 Hazardous Waste Management Plans

Under RCRA (40 CFR § 264.50) and VDEQ (Virginia Administrative Code [VAC] Title 9 Board 20 Chapter 60 Section 550 [9 VAC 20-60-550]) regulations, owners and operators of all HW accumulation areas must develop and implement contingency plans designed to minimize hazards to human health and the environment from fires, explosions, or any unplanned, sudden or non-sudden release of hazardous materials to the air, soil, or surface water. These planning documents include: a Hazardous Waste Contingency Plan, a Hazardous Waste Management Plan, a Military Munitions Implementation Plan, Accumulation Area Requirements, and Satellite Accumulation Point Requirements.

3.7.3.2 Hazardous Waste Storage Management

The HW generator is the first link in the “cradle to grave” management enforced by RCRA regulations. A generator is the entity that first creates a HW or a facility that first makes a waste subject to RCRA regulation. Generators are classified based on the amount of HW generated in any one-month period. NSF Dahlgren is a Large Quantity Generator, which means the facility generates at least 2,200 pounds of nonacute or more than 2.2 pounds of acute HW per calendar month.

According to RCRA regulations, HW can be stored at a "satellite accumulation point" or a "less-than-90-day accumulation area." The difference between a satellite accumulation point and a less-than-90-day accumulation area are the volume and length of time HW may be accumulated. At a satellite accumulation point, up to 55 gallons of HW, or 1 quart of acute HW, may be accumulated for an unlimited amount of time. A satellite accumulation point must be at or near the point of HW generation, and under control of the operator of the process generating the HW.

At a less-than-90-day accumulation area, any amount of HW can be collected and stored in containers for up to 90 days without a permit. The 90-day limit for the container begins as soon as the first drop of HW is added to the container.

All HW that needs to be removed from a satellite accumulation area must be turned over to the NSF Dahlgren less-than-90-day accumulation area, Building 1425. HW is stored at Building 1425 and prepared for transportation to an off-site permitted treatment, storage, and disposal facility (TSDF).

NSWCDD makes an effort to inspect satellite accumulation points weekly as a best management practice (BMP). NSWCDD also encourages personnel to use smaller containers and turn them in more frequently, which helps prevent spills due to deterioration of containers. Less-than-90-day accumulation areas are maintained in good condition, and containers are inspected weekly to ensure the structure and containers are in good condition. Examples of HW stored at satellite accumulation areas include, but are not limited to, lead-contaminated waste, solvents, oxidizers, flammables, bases, mercury, and acids. The locations of these satellite accumulation areas can be established and disestablished frequently, depending on changes in processes and operations. For this reason, NSF Dahlgren maintains a current list of all facility satellite accumulation areas and the NSWCDD Safety & Environmental Office maintains a list of all NSWCDD satellite accumulation areas.

All EHW is stored at Buildings 9481, 9482, 9483, 9484, 408A, 353C, 951, and 952. Unlike HW storage locations, the locations of these EHW storage areas do not change with processes and operations. Building 408A is designated a less-than-90 day EHW storage site which can only accept on-site generated waste. Buildings 951, 952, and 353C are permitted magazines which can also receive on-site or off-site generated EHW. EHW can be stored up to 1 year in these magazines. Buildings 9481 9482, 9483, and 9484 are designated as "conditional exempt" under the MR. These buildings can used to store on-site and off-site generated EHW for an unlimited amount of time. However, as a BMP, the NSWCDD Safety & Environmental Office monitors the amount of time EHW items have been in storage and requests justification for continued storage if an item has not been treated within six months.

3.7.3.3 Petroleum Storage Program

NSF Dahlgren manages underground storage tank (UST), aboveground storage tank (AST), and petroleum-oil-lubricant storage regulatory requirements. Applicable regulations for the storage tanks include state and federal petroleum-storage UST regulations, the Oil Pollution Prevention Regulation of 1973, the Oil Pollution Act of 1990, and OSHA requirements. The regulations are incorporated into the NSF Dahlgren Tank Management Plan (NSWCDL, 2003). The Tank Management Plan is updated by NSF Dahlgren to incorporate any changes in the petroleum regulations or permitted petroleum storage locations at the facility.

NSF Dahlgren's USTs are approved by the Underwriters Laboratory. The USTs are designed to meet Virginia UST regulatory requirements (9 VAC 25-580) and federal UST regulatory requirements (40 CFR § 280) for leak detection, secondary containment, and corrosion protection. A UST removal and replacement project, completed in the summer of 1992, replaced aging USTs and several heating-oil tanks to meet Virginia and federal UST regulatory requirements. NSF Dahlgren performs release-detection monitoring by groundwater monitoring on older USTs, interstitial monitoring by liquid-level sensing on newly installed – 1991 or later – USTs, and by visual inspection of ASTs and petroleum-product storage locations.

ASTs are visually monitored by personnel and the spill-prevention control and countermeasures Plan Coordinator on a regular basis. Regulated ASTs are tested for competency and certified to be free of leaks (NAVSEA, 2010). The ASTs and liquid drum storage areas have secondary spill-containment features that have the capacity to prevent an accidental release of the liquid volume from the AST or drums to the environment. Drums with solid waste are stored without direct ground contact (i.e., on pallets or platforms).

Virginia and USEPA regulators inspect the location and construction of regulated USTs and ASTs to insure compliance with state and federal petroleum-storage regulations. Inspectors from the USEPA Office of Enforcement, Compliance, and Environmental Justice and VDEQ performed the most recent inspection in May of 2008. During the May 2008 inspection, the Office of Enforcement, Compliance, and Environmental Justice inspector noted infractions of RCRA rules regarding release-detection monitoring systems. These infractions were noted and corrective action taken by NSF Dahlgren (USEPA, 2008).

Petroleum products are delivered to NSF Dahlgren via vendor-provided transport and equipment. No. 2 fuel oil, gasoline, diesel fuel, and kerosene are transferred directly from the vendor transport to the appropriate UST or AST. Lubricating oils, hydraulic oils, transmission fluids, motor oils, and greases are delivered in 55-gallon drums, 5-gallon containers, or consumer-size packages. When vessels are fueled at the docks of the Yardcraft area, personnel are prepared to utilize emergency containment booms to prevent a potential spill from spreading away from the immediate dock area (NAVSEA, 2010).

An NSF Dahlgren spill-prevention control and countermeasures plan containing information relevant to the Spill Contingency Plan is in place for NSWCDD facilities and was last updated on September 29, 2009.

3.7.3.4 Pollution Prevention Plans

The Navy and NSF Dahlgren Defense Reutilization and Marketing Office manage material that can be reused or recycled. NSF Dahlgren implements a waste-minimization plan aimed at reducing the use of, controlling, and managing hazardous materials. All operations and storage are conducted in accordance with applicable federal, state, and Navy regulations.

NSF Dahlgren also implements a Stormwater Pollution Prevention Plan (SWP3) for their industrial areas that requires monitoring of runoff from potential pollution areas within the ranges, including outfalls associated with gun mount operations and outfalls associated with open burning and open detonation (OB/OD) operations. These outfalls are monitored quarterly or annually for petroleum hydrocarbons, copper, and/or total suspended solids. In addition, stormwater is analyzed yearly for metals, pesticides, base neutral extractables, volatiles, acid extractables, and miscellaneous constituents in the outfall associated with OB/OD operations.

The SWP3 requires the implementation of both structural and non-structural controls to reduce the impact of stormwater runoff to the maximum extent practicable. The SWP3 is currently in the process of being updated (NAVSEA, 2010).

3.7.4 Environmental Restoration Program (ERP)

Prior to the 1970s, common nationwide disposal practices were very different from today's disposal methods, which are based on enhanced knowledge of contaminants and associated risks to human health and the environment. Disposal in the past involved placing waste, both solid and liquid, into unlined landfills. At Dahlgren, debris, ordnance, scrap metal, petroleum-based liquids, electrical equipment with components containing polychlorinated biphenyls (PCBs), and even entire airplane parts were at one time disposed of in this way.

Petroleum materials may also have been inadvertently released into the environment by leaky USTs, and from oil-water separators, vehicle maintenance and repair activities, and ordnance-testing activities. As a result of past practices, environmental contaminants have been found in areas of NSF Dahlgren – either in soil, surface water, or sediments (NAVFAC and NSA South Potomac, 2008).

In response to past practices – and in conformity with CERCLA and SARA – DoD developed the Installation Restoration Program – now called the ERP – to identify, assess, characterize, and clean up or control contamination from past HW or EHW disposal operations and HM spills at DoD facilities. The Navy implements the ERP at NSF Dahlgren, with USEPA and VDEQ providing regulatory oversight.

The Navy conducted a preliminary assessment/site inspection at Dahlgren in the mid-1980s. USEPA then evaluated the Dahlgren site using a hazard-ranking system (HRS). The HRS is the principal mechanism used by USEPA to place an uncontrolled waste site on the National Priority List (NPL). The HRS is a national, numerically-based screening system that uses information from initial investigations to assess the relative potential of a site to pose a threat to human health or the environment. A national ranking of 28.5 or higher results in a site's being placed on the NPL. Sites are listed on the NPL upon completion of HRS screening and public solicitation of comments. The Dahlgren HRS evaluation led to its being added to the NPL on October 14, 1992 (NAVFAC and NSA South Potomac, 2008).

Following listing on the NPL, clean-up of HW sites became a major focus at Dahlgren. Seventy-five sites were initially identified. Sites ranged from large landfills to areas where a few gallons of oil had been spilled on the ground. A series of studies revealed that relatively little contamination of shallow groundwater had occurred as the result of the outdated disposal methods. The smallest sites were cleaned up immediately. Misidentified sites requiring no remediation were removed from the list. In 1994, the 68 remaining sites became the focus of the Installation Restoration Program (now the ERP).

The Navy, USEPA, and VDEQ signed a Federal Facility Agreement on September 30, 1994, which established the procedural framework and schedule for remedial investigation studies at NSF Dahlgren. The Navy, USEPA, and VDEQ formed a partnering team in 1995 to meet every month to six weeks to prioritize, discuss, and implement cleanup activities at Dahlgren. The public was involved to review progress throughout the process.

The Federal Facility Agreement categorized each of Dahlgren's 68 sites as either requiring further characterization – termed Appendix A Sites – or requiring additional documentation or sampling before a "no further action" determination is warranted – termed Appendix B sites. The Appendix A sites were further organized into six categories: ERP, Priority 1, Priority 2, Priority 3, Priority 4, and the Gambo Creek Ecological Assessment (NAVFAC and NSA South Potomac, 2008). Tables 3.7-1 and 3.7-2 list the Appendix A and Appendix B sites, respectively. The status of each site is shown in the tables.

3.7.5 Operational Range Waste Management

As described under the MR definition of wastes, spent ordnance remaining on NSWCDD's land and water ranges is considered to have been used for the intended purpose of RDT&E activities, and therefore, is not subject to HW regulations. Operational ranges with these types of waste are managed under several military directives, policies, and programs described below that require military bases to remove fired munitions from land ranges. Historic sites with these types of waste are managed under the NSF Dahlgren ERP described in the previous section. Military directives, policies, and programs include:

- DoD Directive 3200.15, Sustainment of Ranges and Operating Areas
- DoD Instruction 3200.16, Operational Range Clearance
- DoD Directive 4715.11, Environmental and Explosives Safety Management on Operational Ranges Within the United States
- Navy Range Sustainment Program
- Department of the Navy Operational Range Clearance Policy for Navy Ranges

DoD Directive 3200.15 establishes the policy that ranges must be managed and operated to support their long-term viability to meet the national defense mission. It also establishes responsibilities for the preparation of range sustainment programs within DoD components. A crucial part of range sustainment is the routine removal of military munitions. DoD Instruction 3200.16 provides procedures for all operational ranges requiring appropriate range clearance of used or fired military munitions, munitions debris, and range-related debris that may impair or inhibit the continued use of an operational range.

Furthermore, DoD Directive 4715.11 directs the heads of DoD components to establish procedures for regular range clearance operations to permit the sustainable use of operational ranges for their intended purpose. These procedures need to determine the frequency and degree of range clearance operations, and consider the safety hazards of clearance and the quantities and types of munitions expended on that range. The Navy's response to DoD Directive 4715.11 is their Range Sustainment Program and the Operational Range Clearance Policy for Navy Ranges. Issued in 2004, this Navy policy is designed to ensure that Navy ranges are operated in an environmentally responsible manner that is protective of the public, while sustaining the highest levels of readiness to meet the Navy's mission requirements (NSWCDL, 2003).

Table 3.7-1
Appendix A Sites

Site Number	Site Name	Current Regulatory Status
ERP Sites		
Site 2	Fenced Ordnance Burial Area	ROD-Remedial Action Completed; Long-term Monitoring Underway
Site 3	Ordnance Burn Structure	ROD-Removal Action Completed; No Further Action
Site 9	Disposal/Burn Area	ROD-Remedial Action Completed; Long-term Monitoring Underway
Site 10	Hideaway Pond	ROD-Long Term Monitoring Underway
Site 12	Chemical Burn Area	During the excavation of the former burn pit (started in December 2008), several canisters/bottles were discovered. Material in these containers could not be identified, the excavation site was closed, and a Chemical Safety Submission is required. Remedial action has been completed.
Site 17	1400 Area Landfill	ROD-Remedial Action Completed; Long-term Monitoring Underway; Wetland Monitoring Underway; Methane Mitigation Trench Planning
Site 19	Transformer Draining Area	ROD-Removal Action Completed; No Further Action
Site 25	Pesticide Rinse Area	ROD-Remedial Action Completed; Wetland Monitoring Underway
Site 29	Battery Service Area	ROD-Removal Action Completed; No Further Action
Site 44	Rocket Motor Pit	ROD-Removal Action Completed; No Further Action
Site 58	Building 1350 Landfill	ROD-Remedial Action Completed
Priority 1 Sites		
Site 6	Terminal Range Airplane Park	ROD-Remedial Action Completed; Wetland Monitoring Underway
Site 21	Gun Barrel Decoppering Area	Removal Action Completed; Decision Document- No Further Action
Site 22	Gun Barrel Degreasing Area	Removal Action Completed; Decision Document- No Further Action
Site 31	Airplane Park Dump, EEA	ROD-Removal Action Completed; No Further Action
Site 32	Fast Cook-off Pit/Pond, EEA	ROD-RI/FS Completed; No Further Action
Site 45	July 28, 1992 Landfill B	Removal Action Completed; Decision Document - No Further Action
Site 46	July 28, 1992 Landfill A	ROD-Remedial Action Completed; Wetland Monitoring Underway
Site 50	Fill Area Northeast EEA	Removal Action Completed; Decision Document-No Further Action; Wetland Monitoring Underway
Site 51	Battery Locker Acid Drain Area	SSP Completed-No Further Action
Site 53	OWS 207 300	Removal Action Completed; Decision Document-No Further Action
Site 55	Cooling Pond	ROD-RI/FS Completed; No Further Action
Priority 2 Sites		
Site 13	Gambo Creek Truck Wash Area	Removal Action Completed; Decision Document-No Further Action
Site 20	Former Electroplating Waste UST	Remedial work started in March 2008 and was completed in March 2010.
Site 23	Building 480 Lot (PCB Storage)	FFS Completed; ROD Completed; Soil Remediation Action Complete
Site 37	Lead Contamination Area	ROD Amendment Completed; Remedial Action Completed; Wetlands Planting Completed

Table 3.7-1 (Continued)
Appendix A Sites

Site Number	Site Name	Current Regulatory Status
Priority 2 Sites (Cont'd)		
Site 56	Gun Barrel Degreasing, Rail Way Spur	SSP Completed; Decision Document-No further Action
Site 57	Shell House Dump	SSP Underway; Draft EE/CA completed and withdrawn as additional sampling indicated that there was not an unacceptable risk related to the soils.
Priority 3 Sites		
Site 4	Case Storage Area	EE/CA Completed; Explosive Safety Submission Completed; Removal Action restarted in April 2009, and field work was completed in fall 2010.
Site 14	Evaporation Pond	EE/CA Completed; Explosive safety completed in June 2009; Record of Decision completed in 2011.
Site 15	Scrap Area	EE/CA Completed; Explosive Safety Submission Completed; Removal Action restarted in April 2009 and Field Work finished in 2011.
Site 38	Building 1349 Pest Control Area	SSP Completed; Decision Document-No Further Action
Site 40	Building 120B Defense Reutilization and Marketing Office Lot	SSP Completed; Decision Document-No Further Action
Site 43	Higley Road Land App Area	Removal Action Completed; Decision Document-No Further Action
Site 61a	Gambo Creek Ash Dump	Remedial work is still ongoing with an unknown completion date.
Site 62	Building 396	ROD-RI/FS Completed; Removal Action Completed
Priority 4 Sites		
Site 1	Old Bombing Range	Decision Document - Action is deferred until the range is closed or transferred
Site 5	Projectile Disposal Area	Decision Document - Action is deferred until the range is closed or transferred
Site 36	Depleted Uranium Mound, EEA	ROD-Removal Action Completed; No Further Action
Site 47a	WWI Munitions Mound	EE/CA completed; Removal Action Completed; Decision Document-No Further Action
Site 47b	Explosive Ordnance Disposal Scrap Area	EE/CA completed; Removal Action Completed; Decision Document-No Further Action
Site 49	Depleted Uranium Gun Butt	ROD-Removal Action Completed; No Further Action

Notes: EE/CA = Engineering Evaluation/Cost Assessment
FS = Feasibility Study
RI/FS = Remedial Investigation/Feasibility Study
FFS = Focused Feasibility Study
ROD = Record of Decision
WWI = World War I
SSP = Site Screening Process
OWS = Oil and Water Separator
Sources: NAVFAC and NSA South Potomac, 2008; USEPA, 2011.

Table 3.7-2
Appendix B Sites

Site Number	Site Name	Current Status
SWMU 3	Building 194AA (Concrete Pad)	Closed Out
SWMU 15	Building 120B Contractor Staging Area	Closed Out
SWMU 20/Site 41	Compost Area	Closed Out
SWMU 23	Building 456 Oil Waste Drum	Closed Out
SWMU 27	Tank 280 Contractor Staging	Closed Out
SWMU 57/Site 60	Building 445 Star Gauge Dock	Closed Out
SWMU 62	Paint Can Crusher	Closed Out
SWMU 64	Building 448 Sand Blast Area	Closed Out
SWMU 67	Building 448 Tar Tank Area	Closed Out
SWMU 70	Building 152 TCA AA	Closed Out
SWMU 77	Building 1329 Wash Area	Closed Out
SWMU 78	Building 1121 Waste Oil UST	Closed Out
SWMU 82	Electroplating Line and WWT	Closed Out
SWMU 101	Building 155 Auto Shop UST	Closed Out
SWMU 115	Building 1282 Auto Hobby Storage	Closed Out
SWMU 119	Building 1282 Auto Hobby Tank	Closed Out
SWMU 125/Site 52	OWS 107-350 (Yardcraft Area)	Closed Out
SWMU 127	OWS (1121-300, 115-350, 402-30,000, and 486-1000)	Closed Out
SWMU 128/Site 54	OWS 1121-Old	Closed Out
SWMU 119	Building 1282 Auto Hobby	Closed Out
SWMU 130	Yardcraft Oil Storage Area	Closed Out
SWMU 131/Site 28	Gambo Creek Compost Area	Closed Out
AOC A	Otto Fuel Spill	Closed Out
AOC O	Building 1369 Pesticide Spill Area	Closed Out
AOC X	Classified Documents Incinerator	Closed Out
AOC X7/Site 39	Open Storage Area Main Battery	Closed Out
AOC Z	Terminal Range Building	Closed Out
Other Units C3	Scar at Phalanx Test Area	Closed Out
Other Units C6	Former Radio Testing Area	Closed Out
Additional Areas X6	South Hanger Tank Area	Closed Out
Site 59	Octagon Pad Dump, EEA	Closed Out
Building 126	Former Powder Magazine	Closed Out
Site 61b	Gambo Creek Disposal Area	Closed Out
Site 63	Building 198 Neutralization Tank	Final EE/CA for OU-28 in December 2009 with the removal action, completed in June 2011.

Notes: AOC = Area of Concern SWMU = Solid Waste Management Unit
Source: NAVFAC and NSA South Potomac, 2008: USEPA, 2011.

The NSWCDD Range Management Plan (RMP) establishes the procedures, necessary actions, and action proponents for comprehensive management of munitions and range residue. The RMP ensures that all range wastes are managed as required by applicable federal, state, and local laws, as well by as DoD directives. Under the RMP, surface or partially buried ordnance and debris are removed in accordance with the CNO's Operational Range Clearance Policy for Navy Ranges. Range maintenance and clearance activities can consist of target repair, munitions sweeps, range residue clearance, grading of selected impact areas, and maintaining signs, roads, and fences. An area is considered adequately cleared if all visible ordnance and target debris are removed (NSWCDL, 2003). In addition to RMP practices, specific post- operation cleanup procedures are set out in a standard operating procedure (SOP) prepared for each RDT&E operation and documented at the conclusion of the operation.

Under the MR, used or fired military munitions are considered a waste when: transported off-range for storage, reclamation, treatment, or disposal; recovered, collected, and disposed of by burial or land-filling either on or off a range (burial of munitions is now strictly prohibited); or fired off-range and not promptly rendered safe or retrieved. These types of waste are currently treated at the NSWCDD thermal treatment sites, also referred to as open burning/open detonation (OB/OD) sites (NSWCDL, 2003). The OB/OD sites are regulated through a VDEQ RCRA Subpart X Permit.

The NSWCDD mission includes EHW storage, and thermal treatment of EHW from on-site and off-site sources and of non-transportable ordnance from on-site. The amount of EHW generated, stored, and treated from on-site or offsite activities varies considerably. The total weight of EHW thermally treated by means of OB/OD by NSWCDD in 2007 was 8,597 lbs by OB and 10,277 lbs by OD. The NSWCDD RCRA Subpart X Permit[1] specifies the requirements, procedures, and conditions that must be followed to thermally treat EHW through open burning or open detonation. The RCRA Subpart X Permit also places limits on the EHW capacity for individual events and on a cumulative basis for each year.

NSWCDD structures 951, 952, and 353C are RCRA-permitted EHW storage magazines. EHW generated from on-site or off-site may be stored in these magazines while awaiting on-site thermal treatment. Building structure 408A has been designated as a less-than-90-day accumulation area for EHW. NSWCDD structures 9481, 9482, 9483 and 9484 are conditionally-exempt storage for EHW. This means that EHW from on-site or off-site may be stored in these structures until treated by NSWCDD (NSWCDL, 2003).

3.7.6 Range Sustainability Environmental Program Assessment

The Navy's Range Sustainability Environmental Program Assessment (RSEPA) is a process developed to provide a consistent approach for assessing and addressing the environmental condition of the Navy's operational land ranges. To address the requirements of the Range

[1] RCRA miscellaneous units are a unique category of hazardous waste management units, covered under 40 CFR Part 264, Subpart X. Units covered under Subpart X do not fit neatly within the definition of the more typical waste management units described in Part 264 (containers, tanks, incinerators, etc.). To be permitted, Subpart X units must meet environmental performance standards, while other Part 264 units must meet specific technology standards.

Sustainability Environmental Program, a Range Condition Assessment (RCA) for NSWCDD land-based operational ranges at NSF Dahlgren was completed in 2010 (NAVSEA, 2010).

The RCA evaluated all land-based ranges where munitions operations are conducted, including the AA Fuze Range, Machine Gun Range, Main Range, Missile Test Range, and Terminal Range on the PRTR Complex, and the Harris and Churchill Ranges on the EEA Range Complex. The types and quantities of munitions used on the land ranges are described in Chapters 1 and 2 of this EIS. The RCA evaluation found RDT&E operations at the land ranges to be in overall compliance with applicable environmental regulations and program requirements (NAVSEA, 2010). The following recommendations for HM and HW resulted from the On-Site Visit Information and Collection Review (Phase III) (NAVSEA, 2010):

- **Water and Wastewater Compliance** – NSF Dahlgren is currently updating the Industrial Wastewater Stormwater Pollution Prevention Plan Operations and Maintenance Manual to meet Virginia Pollutant Discharge Elimination System permit conditions. Wastewater that is generated at Mainside is treated by a permitted Federally Owned Treatment Works that has recently undergone upgrades. The treated water is discharged into Upper Machodoc Creek.
- **Munitions / Munitions Constituents / Solid Waste / Hazardous Materials / Hazardous Waste Compliance –** Munitions from past range operations will be removed if they become exposed due to erosion or other processes. Once exposed, these munitions meet the definition of solid waste in the MR (40 CFR §§§ 266.202(a)(1)(iii), 266.202(c)(2), and 266.202(d)) and are managed accordingly. To mitigate potential risks and deficiencies in compliance, mitigation measures including ordnance sweeps and stabilization measures are implemented as described above. Operational Range Clearance BMPs are followed to reduce potential risks to human health and/or the environment.

  As a result of past hurricanes and severe storms, most notably Hurricane Isabel in 2003, a previously unknown area of buried munitions and debris along the eastern shoreline of the Missile Test Range at the Old Plate Battery Test Area has been exposed. These munitions, exposed from erosion or other processes, meet the definition of solid waste in the MR (40 CFR §§§ 266.202(a)(1)(iii), 266.202(c)(2), and 266.202(d)) and present the potential for a deficiency in compliance with the SWP3 if munitions or debris is not managed in accordance with the applicable regulations (NAVSEA, 2010). To mitigate potential risks to human health and the environment and a deficiency in compliance, qualified ordnance teams sweep this area periodically as well as after storm events. If munitions become exposed from erosion, they are removed by the teams or qualified government or contractor personnel and treated at the OB/OD facility. In addition, actions have been taken to stabilize the Old Plate Battery Test Area of the Missile Test Range and to prevent unauthorized access (NAVSEA, 2010).
- **Emergency Planning and Community Right-to-Know Act –** No deficiencies were noted in the RCA report**.**
- **Range Environmental and Explosives Safety Management –** Munitions from past range operations are handled per the Operational Range Clearance Plan and are removed by qualified ordnance personnel and treated at the permitted OB/OD unit if munitions become exposed due to erosion or other processes. Exposed munitions are subject to regulation as solid waste and mitigation measures including ordnance sweeps and

stabilization measures are implemented. No deficiencies were noted for Range Environmental and Explosives Safety Management.

- **Installation Restoration/Munitions Response –** NSF Dahlgren/NAVFAC is the point of contact responsible for unresolved munitions, munitions and explosives of concern, unexploded ordnance (UXO), and discarded military munitions within and outside operational ranges. Through the ERP, NSF Dahlgren has identified, characterized, and remediated contamination from past HW or EHW disposal operations and HM spills at the facility. The Navy implements the ERP at NSF Dahlgren, with USEPA and VDEQ providing regulatory oversight. No deficiencies in the ERP were noted in the RCA report**.**
- **Storage Tank and Petroleum, Oils, and Lubricants Management –** No deficiencies were noted**.**
- **Safe Drinking Water –** The Operations and Maintenance Plan for the public drinking water needs to be updated to reflect current water distribution maps and well locations.
- **Munitions Constituents –** Perchlorate, hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) detected in the groundwater of the Columbia aquifer at the OB/OD on the EEA are being investigated in coordination with NSWCDD and the VDEQ. Groundwater protection standards have been established at the OB/OD unit by VDEQ. Self-imposed perchlorate evaluations are ongoing and are summarized in Table 3.7-3. The RCA report concluded that monitoring is currently in compliance with the permit requirements and that shallow groundwater contamination does not have the potential to migrate off-range. Therefore, no deficiencies in compliance were noted for the OB/OD unit (NAVSEA, 2010).

The RCA concluded that the Navy is already investigating, and in most cases has already addressed, areas where there is a potential for an off-range release of MCs from land-based operational areas through the ERP and Subpart X permitting requirements. Further, the RCA concluded that there is no need to investigate any areas for potential off-range releases beyond planned investigations (NAVSEA, 2010).

Table 3.7-3
Summary of Perchlorate Detections

Media	Concentrations (µg/L)			Number of Samples	Number of Detects
	Minimum	Maximum	Average[a]		
Groundwater (OB/OD)	ND	2,700	237.9	118	92*
Groundwater (EEA)	ND	1.0	0.29	7	2
Groundwater (other)	ND	20	2.01	104	32
Surface Water	ND	230	11.5	28	11
Sediment	ND	120	b	25	1
Soil	ND	1,200	b	111	9
Drinking Water	ND	ND	ND	4	0

Notes:
[a] Non-detects (NDs) were included at half the detection limit in the calculated average.
[b] Average not calculated because of predominance of non-detections and wide range of detection limits.
* 27 of 92 detects exceeded the groundwater protection standard of perchlorate of 24 µg/L.
µg/L = micrograms per liter.
Source: NAVSEA, 2010.

3.7.7 Munitions Constituents in PRTR Sediment and Water

To support the analysis of environmental impacts in this EIS, NSWCDD estimated the concentrations of MCs in sediment and water in the water range part of the PRTR Complex. The concentrations were derived for use in screening potential effects on human health (Section 4.8) and ecological receptors (Sections 4.11, 4.12, and 4.13). Appendix F of this report discusses the methodologies that were used.

3.7.7.1 PRTR Gun Firing (Munitions) Data

Many types of ordnance have been tested on the PRTR since 1918, including small-, medium-, and large caliber guns up to 16", aircraft bombs and guns (until 1957), rockets (ended in the 1970s), mortars, grenades, mines, depth charges, and torpedoes (although underwater explosives have not been tested since the 1970s). However, most of the information on historical ordnance use is based on anecdotal accounts, and the quantities for most types of munitions used are not readily available. Therefore, the quantitative analysis focused on gun-firing data recorded in firing logs that NSWCDD possesses. Firing-log data included the caliber of gun fired, the number of rounds fired, and the location of the target area. These data were used to estimate the quantities of MCs associated with ordnance fired into the PRTR.

As recorded in the firing logs, from 1918 to 2007 the Navy tested 291,971 inert rounds and 51,844 live rounds on the PRTR for a total of 343,815 large-caliber rounds. Inert rounds accounted for 84.9 percent of the total and live rounds accounted for 15.1 percent of the total. Over the 90 years, an average of 3,820 rounds – comprising an estimated 3,244 inert rounds and 576 live rounds – were tested each year. Most of the rounds (99.7 percent) were fired into the MDZ, with a small number of rounds (0.3 percent) into the LDZ.

The PRTR between the Main Range Gun Firing Line (0 yd) and 25,000 yds in the MDZ accounts for 341,706 rounds, or 99.4 percent of all munitions fired on the PRTR and recorded in the log books (Figure 3.7-1, Distribution of Large-caliber Projectiles in the Potomac River Test Range). For the evaluation performed in Appendix F, this area was called the "diffuse zone." Within this area, the zone from 11,000 to 13,000 yds – called the "dense zone" for evaluation purposes – has the highest density of rounds. This zone has a surface area of approximately 2.3 sq NM and contains approximately 159,580 rounds, yielding a density of 69,686 rounds per sq NM.

3.7.7.2 Munitions Constituents (MCs)

The raw firing activity data obtained were sorted, compiled, and cross-referenced with information on MCs that was obtained from the Munitions Items Disposition Action System (MIDAS) database to determine the type and quantity of MCs in the PRTR. The MIDAS database contains detailed technical data for a wide range of munitions, including the weight and material specifications for individual munitions. These specifications were used to determine the constituents associated with each munitions type. The total weight for each MC associated with each munitions type was calculated by multiplying the number of times a munitions type was fired by the weight of the MC in each munition of that type. Summing those data across munitions types provided the total amount of each constituent associated with live and inert firings.

Distribution of Large-caliber Projectiles in the Middle Danger Zone and Lower Danger Zone

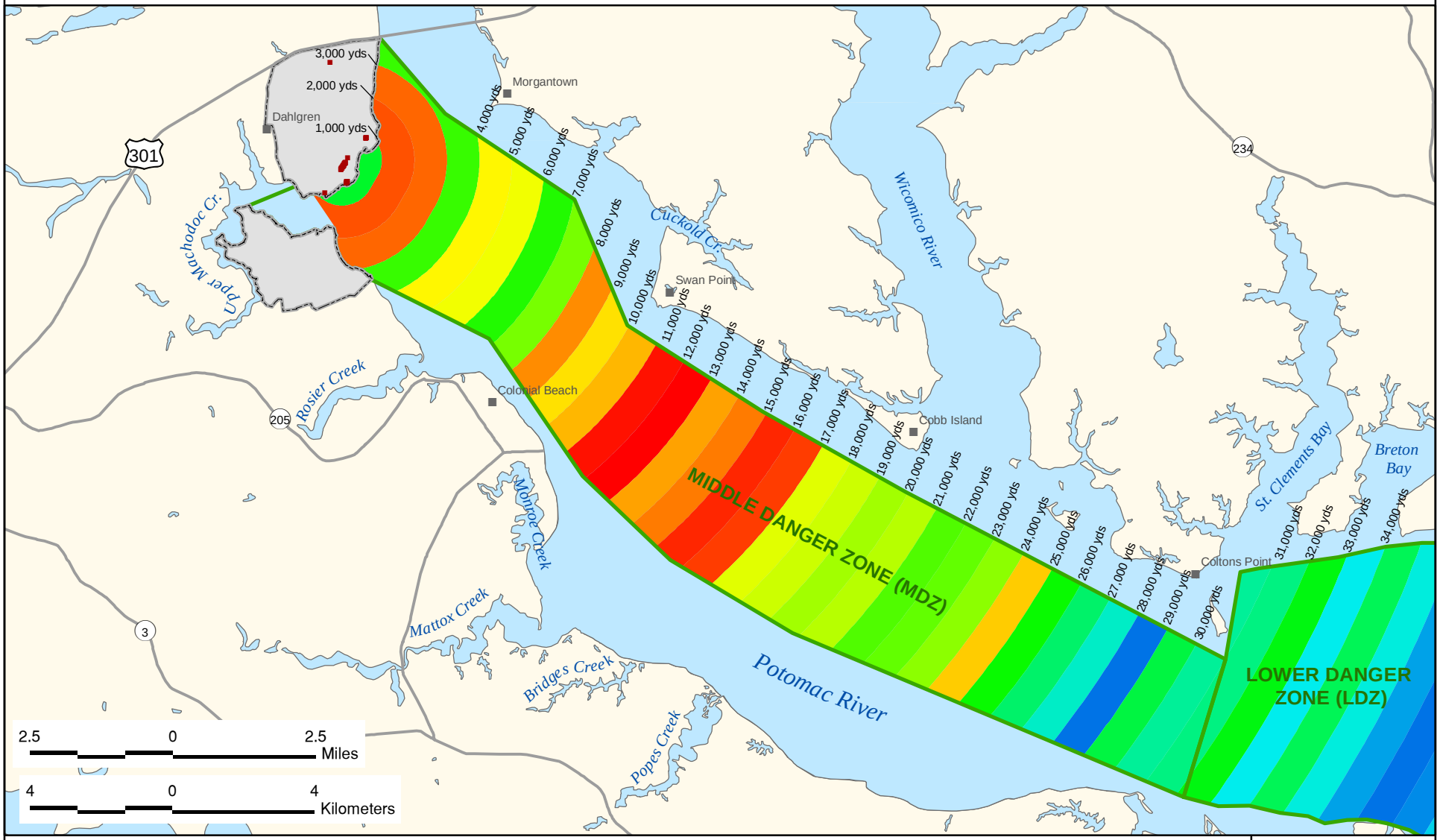

Figure 3.7-1

Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

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Based on the MIDAS records, 110 MCs are associated with the 57 different munitions types tested at the PRTR. A total of approximately 33 million lbs of constituents are associated with the 343,815 total rounds fired into the PRTR, as recorded in the log books. The MCs comprising the majority of the total weight are metals in the projectile casing that is common to both live and inert rounds. The predominant constituent is iron, contributing 31 million lbs or 93.2 percent of the total constituent weight. The second largest contributor is copper at 958,087 lbs, followed by manganese at 463,239 lbs; they contribute 2.9 percent and 1.4 percent of the total amount of constituent weight, respectively. Combined, iron, copper, and manganese account for 97.5 percent of the total constituent weight of munitions over the 90 years of testing.

Ammonium picrate (Explosive D), RDX, and 2,4,6-trinitrotouluene (TNT) were the most common explosives used in testing at the PRTR and are among the top ten constituents by weight associated with live munitions.

As there is potential at the PRTR for human and ecological receptors to be exposed to these MCs in the Potomac River, range-specific screening-level risk assessments (RSSRAs) were performed. A subset of MCs was selected as munitions constituents of potential concern (MCOPCs) based on their total mass (cumulative over the last 90 years), toxicity of constituents, and Navy guidance.

The ecological and human health RSSRAs employed conservative (i.e., stringent/protective) assumptions to evaluate existing data and determine whether additional analysis is necessary; protective measures are warranted; or the range poses acceptable risks. Predicted concentrations of MCOPCs in Potomac River water and sediments were also based on conservative modeling assumptions and did not apply any dilution or burial factors for water or sediment concentrations, respectively.

The RSSRAs evaluated MCOPCs by comparing modeled concentrations in water, sediment, and fish tissues to risk-based screening concentrations. The results of the human health and ecological RSSRAs, discussed in Sections 4.8, 4.11, 4.12, and 4.13, indicate that input of MCOPCs from munitions testing in the PRTR are orders of magnitude – hundreds to billions of times – below concentrations that could cause adverse effects to human health or the environment.

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3.8 Health and Safety

Outdoor RDT&E activities involve the use of explosives, lasers, EM energy, and chemicals. Because of the risks associated with these activities, protecting the health and safety of the public and of NSF Dahlgren personnel must be, and is, an integral part of NSWCDD's mission. NSWCDD RTD&E activities comply with all applicable federal and state, DoD-, Navy-, and installation-level occupational safety and environmental requirements to ensure that these activities are conducted with no or minimal risks to persons or the environment, both on and off the installation and PRTR.

NSWCDD fosters a safety culture that encourages all managers and employees to take responsibility for their safety and that of others and to report any concerns they may have, so that corrective action may be taken without delay. Safety programs and procedures are constantly reviewed and updated to ensure their continuing validity and appropriateness. Personnel are thoroughly trained in the development and implementation of safety procedures. Thanks to this commitment to safety, there have been no fatalities attributable to NSWCDD's RDT&E activities in more than 40 years. In addition, based on review of records for the past 10 years, there have been no illnesses or injuries attributable to outdoor activities.

The Occupational Safety and Health Policy established the following guiding principles to provide every employee with a safe and healthful workplace (NSWCDD, 2011):

- Integrate safety awareness and Operational Risk Management into all aspects of workplace activities and business decisions.
- Continuously improve workplace safety and health through process improvements and eliminating potential hazards to reduce injuries.
- Educate employees with controls and equipment that are essential to sage mission accomplishment.
- Ensure compliance with relevant regulatory standards and laws.
- Foster communication and encourage participation throughout all organizational levels to achieve and maintain a safe and healthful workplace.

This section describes the safety measures NSWCDD employs to protect human health. Section 3.8.1 describes the general safety measures that cover all of NSWCDD's activities. Sections 3.8.2, 3.8.3, 3.8.4, and 3.8.5 describe safety measures specific to ordnance activities, activities requiring EM energy, laser activities, and chemical/biological defense activities, respectively.

3.8.1 Safety Measures for All Activities

Safety-related measures used by NSWCDD to protect human health can be divided into three main types:

- Safety Zones – The establishment and maintenance of safety zones, that is, of areas with special access and land use restrictions designed to protect persons and property from the risks associated with certain facilities and activities. Safety zones typically are only in effect when an operation is taking place.

- Safety Procedures – The development and implementation of safety procedures and methods designed to ensure that specific tests and other RDT&E activities are conducted in as safe a manner as possible, with minimal risk of harm to persons and the environment.
- Protective Equipment – The use of protective equipment by NSWCDD personnel when they are performing hazardous activities, particularly involving the use of explosives, chemicals, and EM energy.

These measures are described below.

3.8.1.1 Safety Zones

PRTR Danger Zones

Danger zones are defined in 33 CFR Part 334. Per the regulations, a danger zone is a "defined water area (or areas) used for target practice, bombing, rocket firing, or other especially hazardous operations, normally for the armed forces. The danger zones may be closed to the public on a full-time or intermittent basis, as stated in the regulations." (33 CFR § 334.2(a)).

The boundaries of the PRTR's UDZ, MDZ, and LDZ (see Figure 1-3) are defined in 33 CFR § 334.230. Specific regulations applicable to the PRTR (33 CFR § 334.230 (a) (2)) include:

(i) Firing normally takes place between the hours of 8 am and 5 pm daily except Saturdays, Sundays, and national holidays, with infrequent night firing between 4 pm and 10:30 pm[2]. During a national emergency, firing will take place between the hours of 6 am and 10:30 pm daily except Sundays.

(ii) When firing is in progress, no person, fishing, or oystering vessels shall operate within the danger zone affected unless so authorized by the Naval Surface Warfare Center's patrol boats. Oystering and fishing boats or other craft may cross the river in the danger zone only after they have reported to the patrol boat and received instructions as to when and where to cross. Deep-draft vessels using dredged channels and propelled by mechanical power at a speed greater than five miles per hour may proceed directly through the danger zones without restriction except when especially notified to the contrary. Unless instructed to the contrary by the patrol boat, small craft navigating up or down the Potomac River during firing hours shall proceed outside of the northeastern boundary of the Middle Danger Zone. All craft desiring to enter the Middle Danger Zone when proceeding in or out of Upper Machodoc Creek during firing hours will be instructed by the patrol boat; for those craft which desire to proceed in or out of Upper Machodoc Creek on a course

Range Control Boat

[2] Although 33 CFR Part 334 allows firing between 4 pm and 10:30 pm, in practice NSWCDD only fires or detonates ordnance Monday through Friday between 8 am and 5 pm.

between the western shore of the Potomac River and a line from the Main Dock of the Naval Surface Weapons Center to Line of Fire Buoy P, clearance will be granted to proceed upon request directed to the patrol boat.

Watercraft and deep-draft vessels are encouraged to communicate with NSWCDD's Range Operations Center (ROC) via marine radio in order to minimize delays. NSWCDD's rigorous implementation of these regulations ensures that activities on the PRTR are conducted safely and with minimal impacts to river users. During activities on the river that could endanger watercraft, a red flag is flown at the Yardcraft piers, near the mouth of Upper Machodoc Creek. Range boats – painted international orange with a white hull and normally stationed near Lower Cedar Point, Maryland; near Swan Point, Maryland; off Colonial Beach, Virginia; and at the mouth of Upper Machodoc Creek – patrol the operational danger zone to ensure that no watercraft are present. To that end, the boats fly red flags warning watercraft not to enter the danger zone without having obtained permission from the nearest range patrol boat or from the ROC, which can be contacted by marine radio. If needed, range boats use a siren as a signal for a passing watercraft to come alongside for information and instructions on how to proceed, or they contact it by marine radio. Depending on the type of operation, traffic can frequently be safely rerouted around the operational area. Deep-draft vessels may be made to hold for a maximum of one hour, but more typically one-half hour, when necessary. To minimize potential inconvenience, advanced notice of scheduled activities and danger-zone restrictions are provided on NSWCDD's website or via a toll-free number. Monitoring equipment, such as the cameras used to record projectile/water impact locations during ordnance activities, is also used for PRTR surveillance during periods of restricted access.

Airfield Safety Zones and Special Use Airspace

Air safety regulations define two- and three-dimensional areas around active runways that must remain clear of obstructions to minimize the risk of accident during takeoffs and landings. For Navy airfields, the size and shape of the safety areas are defined in NAVFAC P-80.3 *Facility Planning Factor Criteria for Navy & Marine Corps Shore Installations*, Appendix F *Airfield Safety Clearances*. The airfield's only functional runway (18/36) currently is not authorized for landings/takeoffs by fixed-wing aircraft. Therefore, only helicopters use it at present. For a helicopter (visual flight rules), the primary surface is 300 feet wide and the length of the runway plus 75 feet at each end.

Range Operations Center (ROC)

The ROC is responsible for controlling test operations on all ranges. The ROC monitors and controls all test sites with patrol boats, air surveillance radar, video surveillance, communications, and other functions required to ensure safe operations. To ensure effective communication in case of emergency, the ROC is always staffed when any of the ranges are being used, when PRTR danger zones are in use, when any airspace is reserved for firing, or when aircraft under NSWCDD's control are conducting tests in or near restricted airspace.

While the air safety area just mentioned is designed to minimize potential hazards to and from helicopters using the NSF Dahlgren airfield, the Special Use Airspace (SUA) associated with the installation's PRTR was established to ensure that non-participating aircraft are not put at risk while activities involving projectiles or flying equipment are being conducted. The dimensions of NSWCDD's SUA are described in Section 1.4.4 and shown in Figure 1-6. Normal restricted airspace operating hours are Monday through Friday from 8 am to 5 pm, excluding holidays.

Activities outside these times require publication of a Notice to Airmen (NOTAM) 48 hours in advance. When not using the SUA for activities, NSWCDD releases the airspace to the control of the Federal Aviation Administration (FAA)'s Potomac Terminal Radar Approach Control (TRACON) for normal use. Closures are coordinated with TRACON. Both visual surveillance and radar are used to make sure the area is clear before proceeding with the planned activities.

Explosive Safety Quantity Distance Arcs

Explosive Safety Quantity Distance (ESQD) arcs are circular perimeters defined around potential explosive sites to minimize the harm an unplanned detonation could cause to persons or buildings. The radius of each ESQD arc is determined based on the NEW of the material at the potential explosive site, as well as on the type of operation. The applicable criteria are contained in NAVSEA OP5: *Ammunition and Explosives Ashore Safety Regulations for Handling, Storage, Production, Renovation, & Shipping* and are defined based on the safety standards established by the DoD Explosives Safety Board. ESQD requirements apply during development; manufacturing; test and maintenance; storage, loading, and off-loading of vehicles; disposal; and all related handling activities.

Existing ESQD arcs at NSF Dahlgren are shown in Figure 3.8-1 (Safety Footprints). On Mainside, ESQD arcs surround the five munitions storage areas (see Figure 3.1-2). Other arcs have been established for the transfer of ordnance by truck in the magazine storage areas and by barge at the piers. Arcs are also present around explosive ranges where outdoor detonations occur, such as at the Explosive Ordnance Disposal (EOD) area and the EEA.

While ESQD arcs represent a significant constraint on development within NSF Dahlgren, they do not substantially affect the local community, being for the most part contained within the confines of the installation. However, as seen in Figure 3.8-1, some of the arcs extend over the waters of Upper Machodoc Creek outside the footprint of the PRTR. When activities involving these arcs extend into the waters of the creek, range boats are deployed to monitor boat traffic within the arcs.

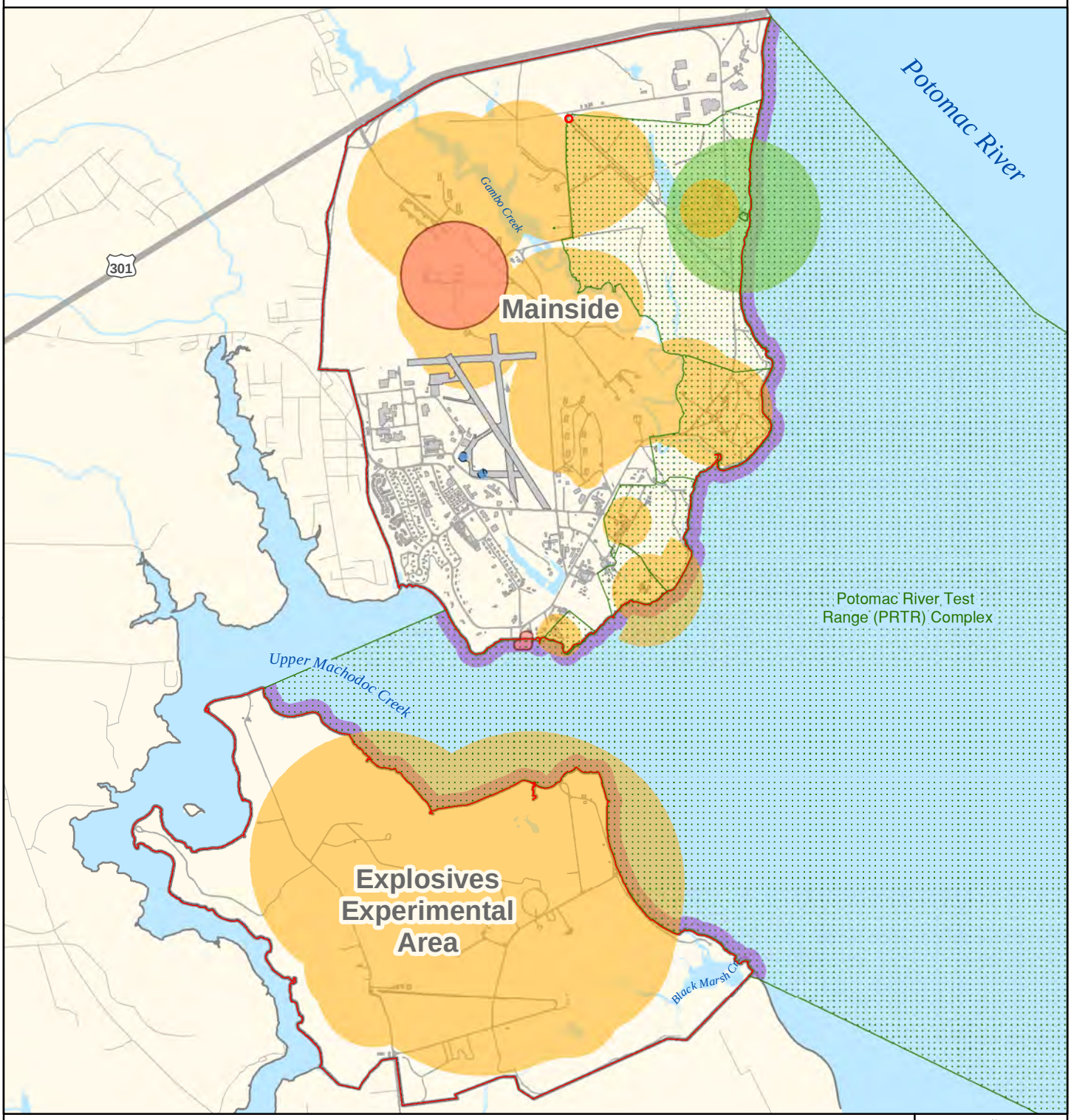
Electromagnetic (EM) Hazard Arcs

An EM hazard occurs when transmitting equipment produces an electronic field sufficient to trigger ordnance (HERO), ignite fuels (HERF), cause harm to persons (HERP), or interfere with electronic equipment (EMI) (described in Section 1.5.2.1). Consequently, arcs are defined around sites producing EM energy to ensure that personnel and sensitive materials are not within range of these potential adverse effects. Two such arcs have been defined in the ground plane area in the Mission Area (Figure 3.8-1). EM arcs vary for the MOATS, NOTES, and ground plane facilities based on individual test scenarios as defined by the risk hazard assessment (RHA) within the standard operating procedure (SOP) or general operating procedure (GOP) (discussed immediately below). NSWCDD coordinates with the Navy and Marine Corps Spectrum Center on all aspects of EM spectrum management.

3.8.1.2 Safety Procedures: RHAs, SOPs and GOP/OPSs

For every new operation that has the potential to be hazardous, an RHA is prepared to determine and document the hazards and ways to mitigate them. If the RHA indicates that a proposed

Safety Footprints



Electromagnetic Launch Facility (EMLF) 80-foot Safety Zone Buffer

Explosive Safety Quantity Distance (ESQD) Arc

Explosive Ordnance Disposal (EOD) Arc

Explosive Transfer Arc

Electromagnetic (EM) Hazard Arcs

100-Yard Unexploded Ordnance (UXO) Buffer

Potomac River Test Range (PRTR) Complex

Naval Support Facility (NSF) Dahlgren

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 3.8-1

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operation could be hazardous, then SOPs or GOPs are developed for the operation based on the RHA. The development and rigorous implementation of RHAs, SOPs, or GOPs with associated operation procedures supplements (OPSs) are at the heart of NSWCDD's safety approach for hazardous operations. SOPs and GOPs are similar in form and content. The main difference is that an SOP pertains to a specific, stand-alone operation, whereas a GOP/OPS is a set of unchanging procedures for a given, multi-use facility or piece of equipment (the GOP) combined with a particular set of procedures for a specific use of this facility or equipment (the OPS). An example of GOP/OPS would be a GOP for the operation of an X-ray facility and an OPS for X-raying a particular rocket motor. Neither the GOP nor the OPS is a stand-alone document; one must always be accompanied by the other.

Policy and guidance on preparing and using SOP/GOP/OPS for energetic material operations or other hazardous operations conducted by NSWCDD is contained in NSWCDL Instruction 8023.2, *Operating Procedures Policy, Guidance, and Format for Energetic Material Operations*, consistent with OPNAVINST 8020.14/Marine Corps Order P8020.11, *Department of the Navy Explosives Safety Policy*; NOSSA 8023.11A, *Standard Operating Procedures Development, Implementation, and Maintenance for Ammunition and Explosives*; NAVSEA OP 5, Vol. 1, *Ammunition and Explosives Ashore-Safety Regulations for Handling, Storing, Production, Renovation, and Shipping*; OPNAVINST 3500.39A/Marine Corps Order 3500.27, *Operational Risk Management*; and other applicable DoD and Navy regulations and instructions, such as the Navy Safety and Occupational Health Program Manual OPNAVINST 5100.23G and NSWCDL 5100.1D and 5100.1M.

Preparation

Preparation of the SOP/GOP/OPS for an operation is the responsibility of the unit organizing and performing the operation. Working with the designated preparer, a technical editor reviews and edits the document for clarity, consistency, and conformance with approved format. Typically, an SOP/GOP/OPS contains the following sections:

- Signature pages (see "Review" and "Implementation" below).
- A general description of the proposed operation.
- A statement of responsibilities, listing what persons will be in charge of what actions.
- A description of the operational location.
- A description of personnel and material limits, which establishes the staff and physical parameters within which the test will take place (this may include definition of a buffer zone; specific meteorological conditions; types of materials needed and their potential interactions, with supporting documentation; etc.).
- A list of safety requirements (which may include the wearing of appropriate personal protective equipment [PPE], a description of conditions under which the test should be cancelled or aborted, specific instructions on how to turn on, operate, and turn off equipment, etc.).
- Emergency response and contingency plans, listing the procedures to follow and assistance/rescue personnel to call in case of accident or emergency, such as a spill, explosive mishap, medical emergency, etc., with names and contact information.

- A description of applicable environmental protection procedures consistent with federal, state, DoD, and Navy regulations.
- Security requirements, establishing the appropriate level of security based on the level of confidentiality of the test.
- A Hazard Control Brief, which is based on the RHA that must be performed as part of every SOP (see text boxes).
- An equipment list, itemizing required safety equipment as well as needed tools and materials.
- A step-by-step description of the procedures to follow before, during, and after the test, with highlighted *Warning* (for personnel) and *Caution* (for equipment) boxes for essential information, as needed.
- Appendices supporting the previous sections, as needed.

An OPS is generally a shorter document that complements the associated GOP with information and measures that are specific to the operation under consideration. Typically, these additions include assembly/disassembly procedures, special handling of equipment or tools, and specific step-by-step instructions, among others.

Review, Validation, and Approval

Operations Safety Committee Composition

- The Range Safety Director.
- Personnel responsible for the technical requirements and execution of the process.
- Representatives of the Explosives Safety Program Office.

Review of the SOP/GOP/OPS is an essential step in the process. It ensures that the documents meet all applicable requirements and are complete, accurate, and effective. After completion of the initial draft, the SOP/GOP/OPS is forwarded to the Range Safety Director (RSD) for review by the Operations Safety Committee (OSC). OSC members review the documents, recommend changes, and, in conjunction with NSWCDD's environmental staff, and if applicable, NSF Dahlgren's environmental staff, determine whether measures can be taken that would lessen impacts to the environment without compromising the purpose of the operation. Following this review, the technical editor revises the SOP/GOP/OPS and prepares it for the next steps in the review and approval process, beginning with validation.

Validation is a key step in the review/approval process. The validation process can take the form either of a paper document or a test run. Validation of the SOP/GOP/OPS ensures that the SOP/GOP/OPS:

- Is effective in making the operation safe.
- Is sufficiently detailed to be used as a stand-alone document.
- Is clear, logical, and consistent.
- Is efficient and conducive of use by the performing personnel.
- Considers environmental issues and is designed to have the least impact practicable.

Policies from NSWCDL Instruction 8023.2, *Operating Procedures Policy, Guidance, and Format for Energetic Material Operations*

Operations involving the processing, movement, or handling of energetic materials shall not take place without approved and documented procedures prepared in accordance with the provisions of this Instruction.

All energetic material operations shall be conducted in a safe manner.

Each operation shall comply with the technical requirements, explosive safety standards, personnel qualification and certification requirements, Navy Occupational Safety and Health standards, federal, state, and local environmental protection requirements, Environmental Management System (EMS) intent and classification and physical security directives.

All personnel shall be responsible for producing quality operations and products in a safe and environmentally responsible manner.

Operating procedures shall clearly identify and minimize existing or potential hazards inherent in the processing of ordnance or ordnance components, and include emergency response, evacuation, and contingency plans, as required.

Prior to the commencement of any operations covered by this Instruction, performing organizations shall ensure that approved operating procedures are available and personnel involved in hazardous operations are qualified and certified, in accordance with NSWCDLINST 8020.1A, *Ordnance Certification Program*.

All operating procedures for energetic material operations shall be approved and released by the Commander, NSWCDD or the approved department manager, who shall be designated in writing.

SOPs must reflect current procedures. Personnel responsible for the technical requirements and execution of the process must ensure that operating procedures are changed and reviewed as necessary to reflect changes.

Personnel involved in a particular operation shall take part in the preparation of operating procedures for that operation.

The preparation of operating procedures shall be delegated to the lowest level consistent with the spirit and intent of this Instruction and technical capability.

A Risk Hazard Assessment (RHA) shall be completed. All hazardous operations shall be thoroughly analyzed for hazards. Hazards shall then be eliminated, controlled, and/or mitigated to a degree that shall result in the establishment of an acceptable level of safety for the process. RHAs shall be conducted in accordance with the Range Operation Policy Statement (ROPS), 05196, and Risk Hazard Assessment Requirements and Template.

Risk Hazard Assessment

A Risk Hazard Assessment (RHA) is prepared to determine the risks of a proposed operation. If hazards are identified, then SOP/GOP/OPSs are prepared, consistent with OPNAVINST 3500.39A/Marine Corps Order 3500.27, *Operational Risk Assessment*. The purpose of an RHA is to carefully examine what could cause harm to people or material during an operation and decide what precautions are needed to mitigate the risk so nobody is injured or becomes ill and no material is damaged. The RHA is then used to generate the SOP/GOP/OPS.

Conducting an RHA involves the following steps:

1. **Identify each component of each task** for the operation under consideration
2. **Determine hazards for each process step**: a hazard is an agent of injury or a condition that could expose a person to danger or harm. Examples of hazards include: working at height, sharp objects, protruding objects, slippery walking surfaces, hot materials, chemicals, energy sources, etc.
3. **Determine mishap-triggering events**: these are the human errors, system faults, or environmental conditions that may cause a mishap. Examples include ergonomic events such as lifting, reaching, or bending; exposures to hazardous materials or energy; or improperly sequenced sub-steps.
4. **Determine potential mishaps**: a mishap is any unplanned or unexpected event causing injury, death, material loss or damage, or an explosion whether damage occurs or not.
5. **Determine risk levels for each process step before mitigation**: the risk level reflects the severity of the potential mishap associated with the step and the probability that the mishap will occur.
6. **Determine appropriate hazard mitigation**: This may consist of engineering controls (e.g., reducing the amount of energy used, substituting materials, using remote controls) and/or administrative controls (e.g., using PPE, using warnings and cautions).
7. **Determine risk levels after mitigation**.

All RHAs are reviewed by the Operations Safety Committee (OSC) and are provided to all personnel who are required to review and approve the corresponding SOP/GOP/OPS.

Source: NSWCDL, 2005b. Range Operation Policy Statement (ROPS) 05196, *Guidance and Template for Risk Hazard Assessment.*

If the SOP/GOP/OPS is for a new or changed process, validation consists of a mock execution of the process – a little like a "dress rehearsal." The validation is conducted by a Validation Team, consisting, at a minimum, of the RSD, the preparer of the SOP/GOP/OPS, a representative of the Explosives Safety Program Office, and a representative of the performing organization. Other personnel may be added, as appropriate. After reviewing the SOP/GOP/OPS, the team observes the procedures being performed using inert materials if possible (if necessary, use of energetic material is allowed, but must be approved). Team members' comments and recommendations are incorporated into the document. The validation process may be repeated until the team is satisfied that the procedures are feasible, correct, and effective. For SOPs/GOPs/OPSs that are revisions or updates of existing, approved documents, validation consists of a line-by-line comparison of the new document with the old one.

Once validation is complete, the Validation Team leader signs the SOP/GOP/OPS and returns it to the preparer for final revisions prior to final review and approval.

The validated SOP/GOP/OPS, along with the validation record, is then forwarded for final approval and release signatures by 1) the performing organization; 2) the Division Head; 3) other activities as applicable; 4) the NSWCDD Safety and Environmental Director in consultation with NSF personnel, as applicable; and 5) the Explosives Safety Officer. Final approval and release authority lies with the NSWCDD Commander or a Department Manager designated by the Commander to that effect. The signature page is the first page of each SOP/GOP/OPS. A sample is shown in Figure 3.8-2 (Sample SOP/GOP/OPS Signature Page).

Once approved, an SOP/GOP/OPS is valid for four years. After four years, the document is considered expired and must undergo a complete review and approval process prior to reissue. Because SOPs/GOPs/OPSs must at all times reflect the most current procedures and techniques, they are subject to continual review and revision, with associated approval requirements commensurate with the scale of the revision. Additional reviews must occur when an action has been inactive for more than six months; if there has been a change or revision to a source document; or if a mishap has occurred. Initiation of any change is the responsibility of the performing organization. Once an SOP/GOP/OPS has been updated, copies of the older version are systematically collected and destroyed. These requirements ensure that SOPs/GOPs/OPSs are always up-to-date and reflective of actual conditions.

Implementation

The measures contained in an SOP/GOP/OPS are implemented every time the operation covered by the document is performed. Prior to the operation, personnel who will be directly involved are provided with the SOP/GOP/OPS and must sign and date a statement certifying they have read and understood the document and have received and understood the corresponding Hazard Control Brief. Within the same time frame, non-performing personnel (i.e., personnel not directly involved in the operation but present in the area) are given the Hazard Control Brief and must sign a statement that they have received and understood the brief. Certifications and signatures are an integral part of each SOP/GOP/OPS and are placed at the very beginning of the document, after the signature page; operations do not begin until all needed certifications and signatures are obtained. The operation is always performed in full compliance with the measures, procedures, warnings, cautions, and step-by-step instructions contained in the SOP/GOP/OPS.

3.8.1.3 Personal Protective Equipment (PPE)

As specified in the SOP/GOP for each operation, to reduce exposure hazards to acceptable levels, personnel may be required to use PPE if they are going to be near the site at which a hazardous operation is taking place. Health and safety concerns decrease rapidly as personnel move away from the operational sites to the point where PPE is no longer required. PPE may include one or more of the following: protective suits, coveralls, hoods, goggles, gloves, boots, respiratory equipment, eye protection, or ear protection.

In developing the SOP/GOP, NSWCDD relies on the RHA process to calculate the duration of exposure, type of exposure, materials being handled, proximity to the test site, and hazards of the exposure to determine the type of PPE required. Personnel receive training in the use of PPE, and use is monitored in line with the SOP/GOP for each operation. The types of PPE specified for a

particular test follow USEPA and US Department of Labor (USDOL), Occupational Safety and Health Administration (OSHA) guidance (OSHA, 2003).

3.8.2 Ordnance Activities Safety

Activities involving the use, transport, and storage of ordnance are inherently hazardous; consequently, NSWCDD takes great care to avoid injuries and property damage from ordnance on- and off-base. As discussed in the previous section, detailed policy and guidance for use of ordnance and other energetic material activities is contained in both general DoD and Navy policy and guidance and in instructions developed specifically for NSWCDD, as well as in range and airspace control measures. In addition to the SOPs and GOPs/OPSs described in Section 3.8.1.2 and the range- and airspace-control measures detailed in Section 3.8.1.1, additional safety-control measures are also implemented, as described below.

3.8.2.1 Gun Firing Control Measures

The gun-firing system constitutes one of the primary safety devices for firing projectiles. Electrical or electrically-controlled mechanical devices initiate nearly all gun firings, detonations, and ignitions of ammunition remotely, allowing personnel to be located at a safe distance from the ordnance being fired or detonated. Because NSWCDD tests new weapons and weapon systems components, which do not necessarily act as designed, this is an important safeguard for personnel. NSWCDD's extensive use of instruments to measure and record the outcome of tests also allows personnel to be located well away from RDT&E activities.

The use of firing cut-outs on all NSWCDD's guns provides protection against a gun's firing in the wrong direction or at the wrong angle. Firing cut-outs limit the operational bearing and elevation of a gun's range of motion. On a ship, they keep missiles, guns, and other munitions from firing into the ship's structure. They ensure that guns always fire in the right direction and never accidentally swing away from it. Thus, the area within which the projectile may fall can be precisely determined.

NSWCDD has measures in place to reduce shrapnel and the potential injuries to personnel and property that flying shards of metal could cause when ordnance is detonated. Most detonations are conducted on the EEA[3], which is remote from the rest of the base, has a low density of buildings and personnel, and has access control. To reduce potential shrapnel and noise, some explosives over 200 pounds (lbs) NEW are buried under 6 to 8 ft of soil before detonation[4]. Cameras and other instruments record detonations, allowing personnel to view them from a safe, remote location.

[3] A few detonations take place on the Explosive Ordnance Disposal Training Range, located within the Missile Test Range.

[4] This applies to open detonations for treatment of explosive hazardous waste, but does not apply to such operations as fast cook-off or arena tests.

Sample SOP/GOP/OPS Signature Page

Outdoor Laser SOP#XSL-OS-005-07

NAVAL SURFACE WARFARE CENTER
DAHLGREN SITE
DAHLGREN, VA 22448-5100

Subj: *STANDARD OPERATING PROCEDURES FOR OUTDOOR HIGH ENERGY LASER TESTING*

Prepared and Approved by: _____ _____
Name, Q22 *(Organization Code)* Date
Laser Safety Specialist

Reviewed and Approved by: _____ _____
Name, Q22 Date
Test Director

_____ _____
Name Date
Lead Engineer

_____ _____
Name, Q22 Date
Branch Head

_____ _____
Name, Q20 Date
Directed Energy Technology Office

_____ _____
Name, G604 Date
Dahlgren Range Safety Director

Validated by: _____ _____
Validation Team Leader Date
Code

Approved by:

_____ _____ _____ _____
Name, XDC8 Date *Name*, XDC8 Date
Safety and Environmental Manager Laser System Safety Officer

_____ _____
Name, Q20 Date
Division Head

Approved and Released by: _____ _____
Name, Q Dept Date
Department Head

THIS DOCUMENT SHALL NOT BE REPRODUCED WITHOUT WRITTEN APPROVAL FROM THE RANGE SAFETY DIRECTOR.

NSWCDD EIS

Source: NSWCDD 2008

Figure 3.8-2

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3.8.2.2 Unexploded Ordnance

A hazard associated with certain RDT&E activities results from unexploded ordnance (UXO). UXO includes all types of explosive or live ordnance that have completely or partially failed to detonate or explode on impact at a target and, therefore, still contain explosives that make them hazardous. Over the years, RDT&E activities at NSF Dahlgren have generated four main types of UXO: naval gun projectiles, small explosives such as grenades, aircraft bombs, and small rockets.

UXO may be present in some areas of NSF Dahlgren, as shown in Figure 3.8-3 (UXO-Impacted Areas). The sediments at the bottom of the Potomac River within the PRTR, most particularly the MDZ, also contain UXO. Because of the difficulties and risks associated with the recovery and disposal of UXO, the preferred option is to leave it undisturbed unless it presents an immediate risk to humans or the environment or must otherwise be disturbed for a different use.

On-installation hazardous UXO areas are clearly marked and access is restricted or controlled, thus minimizing the risks of accidental exposure for personnel who work at NSF Dahlgren. UXO within the installation poses no risk to neighbors.

Within the PRTR, live projectiles that do not detonate at the target area continue into the water and are propelled about eight feet into the muddy and sandy sediments on the river bottom. River users are very unlikely to ever come in contact with most in-river UXO because it remains buried in sediment. Occasionally, during violent storms or hurricanes, embedded UXO may be dislodged as the sediments shift and may drift to reemerge along the shores of the river or settle in shallow waters, where boaters or other river users may accidentally find it. NSWCDD has qualified emergency response ordnance personnel for such occasions. Ordnance personnel collect the UXO and treat it on base at the open detonation area within the EEA.

The installation has prepared and published widely-available fact sheets on what to do if UXO or possible UXO is found. The standard procedure for any potentially explosive item that is discovered is to treat the item as UXO. Finders are urged never to touch or otherwise disturb the item and are provided a telephone number to call to alert the installation, which will then send qualified ordnance personnel to recover the UXO safely. Both on and off the installation, the detection, identification, field evaluation, neutralization, recovery, evacuation, and treatment of UXO is conducted exclusively by highly-trained ordnance personnel.

(In addition to safety concerns, UXO raises environmental concerns due to the potential presence of pollutants that may leach into the environment; this aspect of the UXO issue is addressed in Sections 3.11 and 3.13.)

3.8.3 Electromagnetic Energy Activities Safety

NSWCDD's higher-power EM energy-emitting devices evaluated in this EIS operate in the frequency range of 300 kilohertz (kHz) to more than 300 gigahertz (GHz) and at average powers ranging from 10 watts (W) to 500 megawatts (MW). As shown in Figure 1-2, these frequencies are in the lower end of the EM spectrum, primarily in the radio frequency (RF) range. Microwaves and radio waves are nonionizing radiation – radiation (energy transmitted by waves) in which the energy is insufficient to strip electrons from atoms.

SOPs/GOPs are developed for each operation using EM energy-emitters. SOPs identify and incorporate safe operating parameters with respect to personnel (HERP), ordnance (HERO), fuels (HERF), and EMI with electronic equipment. EMI operating parameters are generally more stringent than HERP, HERO, or HERF operating parameters due to the high sensitivity of the electronics equipment and computers used to monitor the experiments.

Examples of safe distances for continuous exposure to the strongest emitters used at outdoor test facilities are provided in Table 3.8-1. Safety zones for pulsed emitters are generally smaller than for continuous wave emitters, but depend on the pulse characteristics (radiated power per pulse, beam width, repetition rate, pulse width, and radiated energy).

Table 3.8-1
Examples of Safe Distances for Continuous Exposure to EM

Emitter (Status or Make)	Frequency (MHz)	Power (Maximum)	Safety Distances for Continuous Exposure		
			HERO	HERP	EMI
Large Experimental Dipole Radiator (R&D)	18-100	12.5 KW	N/A	15 m	360 m
Medium Experimental Dipole Radiator (R&D)	20-100	12.5 KW	N/A	15 m	360 m
RADAN	200-800	40 W	N/A	2 m	48 m

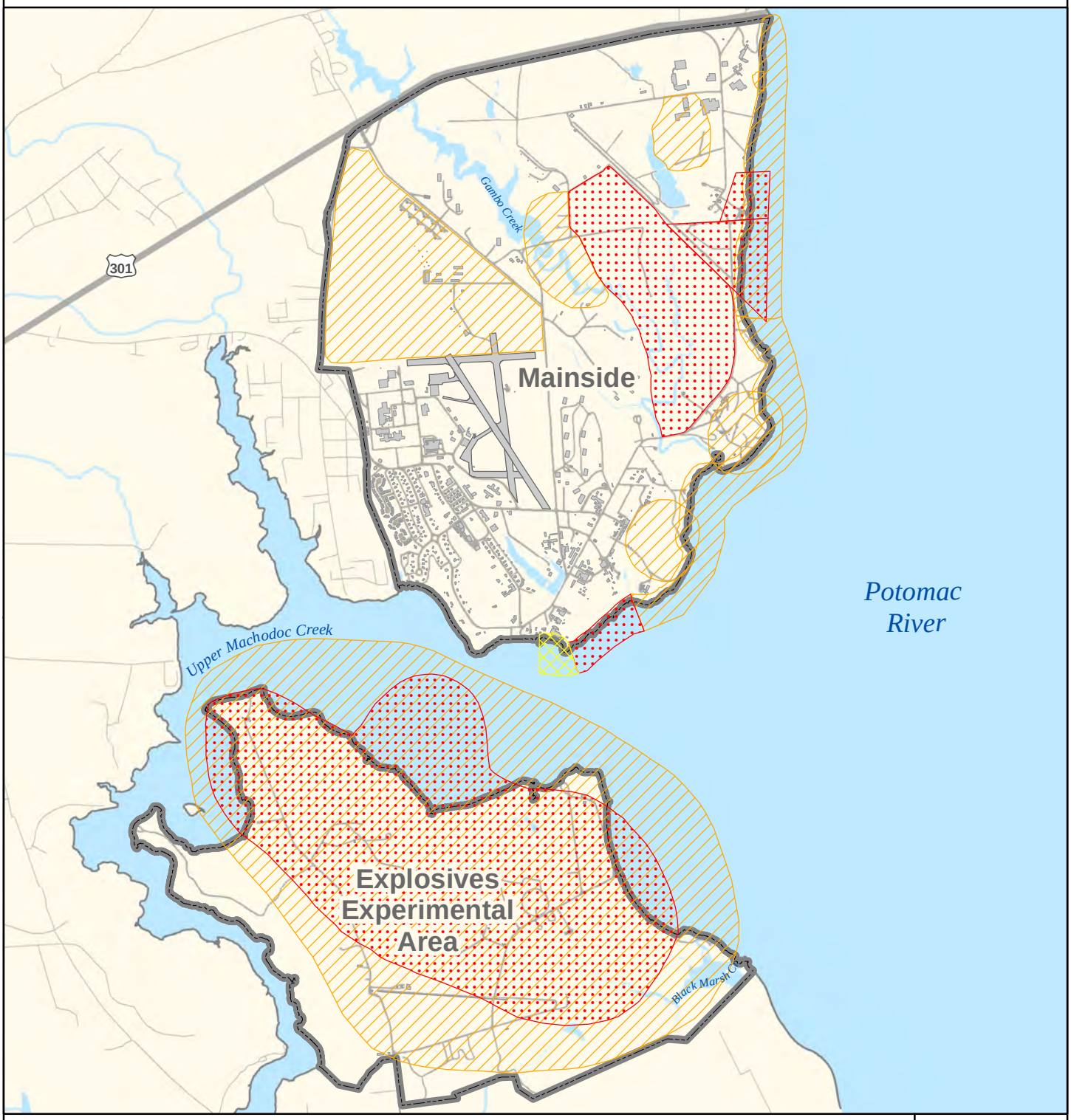
Notes:
N/A = not available; however, HERO safety zones are determined for each emitter in SOPs.
Source: NSWCDL, 2005a.

SOPs are established and maintained in accordance with OPNAVINST 5100.23G, *Navy Safety & Occupational Health Program Manual* and NSWCDLINST 5100.1D. In addition, the operation of all radiofrequency, microwave, or similar millimeter-wave systems must comply with DoD 6055.11, *Protection of DoD Personnel from Exposure to Radiofrequency Radiation and Military Exempt Lasers* to ensure the protection of the workers at the site. Specific policies for EM emissions control at NSWCDD can be found in the NSWCDLINST 5104.3(series), "*Control of Electromagnetic Emissions with Respect to Energetic Operations within NSWCDL*."

For HERP, a safety zone is calculated for each test, depending on the power and frequency of the emission, and personnel exposure time limits within that zone are determined. Personnel are only allowed within the safety zone near the facility when the facility is emitting EM energy for the exposure time calculated for the test; beyond the calculated duration, personnel are required to don PPE for protection. Base personnel (and off-base neighbors) located beyond the safety zone are not affected by the emissions.

To estimate permissible HERP EM exposure, the rate at which energy is absorbed in body tissues, called the specific absorption rate (SAR), is generally used. The SAR varies based on distance from the source – whether exposure is within the near field or far field. The near field is the region where the distance from a radiating antenna is less than the wavelength of the radiated EM field. In this area, the electric and magnetic fields' power does not decrease with the square of the distance from the source. In contrast, in the far field the power decreases with the square of the distance from the source.

Unexploded Ordnance - Impacted Areas



Unexploded Ordnance (UXO)-Impacted Area:

- High Density
- Medium Density
- Low Density
- Naval Support Facility (NSF) Dahlgren

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 3.8-3

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The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields up to 300 GHz (ICNIRP, 1998). Exposure restrictions to EM energy are based on short-term, immediate health effects, including stimulation of peripheral nerves and muscles, shocks and burns caused by touching conducting objects, and elevated tissue temperatures resulting from absorption of energy during exposure to EM fields (ICNIRP, 1998). There are two categories of guidance – basic restrictions and reference levels – as described below.

- **Basic restrictions** are restrictions on exposure to time-varying electric, magnetic, and electromagnetic fields that are based directly on established health effects. Depending upon the frequency of the field, the physical quantities used to specify these restrictions are current density (J), SAR, and power density (S). Only power density in air, outside the body, can be readily measured in exposed individuals.
- **Reference levels** are provided for practical exposure assessment purposes to determine whether the basic restrictions are likely to be exceeded, as most of the quantities used to establish basic restrictions cannot be easily measured. Some reference levels come from basic restrictions using measurement and/or computational techniques, such as electric field strength (E), magnetic field strength (H), magnetic flux density (B), power density (S), and currents flowing through the limbs. Others reference levels are based on perception and adverse indirect effects of exposure to EM fields, such as contact current and, for pulsed fields, specific energy absorption.

If a reference level is not exceeded, then the relevant basic restriction will not be exceeded. However, a measured or calculated value above the reference level does not always indicate an exceedance of the associated basic restriction. Whenever a reference level is exceeded, it is necessary to test compliance with the relevant basic restriction and to determine whether additional protective measures are necessary (ICNIRP, 1998).

The standards for lower frequencies (3 kHz to 5 megahertz [MHz]) are intended to minimize risks associated with electrostimulation (shocks and burns), while higher frequency standards (100 kHz to 300 GHz) are for protection against effects associated with heating. Absorption of EM energy by the human body changes with frequency. Above 10 GHz, basic restrictions on SAR are provided to prevent whole-body heat stress and excessive localized tissue heating. Between 10 to 300 GHz, basic restrictions are provided on power density (S) to prevent excessive heating in tissue at or near the body surface (ICNIRP, 1998). It should be noted that there is insufficient information on the biological and health effects of EM exposure of human populations and experimental animals to provide a rigorous basis for establishing safety factors over the whole frequency range and for all frequency modulations (ICNIRP, 1998).

Navy permissible exposure limits (PELs), equivalent to basic restrictions, are specified for locations that are defined as either controlled or uncontrolled environments (US Navy, 2011). *Controlled environments* are areas where exposure may be incurred by personnel who are aware of the potential for RF or other types of EM exposure. All tests performed at NSWCDD are conducted in a controlled environment. The EM exposure limits for controlled environments represent scientifically-derived values to limit absorption of RF energy in the body and to restrict the magnitude of EM currents induced in the body and are the equivalent of personnel exposure standards for all individuals (US Navy, 2011). Exposure standards for controlled environments must be adhered to by anyone entering those areas regardless of whether or not they are

personnel directly involved with the research and testing being conducted (US Navy, 2011). Levels of EM energy below the exposure limits are considered insufficient to cause adverse effects on health, even under repeated or long-term exposure conditions.

In *uncontrolled environments* where access is not restricted or controlled, lower permissible exposure levels have been adopted to maintain lower exposure levels outside of well-defined areas. The Institute of Electrical and Electronics Engineers' (IEEE, 1999) RF standards limit whole- body-averaged SAR exposure to 0.4 and 0.08 watts per kilogram (W/kg) for controlled and uncontrolled environments, respectively. The exposure limit for controlled environments is considered to be protective, as it based on a whole-body average and the threshold for effects on the most sensitive tissues is greater than this value (ICNIRP, 1998). These levels are also used as basic restrictions by ICNIRP under the categories of occupational and general public exposure, respectively, for EM frequencies from 100 kHz to 10 GHz (ICNIRP, 1998). For frequencies between 10 and 300 GHz, occupational and general public exposure levels should be restricted to 50 and 10 W/m^2, respectively.

Table 3.8-2 summarizes the ICNIRP (1998) reference levels for controlled and uncontrolled exposure, which can be used to estimate EM exposure by measurement of alternative variables for practical exposure assessment purposes, as discussed previously.

Table 3.8-2
Reference Levels for Exposure to Time-Varying Electric and Magnetic Fields

Frequency Range (Hz)	E-field Strength (V/m)	H-field Strength (A/m)	B-field Strength (μT)	Equivalent Plane Wave Power Density (S_{eq}) W/m^2
Controlled Exposure (Occupational)				
0.82-65 kHz	610	24.4	30.7	--
0.065-1 MHz	610	1.6/*f*	2.0/*f*	--
1-10 MHz	610/*f*	1.6/*f*	2.0/*f*	--
10-400 MHz	61	0.16	0.2	10
400-2,000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$0.01f^{1/2}$	*f*/40
2-300 GHz	137	0.36	0.45	50
Uncontrolled Exposure (General Public)				
3-150 kHz	87	5	6.25	--
0.15-1 MHz	87	0.73/*f*	0.92/*f*	--
1-10 MHz	$87/f^{1/2}$	0.73/*f*	0.92/*f*	--
10-400 MHz	28	0.73	0.092	2
400-2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	*f*/200
2-300 GHz	61	0.16	0.20	10

Notes:
Hz = Hertz (alternating electricity); V/m = volts per meter (electric field strength)
A/m = amperes per meter (magnetic field strength); μT = microTesla (magnetic flux density)
S_{eq} = equivalent plane wave power density; W/m^2 = watts per square meter (electric); *f*= frequency
Source: ICNIRP, 1998.

Exposure limits for magnetic fields are also provided in the IEEE and are provided in their *Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3-kHz to 300 GHz* (IEEE, 1999).

3.8.4 Laser Operations Safety

High-energy (HE) laser RDT&E will focus on directing increasing levels of power at various types of targets. Existing HE lasers do not perform well in the marine environment, a shortcoming that becomes more pronounced during inclement weather such as fog and rain. Therefore, it is important to test different types of HE lasers using different frequencies and power levels in a variety of weather conditions.

The military has been conducting long-range outdoor laser activities since the 1980s; outdoor laser activities have been taking place at NSF Dahlgren since the 1990s. As a result, the health and safety issues associated with the technology have been extensively studied and procedures have been developed and well-tested to ensure safety.

Before HE lasers are operated outdoors at NSF Dahlgren, the planned activities must comply with OPNAVINST 5100.27/Marine Corps Order 5104.1A *Navy Laser Hazards Control Program.* This OPNAVINST incorporated the industry standard, American National Standards Institute (ANSI) Z136.1, *Safe Use of Lasers*, into its requirements. In addition to OPNAVINST 5100.27, NSWCDD develops RHAs and detailed SOPs for each operation involving the use of HE lasers outdoors. These identify and implement controls to ensure the safety of installation personnel and the public and establish the procedures for review, authorization, and operation of NSWCDD's outdoor HE lasers.

Additionally, the Navy's Laser Safety Review Board (LSRB) provides a systems-safety review of all Navy lasers that are used in combat, in combat training, or are classified in the interest of national security, as well as all HE lasers capable of exceeding Class 3a levels (see Table 2-1). Guidance relating to laser safety on military ranges is contained in MIL-HDBK-828A, *Department of Defense Handbook: Laser Safety on Ranges and in Other Outdoor Areas*, and ANSI Z136.6 (2007). *Safe Use of Lasers Outdoors* also contains guidance and recommended practices.

The LSRB is composed of the Bureau of Medicine and Surgery, which serves as the Administrative Lead Agency, Marine Corps Headquarters, the Naval Safety Center, the Lead Technical Navy Laboratory for lasers, and all systems commands, such as Naval Air Systems Command and Naval Sea Systems Command. The Lead Technical Navy Laboratory for the Navy is NSWCDD, based on its expertise in lasers and laser safety. NSWCDD's head of the Lead Technical Navy Laboratory also is a sitting member on a number of ANSI Z136 subcommittees focused on the safe use of lasers. All high energy laser outdoor activities must be approved by the Navy's LSRB and NSWCDD's Laser System Safety Officer.

All laser activities must follow a comprehensive SOP/RHA process that includes validation of the process. The purpose of an RHA is to carefully examine what could cause harm to people or material during an operation and decide on what actions are needed to mitigate the risk to an acceptable level so as to minimize the risk of anyone being injured or becoming ill as well as the risk of damage to material. Steps associated with an RHA are listed in the text box in Section 3.8.1.2.

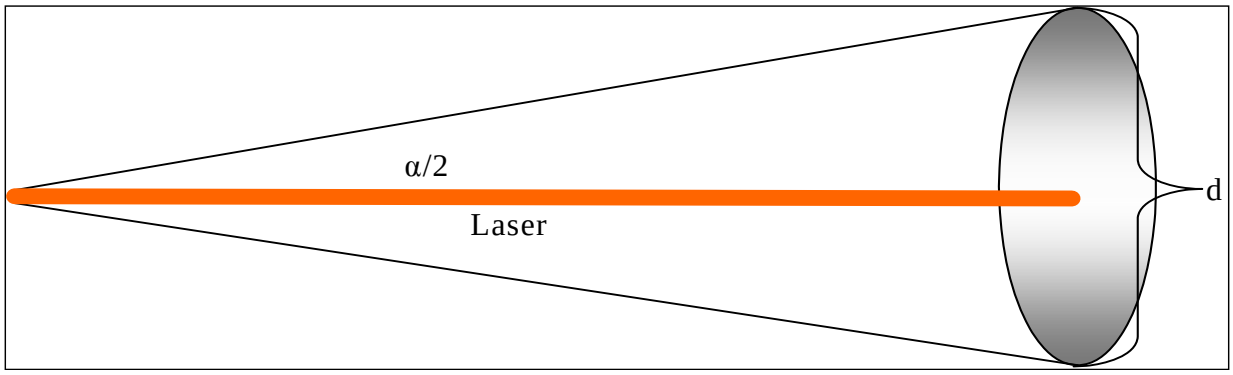
3.8.4.1 General Laser-Control Measures

General laser-control measures have been established for the protection of personnel, the public, and the environment, including: laser safety analysis as part of the RHA process, SOPs, safety

buffer zones, remote viewing and operation, range-control measures (barriers and warning systems), interlock controls, and target backstops. These measures include engineering, administrative, and procedural controls that are currently used by NSWCDD and would apply to the Proposed Action. Some of the key control measures are described below, but additional controls may also be used, depending on the testing needs.

- **Laser Safety Analysis**. A prerequisite prior to each outdoor test is a laser safety analysis that quantifies potential ocular and skin hazards and provides recommendations for avoiding hazards. Written approval from the LSRB for the test is required.
- **Test Plan**. As required by ANSI Z136.1 and ANSI Z136.6 standards, as well as the Navy's own laser protection standard, each laser system and designated laser Class 3 or 4 firing must have a test plan developed and approved. The test plan designates the individual(s) responsible for the safe operation of the laser system, the specific control measures employed to minimize unintended exposures, the conditions under which the laser system may be operated, the appropriate personal protective equipment for operators, and the specific nominal ocular hazard distance (NOHD) and nominal hazard zone (NHZ). Each test plan for outdoor activities must be submitted to NSWCDD's Laser System Safety Officer for approval; only after approval may the laser test be conducted. Test plans require laser safety training as well as medical surveillance for the operators to ensure their health and safety.
- **Laser Safety Buffer Zone (Laser Hazard Cone)**. Range control measures include use of safety zones, from which personnel and wildlife are excluded during activities. In accordance with laser range operational procedures, horizontal and vertical buffer zones are established prior to lasing activities. The laser safety buffer zone (or laser hazard cone), shown in Figure 3.8-4 (Laser Safety Buffer Zone) is the combined area of the calculated NOHD and the NHZ. The NOHD is the distance along the axis of the direct laser beam to the human eye beyond which the maximum permissible exposure (MPE) of the laser is not exceeded. The NHZ is the area where direct, reflected, or scattered laser emissions exceed established MPE limits during normal operations. MPEs are set at levels below known hazardous levels. For instance, the MPE for NOHD is based on a power density – the power of the laser beam at a given distance from its source (since its energy dissipates over distance) – of only 10 percent of the power necessary to potentially cause permanent eye damage.
- **Administrative Controls**. Access to the laser operational area is restricted to authorized and properly-trained personnel, which reduces the possibility of inadvertent exposure to laser radiation. Prior to any outdoor lasing activities, and in accordance with laser SOPs, the operational area is swept to clear all unauthorized personnel as well as all materials with reflective surfaces to minimize reflective hazards. Spotters are positioned to look for wildlife. Laser activities are stopped if wildlife gets close to the operational buffer zone. Signage indicating a laser controlled area is posted in accordance with ANSI Z136.1 specifications for the operation of Class 4 lasers. Additional administrative controls are outlined in ANSI Z136.1, *Safe Use of Lasers*, which has been adopted by the DoD as the governing standard for laser safety.

Figure 3.8-4
Laser Safety Buffer Zone



- **Barriers and Warning Systems**. Barriers are erected before activities to exclude personnel from the laser controlled area. Various types of warning systems, such as warning lights (flashing siren and light), audible sirens, and alarms, are initiated prior to operations to alert personnel of the pending laser operation.
- **Remote Operation**. Personnel may operate laser systems from remote locations when safety procedures require that personnel be a safe distance from the operating laser systems. The laser system is connected to a computer system, allowing the operators and technicians to monitor its operation and measurement instruments in a safe manner. The NOHD and NHZ are determined for each laser system to ensure that the operators, as well as other personnel and the general public, are located beyond the distances where skin or ocular hazards are present, including those attributable to both the diffuse reflection and specular reflection (as from a highly reflective surface, such as a mirror) of laser energy.
- **Laser Safety Interlock Controls**. Safety interlocks work through an instantaneous feedback loop to cut off the power to an emitting laser if a single mechanical or electrical component fails or if the laser beam strays from the anticipated beam path. For example, lower-power beams are initially used to validate that the center of the intended target is being illuminated when fired upon. Validation is accomplished by calorimeter sensors placed around the intended aim point of the target. The sensors detect the position of the narrow laser beam by fractions of an inch relative to the center of the aim point. The laser beam is then intentionally made to drift off target to check the sensors. If the laser beam veers off the intended path, the beam will heat up the calorimeter sensors, which will in turn send a signal that the laser is off-target and instantaneously turn off the power to the laser. Another safety interlock example is a system that must be engaged to allow power to flow to the laser system, such as a magnetic connection between a closed door and the door frame leading into the area where the laser system is operated. If this door is opened, then electrical power is disconnected from the system and the laser system cannot operate.
- **Laser Backstops.** A laser beam is composed of light, which, if it encounters no obstacle, can continue traveling in a straight line to infinity. To prevent any chance of a laser beam's traveling farther than required, NSWCDD uses a backstop made of a material that

captures most of the light energy that might otherwise pass by the target or be reflected by it. The size of the backstop used is dependent on a number of variables, including the energy of the laser being tested. To minimize reflected laser energy at the target/backstop, all materials and objects associated with the target – for example, a stand holding it in place – are painted with or composed of light-absorbing materials so that light is not reflected out of the target area.

3.8.4.2 Non-Beam Control Measures

Potential non-beam hazards associated with the use of HE lasers, along with the health and safety measures in place to minimize these hazards, are described below.

- **Electrical Accidents.** Operators of the laser systems have many controls in place, including electrical interlocks, ground fault circuit interrupters, proper grounding, and SOPs outlining how to operate the system to minimize the possibility of electrical shock accidents.
- **Fire Hazard.** The irradiation of targets by an HE laser beam can cause the target to catch on fire; however, the target boards and rotoplane target boards (windmill-like devices) are constructed of flame-retardant materials, as defined by the National Fire Protection Association (NFPA), to minimize the potential fire hazard. Furthermore, the control of the beam path and target area minimizes the potential for any fires to spread beyond the immediate target area or range boundary.
- **Laser-generated Air Contaminants (LGACs).** Air contaminants may be generated when certain Class 4 laser beams interact with matter such as plastics, composites, metals, and tissues (ANSI, 2007). For this reason, target areas are cleared of debris prior to operations. NSWCDD ensures that appropriate industrial hygiene characterizations of exposure to LGACs take place in accordance with 29 CFR § 1910.1000, *Air Contaminants* and Air Force Office of Safety and Health Standard 48-8, *Controlling Exposures to Hazardous Material*s, and limits the exposure of personnel to LGACs.
- **Collateral Electromagnetic Radiation.** Potential collateral EM radiation, or broad-band black-body radiation (i.e., ultraviolet or blue light), produced as a result of air breakdown at the laser/target interface does not present an immediate hazard to personnel, because no personnel will be close to the target impact area. Once lasing activities stop, all collateral radiation (if any) ceases and no residual collateral radiation remains.

3.8.5 Chemical and Biological Simulant Activities Safety

As described in Chapter 2, chemical and biological agent detectors enable early warning of threats to provide protection for military personnel and civilians. The exposure of military personnel or the public to even small amounts of real contaminants, such as nerve or blistering agents, or harmful biological organisms, such as anthrax, is not legal in most countries in the world, including the US. The 1993 Chemical Weapons Convention bans the use of chemical weapons; unlike the 1925 Geneva Protocol, it also bans their development, production, stockpiling, and transfer and it requires that all existing stocks of chemical weapons be destroyed within 10 years. The US signed the Chemical Weapons Convention on January 13, 1993 and

ratified it on April 25, 1997. Therefore, DoD scientists have searched for relatively harmless compounds (simulants) that can simulate the effects of dangerous chemical and biological agents without irritating or injuring personnel involved in testing detectors or harming the environment.

Substitute materials must have one or more characteristics – size, density, and/or aerosol behavior – similar to those of real chemical agents so they can effectively mimic them, and they must also carry minimum risk to human health and the environment so that they can be used safely in outdoor tests. After evaluating simulant materials, NSWCDD's research group recommends proposed test simulants to the Safety and Environmental Office for approval. The criteria for selection include:

- **Potential safety and environmental issues related to the simulants' use**. The simulants selected are relatively benign (i.e., low toxicity or effects potential) from a human health, safety, and environmental perspective. Many simulants are present naturally in the environment. Exposure levels during activities would be well below concentrations associated with any adverse effects. The degradation products of the chemical simulants are also considered to be harmless.
- **The spectral location of the absorbance peaks.** The spectral absorbance peaks for the chemicals should be within a certain range of the spectral absorbance peaks of the warfare agents they are intended to mimic, in order to assess the capacity of infrared sensor detectors to absorb spectral peaks within these ranges.

Because of the need for early detection of chemical agents, testing is designed to detect simulants at very low levels – levels well below quantities that could present risks to human health and the environment. Vapor releases would take place within the boundaries of the ranges and Mission Area so that vapor clouds would disperse before reaching the boundaries of the ranges or Mission Area, as determined by modeling and by monitoring weather conditions just prior to the test. Simulant vapor tests are designed to minimize deposition on land and water areas.

As described in Section 2.5.4, chemical simulants approved for use in NSWCDD's past indoor or outdoor RDT&E activities include methyl salicylate (MeS), polyethylene glycol (PEG 200), sulfur hexafluoride (SF_6), triethyl phosphate (TEP), glacial acetic acid (GAA), dipropylene glycol methyl ether (DPGME), dimethyl methylphosphonate (DMMP), diethyl malonate (DEM), diethyl phthalate (DEP), dimethyl adipate (DMA), and diethyl ethyl phosphonate (DEEP). PEG 200, MeS, SF_6, TEP, and GAA have been used as simulants outdoors by NSWCDD, while the remaining six simulants (DPGME, DMMP, DEM, DEP, DMA, and DEEP) have only been used indoors. Future outdoor tests might use any of these simulants, or other ones with similar or lower toxicities. Prior to use, all simulants would be reviewed and approved by the NSWCDD Safety and Environmental Office in consultation with NSF Dahlgren personnel, as applicable, and would be approved only after considering toxicity data relative to the intended quantity and concentration of the simulant to be used.

3.8.5.1 Chemical Simulants

Some physical properties of the eleven previously-approved chemical simulants used by NSWCDD are summarized in Table 3.8-3. Most of these benign chemical compounds are commonly found in household products and in industry, as outlined in Table 3.8-4. The lowest published lethal dose or concentration for each of these simulants is provided in Table 3.8-5. A general description of each simulant, inclusive of toxicity data, is provided below. These descriptions are based on studies that are often performed with very high concentrations of a compound over an extended period of time. In contrast, NSWCDD's activities would involve the use of much lower chemical concentrations, with an approximate frequency of one to two test periods of about two weeks per year, each with a maximum of 20 releases. Toxicity data are presented here to provide a better understanding of each compound rather than as a basis for comparative exposures. Chapter 4 provides estimates of the concentrations of each compound that would be released during activities, associated exposure concentrations, and comparisons to safety limits.

The three gases listed, SF_6, 1,1,1,2-tetrafluoroethane (R-134), and 1,1-difluoroethane (R-152a), could be used for the calibration of sensors. The use of SF_6 is being phased out because of its high global warming potential (USEPA, 2006). Only R-134 and R-152 were used in most of the tests performed in July 2009 (NSWCDL, 2009b) and are included in the SOP prepared for those tests (NSWCDL, 2009a).

Methyl Salicylate (MeS)

MeS is a colorless or pale yellow liquid with a strong characteristic wintergreen odor. It is used as a simulant for blistering agents such as sulfur mustard agents (Seitzinger et al., 1990). It occurs naturally in plants, where it probably developed as an anti-herbivore defense. Some of the plants that produce it are in the wintergreen family (Pyrolaceae), providing it with its common name, oil of wintergreen. Other plants that produce MeS include various species of *Gaultheria* (Ericaceae family) – for example, the eastern teaberry (*Gaultheria procumbens*) – and some birches (Betulaceae family), such as the sweet birch (*Betula lenta)*. A recent study by Karl et al. (2008) found that levels of methyl salicylate emissions in forest plants increased dramatically when the plants, which were already stressed by a local drought, experienced unseasonably cool nighttime temperatures followed by large daytime temperature increases. Instruments mounted on towers about 100 ft above the ground measured up to 0.025 milligrams (mg) of methyl salicylate rising from each square ft of forest per hour. The study speculated that the methyl salicylate stimulates plants to begin a process analogous to an immune response in an animal and may also alert neighboring plants to threats.

MeS has been commonly used as an ingredient in liniments or balms applied to the skin to relieve pain associated with lumbago, sciatica, and rheumatic conditions by people of many cultures, including those of China and pre-Columbian North America.

Table 3.8-3
Physical Properties of Chemical Simulants

Simulant Name	Physical State @ 20 °C	Odor	Mol. Weight[1] (g/mole)	Boiling Point °C	Melting Point °C	Specific Gravity[2]	Vapor Density (g/cm^3)[3]	Solubility in Water
Methyl Salicylate (MeS) $HOC_6H_4COOCH_3$	Liquid	Strong	152.14	223	-8.6	1.184	5.24	Slightly soluble
Polyethylene glycol (PEG 200) $(C_2H_4O)nH_2O$	Liquid	Slight	190-210	250	-50	1.125	↓with increase in MW (1.12-1.13)	Soluble
Dimethyl Methylphosphonate (DMMP) $C_3H_9O_3P$	Liquid	Slight	124.08	181	62	1.15-1.174	NA	Soluble
Diethyl Malonate (DEM) $C_7H_{12}0_4$	Liquid	Aromatic -like	160.17	199	-50	1.055	5.52	Partially soluble
Triethyl Phosphate (TEP) $C_6H_{15}O_4P$	Liquid	Ester-like	182.16	215	-56	1.072	6.28	Soluble
Glacial Acetic Acid, (GAA) $C_2H_4O_2$	Liquid	Strong	60.05	118	16.06	1.049	2.07	Partially soluble
Sulfur Hexafluoride (SF_6)	Gas	None	146.05	-63.9	-50.8	NA	5.10	Low solubility
1,1,1,2-Tetrafluoroethane (R-134) $C_2H_2F_4$	Gas/cryogenic liquid	Ether-like	102.03	-26	-101	NA	3.50	Insoluble
1,1-Difluoroethane (R-152a) $F_2HC\text{-}CH_3$	Gas	Slight ether-like	66.05	-25	-117	0.95	NA	Slightly soluble
Diethyl phthalate (DEP) $C_{12}H_{14}O_4$	Liquid	Slight aromatic-like	222.4	295	-40	1.12	7.66	Very low solubility
Dimethyl adipate (DMA) $C_8H_{14}O_4$	Liquid	Mild	174.2	115	10.3	1.063	NA	Slightly soluble
Dipropylene glycol methyl ether (DPGME) $C_7H_{16}O_3$	Liquid	Mild ether-like	148.2	190	-80	0.951	5.11	Soluble
Diethyl ethyl phosphonate (DEEP) $C_6H_{15}O_3P$	Liquid	Mild	166.16	198	180-181	1.0259	NA	Slightly soluble

Notes:
1. Mol. Weight = molecular weight
2. Specific gravity of water = 1
3. Vapor density of air =1

Sources:
Toxicology Data Network (2008) and NOAA (2009).

Table 3.8-4
Common Household and Industrial Uses of Chemical Simulants

Methyl Salicylate (MeS) (Oil of Wintergreen): Used in household products such as Ben Gay, tiger balm, Listerine, toilet cleaners (Clinging Bowl, Lime A Way), Bioganic lawn and garden spray, Nilodor pet products (shampoo, cleaner, cat box additive), and Four Paws pet dental liquid tartar remover for dogs.
Polyethylene glycol (PEG 200): Used as basis of laxatives (e.g. GoLYTELY, GlycoLax, Fortrans, TriLyte, Colyte. MiraLax or GlycoLax). It is the basis of many skin creams and sexual lubricants, frequently combined with glycerin. Whole bowel irrigation (polyethylene glycol with added electrolytes) is used for bowel preparation before surgery or colonoscopy and drug overdoses. It is also used in a number of toothpastes as a dispersant, is under investigation for use in body armor and tattoos to monitor diabetes, and is commonly used in the laboratory for a variety of purposes.
Dimethyl methylphosphonate (DMMP): Major uses are industrial in heavy metal extraction and solvent separation; pre-ignition additive for gasoline; defoamer; plasticizer & stabilizer; textile conditioner & antistatic substance; additive in solvents & low temp hydraulic fluids.
Diethyl Malonate (DEM): Occurs naturally in grapes and strawberries as a colorless liquid with an apple-like odor, and is used in perfumes. It is also used to synthesize other compounds, such as barbiturates, artificial flavorings, Vitamin B1, and Vitamin B6.
Triethyl Phosphate (TEP): Primarily used as an industrial catalyst, a polymer resin modifier, and a plasticizer (e.g., for unsaturated polyesters). Secondarily used as a solvent, flame retardant, an intermediate for pesticides and other chemicals, and a stabilizer for peroxides.
Glacial Acetic Acid (GAA): This is the compound that gives vinegar its sour taste and pungent smell. Used in household products such as sealants, waterproofing, adhesives (silicone adhesive sealant clear, Loctite Stick With It; Radio Shack Silicone Adhesive Sealant, Dow Corning Aquarium Sealant, Nikwax Polar Proof Wash-In Waterproofing), window and floor cleaners (Earth Friendly window kleener and floor kleener; Pledge Grab It Vinegar Wet Floor Wipes), personal care (Grecian Formula 16, Liquid with Conditioner). It is also used industrially in the production of soft drink bottles, photographic film, and wood glue, as well as synthetic fibers and fabrics.
Sulfur Hexafluoride (SF_6): Used in industry as a gaseous insulating material (electrical equipment, radar wave guides) and semiconductors (dry/plasma etching). There is also limited use in special applications ranging from medical applications to space research.
1,1,1,2-Tetrafluoroethane (R-134): Primarily used as a high-temperature refrigerant for domestic refrigeration and automobile air conditioners. Other uses include plastic foam blowing, cleaning solvent, propellant for the delivery of pharmaceuticals, gas dusters (usually used to clean or dust delicate or sensitive items such as electronic components and computer equipment), and removing the moisture from compressed air. Production currently exceeds 1 million pounds annually in the US.
1,1-Difluoroethane (R-152a): Used as a refrigerant, an aerosol propellant, and in electronic cleaning products.
Diethyl phthalate (DEP): A plasticizer that is widely used in tools, automotive parts, toothbrushes, food packaging, cosmetics and insecticides.
Dimethyl adipate (DMA): Used commonly in paint-stripping formulations for home maintenance (Klean Strip Easy Liquid Sander, Parr Paint and Resin Removing Hand Cleaner, Parks Pro Stripper II Liquid Paint Stripper, Parr Painters Clean Hand Cleaner) and also in auto products (Sprayway Industrial Strength Cleaner Wipes). DBE blends are also used in the coating industry to clean up polyurethane adhesives, polyurethane foams, and unsaturated polyester resins. It is also used as a chemical intermediate and as a plasticizer in the production of paper and cellulose resins.
Dipropylene glycol methyl ether (DPGME): Used in the manufacture of a wide variety of industrial and commercial products, including household maintenance products such as paints, varnishes, inks, and cleaners (Parks Adhesive Remover, Parks Aluminum Siding Cleaner, DIF Wallpaper Stripper, Custom Grout Colorant, Aqua Mix Protective Gloss Finis, AFM Safecoat Polyureseal BP Gloss, AFM Safecoat MexeSeal Interior, Exterior, Sherwin-Williams Wood Classics Interior Waterborne Polyurethane Varnish, Gloss, Sherwin-Williams Armorseal Tread Plex Water Based Acrylic Floor Coating, StoneTech Stone and Tile Cleaner, Ready-to-Use, Wet Look Grout Sealer, Fletco Elite Diamond Finish Gloss, Parks Pro Liquid Paint Stripper, Zinsser Shieldz Prewallcovering Primer, Custom Epoxy Haze Remover & Degreaser, Sherwin-Williams Woodscapes House Stain Exterior Polyurethane Semi-Transparent, StoneTech Stone and Tile Cleaner Wipes). It is also used as component of pet care and pesticide products (Enforcer Flea Spray for Homes, Ortho Dursban Ready-Spray Outdoor Flea & Tick Killer, Ortho Dursban Lawn Insect Spray 1, Nilodor Air Freshener-Floral, and Nilodor Kennel Wash).
Diethyl ethyl phosphonate (DEEP): Used as a gasoline additive; also used in heavy-metal extraction, as a defoamer, plasticizer and antistatic substance.
Sources: Household Products Database, National Library of Medicine, 2010; Hazardous Substances Data Bank [HSBD], 2008a,2008b, 2008c, 2008d, 2008e, 2009; Wikipedia, 2008a, 2008b, 2008c, 2008d, 2008e, 2008f, 2008g; Chemicalland21, 2008; USCPSC, 1994; Oxford University, 2008a.

Table 3.8-5
Lowest Published Toxicity of Chemical Simulants Approved for Use Previously by NSWCDD

Simulant Name	Exposure Route	Toxicity*		Species
Methyl salicylate (MeS)	Ingestion	LD50	700-1,500 mg/kg	Guinea Pig
Polyethylene glycol (PEG 200)	Ingestion	LD50	1,400 mg/kg	Rabbit
Dimethyl methylphosphonate (DMMP)	Ingestion	LD50	8,210 mg/kg	Rat
Diethyl malonate (DEM)	Ingestion	LD50	14.9 ml/kg	Rat
Triethyl phosphate (TEP)	Inhalation	LD50	28,000 ppm/6H (28,000 ppm)	Rat
Glacial acetic acid (GAA)	Inhalation	LC50	5,360 ppm/1H	Mouse
Sulfur Hexafluoride (SF_6)[1]	Intravenous	LD50	5,790 mg/kg	Rabbit
1,1,1,2-Tetrafluoroethane (R-134)	Inhalation	LC50	1,500 g/kg	Rat
1,1-Difluoroethane (R-152a)	Inhalation	NOAEL	67,485 mg/m^3 (25,000 ppm)	Rat
Diethyl phthalate (DEP)	Ingestion	LD50	1,000 mg/kg	Rabbit
Dimethyl adipate (DMA)	Intraperitoneal	LD50	1.8 ml/kg	Rat
Dipropylene glycol methyl ether (DPGME)	Ingestion	LD50	5.4 ml/kg	Rat
Diethyl ethyl phosphonate (DEEP)	Ingestion	LD50	2,330 mg/kg	Rat

Notes: LCLo – lowest published lethal concentration
LD50 – lethal dose resulting in 50 percent mortality
NOAEL – no-observed-adverse-effect level
[1]- Non-toxic in small amounts; otherwise like other dense odorless gases it may present a risk of suffocation.
NA – Not Available
Source: HSDB, 2008a, 2008b, 2008c, 2008d, 2008e, 2009, 2011a, 2011b.

In very small quantities, MeS is used as a flavoring in products, including chewing gum, baked goods, syrups, candy, non-alcoholic beverages (birch beer, for example) and ice cream (Hazardous Substances Data Bank [HSDB], 2008a). It is also used as a fragrance to mask other odors in products such as toilet cleaners and pesticides.

MeS has a half-life of about 1.4 days due to its reaction with photochemically-produced hydroxyl radicals (Meylan and Howard, 1993). It is slightly soluble in water, with lowest solubility of 0.11 percent at an acid concentration of 62 percent acid and increasing in solubility at concentrations both above and below this value (Rubel, 1989).

MeS belongs to the salicylate group of analgesics (painkillers) that are derivatives of salicylic acid (such as aspirin). Salicylates are considered to be relatively safe drugs, but normal doses can cause gastrointestinal disturbances in sensitive patients and large doses can be toxic or fatal, especially to children (Columbia Encyclopedia, 2011). One teaspoon or 5 milliliters (ml) of MeS contains 7,000 mg of salicylate, equivalent to 21 aspirin tablets, and a dose as low as 4 ml (4.7 grams [g]) may be fatal in children (Gilman et al., 1990). The lethal dose of MeS for children is 10 ml, and, for adults, 30 ml, which is equivalent to a dose of about 0.5 grams per kilogram (g/kg), assuming an average weight of 132 lbs (Clayton and Clayton, 1982).

Ingestion of salicylates at high doses produces toxic symptoms such as tinnitus (ringing in the ears), nausea, and vomiting (HSDB, 2008a). The lethal single dose of MeS administered orally required to kill 50 percent of the test animals exposed, known as the LD50 (see text box), ranges from 890 milligrams per kilogram (mg/kg) for rats to 2,800 mg/kg for rabbits (Clayton and Clayton, 1982). The LD50 for dermal exposure is 70,000 mg/kg for guinea pigs (Clayton and Clayton, 1982). The biological half-life for MeS is 2 to 3 hours when given in low doses, about 12 hours at doses used for anti-inflammatory purposes, and up to 15 to 30 hours at high therapeutic doses or when there is intoxication (Gilman et al., 1990).

Toxicological Terms

LD50/Lethal Dose: The dose of a toxicant (generally oral or dermal) that will kill 50 percent of the test organisms within a designated period. The lower the LD50, the more toxic the compound. For example, the LD50 of salt (sodium chloride) for rats is 3,000 mg/kg (milligram per kilogram or parts per million [ppm]).

LC50/Lethal Concentration: Median lethal concentration (e.g., in air) needed to kill half of a group of experimental organisms in a given time.

Biological half-life: The time an organism takes to eliminate one half the amount of a compound.

No observed adverse effect level (NOAEL): Exposure level at which there are no statistically or biologically significant differences in the frequency or severity of any effect in the exposed or control populations.

Lowest observed adverse effect level (LOAEL): The lowest level of a stressor that causes statistically and biologically significant differences in test samples as compared to other samples subjected to no stressor.

Sources: USEPA, 2010; Oxford University, 2008b.

Phillips and Wentsel (1993) examined the acute toxicity of MeS on cucumbers (*Cucumis sativus*) and the red wriggler earthworm (*Eisenia foetida*). They grew cucumbers in soil with six concentrations of MeS – 0 (control), 50, 100, 200, 350, and 500 mg/kg. Sublethal effects on cucumbers were observed at the 350 and 500 mg/kg levels, but the survival rate was 100 percent at all concentrations. Earthworms were exposed to the same six MeS concentrations in soil as were cucumbers. As concentrations of MeS increased, earthworms showed an increasing weight loss and mortality rate. Weight loss was seen beginning at the 100 mg/kg dose level. Earthworm survival rates were 100 percent at the 0 to 200 mg/kg levels, 87 percent at 350 mg/kg, and 0 percent at the 500 mg/kg level, with acute toxicity beginning between 350 and 500 mg/kg.

Occupational Exposure Terms

Time-weighted average (TWA): Average exposure for one individual over a given working period. Typically, 8 hours (hr)/day, 40 hr/week (wk).

Permissible exposure limit (PEL): Established by OSHA. The concentration in air of a substance to which nearly all workers may be repeatedly exposed 8 hrs/day, 40 hr/wk, for 30 years with no adverse effects.

Short-term exposure limit (STEL): A 15-minute TWA exposure that should not be exceeded at any time during the workday. Exposures at these levels are allowed up to 4 times per day with at least 60 minutes between exposures.

Source: American Industrial Hygiene Association, 1999.

Polyethylene glycol (PEG 200)

Polyethylene glycol (PEG) occurs as a clear liquid or as a white semi-solid to solid with a slightly sweet (mild) odor, depending on its molecular weight and ambient temperature. It can be

used as one of the components of a chemical simulant for a G-agent (nerve agent) or H-agent (blistering agent) due to its physicochemical properties (US Patent Office, 2003). It is the most commercially important type of polyether (a compound with more than one ether group). Low-molecular PEG is a clear liquid that has many uses, including as a textile auxiliary (chemicals added to protect or increase the flexibility of fibers), as the basis of a number of laxatives, skin creams, tablets, and lubricants, as a dispersant in toothpastes, as a thickener (e.g., in hydraulic fluids), and as a binding substance in making molds for ceramics, casting and powder metallurgy, and to create very high osmotic pressures (tens of atmospheres) in water systems in biochemistry experiments (ChemIndustry, 2008). Other uses include attaching PEG to various protein medications to allow for a slowed clearance of the carried protein from the blood, permitting a longer-acting medicinal effect with reduced toxicity (Caliceti and Veronese, 2003). PEG has been shown to be a strong inhibitor of colon cancer in rats (e.g., Corpet et al., 2000).

Dimethyl Methylphosphonate (DMMP)

Dimethyl methylphosphonate (DMMP) is a colorless gas with a distinct odor. It is used as a simulant for anticholinesterase (nerve) agent (e.g., sarin gas) training exercises and for the calibration of detectors. DMMP is primarily used in industrial settings with applications such as heavy metal extraction; solvent separation; gasoline pre-ignition additive; plasticizer and stabilizer; flame retardant; and as a viscosity depressant in polyester and epoxy resins, among many other applications (Table 3.8-4). The US produces about 0.2 to 2 million lbs of DMMP per year (NTP, 1987). Trade names include Fran TF 2000, Fyron DMMP, Metaran, NSC 62240, and Reoflam DMMP. The estimated half-life in soil ranges from 0.2 to 60 days, with an average of 12.4 days (HSDB, 2008b). The atmospheric vapor phase half-life for DMMP is estimated to be 1.6 months (GEMS, 2007). DMMP is considered for use as a G-agent – the first and oldest series of nerve gases, developed in the 1930s – simulant due to its physicochemical properties (Bartelt-Hunt et al., 2008).

The National Toxicology Program (NTP) performed a series of DMMP toxicity studies on mice and rats consisting of single-administration, 15-day, and 13-week studies to obtain toxicity data, to establish dose levels for two-year studies, and to identify target tissues (NTP, 1987). DMMP was administered orally in corn oil by gavage (force-feeding). In the single-dose studies, rats and mice were given one of six doses – either 0, 1,250, 2,500, 5,000, 10,000, or 15,000 mg/kg DMMP – equivalent to up to 6,810 mg/kg body weight. No compound-related deaths were seen in male or female rats or male mice, but two high-dose female mice died. The acute oral LD50 value is estimated to be greater than 3,000 mg/kg for rats and greater than 6,000 mg/kg for mice (NTP, 1987).

The 15-day study consisted of rats and mice receiving doses of 0, 1,250, 2,500, 5,000, 10,000, or 15,000 mg/kg DMMP per day. Compound-related deaths occurred in the three highest-dose groups of rats and the two highest-dose groups of mice (NTP, 1987).

In the 13-week study, DMMP was given at doses of 0, 250, 500, 1,000, 2,000, or 8,000 mg/kg. Compound-related deaths occurred at 2,000, 4,000, and 8,000 mg/kg in rats and at 4,000 and 8,000 mg/kg in mice (NTP, 1987). Decreased weight gain was seen at doses of 2,000 mg/kg and higher. Reproductive effects were seen in rats dosed with concentrations of up to 2,000 mg/kg DMMP for a 13-week period. Undosed female rats and mice mated with dosed individuals showed an increase in the number of fetal resorptions (NTP, 1987). Histopathologic changes were seen in the kidney and testes of male rats, and decreases in sperm count and sperm motility

occurred in male rats but not in male mice. Toxic effects to the reproductive system of male rats and mice were reversible after a 13- to 14-week recovery period (NTP, 1987).

In the two-year studies, rats were dosed with 0, 500, or 1,000 mg/kg DMMP per day and mice were dosed with 0, 1,000, or 2,000 mg/kg per day (NTP, 1987). All animals were dosed five days per week for 103 weeks. There was some evidence of carcinogenic activity, renal toxicity, and decreased survival of male rats fed 1,000 mg/kg DMMP, but no evidence of carcinogenic activity for female rats given doses of 500 or 1,000 mg/kg (NTP, 1987). Renal toxicity and decreased survival occurred in dosed male rats at dose levels of 500 and 1,000 mg/kg (NTP, 1987).

Diethyl Malonate (DEM)

Diethyl malonate is a naturally occurring compound found in grapes and strawberries. It is a colorless liquid with an apple-like odor. DEM is also used to synthesize other compounds, particularly flavors and fragrances (Table 3.8-4). DEM is considered for use as a G-agent simulant due to its physicochemical properties (Bartelt-Hunt et al., 2008).

In a study designed to provide baseline data on the toxicity of DEM to plants, soil microorganisms, and earthworms, it was determined that DEM deposited on soil and leaf surfaces was rapidly lost through volatilization processes, with a half-life of 1 to 3 hours for the short-residence-time component and 16 to 242 hours for the long-residence-time component (Cataldo et al., 1990). Earthworms exposed to soil doses with 0.0107 and 0.0207 mg per m^2 had survival rates of 86 percent and 66 percent, respectively. At higher dose levels, the activity or mobility of the earthworms was affected in more than half the individuals exposed.

Mammalian toxicity information indicates that DEM causes slight irritation to rabbit skin and severe burning to rabbit eyes, but no skin sensitization or skin irritation was induced in human volunteers treated with dilute solutions (BIBRA, 1996). Toxicity information on DEM is limited, but tests on laboratory animals show low acute oral and dermal toxicity (BIBRA, 1996).

Triethyl Phosphate (TEP)

Triethyl phosphate is a colorless liquid with a slight, pleasant or sweetish odor (Lewis, 2001 as cited in HSDB 2008c) that is soluble in most organic solvents, alcohol, and ether, and is completely miscible in water (Lewis, 1999 as cited in HSDB 2008c). It is used primarily in industry, but is also used as a flame retardant (Table 3.8-3). Consumer exposure to triethyl phosphate via inhalation during its use as a flame retardant in plastic materials was calculated to be approximately 0.001 mg/m^3 (NIOSH, 1983 as cited in HSDB 2008c). TEP is considered for use as a G-agent (e.g., Sarin) simulant due to its physicochemical properties (Bartelt-Hunt et al., 2008).

The LD50 for oral ingestion was determined to be 1,600 mg/kg in rats and rabbits and more than 1,500 mg/kg in mice (Bingham et al., 2001 as cited in HSDB 2008c). The dermal LD50 was ascertained to be greater than 21,400 mg/kg in guinea pigs (United Nations Environmental Program [UNEP], 1998) and greater than 20,000 mg/kg in rabbits (Bingham et al., 2001 as cited in HSDB 2008c). Exposure of rats via inhalation resulted in an LD50 greater than 8,817 mg/m^3 for a 4-hour exposure with a no-observed-adverse-effect level (NOAEL) of 1,400 mg/m^3 (UNEP, 1998).

In subchronic studies on rats, TEP was determined to have low toxicity with no serious damage in oral doses up to 6,700 mg/kg body weight. The NOAEL in the most relevant tests was 1,000 mg/kg body weight per day (UNEP, 1998). When reproductive effects in rats were examined, a NOAEL of 335 mg/kg body weight per day was determined, based on effects on litter size (UNEP, 1998).

In a 14-day toxicity test on the red wiggler earthworm (*Eisenia foetida*), the only noticeable effect from the *highest* exposure concentration of 1,000 mg/kg was a slight hardening of the earthworms at the end of the study (UNEP, 1998). Studies were also conducted to determine the phytotoxicity of TEP using sorghum-sudangrass (*Sorghum bicolor*), tomato (*Lycopersicon lycopersicum*), and glossy privet (*Ligustrum lucidum*). Triethyl phosphate was applied to sod and foliar tissue at rates of 0, 4, 400, and 40,000 mg/m^2 and was also applied in a thickened formulation at an application rate of 40,000 mg/m^2 on both soil and foliar tissue. Toxicity was observed only at the highest application rate of 40,000 mg/m^2 and the absence of phytotoxicity symptoms indicated no adverse effects to plants at application rates of 400 mg/m^2 or lower (Sikora et al., 1994).

In aquatic systems, LD50s ranged from more than 100 to 2,140 mg/kg for fish and from more than 100 to 2,705 mg per liter (mg/L) for invertebrates in tests ranging from 48 to 96 hours (UNEP, 1998). In a subchronic 21-day test, the concentration at which half the test individuals showed effects, known as the Effective Concentration 50 (EC50), for the water flea *Daphnia magna* was 729 mg/L (Verschueren, 2001). The bioconcentration potential of TEP in aquatic organisms is considered to be low (HSDB, 2008c).

TEP is considered to be moderately toxic, with a probable oral lethal dose to humans of between 500 to 5,000 mg/kg, which equates to between 1 ounce [oz] and 16 oz for a 150-pound individual (Gosselin et al., 1984).

Glacial Acetic Acid (GAA)

Glacial acetic acid is a colorless liquid that gives vinegar its sour taste and pungent smell. It is highly soluble in water. It is a weak acid that is used both in industry and in the house (Table 3.8-4). Acetic acid-producing bacteria are ubiquitous throughout the world and have been widely used throughout history. In the third century BC, the Greek philosopher Theophrastos described using vinegar on metals to produce pigments. The worldwide production of acetic acid is estimated at 5 million tons per year, about half of which is produced in the US. Glacial acetic acid is an excellent polar protic solvent – a solvent with a dissociable H^+ – and pure acetic acid is used in the production of terephthalic acid, the raw material for polyethylene terephthalate (PET), which is widely used to make drink, food, and other containers. It is used as a simulant for the second series of nerve agents, the V-agents.

The National Institute for Occupational Safety and Health (NIOSH) estimated in a survey performed from 1981 to 1983 that more than 900,000 workers are potentially exposed to acetic acid in the US (NIOSH, 1983 as cited in HSDB 2008d). Occupational exposure may occur through inhalation and dermal contact at workplaces where acetic acid is produced or used. Acetic acid occurs throughout the environment and is a normal metabolite in animals, hence people are continually exposed to low concentrations of it through the ingestion of food and the inhalation of air (HSDB, 2008d). Acetic acid is absorbed from the gastrointestinal tract and

through the lungs and is almost completely oxidized by tissues (World Health Organization [WHO], 1967).

As an acid, a splash of vinegar (4 to 10 percent acetic acid solution) in the human eye causes immediate pain and redness, sometimes with injury of the corneal epithelium (Mackison et al., 1981 as cited in HSDB 2008d). Repeated or prolonged contact with the skin may cause dermatitis. Acetic acid vapor is irritating to the eyes and nose, causing tears and reddening (hyperemia) (HSDB 2008d).

Individuals with chronic respiratory, skin, or eye disease are at increased risk from acetic acid exposure (Mackison et al., 1981 as cited in HSDB 2008d). Application of a 10-percent acetic acid solution to intact or abraded skin patches did not produce any effect in guinea pigs or rabbits, but concentration of 50 percent produced mild injuries, from 50 to 80 percent produced moderate to severe burns, and above 80 percent produced severe burns (Bingham et al., 2001 as cited in HSDB 2008d). Ingestion of acetic acid may also irritate the gastrointestinal tract, resulting in digestive disorders, including pyrosis (heartburn) and constipation.

LD50s for ingestion of GAA range from 1,200 mg/kg for rabbits over a 6-day exposure period to 4,960 mg/kg for mice (WHO, 1967). The LD50 for dermal exposure of rabbits was determined to be 1,060 mg/kg (Lewis, 1999 as cited in HSDB, 2008d). LC50s for inhalation exposure are between 5,620 mg/L for mice 11,400 mg/L for rats (USEPA, 2003).

High concentrations of acetic acid are harmful to aquatic life due to decreased pH levels that are toxic to oxidizing bacteria, inhibiting oxygen demand (Environment Canada, 1981). The survival rate of mosquito fish (*Gambusia affinis*) exposed to acetic acid at concentrations of up to 100 mg/L for 96 hours was 100 percent, but at concentrations of 320 mg/L and higher the survival rate fell to 0 percent within 24 hours (USEPA, 2003). The LC50 for fathead minnows (*Pimephales promelas*) was greater than 315 mg/L for a 1-hour exposure, but decreased to 88 mg/L for a 96-hour exposure (Verschueren, 2001).

Sulfur Hexafluoride (SF_6)

Sulfur hexafluoride is a colorless, odorless gas. It is soluble in potassium hydroxide and alcohol, but has a low solubility in water. It is primarily used in industry as a gaseous electrical insulating material and for the production of semiconductors (dry/plasma etching) (Table 3.8-4).

As with other gases, direct exposure to large concentrations could cause asphyxiation as a result of the displacement of oxygen (ACGIH, 1994). However, ordinarily SF_6 does not exist in a pure state (Sittig, 2002). The degeneration products of SF_6 (e.g., sulfur tetrafluoride) can be toxic, causing nose and ear irritation, nausea and vomiting, coughing, shortening of the breath, tightness of the chest, and pulmonary edema. Sulfur hexafluoride (known as Sonovue) is used (via injection) in echocardiography, but is contraindicated for patients with hypersensitivity to sulfur hexafluoride or pre-existing cardiac conditions and is not recommended for pregnant or lactating women, as its safety and effectiveness has not been established (European Medicines Agency, 2004).

Acute exposure of 50 rats to an 80 percent SF_6 atmosphere for periods from 16 to 24 hours showed no effects and the acute toxicity potential of SF_6 is probably very low (HSDB, 2011a).

The estimated bioconcentration factor (BCF) suggests the potential for bioconcentration in aquatic organisms is low (HSDB, 2011a).

1,1,1,2-Tetraflouroethane (R-134)

1,1,1,2-Tetraflouroethane (R-134) is an inert colorless, odorless gas used primarily as a high-temperature refrigerant for refrigeration and automobile air conditioners (Table 3.8-4). Trade names include tetrafluoroethane, R-134a, Genetron 134a, Freon 134a and HFC-134a. It began to be used in the 1990s to replace dichlorodifluorometane (Freon-12), which was banned in the US and other countries in 1994 because of its ozone depleting properties.

R-134 exhibits relatively low toxicity in animals (WHO/International Program on Chemical Safety [IPCS], 1998), with a four-hour (acute toxicity) lethal concentration of 567,000 ppm (2.36 × 106 mg/m^3) reported for rats and no effects observed at 81,000 ppm (337,770 mg/m^3) (WHO/IPCS, 1998). At concentrations in excess of 200,000 ppm (834,000 mg/m^3), exposure to 1,1,1,2-tetrafluoroethane depressed the central nervous system of rats (WHO/IPCS, 1998).

A study examining delayed fetal development in rats following chronic exposure to R-134 found delayed fetal development following exposure of females to 50,000 ppm (208,500 mg/m^3), but no effects were seen at exposure at 10,000 ppm (41 700 mg/m^3) (Hodge et al., 1980 as cited in WHO/IPCS, 1998). No exposure-related neoplastic (abnormal growth) or non-neoplastic effects were observed in two-year inhalation studies (one-hour daily nose-only exposure) at R-134 concentrations up to 50,000 ppm (208,500 mg/m^3) in rats and up to 75,000 ppm (312,750 mg/m^3) in mice (Alexander et al., 1995a) or in a similarly designed one-year study in which dogs were exposed to 120,000 ppm (500,400 mg/m^3) (Alexander et al., 1995b).

In aquatic systems, R-134 has shown low toxicity for the few organisms it has been tested on. It also has a low estimated half-life for volatilization from a river of about three hours (HSDB, 2008e). The low toxicity and high volatility indicate negligible risk to aquatic organisms (WHO/IPCS, 1998). In addition, low estimated bioconcentration indicates that 1,1,1,2-tetrafluoroethane will not bioconcentrate in fish and aquatic organisms (Lyman et al., 1982 as cited in HSDB, 2008e).

A health-based occupational exposure limit for 1,1,1,2-tetrafluoroethane of 1,000 ppm (4,170 mg/m^3) (eight hour time-weighted average) is in effect within the US and the United Kingdom UK based on the NOAEL of 10,000 ppm (41,700 mg/m^3) determined for the Hodge et al. (1980) chronic study on rats divided by an uncertainty factor of 10 (WHO/IPCS, 1998; American Industrial Hygiene Association, 1999).

1,1-Difluoroethane (R-152a)

1,1-Diflouroethane (R-152a) is an inert colorless, odorless gas used primarily as a high-temperature refrigerant for refrigeration and air conditioners and as an aerosol propellant (Table 3.8-4). It is also known as Freon 152a, Genetron 152, and HCFC-152a. R-152a is recommended as an alternative refrigerant to R-134, as it has a lower global warming potential (USEPA, 2008).

A two-year inhalation study on rats was used to evaluate the toxicity of R-152a, where rats were exposed to 0, 2,000, 10,000, or 25,000 ppm 1,1- difluoroethane (equal to 0, 5399, 26,994, or 67,485 mg/m^3, respectively) (McAlack and Schneider, 1982 as cited in Integrated Risk Information System [IRIS], 2009). The 25,000 ppm concentration was designated as a chronic NOAEL, as no significant respiratory, mortality, metabolic, or other effects were observed.

Exposure to higher concentrations of R-152a in an acute study indicates that is practically nontoxic. Male albino rats exposed to 74,000, 100,000, or 200,000 ppm R-152a for two hours

(Limperos and Zapp, 1951 as cited in IRIS 2009) showed no mortality and the most pronounced effect of acute or sub-acute exposures to R-152a was reversible central nervous system depression observed at high concentrations (100,000 ppm or greater). This central nervous system effect was not observed at any of the concentrations tested in the critical study of chronic duration. The findings of other studies where rats were exposed to up to 100,000 ppm of R-152a were consistent with the Limperos and Zapp (1951) study (IRIS, 2009).

Diethyl Phthalate (DEP)

Diethyl phthalate (DEP) is an odorless oily liquid that is commonly used in plastic products, such as toothbrushes, automobile parts, tools, toys, and food packaging in order to make them more flexible, as well as in cosmetics, insecticides, and aspirin (Table 3.8-4; Agency for Toxic Substances and Disease Registry [ATSDR], 1995). Because it is not a part of the chain of chemicals (polymers) that makes up the plastics, it can be released fairly easily from these products. It has a similar octanol-water coefficient[5] (K_{ow}) to VX (S-[2-(di-isopropylamino)ethyl]-O-ethyl methylphosphonothioate), an extremely toxic substance that is used a nerve agent (V-agent) (Bartelt-Hunt et al., 2008).

DEP has caused death in animals when given in very high oral doses, but brief ingestion of lower doses caused no harmful effects (ATSDR, 1995). Based on a study by Brown et al. (1978), the USEPA derived a NOAEL for DEP of 1 percent of the diet (750 mg/kg-day) and a LOAEL of 5 percent of the diet (3,160 mg/kg-day) (IRIS, 2008). In the Brown et al. study, groups of rats were fed diets containing 0, 0.2, 1.0, or 5.0 percent DEP for 16 weeks. There was significantly less weight gain and associated food consumption in both male and female rats fed 5 percent DEP and in females fed 1 percent DEP. No changes in behavior or other clinical signs of toxicity were observed. The livers and kidneys of animals fed 5 percent DEP were larger than normal, but not from any harmful effect that could be directly attributed to DEP (ATSDR, 1995). DEP is not known to cause cancer in humans or animals (ATSDR, 1995; IRIS, 2008).

Dimethyl Adipate (DMA)

Dimethyl adipate (DMA) is a colorless liquid. Its blends are used in the coating industry to clean up polyurethane adhesives, polyurethane foams, and unsaturated polyester resins (Table 3.8-3). DMA is part of a dibasic ester (DBE) blend that is used as a major ingredient in several paint strippers. The DMA content in DBE blends varies from about 15 to 90 percent. The other components of the DBE blends are dimethyl glutarate and dimethyl succinate. The most popular DBE blends used in paint stripping formulations contain about 90 percent DMA, with most of the final DBE content in consumer paint strippers ranging from about 20 to 50 percent (NTP, 1994). DMA is also used as a chemical intermediate and as a plasticizer in the production of paper and cellulose resins (USCPSC, 1994). It is a potential simulant of the blister agent mustard gas (Bartelt-Hunt et al., 2008), based on its Henry's Law constant[6] (K_h).

There are reports of blurred vision from the use of DBE-based paint strippers. These effects occurred when the product was used under conditions of low ventilation and the mixtures used

[5] The octanol-water partition coefficient is the ratio of the concentration of a chemical in octanol and in water at equilibrium and at a specified temperature.

[6] Henry's Law states that the mass of a gas which will dissolve into a solution is directly proportional to the partial pressure of that gas above the solution.

contained less than 20 percent DMA and higher percentages of the more volatile dimethyl glutarate and dimethyl succinate (USCPSC, 1994).

DMA is regarded as showing little acute or chronic toxicity. There are no apparent dermal irritant or sensitizing effects, but if it is hot or heated it may cause transient irritation of nose or throat (Clayton and Clayton, 1982). Subchronic inhalation studies using rats investigated toxicity of DBE aerosol-vapor mixture using concentrations of 160, 390, and 1,000 mg/m^3 and lower concentrations of 20, 76, and 390 mg/m^3. Rats were exposed for six hours a day, five days a week, for approximately 90 days. Mild olfactory degeneration was found at 90 days of exposure in female and male rats exposed to 20 mg/m^3 and above and 76 mg/m^3 and above, respectively (Kelly et al., 1986). The incidence, severity, and extent of the lesions increased with DBE concentration and duration of exposure. Other adverse effects that occurred as a result of subchronic DBE exposure included a dose-dependent decrease in liver weight beginning at 160 mg/m$^{3.}$ Serum sodium levels were slightly decreased at 76 mg /m$^-$ and above, while a decrease in body weight was noted in rats exposed to the highest DBE concentration (1,000 mg/m^3).

A single-generation reproductive effects study was conducted on male and female rats exposed to DBE concentrations up to 1,000 mg/m^3 for six hours a day, five days a week for 90 days, followed by daily exposure during mating, gestation, and lactation. The total study period was approximately 150 days. It was concluded that reproduction in rats was not altered by repeated inhalation exposure of to up to 1.0 mg/m^3 DBE – a concentration that produced both body weight and histological effects in parental rats (Kelly et al., 1998).

Dipropylene glycol methyl ether (DPGME)

Dipropylene glycol methyl ether (DPGME) is a clear liquid with an ethereal (ether-like; pungent) odor. It is used in many home-maintenance products (Table 3.8-4) and also in some pet products and pesticides (Household Products Database, 2010). It is a potential simulant of G (nerve)-agents (Bartelt-Hunt et al., 2008).

DPGME causes narcosis in animals at very high concentrations. Rats exposed for 7 hours to 500 ppm showed signs of mild narcosis but recovered rapidly (UNEP, 2001). The acute oral LD(50)s in rats and dogs are 5,135 mg/kg and 7,500 mg/kg, respectively and the dermal LD(50) in rabbits is 9,500 mg/kg (UNEP, 2001). Direct eye contact or eye exposure to a high ambient concentration results in slight and transient eye irritation, but does not cause permanent damage (UNEP, 2001).

The current OSHA-PEL for dipropylene glycol methyl ether is 100 ppm of air (600 mg/m^3) as an 8-hour time-weighted average (TWA) concentration (OSHA, 2011). NIOSH also has a short-term exposure limit (STEL) of 150 ppm (900 mg/m^3) (OSHA, 2011). Exposures at the STEL concentration should not be repeated more than four times a day and should be separated by intervals of at least 60 minutes. These exposure limits are the same as those recommended by American Conference of Governmental Industrial Hygienists (ACGIH, 1994 as cited in OSHA, 2011).

Diethyl ethyl phosphonate (DEEP)

Diethyl ethyl phosphonate (DEEP) is a colorless liquid that is used as a gasoline additive. It is also used in heavy-metal extraction, as a defoamer, as a plasticizer, and as an antistatic

compound (Oxford University, 2008a). It is used as a simulant for G-agents (nerve agents) (Bartelt-Hunt et al., 2008).

DEEP has been classified as "not hazardous" according to European Union Directive 67/548/EEC, relating to the classification, packaging, and labeling of dangerous substances (as amended) – one of the main European Union laws concerning chemical safety. Toxicity values for oral exposure are an LD50 of 2,330 mg/kg in rats and an LD50 of 2,500 mg/kg in mice (Oxford University, 2008a). Blumbach et al. (2000) examined relative kidney weights of rats that received oral doses of 50 or 100 mg/kg DEEP per day for five days. Male rats showed increased kidney weights after both dose regimens, but female rats showed no changes relative to controls. The increases were likely due to binding to α_{2u}-globulin, a male rat-specific protein that is not found in female rats, or in either sex of mice, and is therefore unlikely to occur in humans.

3.8.5.2 Biological Simulants

RDT&E activities using biological simulants are included in Alternatives 1 and 2. NSWCDD would only use Biosafety Level (BSL)-1 organisms as biological simulants. BSL-1 is the basic level of protection and is appropriate for working with microorganisms that are not known to adversely affect normal healthy humans (Centers for Disease Control and Prevention [CDC] and National Institutes of Health [NIH], 2007). BSLs range from the lowest level of 1 (BSL-1) where precautions are minimal, often consisting of gloves and some sort of facial protection to the highest level of 4 (BSL-4) that require the use of a positive pressure personnel suit with a segregated air supply, a biolab with electronically secured multiple airlocks to prevent both doors opening at the same time, multiple showers, a vacuum room, an ultraviolet light room, and other safety precautions designed to destroy all traces of the biohazard.

BSL-1 organisms representing potential threats from fungi, bacteria, viruses, and toxins could be used in future RDT&E of biological detectors. Potential species include the bacteria *Bacillus atrophaeus* (formerly known as *Bacillus globigii*), *Bacillus subtilis, Bacillus thuringiensis, Pantoea agglomerans* (formerly known as *Erwinia herbicola*), and *Deinococcus radiodurans;* the fungus *Aspergillus niger*; the protein ovalbumin; the MS2 bacteriophage; and/or BSL-1 organisms similar to them. Each of these types of simulants is discussed below.

Spore-Forming Bacteria: Bacillus atrophaeus, Bacillus subtilis, and Bacillus thuringiensis

Bacillus species produce an endospore, which is a dormant, tough, non-reproductive structure that allows the bacteria to survive through periods of environmental stress such as extreme heat and desiccation (USEPA, 1997). Under most conditions *Bacillus* are not biologically active but exist in endospore form. The endospores are ubiquitous in soil and rocks and are easily dispersed by wind and water (Moeller et al., 2004). *Bacillus* species are also commonly found in dust, air, water, and wet surfaces throughout the world (Center for Research Information [CRI], 2004). They generally occur at population levels of 10 to 100 per gram of soil (Alexander, 1977). However, concentrations of *Bacillus* occurring naturally in the desert have been measured at 100,000 spores per gram of surface soil (US Army, Dugway Proving Ground, 2003). Benign species of *Bacillus* are used to simulate the toxic spore-forming bacterium, *Bacillus anthracis*, commonly known as anthrax. *Bacillus atrophaeus* has been used for over 70 years in this role and is the most frequently used simulant for anthrax (Borden Institute et al., 1997; Edgewood Chemical Biological Center, 2004; Greenberg et al., 2010).

Bacillus subtilis and similar *Bacillus* species are common in the environment and are uncommon causes of disease to healthy individuals (DoD, 2003a, b). *B. subtilis* is one of the most widely-used bacteria for the production of enzymes and specialty chemicals (USEPA, 1997). Industrial uses of *B. subtilis* include the production of amylase, protease (e.g., cleaning aids in detergents), inosine, ribosides, and amino acids (USEPA, 1997). *B. subtilis* is not a human pathogen but has on several occasions been isolated from human infections (USEPA, 1997). Infections were only found in patients in compromised immune states, indicating that there must be immunosuppression of the host followed by inoculation in high numbers for infection to occur, and would not cause disease in normal healthy humans. USEPA concluded in a risk assessment (USEPA, 1997) that *B. subtilis:*

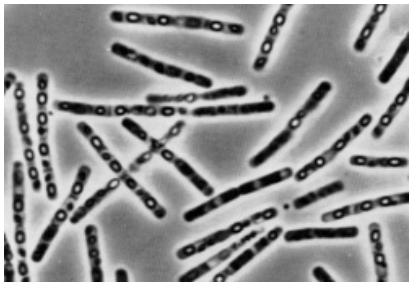
> …is not a human pathogen, nor is it toxigenic like some other members of the genus. The virulence characteristics of the microorganism are low. According to Edberg (1991) either the number of microorganisms challenging the individual must be very high or the immune status of the individual very low in order for infection with *B. subtilis* to occur.

Identification of Bacteria

A *strain* is a subset of a bacterial species differing from other bacteria of the same species by some minor but identifiable difference. One strain of a species is designated as the *type strain*. It is usually one of the first strains studied and is often more fully characterized than other strains, although it does not have to be the most representative member. Only those strains very similar to the *type strain* are included in a species.

Source: Abedon, 1998.

B. subtilis is also not known to be an animal or plant pathogen (USEPA, 1997). These benign bacteria would be used to simulate the release of toxic bacteria, such as *B. anthracis* (anthrax), which have similar spores and dispersal characteristics (Carrera et al., 2007).



Bacillus thuringiensis
(1000x magnification)

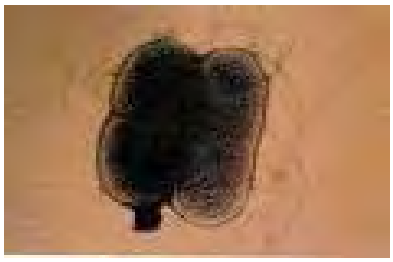
B. atrophaeus produces its own toxins and can sicken people whose immune systems have been compromised, but not healthy individuals. Human infection by *B. atrophaeus* primarily results from deep incisions in the skin, such as penetrating injuries, surgical procedures, and catheters and intravenous lines, and/or a debilitated health state (CRI, 2004); therefore it is often encountered as a nosocomial (acquired or occurring in a hospital) pathogen. *B. atrophaeus* is also a cause of food poisoning, resulting in diarrhea and vomiting, but fatalities are rare (CRI, 2004). It can contaminate cooked meat, cooked vegetables, milk, infant formulae, and is a significant contaminant of bread (CRI, 2004). It has also been isolated from recycled-paper products, which, if used for packaging foodstuffs, could result in contamination and possible food poisoning (CRI, 2004). Infections are usually treated with antibiotics (Blue et al., 1995). Cases of long-term persistence or recurrence or of extended latency have not been found (CRI, 2004).

Bacillus subtilis
(spores are green)

B. thuringiensis is a naturally occurring bacterial disease of insects and is used as an active ingredient in some insecticides (Cranshaw, 2006). Several strains of *B. thuringiensis* can infect and kill Lepidoptera (moths, butterflies, and caterpillars) by producing proteins that react with the cells

of the gut lining of susceptible insects and paralyze the digestive system (Cranshaw, 2006). Infected insects generally die from starvation, which can take several days. The most commonly used strain of *B. thuringiensis* (*kurstaki* strain) kills only leaf- and needle-feeding caterpillars. Recently, strains have been developed that control certain types of fly larvae (*israelensis* strain), and these strains are used against larvae of mosquitoes, black flies and fungus gnats. Other strains have been developed with activity against some leaf beetles, such as the Colorado potato beetle and elm leaf beetle (*san diego* strain, *tenebrionis* strain) (Cranshaw, 2006). Among the various strains, insecticidal activity is specific to the target insect group and *B. thuringiensis* is considered safe to people and nontarget species. Some formulations are considered safe to be used on food crops (Cranshaw, 2006).

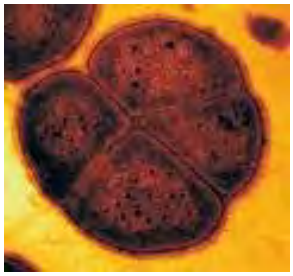
Because the *Bacillus* species proposed for use are ubiquitous in the environment, the releases expected from activities will not significantly increase populations in the environment.



Pantoea agglomerans

Non- Spore-Forming Bacteria: Pantoea agglomerans and Deinococcus radiodurans

Pantoea agglomerans is a gram-negative, rod-shaped bacterium that is associated with plants. *P. agglomerans* is used as a simulant for pathogenic gram-negative species, such as *Yersinia pestis* – the cause of the bubonic plague – and *Francisella tularensis* – the cause of tularemia or rabbit fever. *P. agglomerans* is nonpathogenic and has beneficial uses. For example, it is used for biological control of the fire blight bacteria (*Erwinia amylovora*) that infects pear and apple trees and makes affected areas appear blackened, shrunken, and cracked, as though scorched by fire (USEPA, 2006). No adverse human health effects associated with *P. agglomerans* have been observed through data reports submitted to USEPA or public literature. Based on available data and its low toxicological significance, USEPA classifies *P. agglomerans* (strain E325) as having the lowest toxicity level, toxicity category IV (USEPA, 2006). Toxicity categories for pesticide products range from toxicity category I, for products that are considered highly toxic and/or severely irritating to toxicity category IV, for products that are practically non-toxic and non-irritant.

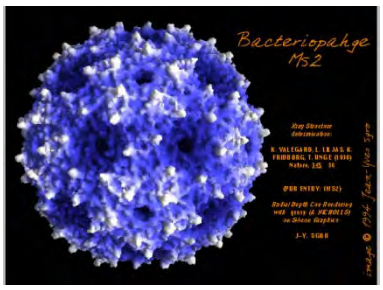


Deinococcus radiodurans

Deinococcus radiodurans is a gram-positive extremophilic bacterium – an organism that thrives in physically or geochemically extreme conditions. It is one of the most radioresistant (resistant to radiation) organisms known and it can survive conditions that include cold, dehydration, vacuum, and acid (DeWeerdt, 2002). Exposure to ionizing radiation can result in numerous DNA double-strand breaks, but *D. radiodurans* may compensate for extensive DNA damage through adaptations that allow cells to avoid detrimental effects of DNA strand breaks and increase the efficiency of the DNA-repair proteins (Cox and Battista, 2005). They could also be assisted by the accumulation of manganese complexes, which can provide an irradiated cell with sufficient enzymatic activity needed to repair DNA and survive (Daly, 2009). Due to its unique properties, the use of *D. radiodurans* for detoxifying mixed radioactive wastes containing ionic mercury and other metals is being examined (e.g., Brim et al., 2000). While *D. radiodurans* is quite hardy, it is a relatively weak competitor. It is not considered a human pathogen and a *Deinococcus*-related bacterium has been found living inside the human stomach (Bik et al., 2006).

Ovalbumin

Ovalbumin is a glycoprotein (a conjugated protein having a carbohydrate as the nonprotein component). It is the main protein found in egg white and is used as a key reference protein for immunization and biochemical studies. It can also be used to simulate protein toxins, such as ricin – a protein extracted from the castor bean (*Ricinus communis*) – and botulinum toxin – a potent neurotoxic protein produced by the bacterium *Clostridium botulinum* (Aberdeen Proving Ground, 2002). Ovalbumin is commonly consumed in food products and used as a medium to grow vaccines. Individuals with ovalbumin (egg) allergies should avoid exposure to it.



Bacteriophage MS2

Bacteriophage MS2

Bacteriophage MS2 (family *Leviviridae*) is a small, icosahedral, bacteriophage of *Escherichia coli*, a bacterium that is commonly found in the intestine of warm-blooded animals, including humans. A bacteriophage is a virus that infects bacteria. MS2 are ubiquitous and are found in places populated by their bacterial hosts such as soil or the intestines of animals.

The small size of MS2, its simple structure, its RNA genome, and harmlessness to humans, animals, plants, and other higher organisms make it a useful simulant for deadly small RNA viruses, such as Ebola virus (*Ebolavirus*), Marburg virus (*Marburgvirus*), and smallpox (*Variola major* and *Variola minor*) (O'Connell et al., 2006). MS2 is used in place of pathogenic viruses in a wide variety of studies that range from the testing of compounds for disinfecting surfaces to studying the environmental transport and fate of pathogenic viruses in groundwater (O'Connell et al., 2006).

Aspergillus niger

Aspergillus niger

The fungus *Aspergillus niger* is one of the most common species of the genus *Aspergillus*. It causes a disease called black mold on certain fruits and vegetables such as grapes, onions, and peanuts, and is a common contaminant of food. It is ubiquitous in soil and is commonly reported in indoor environments. It is widely used in biotechnology and has been in use for many decades to produce extracellular (food) enzymes and citric acid (Schuster et al., 2002).

A. niger is less likely to cause human disease than some other *Aspergillus* species, but, if large amounts of spores are inhaled, a serious lung disease, aspergillosis, can occur. Since *Aspergillus* is so common in the environment, most people breathe in *Aspergillus* spores every day (CDC, 2008). The spores do not harm people with healthy immune systems, but individuals with compromised immune systems breathing in many spores (such as in a very dusty environment) may become infected. Aspergillosis may occur among horticultural workers that inhale peat dust, which can be rich in *Aspergillus* spores. *A. niger* is also a cause of otomycosis, a fungal infection of the outer ear that occurs in tropical areas.

The EPA's *Aspergillus niger Final Risk Assessment*, dated February 1997, states in the Summary of Risk Integration section that: "*Aspergillus niger* is worldwide in distribution and has been isolated from numerous habitats. Humans are continually exposed to *A. niger* spores and

vegetative forms on foodstuffs and in the air. The vast majority of strains of *A. niger*, especially those used in industrial fermentation, have a history of safe use. While there are sporadic reports to the contrary, most isolates have not been documented to be serious pathogens of humans, animals or plants. Specific strains may produce certain mycotoxins or may elicit allergic responses among workers. Those limited instances of adverse effects seem to be associated with a limited number of strains. With proper characterization of industrial strains, use of those with potential for such effects can be avoided. Schuster et al. (2002) also concluded in a review that with appropriate safety precautions, *A. niger* is a safe production organism.

3.9 Geology, Topography, Soils, and Sediments

3.9.1 Geology

NSF Dahlgren is located within the Coastal Plain physiographic province, which extends along the Atlantic Ocean from Cape Cod, Massachusetts to Florida and along the Gulf Coast to Texas. The Coastal Plain province consists of an eastward-thickening sedimentary wedge of unconsolidated sediments, including silt, clay, and sand, with some gravel and lignite. The sediments range in geologic age from the Cretaceous to the Quaternary periods. There are approximately 1,500 ft of Coastal Plain unconsolidated sediment beneath NSF Dahlgren (Meng and Harsh, 1988). The unconsolidated sediments are underlain by crystalline basement rock. The geologic age and lithologic units in the vicinity of NSF Dahlgren are summarized in Table 3.9-1. The geology of NSF Dahlgren and the PRTR area are illustrated in Figure 3.9-1 (Geology - NSF Dahlgren) and Figure 3.9-2 (Geology - PRTR).

Table 3.9-1
Generalized Lithologic Units in the Vicinity of NSF Dahlgren

Geologic Age		Stratigraphic Formation
Period	**Epoch**	
Quaternary	Holocene	Holocene deposits
	Pleistocene	Tabb Formation
Tertiary	Miocene	Calvert Formation *
	Eocene	Chickahominy Formation *
		Piney Point Formation *
		Nanjemoy Formation
	Paleocene	Marlboro Clay
		Aquia Formation
Cretaceous	Late Cretaceous	Potomac Group
	Early Cretaceous	

Note: Absent in portions of the NSF Dahlgren vicinity.
Source: Meng and Harsh, 1988.

Surficial sediments at NSF Dahlgren are Quaternary-age deposits derived from Holocene deposits and the Tabb Formation, and Tertiary-age deposits derived from the Calvert Formation, Chickahominy Formation, and Piney Point Formation sediments. The surficial deposits vary in thickness due to erosion and deposition over time. The Calvert, Chickahominy, and Piney Point formations may be absent in portions of the installation. The Nanjemoy Formation underlies the surficial sediments. This formation is approximately 148 ft thick and is composed of alternating quartz and glauconite sands, clays, and calcitic units of shell and cavernous shell limestone of the Tertiary Period. The Marlboro Clay in turn underlies the Nanjemoy Formation. The Marlboro Clay is a 20- to 30-foot-thick clay, alternating pinkish-orange and dark gray in color. The Aquia Formation underlies the Marlboro Clay and consists of distinctive dark green to gray-green, argillaceous, glauconitic, well-sorted sand with indurated shell beds. The thickness of the Aquia Formation ranges up to 100 ft. Finally, the Cretaceous Period Potomac Group underlies the Aquia Formation; it is approximately 1,000 ft thick and is the oldest and deepest formation, resting on the crystalline basement rock (NSF Dahlgren, 2007).

3.9.2 Topography

Figures 3.9-3 (Topography - NSF Dahlgren) and 3.9-4 (Topography - PRTR) illustrate the existing topography of NSF Dahlgren and the PRTR, respectively. In Virginia, the Coastal Plain physiographic province is characterized by low relief, with elevations ranging from sea level in coastal areas to 400 ft above mean sea level (MSL) in the western portions of the province. The Chesapeake Bay and Potomac River are prominent features of the Coastal Plain in the vicinity of NSF Dahlgren and the PRTR area.

NSF Dahlgren's topography is generally low and flat, with elevations ranging from MSL near the Potomac River and its tributaries to 28 ft above MSL in the northwestern part of Mainside and the southwestern parts of the EEA. The broad, low-lying area within which NSF Dahlgren is located is interpreted to be an earlier shore of the Potomac River, where alluvial deposition has produced the present flat topography. Most of the area's slopes are gradual. However, steep slopes are found along sections of streams within the installation and along the Potomac River shoreline (NSF Dahlgren, 2007).

3.9.3 Soils

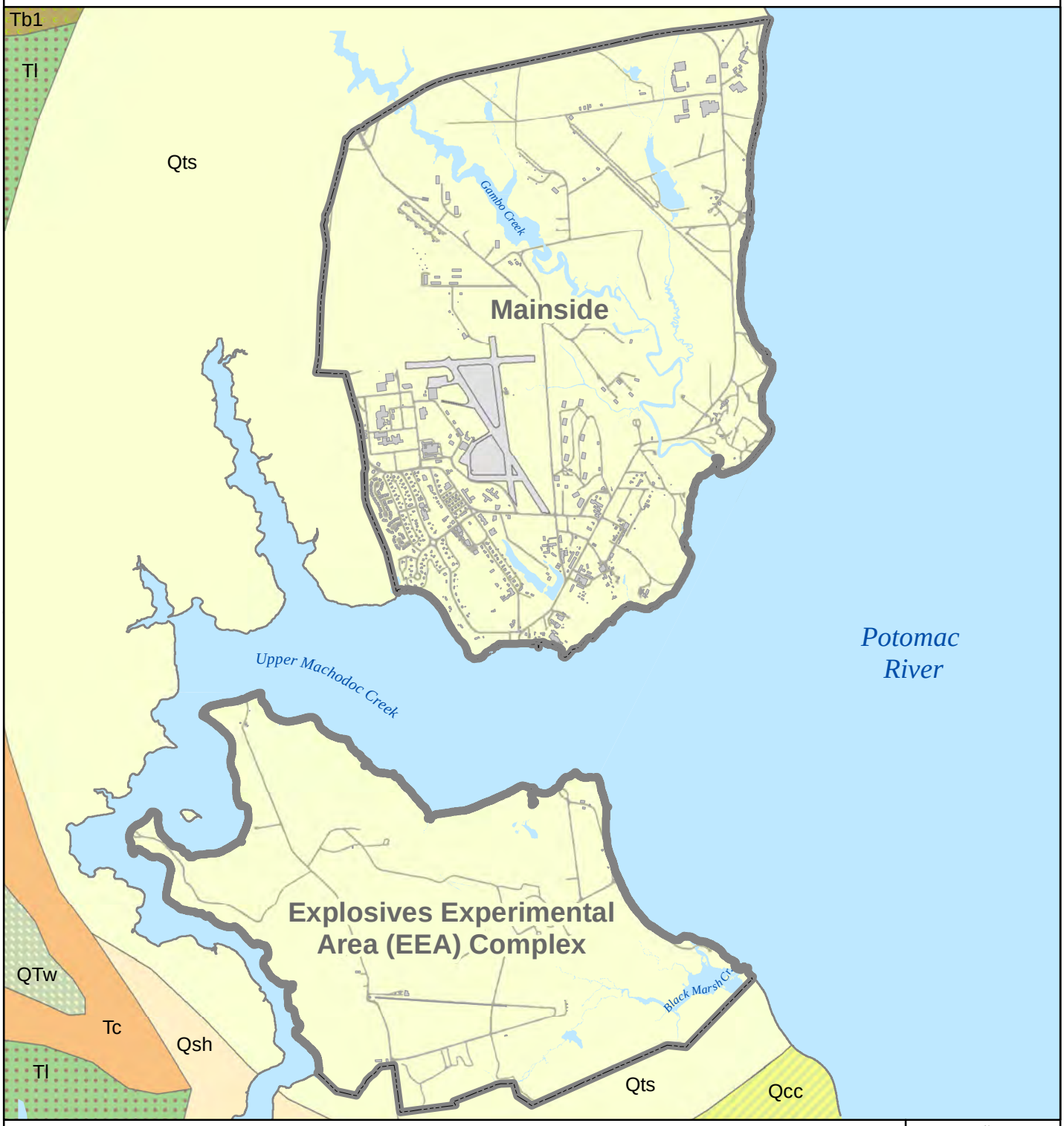
3.9.3.1 NSF Dahlgren Soils

The Soil Conservation Service (SCS) – now the Natural Resources Conservation Service (NRCS) – has surveyed King George County soils, including those on NSF Dahlgren (SCS, 1974). The survey described and delineated twenty named soil types within the installation, as shown in Figure 3.9-5 (Soils - Mainside) and Figure 3.9-6 (Soils - EEA). A brief description of each soil type is provided in Table 3.9-2.

The primary soil type found at NSF Dahlgren consists of the Tetotum-Bladen-Bertie soil association. This soil association is characterized by deep, moderately well-drained to poorly drained soils with clay loam, sandy clay loam, or clay subsoil in broad, low-lying areas (SCS, 1974).

The NRCS National Hydric Soil List identifies three hydric soil types that occur at NSF Dahlgren: Bladen loam, Fallingston very fine sandy loam, and Pooler loam. Hydric soils typically support hydrophytic vegetation and occur in wetland areas. Bladen loam is found throughout large sections of the installation. This soil has a clayey texture and is common where a seasonally high water table remains near the surface for long periods of time. Fallingston very fine sandy loam is also found throughout NSF Dahlgren. The texture of this soil ranges from very fine sandy loam to sandy clay loam; it is common where the high water table is at the surface or within a depth of 1.5 ft during wet periods. Pooler loam is found only within the western portions of the EEA. This soil's texture ranges from heavy clay loam to very fine sandy loam; the seasonal high water table is usually at a depth of 1 to 1.5 ft below ground in winter and spring.

Geology - NSF Dahlgren



Tertiary
- Tb1, gravel, sand
- Tc, sand, silt
- Tl, sand, silt

Quarternary
- Qcc, sand, silt
- Qsh, gravel, sand
- Qts, Tabb Formation, sand

Tertiary-Quarternary
- QTw, undifferentiated, gravel, sand

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Sources: NSWCDD GIS (2008 - 2011), Geology: 2005, Integrated Geologic Map Databases for the United States: Delaware, Maryland, New York, Pennsylvania, and Virginia: U.S. Geological Survey Open-File Report 2005-1325, U.S. Geological Survey, Reston, VA.

Figure 3.9-1

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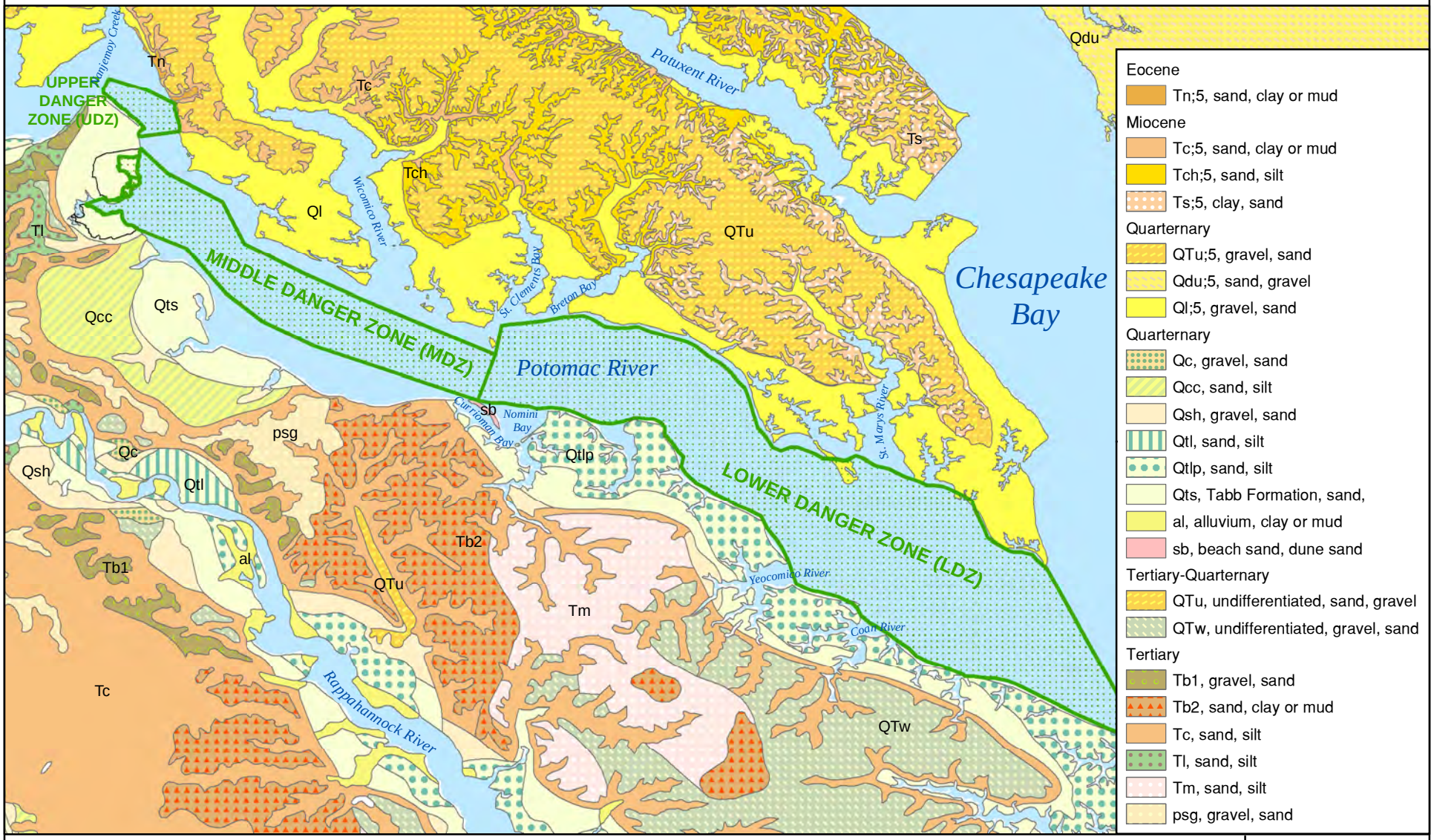
Geology - PRTR



Potomac River Test Range (PRTR) Complex

Naval Support Facility (NSF) Dahlgren

7 0 7 Miles

11 0 11 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Sources: NSWCDD GIS (2008 - 2011), Geology: 2005, Integrated Geologic Map Databases for the United States: Delaware, Maryland, New York, Pennsylvania, and Virginia: U.S. Geological Survey Open-File Report 2005-1325, U.S. Geological Survey, Reston, VA.

Figure 3.9-2

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Topography - NSF Dahlgren

Elevation Contour Interval - 4 feet

- 0'
- 4'
- 8'
- 12'
- 16'
- 20'
- 24'
- 28'

Naval Support Facility (NSF) Dahlgren

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 3.9-3

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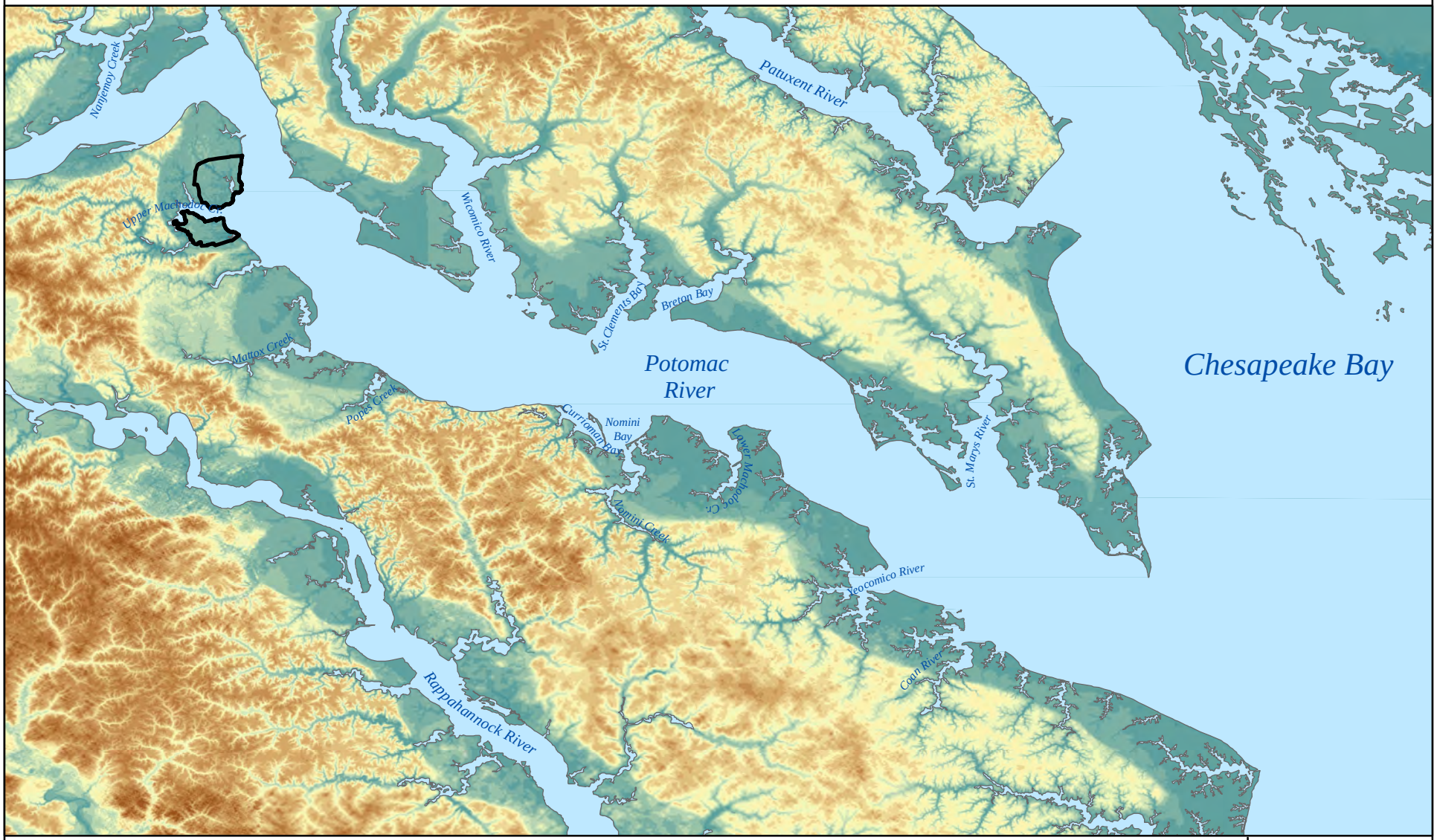
Topography - PRTR



Elevation

< -5 | -5 - 0 | 0 - 5 | 5 - 10 | 10 - 15 | 15 - 20 | 20 - 25 | 25 - 30 | 30 - 35 | 35 - 40 | 40 - 45 | 45 - 50 | 50 - 55 | 55 - 60 | 60 - 65 | 65 - 70

Naval Support Facility (NSF) Dahlgren

7 0 7 Miles

11 0 11 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Figure 3.9-4

Source: USGS 30 meter National Elevation Data U.S. Geological Survey, 2007.

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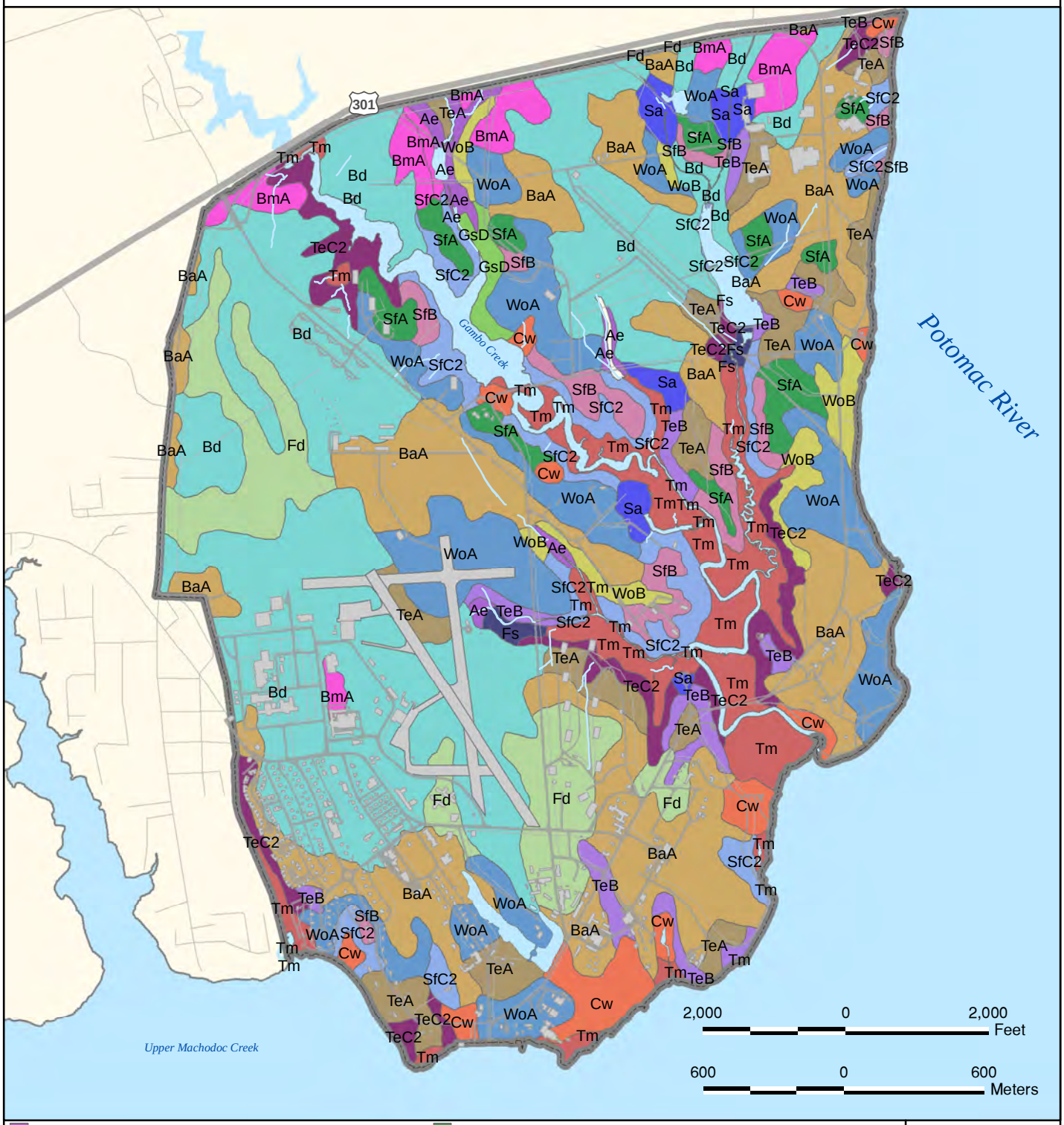
Soils - Mainside



Ae, Alluvial land, Severe flooding
BaA, Bertie very fine sandy loam, Severe seasonal high water table
Bd, Bladen loam, Severe seasonal high water table shrink-swell potential
BmA, Bourne fine sandy loam, Severe seasonal high water table
Cw, Cut and fill land, Soil material removed or reworked by machinery
Fd, Fallsington very fine sand loam, Severe seasonal high water table
Fs, Fresh water swamp, Severe wetness
GsD, Galestown-Sassafras complex, Moderate slope building limitations
Sa, Sand and gravel pits, Mined area or dump containing waste material
SfA, Sassafras fine sandy loam, Moderate slope 0-2%
SfB, Sassafras fine sandy loam, Moderate slope 2-6%
SfC2, Sassafras fine sandy loam, Moderate slope 6-10%
TeA, Tetotum fine sandy loam, Severe seasonal high water table
TeB, Tetotum fine sandy loam, Severe seasonal high water table
TeC2, Tetotum fine sandy loam, Severe seasonal high water table
Tm, Tidal marsh, Severe wetness
WoA, Woodstown fine sandy loam, Severe seasonal high water table
WoB, Woodstown fine sandy loam, Severe seasonal high water table

Sources: NSWCDD GIS (2008 - 2011) and Soil Conservation Service (1974).

Figure 3.9-5

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

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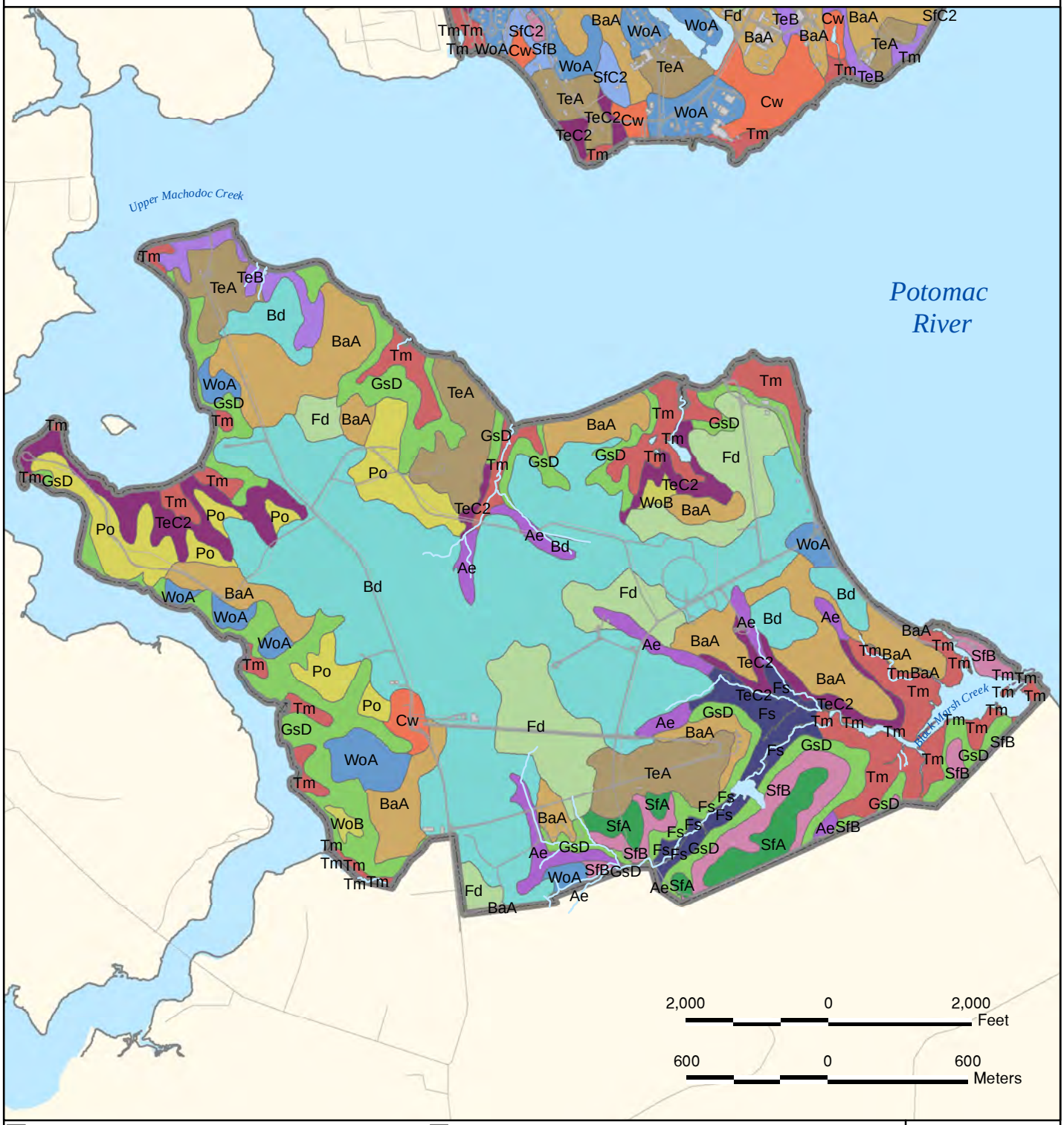
Soils - EEA



- Ae, Alluvial land, Severe flooding
- BaA, Bertie very fine sandy loam, Severe seasonal high water table
- Bd, Bladen loam, Severe seasonal high water table shrink-swell potential
- Cw, Cut and fill land, Soil material removed or reworked by machinery
- Fd, Fallsington very fine sandy loam, Severe seasonal high water table
- Fs, Fresh water swamp, Severe wetness
- GsD, Galestown-Sassafras complex, Moderate slope building limitations
- Po, Pooler loam, Severe seasonal high water table shrink-swell potential
- SfA, Sassafras fine sandy loam, Moderate slope 0-2%
- SfB, Sassafras fine sandy loam, Moderate slope 2-6%
- SfC2, Sassafras fine sandy loam, Moderate slope 6-10%
- TeA, Tetotum fine sandy loam, Severe seasonal high water table
- TeB, Tetotum fine sandy loam, Severe seasonal high water table
- TeC2, Tetotum fine sandy loam, Severe seasonal high water table
- Tm, Tidal marsh, Severe wetness
- WoA, Woodstown fine sandy loam, Severe seasonal high water table
- WoB, Woodstown fine sandy loam, Severe seasonal high water table

Sources: NSWCDD GIS (2008 - 2011) and Soil Conservation Service (1974).

Figure 3.9-6

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

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Table 3.9-2
NSF Dahlgren Soils

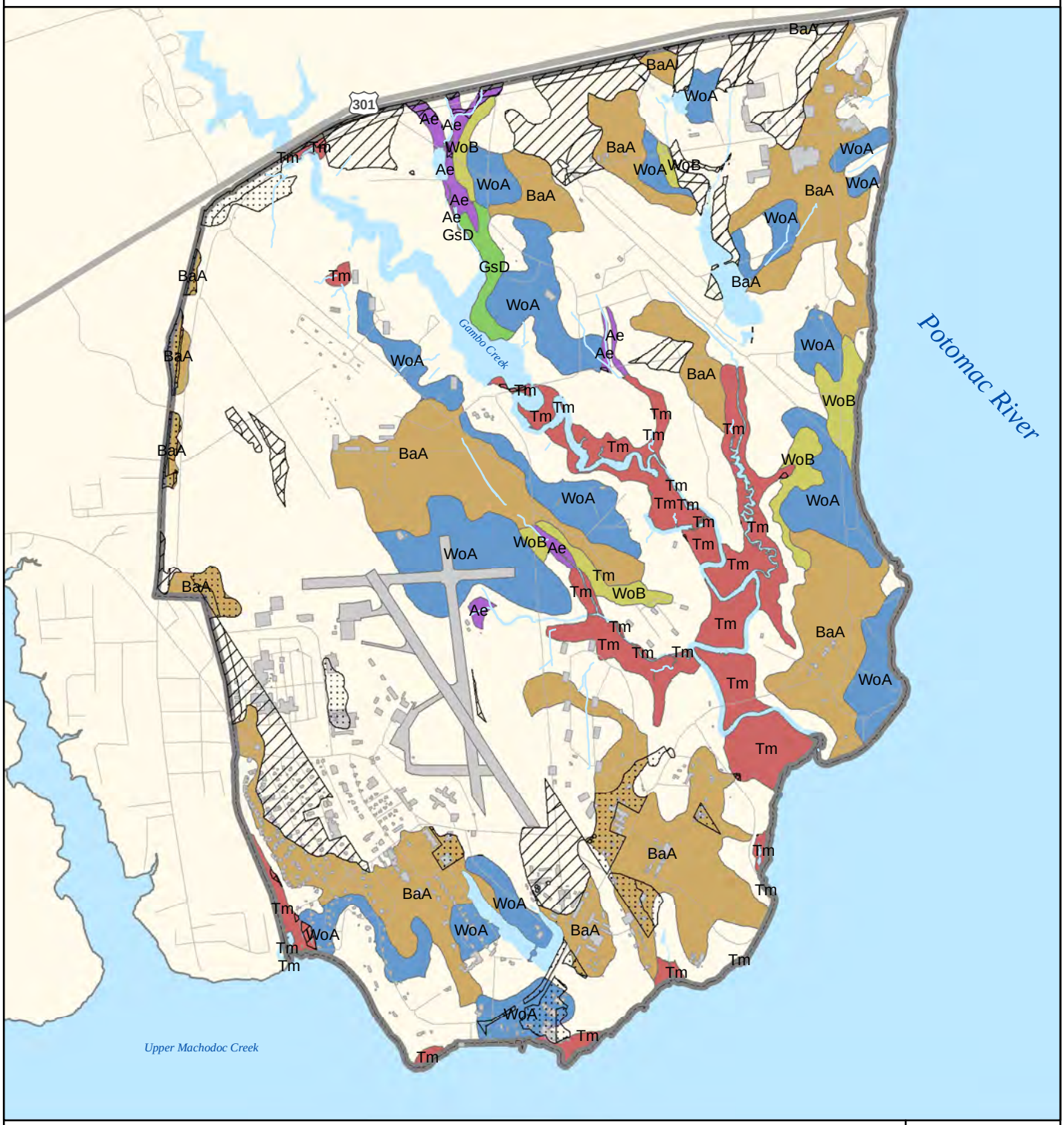
Soil Symbol	Soil Name	Soil Description
Ae	Alluvial Land, wet	A nearly level–to-gently sloping soil found along drainageways and small streams. Textures range from loamy sand to sandy loam and loam. The soil is strongly-to-very strongly acid. It is low in natural fertility and organic-matter content. Permeability is moderate to rapid. A seasonal high water table is at the surface for many months. It is subject to seepage and flooding from uplands.
BaA	Bertie very fine sandy loam, 0-3% slopes	A deep, somewhat poorly drained, nearly level-to- very gently sloping soil in low areas. Soil textures range from fine sandy loam to sandy clay loam and clay loam. It is strongly-to-extremely acid. It is low in organic-matter content and natural fertility. Permeability is moderate. A seasonal high water table is 1.5 ft in winter and in spring.
Bd	Bladen loam, 0-2% slopes	A deep, poorly drained, nearly level soil. Textures range from loam clay to clay. Permeability is slow. It is very strongly acid and low in natural fertility and organic matter content. A seasonal high water table remains near the surface for long periods.
BmA	Bourne fine sandy loam, 0-2% slopes	A moderately well-drained, nearly level-to-sloping soil on uplands. There is a moderate-to-strong fragipan at a depth of about 18 to 24 inches. The soil is strongly-to-very strongly acid. It is low in natural fertility and organic-matter content. Subsoil above the fragipan is moderately permeable, but the fragipan is slowly-to-very slowly permeable. A parched water table occurs above the fragipan during wet periods.
BmB	Bourne fine sandy loam, 2-6% slopes	Similar to BmA above, but has steeper slopes.
Cw	Cut and Fill	Cut-and-fill land consists of areas where soil has been removed or reworked by machinery. Texture ranges from loamy sand to clay loam and clay, but some areas are very gravelly. Sediment production is medium to high. Runoff is rapid, and permeability is moderate to slow.
Fd	Fallingston very fine sandy loam, 0-2% slopes	A deep, poorly drained, nearly level soil on lowlands. Texture ranges from very fine sandy loam to sandy clay loam. It has a very strongly acid-to-extremely acid subsoil, and is low in organic-matter content and natural fertility. The subsoil has moderate permeability. Available moisture capacity is moderate. It has a seasonal high water table at the surface or within a depth of 1.5 ft during wet periods.
Fs	Fresh water swamp	Low-lying areas consisting of mixed alluvium that is waterlogged or covered by fresh water, except during extended dry periods. These areas consist of layers of sandy loam, fine sandy loam, loam, and silt loam. A mat of partly-decayed organic material is on the surface in many areas. The surface layer commonly is gray to dark gray. The lower layers are strongly glued.
GsD	Galestown-Sassafras complex, 6-15% slope	This complex consists of deep, well-to-somewhat excessively drained soils on uplands. Texture ranges from loamy fine sand to fine sand. It is very strongly acid and is low in natural fertility and organic-matter content. Galestown soils make up about 45% of the complex, with Sassafras representing about 30%. Permeability is rapid, and available moisture capacity is low. Runoff is medium, and erosion is a moderate hazard if the soil is exposed.
Po	Pooler loam, thin solum variant	A deep, somewhat poorly drained, nearly level soil. Textures range from heavy clay loam to very fine sandy loam. It has a strongly acid-to-very strongly acid subsoil. It is low in natural fertility and organic- matter content. Permeability is slow in the subsoil, and available moisture capacity is moderate. The seasonal high water table is at a depth of 1 to 1.5 ft in winter and in spring.

Table 3.9-2 (Continued)
NSF Dahlgren Soils

Soil Symbol	Soil Name	Soil Description
Sa	Sand and Gravel Pits	The soil material of this type is generally coarse. Runoff is slow, and permeability is moderately rapid. These soils commonly have a thin cover of weeds, brush, and small trees. Thin strands of grass cover fine-textured materials.
SfA	Sassafras fine sandy loam, 0-2% slopes	A deep, well-drained soil on nearly level slopes. Texture ranges from fine sandy loam near the surface to sandy clay loam, loamy fine sands, and fine sands at lower substrata. Permeability is moderate in the subsoil, and available moisture capacity is moderate.
SfB	Sassafras fine sandy loam, 2-6% slopes	The same as SfA above, except that the slopes are increased. Its runoff is medium. Erosion has a moderate hazard rate if this soil is clean-tilled or exposed.
SfC2	Sassafras fine sandy loam, 6-10% slopes	The same as SfB above, but with increased slopes. Runoff is medium on this soil. Erosion is a very severe hazard if this soil is clean-tilled or exposed.
TeA	Tetotum fine sandy loam, 0-2% slopes	A deep, moderately well-drained soil on nearly level slopes. Texture ranges from fine sandy loam near the surface to sandy clay loam to mottled clay loam at lower layers. The subsoil is moderately permeable. Available moisture capacity is moderate. A seasonal high water table is at a depth of 1.5 to 2.5 ft during winter and spring.
TeB	Tetotum fine sandy loam, 2-6% slopes	The same as TeA above, except that slopes have increased. Runoff is slow to medium, and erosion is a moderate hazard if it is clean-tilled or exposed.
TeC2	Tetotum fine sandy loam, 6-10% slopes	The same as TeB above, except that slopes have increased. This creates a severe erosion hazard if the soil is clean-tilled or exposed.
Tm	Tidal Marsh	Broad, low areas of mixed alluvium that are covered periodically by tidal water. Textures range from coarse to medium materials. There are various layers of sandy, loamy, clayey, and muck materials. Subsurface is commonly glued. Tidal marsh is constantly waterlogged. Such areas play an important role in wildlife ecology.
WoA	Woodstown fine sandy loam, 0-2% slopes	A deep, moderately well-drained soil on nearly level to gentle slopes. It has a medium acid-to-very strongly acid subsoil. The subsoil is moderately permeable, and available moisture capacity is moderate. There is a seasonally-high water table at a depth of 1.5 to 2.5 ft, which makes artificial drainage beneficial for farm use.
WoB	Woodstown fine sandy loam, 2-6% slopes	The same as WoA above, except that the slope has increased. Runoff is slow to medium, and erosion is a moderate hazard if the soil is clean- tilled or exposed.
Source: SCS, 1974.		

As noted in Table 3.9-2, soil erosion is a moderate to severe hazard at NSF Dahlgren when certain soils are tilled or exposed. Some soils have steep slopes or other characteristics – e.g., a seasonal high water table – that restrict potential uses. Such soils include Alluvial land, Bertie very fine sandy loam, Galestown-Sassafras Complex, Tidal Marsh, and the Woodstown fine sandy loam. Erosion hazards, steep slopes, or other soil restrictions are shown in Figure 3.9-7 (Soil Restrictions - Mainside) and Figure 3.9-8 (Soil Restrictions - EEA).

Soil Restrictions - Mainside



Ae, Alluvial land, Severe flooding

BaA, Bertie very fine sandy loam, Severe seasonal high water table

GsD, Galestown-Sassafras complex, Moderate slope building limitations

Tm, Tidal Marsh, Severe wetness

WoA, Woodstown Fine Sandy Loam, Severe seasonal high water table

WoB, Woodstown Fine Sandy Loam, Severe seasonal high water table

Soil Characteristics Restrictions

Steep Slope Restrictions

2,000 0 2,000 Feet

600 0 600 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Sources: NSWCDD GIS (2008 - 2011) and Soil Conservation Service (1974).

Figure 3.9-7

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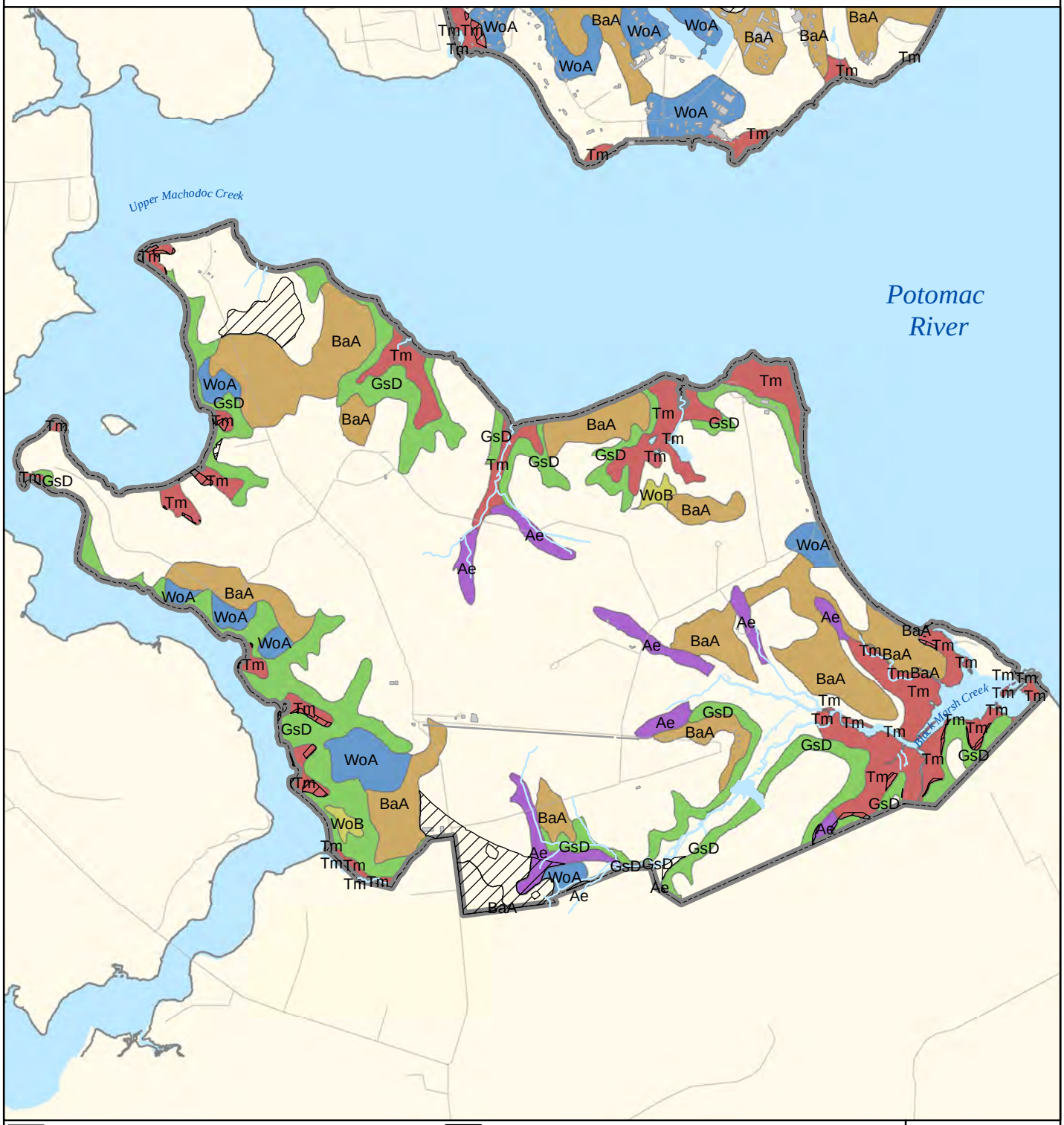
Soil Restrictions - EEA



Sources: NSWCDD GIS (2008 - 2011) and Soil Conservation Service (1974).

Figure 3.9-8

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3.9.3.2 Potomac River Shore Erosion

NSF Dahlgren Shoreline Erosion

NSF Dahlgren is located on the western shore of the Potomac River and is bisected by Upper Machodoc Creek; it is traversed by Gambo Creek and other tributaries to the Potomac. Over the years, the installation's shorelines have experienced significant erosion from strong storms. The hydrology of the Potomac River in this area further aggravates the erosion problem. At NSF Dahlgren, the river varies from less than 2 mi to approximately 5.7 mi wide with extensive shallow areas less than 10 feet deep near the installation. The width of the river provides a long fetch, which allows wave energy to build up when strong winds are present. In addition, soil stratification in the region allows groundwater seepage into subsurface soils along shoreline embankments, which tends to undermine the layers above. This seepage, in conjunction with the undermining action of the waves, is a cause of erosion and bank failure. Increased boat traffic, multi-directional currents, and overland storm flow also contribute to increasing the erosion rate (Naval District Washington [NDW], 2007).

In 1998, NSWCDD contracted with the US Department of Agriculture's Natural Resources Conservation Service to assist in development of a Shoreline Management Plan to address shoreline erosion. The purpose of the Shoreline Management Plan was to inventory the existing shoreline conditions at the installation, identify areas with erosion problems, and provide recommendations to correct the erosion problems, where required.

The Shoreline Management Plan estimated that volume-erosion rates along NSF Dahlgren shorelines are contributing sediment to the Chesapeake Bay at a rate that is 4 to 6 times greater per unit than the rate of sediment contributed by the Potomac River watershed as a whole (NSWCDL, 1999). As expected, higher banks contribute the majority of the sediment. On Mainside, only 26 percent of the shoreline has banks higher than 10 feet, however, 54 percent of the sediment is contributed to the river from them. On the EEA, nearly 48 percent of eroded sediment comes from the 18 percent of the shoreline with banks higher than 10 feet. The annual recession rate of shorelines at NSWCDD estimated in the Shoreline Management Plan range from 0.5 to 1.5 feet per year.

Based on the Shoreline Management Plan prioritization of areas with erosion problems, NSF Dahlgren proposed to construct a combination of sills and/or shoreline revetments at five sites (Site A, Site C, Site EOD, Site B994, and Site B1490) along the west bank of the Potomac River to protect facilities and infrastructure from shoreline erosion and bank failure (NSF Dahlgren, 2007). Due to budget restraints, the application of shoreline erosion reduction measures is being conducted in a priority order. NSF Dahlgren has completed shoreline erosion control measures at three of the sites (Site C, Site B994, and Site B1490) to stem the erosion. The projects included the construction of 1,500 feet of revetments and sills and the creation of wetland habitat to reduce erosion and sedimentation and enhance water quality in the vicinity of the Potomac River.

Currently, NSF Dahlgren proposes to construct shoreline stabilization and restoration structures and to consider employing living shoreline techniques along approximately 11,730 feet of the installation's shoreline on the Potomac River and Upper Machodoc Creek (NSF Dahlgren and Naval Facilities Engineering Command, Washington, 2012). The shoreline stabilization and restoration measures would be implemented in four phases, by priority, for 12 shoreline reaches.

Shoreline Erosion along the Tidal Potomac River and Estuary

In 1977, the US Geological Survey (USGS) began a five-year inter-disciplinary study of the tidal Potomac River and estuary which also included evaluation of shoreline erosion rates. Findings were published by USGS in 1985 (USGS, 1985) and are described below.

The USGS study measured erosion rates by comparing digitized historical shoreline maps and modern maps and stereopairs of aerial photographs taken at different points in time, with the aid of an interactive computer-graphics system and a digitizing stereo-plotter. Cartographic comparisons encompassed 90 percent of the tidal Potomac River and spanned periods of 38 to 109 years, with most measurements spanning at least 84 years. Photogrammetric comparisons encompassed 49 percent of the study reach and spanned 16 to 40 years. Field monitoring of erosion rates and processes at two sites, Swan Point, Maryland, and Mason Neck, Virginia, spanned periods of 10 to 18 months.

The USGS found that in the study area shoreline bank erosion was accelerated by wind-driven waves which break down and remove accumulated debris in the shore zone and abrade and undercut the base of the bank. Slope processes, including surficial erosion and mass movement, play an important role in mobilizing and delivering debris to the base of the bank. These processes are most active at sites with high bank relief and at sites marked by seepage or zones of concentrated ground-water flow from the face of the bank. Seasonal patterns of temperature and precipitation influence the level of activity of slope processes, and local patterns of sediment transport and beach elevations affect the frequency of wave attack and the amount of under-cutting at the base of the bank. The cycle of slope erosion has a variable time scale, and the time period for completion of a cycle initiated by basal erosion increases with height and complexity of the slope

USGS field measurements at monitoring sites at Swan Point, Maryland, and Mason Neck, Virginia, indicate that short-term (10- to 18-month) recession and volume-erosion rates along a shoreline less than 3,280 ft long may vary greatly and that local factors, such as the capacity of the beach to buffer wave impact, presence or absence of obstructions that modify patterns of sediment transport, and trees at the top of the bank, may be primarily responsible for these variations. Although such variations are not likely to persist over a period of decades, they illustrate the importance of longer-term measurements and synoptic measurement for estimating average erosion rates and sediment loads.

USGS estimated that average recession rates, the horizontal distance that a shoreline recedes in a year, along the estuary (all of the PRTR is in the estuary) were 1.4 to 1.7 ft per year along the Virginia shore and 1.0 to 1.3 ft per year along the Maryland shore. Average recession rates of shoreline in the tidal river and transition zone upriver from the PRTR were close to 0.49 ft per year.

USGS estimated that average volume-erosion rates, a measure of the quantity of material eroded from a bank in a year, along the estuary were 13.5 to 20.1 cubic ft per foot of shoreline per year (Virginia shore) and 6.0 to 7.9 cubic ft per foot of shoreline per year (Maryland shore). Estimated average volume-erosion rates along the shores of the tidal river and transition zone upriver from the PRTR were 0.55 to 0.74 cubic ft per foot of shoreline per year.

Weighted average volume-erosion rates along the Virginia shore of the estuary were 20.1 cubic ft per foot of shoreline per year; comparable volume-erosion rates along the Maryland shore of

the estuary were 7.9 cubic ft per foot of shoreline per year. Average rates along the tidal river and transition zone were 6.2 cubic ft per foot of shoreline per year.

The maximum average volume-erosion rates for an individual reach, 89 cubic ft per foot of shoreline per year, were measured along the Nomini Cliffs in Westmoreland County (adjacent to the PRTR MDZ), where maximum ground surface elevations were 154 ft above MSL. The most complicated set of erosional processes occurs on high bluffs with complex stratigraphy such as Nomini Cliffs. Erosion processes occurring on the Nomini Cliffs are affected by the presence of multiple seepage zones, discontinuous ironstone ledges, sheet joints, and tectonic joints. Large landslips occur on the upper 10 to 20 meters of the cliffs above seepage zones marking perched water tables. Channels incised in the face of the slope form permanent drainage systems for transportation of water and sediment. Along some sections of these bluffs, pinnacles have been carved in the upper part of the slope by rill and gully erosion (USGS, 1985).

3.9.4 Sediments

This section describes the physical distribution and characteristics of sediments within NSF Dahlgren and the PRTR based on available information. Further information on sediments is provided in Section 3.10 of this EIS, which discusses water and sediment quality. Figure 3.9-9, Sediments - PRTR, illustrates the sediment types found along the Potomac River.

The terraced lowlands surrounding tributaries within NSF Dahlgren and the PRTR are comprised of “lowland deposits” consisting of coarse (sandy) and fine (clayey or silty) sediments with cobbles and boulders. These deposits commonly contain reworked glauconite, varicolored silts and clays, brown-to-dark gray lignitic silty clay, and remnants of marine fauna (Maryland Geological Survey [MGS], 2008).

The bottom of the PRTR is covered by sediments that may have been carried into the river by tributaries, eroded from the Potomac River shoreline, transported downriver from upstream locations, transported from the Chesapeake Bay, introduced from the atmosphere, or generated by biological activity (USGS, 2003).

The sediments are composed of different proportions of sand-, silt-, and clay-sized particles. Larger in size, sands are generally located along the shallow margins of a waterbody, adjacent to the shoreline, and on shelves around peninsulas. Sands typically accumulate in higher-energy environments. Stronger waves and currents near shore typically remove, or prevent the deposition of, finer-grained sediments, leaving sands behind. In contrast, silts and clays – “mud” – generally occur in low-energy environments and in slow-moving tributaries or river channels.

The silts and clays represent the deposition of fine material from suspension in lower-energy environments, where sand-sized particles cannot be carried (USGS, 2003). Mixed sediments may be deposited by alternating high- and low-energy events, which produce inter-layered sands and silty clays that are later mixed by biological activity. They may represent underwater exposures of pre-Holocene sediments deposited under different conditions. Human activities, such as dredging and the overboard placement of dredged material, may also generate mixed sediments (USGS, 2003).

3.9.5 Seismic Activity

Most of the world's earthquakes occur near plate boundaries of the earth's crust. Since places like the California coast are on a boundary between two plates, they have many more earthquakes than places like Virginia and Maryland, which are near the center of the North American plate. Nevertheless, earthquakes still occur in this region, and Virginia has had more than 160 earthquakes since 1977, of which 16 percent were felt. This equates to an average of one earthquake occurring every month, with two felt each year (Virginia Tech Seismological Observatory, 2011b).

Recently, on August 23, 2011, an earthquake with a magnitude of 5.8 occurred near Louisa and Mineral, Virginia, approximately 56 mi west-southwest of NSF Dahlgren (USGS, 2011b, c, d; Virginia Tech Seismological Observatory, 2011c). The shallow earthquake caused moderate shaking and was felt from Florida to Ontario to Missouri. There were hundreds of aftershocks (USGS, 2011b). Moderately heavy damage occurred in Louisa County southwest of Mineral, and widespread light to moderate damage occurred from central Virginia to southern Maryland, including the Washington, DC area (USGS, 2011b, 2011d). The USGS Earthquake Hazard Program received 74 reports of the earthquake from persons in Dahlgren, Virginia, where the intensity was estimated as 5.6 on the Modified Mercalli Intensity scale, indicating that the earthquake was felt by nearly everyone and damage was minimal (USGS, 2010, 2011a). The August 23, 2011 earthquake was almost as strong as the strongest recorded earthquake in Virginia, a magnitude 5.9 earthquake that occurred in May 1897, in Giles County (USGS, 2006, 2011c).

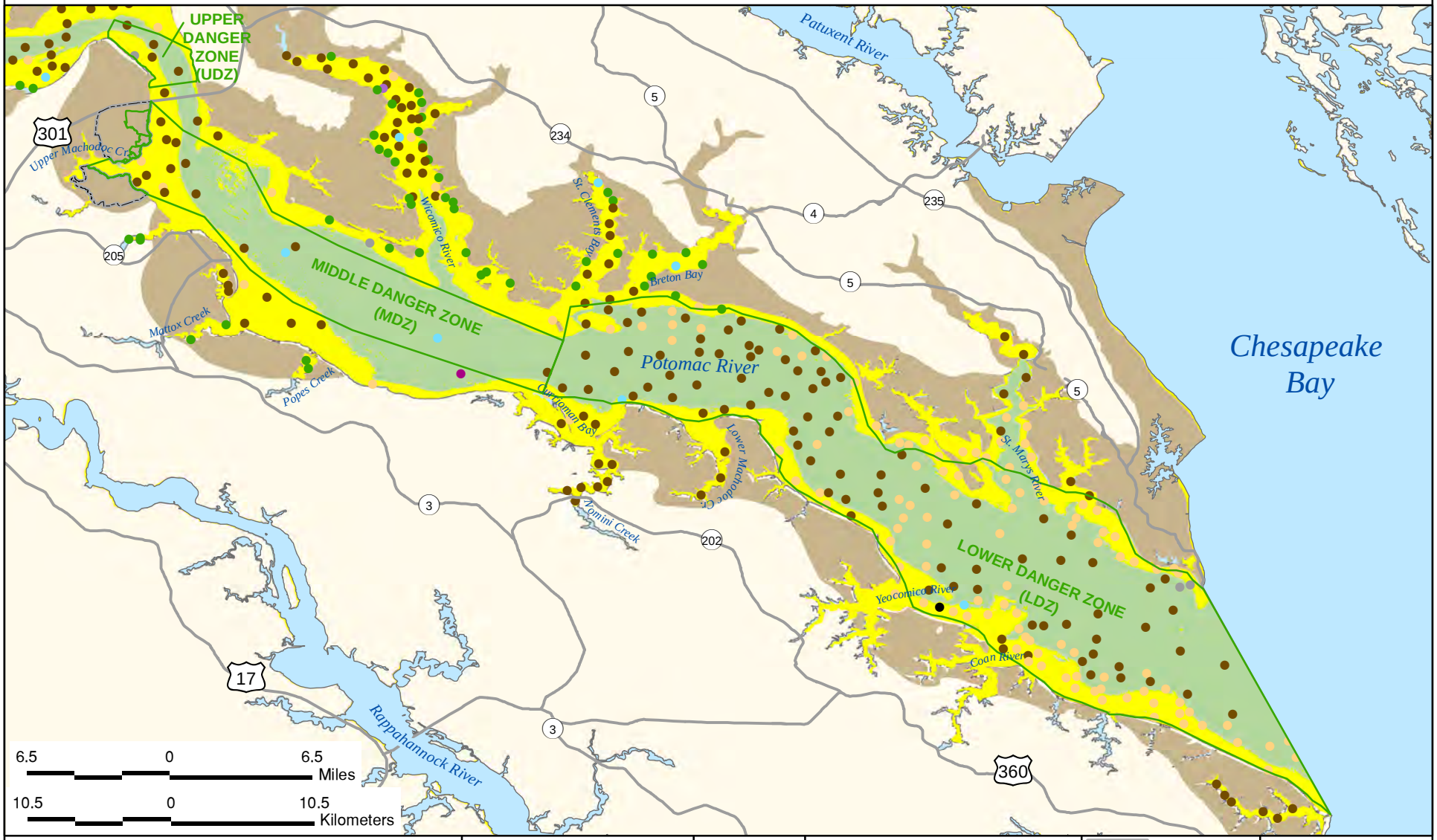
The 2011 earthquake occurred within the Central Virginia Seismic Zone, a previously recognized seismic zone (USGS, 2011b, d). The zone is laced with mapped geological faults, as well as numerous, undetected smaller or deeply-buried faults (Virginia Tech Seismological Observatory, 2011a). The Central Virginia Seismic Zone has produced small and moderate earthquakes since at least 1774 (USGS, 2006; Virginia Tech Seismological Observatory, 2011a). As of 2006, the largest known damaging earthquake in the zone occurred in 1875, with a magnitude of 4.8 (USGS, 2006).

The earthquake hazard in the United States has been estimated in a variety of ways. Chief among them is the production of risk maps. These maps were created to provide design values to assist engineers in designing buildings, bridges, highways, and utilities that will withstand shaking from earthquakes in the United States. Such maps also prove useful in establishing building codes and insurance rates in areas of high risk. These seismic risk maps are based either on relative risk or the probability of a certain seismic event at a particular time and place.

The USGS National Seismic Hazard Map is a risk map that shows the distribution of earthquake shaking levels that have a certain probability of occurring in the United States. Based on this seismic hazard map, NSF Dahlgren is located in a very low seismic hazard area – 2 to 4 percent probability – as compared to high seismic hazard areas – 32 percent or greater probability – such as California (USGS, 2002).

The Maryland Geological Survey (MGS) produced Maryland seismic hazard maps based on the USGS national database. Perhaps the most significant finding of Maryland's seismic hazard maps is the categorization of all but the northeastern corner of Maryland as a region of negligible seismicity, with very low probability of collapse of structure (MGS, 1998).

Sediments - PRTR



Clay | Mud | Sand
SAV | Oysters | Shells
Gravel | Rock /Rocky

Source: National Oceanic and Atmospheric Administration (NOAA) electronic navigational chart, 2007.

Silty Clay

Approximate Shoreward limit of "mud"

Source: Knebel et al., 1981

Figure 3.9-9

"Lowland Deposits" consisting of coarse (sandy) and fine (clayey or silty) sediments with cobbles and boulders.

Source: Draft Physiographic Map of Maryland, Maryland Geologic Survey (MGS), 2008.

NSF Dahlgren

Potomac River Test Range (PRTR) Complex

Source: NSWCDD GIS (08 -11); Danger Zones defined in CFR 33, Part 33.230.

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The seismic hazard map was widely used for many years, because it was the best risk map available. However, this type of risk map has certain drawbacks. For one thing, there is no justification for assuming that events larger than those observed historically will not occur in the future. It is also known that ground-motion attenuation – the dying out of the earthquake shock waves – with distance is far less in Virginia and Maryland than in the western states. In other words, an earthquake east of the Rocky Mountains affects an area about ten times as large as a West Coast earthquake of the same magnitude (USGS, 2006).

A more recent seismic risk assessment method is the probabilistic map. This map shows the expected maximum horizontal ground acceleration as a percentage of g (the acceleration due to gravity, or 32.2 ft/sec^2) in the United States. These ground accelerations, which are one measure of ground shaking, have a 2, 5, or 10 percent probability of being exceeded in 50 years. Structural damage in poorly-constructed buildings begins to occur at about 16-18 percent g in probabilistic assessment (USGS, 2006).

According to probabilistic ground motion mapping for peak ground acceleration, the NSF Dahlgren geographic area has a very low chance of experiencing a damaging earthquake within the next 50 years. A structure built on firm rock has 2 percent probability (1-in-50 odds) of undergoing ground shaking of between 5 and 10 percent g or higher in the next 50 years (USGS, 2008). By comparison, areas within the Central Virginia Seismic Zone, where the August 23, 2011 earthquake occurred, have a 2 percent probability of undergoing ground shaking of between 12 and 15 percent g or higher.

As these probabilities were calculated by the USGS for the 2008 National Seismic Hazard Maps update, seismic data from the 2011 magnitude 5.8 earthquake were not considered. The USGS currently is updating the National Seismic Hazard Maps for release in 2014 (Gade, pers. comm., November 14, 2011). The USGS will assess the data from the August 23, 2011 earthquake and will incorporate the resulting findings, as well as other new findings on earthquake ground shaking, faults, seismicity, and geodesy, in the 2014 update.

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3.10 Water Resources

3.10.1 Surface Water

Figure 3.10-1, Surface Water Resources – NSF Dahlgren, shows surface water resources on and in the vicinity of Dahlgren. Figure 3.10-2, Surface Water Resources - PRTR, shows the tributaries to the Potomac River in the vicinity of the PRTR. Major surface water features at NSF Dahlgren and the PRTR Complex include the Potomac River and Upper Machodoc Creek. In the vicinity of NSF Dahlgren and the PRTR, the Potomac River flows northwest to southeast from Mathias Point, Virginia to the river mouth. Upper Machodoc Creek flows west to east along the southern boundary of Mainside, dividing NSF Dahlgren into two areas, Mainside to the north and the EEA Complex on Pumpkin Neck to the south. NSF Dahlgren has approximately 4 mi of shoreline on the Potomac River and about 6 mi of shoreline on Upper Machodoc Creek (NSWCDD, 2001).

Gambo Creek flows from northwest to southeast through Mainside, dividing it into approximately equal tracts. On Pumpkin Neck, Black Marsh Creek flows from west to east across the southeastern portion of the EEA Complex. Small, unnamed tributaries to the Potomac River, Upper Machodoc Creek, and Gambo Creek flow through NSF Dahlgren as well. Several ponds are present on the installation, including Beaver Pond and Lespedeza Pond on Mainside. In addition, two manmade freshwater impoundments – Hideaway Pond and Cooling Pond – are located within Mainside.

Williams Creek and Deep Creek flow into Upper Machodoc Creek west of Mainside. On the Virginia side, several creeks and rivers – including Rosier Creek and Mattox Creek – flow into the Potomac River south of the NSF Dahlgren boundary, adjacent to the MDZ and LDZ. Across the river, on the Maryland side, the major tributaries to the Potomac River, east of the PRTR, are the Port Tobacco, Wicomico, and St. Marys Rivers. Two smaller tidal creeks – Piccowaxen Creek and Cuckold Creek – enter the Potomac River across from NSF Dahlgren.

3.10.1.1 Jurisdictions and Standards

From Washington, DC to the river mouth – including the vicinity of NSF Dahlgren and the PRTR – the State of Maryland has jurisdiction over the Potomac River to the low water mark of the shore on the right bank (the bank on the Virginia side) of the river. The river in the vicinity of the PRTR is designated as Use II waters under the Maryland Water Quality Regulations (Code of Maryland Regulations [COMAR] Title 26 Subtitle 08 Chapter 02 Regulation 02 [26.08.02.02]), indicating that it is suitable for support of estuarine and marine aquatic life and shellfish harvesting. On the Maryland side of the river in the vicinity of the PRTR, the tributaries to the Potomac River likewise are designated as Use II waters.

Maryland has various numeric criteria for the protection of aquatic life and human health that set the minimum water quality to meet the designated uses. Criteria are published for temperature, dissolved oxygen (DO), turbidity, bacteria, and toxics. The numeric criteria for Use II waters include the following:

- **Temperature**: The maximum temperature outside the mixing zone (the area contiguous to a discharge) may not exceed 90˚F or the ambient temperature of the surface waters, whichever is greater.
- **pH**: Normal pH values may not be less than 6.5 or greater than 8.5.

Under the Virginia Water Quality Standards (9 VAC 25-260), all state waters, including wetlands, are designated for the following uses:

- Recreational uses (e.g., swimming and boating)
- Propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them
- Wildlife
- Production of edible and marketable natural resources (e.g., fish and shellfish)

On the Virginia side of the Potomac River, in the vicinity of the PRTR, the tidal portions of tributaries to the river are designated Class II waters. The tidal tributaries that enter the Potomac River in the vicinity of the PRTR upstream from Buoy 33 near NSF Dahlgren – approximately 1.3 nautical miles (NM) downstream of the Harry Nice Bridge – are designated further as transition-zone waters. (Figure 3.10-2 shows the location of Buoy 33.) Those tributaries that enter the river downstream of Buoy 33 are designated estuarine waters. For the Chesapeake Bay and its tidal tributaries, including the Potomac River and its tributaries, Virginia requires that Class II waters meet a standard of pH 6.0 to 9.0.

Maryland and Virginia have adopted the five tidal-water designated uses – migratory fish spawning and nursery, shallow-water, open-water fish and shellfish, deep-water seasonal fish and shellfish, and deep-channel seasonal refuge – proposed by the Chesapeake Bay Program (CBP) for the Chesapeake Bay and its tidal tributaries (CBP, 2003). All five designated uses occur in portions of the Potomac River and its tidal tributaries in the vicinity of NSF Dahlgren and the PRTR. Table 3.10-1 summarizes the boundaries of the tidal-water designated uses and their vertical and horizontal extents in the vicinity of the PRTR.

The two states have adopted common numeric criteria for DO concentrations in the Chesapeake Bay and its tidal tributaries that are consistent with the DO criteria recommended by the CBP (COMAR 26.08.02.02, 9 VAC 25-260). Table 3.10-2 presents the DO criteria.

The designated uses for waterbodies are protected by the application of states' numerical and narrative water quality criteria. The Maryland Department of the Environment (MDE) and the Virginia Department of Environmental Quality (VDEQ) administer the Federal Water Pollution Control Act – commonly referred to as the Clean Water Act (CWA) – and implement regulatory and planning programs to reduce the input of pollutants to the waters of the states. The long-term goal of these programs, in part, is to ensure that all streams, rivers, and bays support their designated uses. The states establish total maximum daily loads (TMDLs) as a tool for achieving this goal and implementing state water quality standards.

Surface Water Resources - NSF Dahlgren

Potomac River Test Range (PRTR) Complex

Mission Area

Explosives Experimental Area (EEA) Complex

Naval Support Facility (NSF) Dahlgren

3,300 0 3,300 Feet

1,000 0 1,000 Meters

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Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 3.10-1

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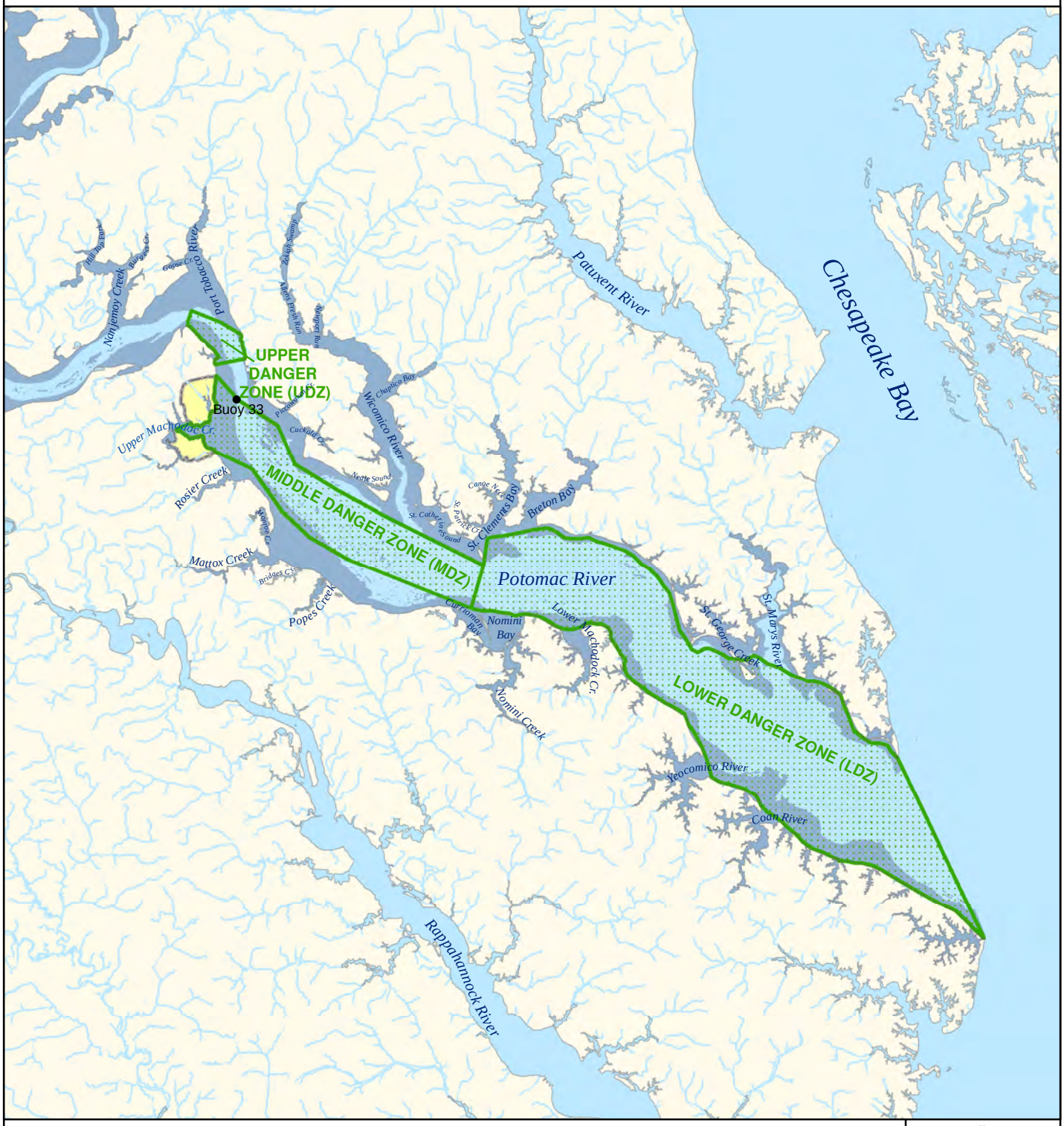
Surface Water Resources - PRTR



Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR)

Surface Water

Stream

8 0 8 Miles

13 0 13 Kilometers

Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 3.10-2

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Table 3.10-1
Boundaries and Extents of Tidal Water Designated Uses

Migratory Fish Spawning and Nursery Designated Use
Boundaries: The use extends horizontally from the intertidal zone (mean low water) across the body of water to the adjacent intertidal zone, and down through the water column to the bottom water-sediment interface. *Extent in the vicinity of the PRTR*: The Potomac River and its tidal tributaries upstream of and including the Wicomico River; and St. Clements Bay, Breton Bay, and St. Marys River.
Shallow-Water Bay Grass Designated Use
Boundaries: The use covers tidally-influenced waters from the intertidal zone to a CBP segment-specific depth contour. The use applies during the bay grass growing season: April 1 through October 31 for the Potomac River and its tributaries in the vicinity of the PRTR. *Extent in the vicinity of the PRTR*: The Potomac River and its tidal tributaries from the intertidal zone to the 3.3-ft depth contour in Nanjemoy Creek and the Port Tobacco River (upstream of the UDZ), the 6.6-ft contour upstream of the UDZ to approximately the middle of the UDZ, and the 1.6-ft contour from the middle of the UDZ to the mouth of the Potomac River.
Open-Water Fish and Shellfish Designated Use
Boundaries: From June 1 through September 30, the use includes tidally-influenced waters extending horizontally from the shoreline measured at mean low water, to the adjacent shoreline, and extending through the water column to the bottom water-sediment interface. If the presence of a pycnocline[1] prevents oxygen replenishment, the use extends only as far as the upper boundary of the pycnocline. From October 1 through May 31, the use includes all tidally-influenced waters extending horizontally from the shoreline, measured at mean low water, to the adjacent shoreline, and down into the water column to the bottom water-sediment interface. *Extent in the vicinity of the PRTR*: The Potomac River and its tidal tributaries.
Deep-Water Seasonal Fish and Shellfish Designated Use
Boundaries: Tidally-influenced waters located between the measured depths of the upper and lower boundaries of the pycnocline, where a measured pycnocline is present and presents a barrier to oxygen replenishment from June 1 through September 30. In some areas, the use extends from the upper boundary of the pycnocline down to the bottom water-sediment interface, where a lower boundary of the pycnocline is not calculated due to the depth of the water column. *Extent in the vicinity of the PRTR*: The Potomac River.
Deep-Channel Seasonal Refuge Designated Use
Boundaries: Tidally-influenced waters at depths greater than the measured lower boundary of the pycnocline in isolated deep channels. The use is defined laterally by bathymetry of the trough, and vertically by the lower boundary of the pycnocline above and the bottom water-sediment interface below. *Extent in the vicinity of the PRTR*: The Potomac River – notably, the waters of the lower Potomac River trench.
Note: 1. The pycnocline is the zone between waters with different densities; e.g., a zone separating shallow, fresher water from deep, more saline water. **Source:** Based on CBP, 2003; USEPA, 2004.

Table 3.10-2
Tidal Water Designated Uses Dissolved Oxygen (DO) Criteria

Designated Use	Criteria [1,2]	Temporal Application
Migratory Fish Spawning and Nursery [3]	▪ 7-day mean ≥6 milligrams per liter (mg/l) ▪ Instantaneous minimum ≥ 5 mg/l	February 1 to May 31
Shallow-Water Bay Grass	▪ 30-day mean ≥5.5 mg/l in low salinity (tidal fresh waters, salinity ≤0.5 ppt) ▪ 30-day mean ≥5 mg/l in high salinity (>0.5 ppt) ▪ 7-day mean ≥4 mg/l ▪ Instantaneous minimum ≥3.2 mg/l [4]	Year-round
Open-Water Fish and Shellfish	▪ 30-day mean ≥5.5 mg/l in low salinity (tidal fresh waters, salinity ≤0.5 ppt) ▪ 30-day mean ≥5 mg/l in high salinity (>0.5 ppt) ▪ 7-day mean ≥4 mg/l ▪ Instantaneous minimum ≥3.2 mg/l [4]	Year-round
Deep-Water Seasonal Fish and Shellfish [5]	▪ 30-day mean ≥3 mg/l ▪ 1-day mean ≥2.3 mg/l ▪ Instantaneous minimum ≥1.7 mg/l	June 1 to September 30
Deep-Channel Seasonal Refuge [5]	▪ Instantaneous minimum ≥1 mg/l	June 1 to September 30

Notes:
1. ≥ indicates greater than or equal to; > indicates greater than; ≤ indicates less than or equal to.
2. ppt indicates parts per thousand.
3. Open-water fish and shellfish criteria apply from June 1 to January 31.
4. At temperatures considered stressful to shortnose sturgeon (Acipenser brevirostrum) (>84 degree Fahrenheit [°F]), DO concentrations above an instantaneous minimum of 4.3 mg/l will protect survival of this listed sturgeon species.
5. Open-water fish and shellfish criteria apply from October 1 to May 31.

Source: CBP, 2003; COMAR 26.08.02.02; 9 VAC 25-260.

Section 303(d) of the CWA requires that states (as well as territories and authorized tribes) develop lists of impaired waters – waters that do not meet water quality standards, even after point sources of pollution have installed the minimum required levels of pollution control technology (USEPA, 2008b). The act requires that the states establish priority rankings for waters on the lists and develop TMDLs for these waters. Table 3.10-3 lists the TMDLs that Maryland and Virginia are developing for impaired waters of the Lower Potomac River and the creeks in the immediate vicinity of NSF Dahlgren.

A TMDL specifies the maximum amount of the pollutant that the waterbody can receive and still meet water quality standards, and allocates pollutant loadings among point and nonpoint pollutant sources (USEPA, 2011). The USEPA must approve or disapprove the TMDL.

3.10.1.2 Potomac River

Physical Characteristics

The Potomac River basin encompasses 14,670 sq mi in four states – West Virginia, Pennsylvania, Virginia, and Maryland – and the District of Columbia (Interstate Commission on the Potomac River Basin [ICPRB], 2007). Forests cover the majority (57.6 percent) of the basin land area, and agriculture, water and wetlands, and developed land cover 31.8, 5.0, and 4.8 percent of the land area, respectively (ICPRB, 2007).

Table 3.10-3
Lower Potomac River and NSF Dahlgren Vicinity Total Maximum Daily Loads (TMDLs)

Water	Cause for Listing
Maryland	
Oligohaline Lower Potomac River	▪ Total nitrogen ▪ Total phosphorus ▪ Total suspended solids
Mesohaline Lower Potomac River	▪ Total nitrogen ▪ Total phosphorus ▪ Total suspended solids
Virginia	
Deep Creek	▪ Dissolved oxygen ▪ Fecal coliform ▪ Aquatic plants (macrophytes)
Gambo Creek	▪ Dissolved oxygen ▪ Fecal coliform ▪ Aquatic plants (macrophytes)
Upper Machodoc Creek	▪ Dissolved oxygen ▪ Fecal coliform ▪ Enterococcus ▪ Polychlorinated biphenyls (PCBs) in fish tissue ▪ Aquatic plants (macrophytes)
Williams Creek	▪ Dissolved oxygen ▪ Fecal coliform ▪ pH ▪ Aquatic plants (macrophytes)
Note: Oligohaline indicates 0.5 to 5 ppt; mesohaline indicates 5.0 to 18 ppt. **Source:** MDE and Maryland Department of Natural Resources (MDNR), 2008; VDEQ and Virginia Department of Conservation and Recreation (VDCR), 2008.	

The Lower Potomac River basin drains 1,756 sq mi (Irani, pers. comm., October 14, 2011). Approximately 26 percent of the basin is open water and 10 percent is wetlands. The most extensive land use is forest, covering almost 38 percent of the basin, with agriculture covering 16 percent and urban land covering 4 percent (Irani, pers. comm., October 14, 2011). Impervious surfaces account for over 4 percent of the land area in the Lower Potomac River basin (Irani, pers. comm., October 14, 2011).

The Potomac River flows over 383 mi from Fairfax Stone, West Virginia to the river mouth at Point Lookout, Maryland (ICPRB, 2007). The length of the tidal reach of the river is 114 mi (Landwehr et al., 1999). The Potomac River flows into the Chesapeake Bay about 43 NM south of NSF Dahlgren. Within the PRTR portion of the Potomac River, the river ranges in width from approximately 1.2 NM at a narrow section within the PRTR Upper Danger Zone to more than 6 NM at the river's mouth.

The bathymetry of the PRTR portion of the Potomac River is illustrated in Figure 3.10-3, PRTR Bathymetry. The lower Potomac River trench extends from Ragged Point to the mouth of the river (USEPA, 2003). The depth of the trench averages from 49 to 82 ft and a 33- to 49-ft-deep shelf extends from the sides of the trench (USEPA, 2003). There is no sill across the mouth of the Potomac River.

The PRTR portion of the Potomac River is tidal and it is an estuary – i.e., a partially enclosed body of water that has a free connection to the open sea and where saltwater from the sea mixes with freshwater from rivers, streams, and creeks (National Oceanic and Atmospheric Administration [NOAA], 2011a). This portion of the Potomac River exhibits features that are characteristic of a partially mixed estuary – specifically, strong tidal currents, moderate vertical stratification, and considerable longitudinal variation in salinity (Wilson, 1977). Moderate vertical stratification is characterized by the occurrence of two basic water layers – a less-saline, upper water provided by the river, and a deeper marine water – separated by a zone of mixing (Thurman, 1994). Within the PRTR, the mean salinity of the Potomac ranges from approximately 4 to 8 parts per thousand (ppt) in the vicinity of NSF Dahlgren, between the UDZ and the MDZ, to approximately 11 to 16 ppt around the downstream end of the LDZ, near the mouth of the Potomac (based on Maryland Department of Natural Resources [MDNR], 2010).

Tidal-height data obtained from temporary tide gauges established between NSF Dahlgren and Lewisetta, Virginia, encompassing both the MDZ and the LDZ, indicate that the PRTR portion of the Potomac River has a semidiurnal tide period of 12.4 hours (Wilson, 1977). According to Wilson (1977), the tidal range decreases from about 2.17 ft at Dahlgren, Virginia to about 1.57 ft at Lewisetta, and the high tide at Dahlgren occurs approximately 1.8 hours after that at Lewisetta. A permanent tide gauge (NOAA Station 8635750) was installed in July 1990 in Lewisetta (Figure 3.10-4, Water Quality and Benthic Monitoring Stations). The mean tidal range at the Lewisetta station is 1.24 ft and the diurnal range is 1.50 ft (NOAA, 2011b).

Mean tidal range is the difference in height between mean high water and mean low water. Mean high water is the average of all the high-water heights and mean low water is the average of all the low-water heights observed over a 19-year period.

Diurnal range, or great diurnal range, is the difference in height between mean higher high water and mean lower low water. Higher high water is the higher of two high waters and lower low water is the lower of two low waters occurring during a tidal day. The mean higher high water is the average of the higher high water heights observed over a 19-year period. The mean lower low water is the average of the lower low water heights observed over a 19-year period.

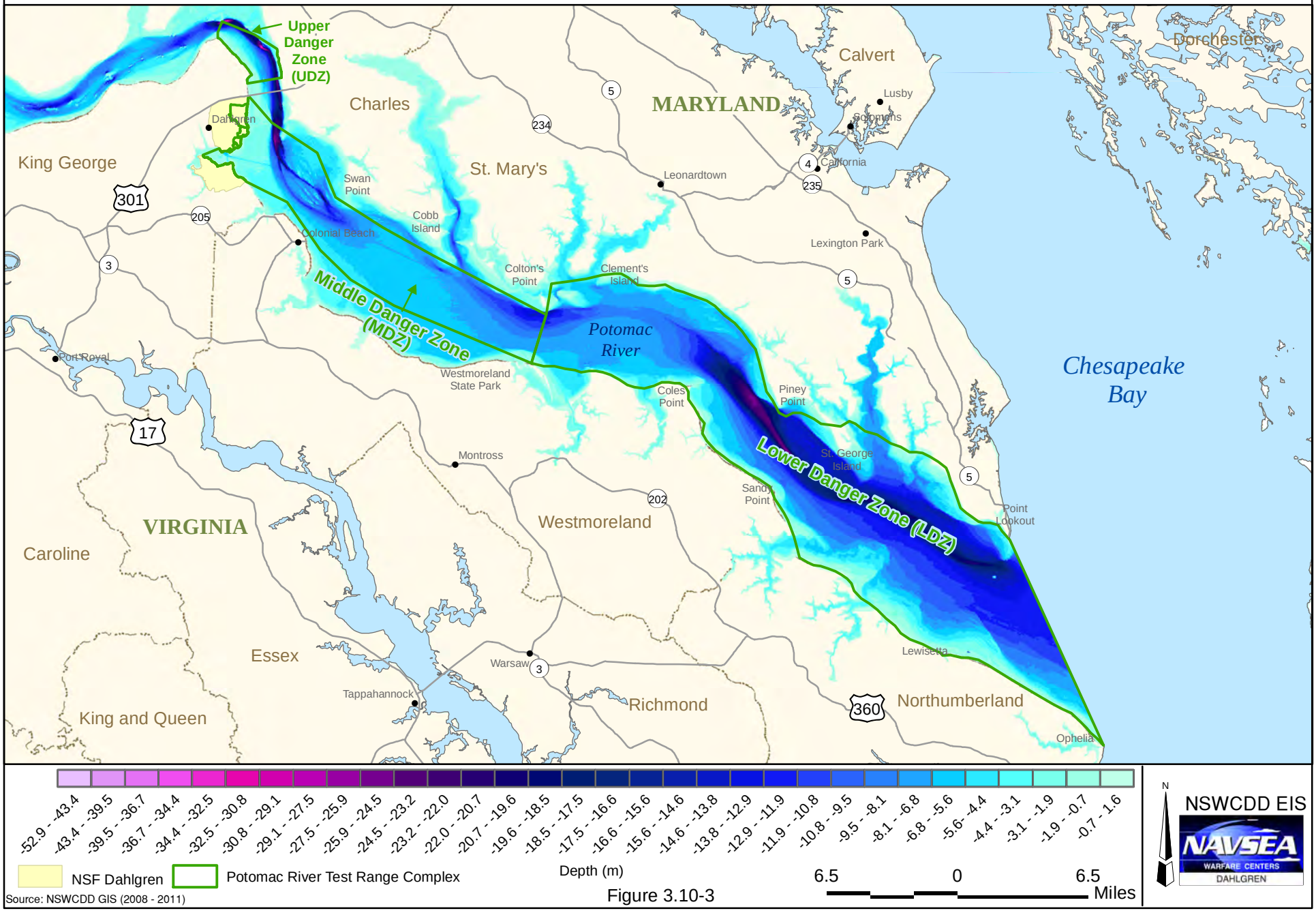
Source: Based on Thurman, 1994; NOAA, 2000.

Because of the constriction in the Potomac River channel cross section upstream of NSF Dahlgren at the Nice Bridge (between the UDZ and the MDZ), current velocities there are higher than downstream (Wilson, 1977). Current phases at Dahlgren lag those near Lewisetta by 1.5 to 2 hours (Wilson, 1977). In the vicinity of the MDZ, the river makes a bend to the south and widens considerably. As this occurs, the water velocity decreases drastically.

Water Quality

The MDNR has routinely sampled water quality year round in the Chesapeake Bay and the Potomac River (as well as other tidal tributaries to the Chesapeake) since 1985 (MDNR, 2010). Five MDNR monitoring stations are located in the vicinity of NSF Dahlgren and the PRTR, as shown on Figure 3.10-4. The MDNR collects data 12 to 20 times a year at the four Potomac River stations (RET2.2, RET2.4, LE2.2, and LE2.3) and 16 times a year at Station CB5.3 in the Chesapeake Bay, near the mouth of the Potomac.

PRTR Bathymetry



Source: NSWCDD GIS (2008 - 2011)

Figure 3.10-3

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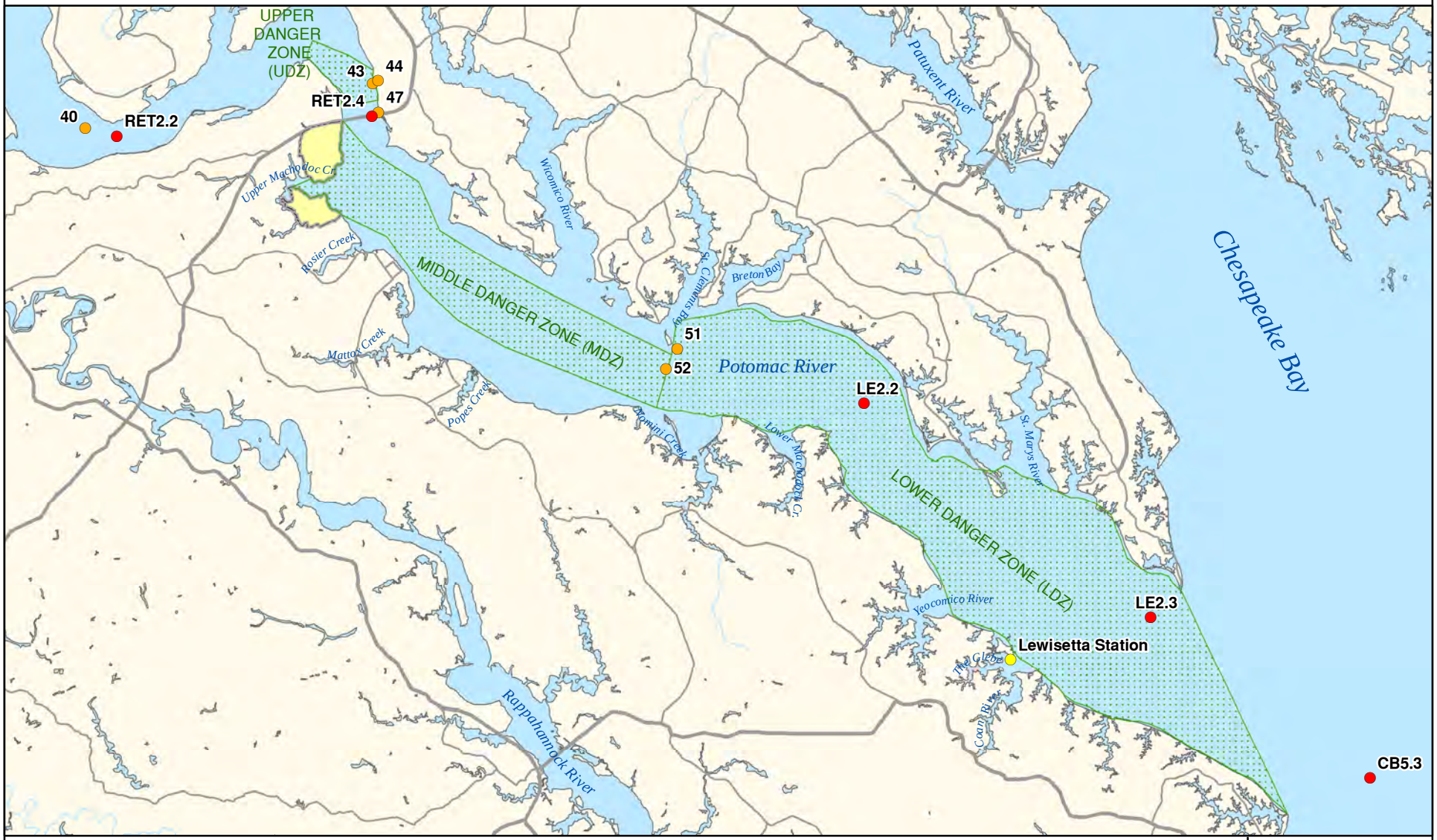
Water Quality and Benthic Monitoring Stations



Lewisetta, VA Station – NOAA Station 8635750

Maryland Department of Natural Resources (MDNR) Fixed Water Quality Monitoring Station

MDNR Fixed Benthic Monitoring Sites

Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR) Complex

Surface Water

6.5 0 6.5 Miles

10.5 0 10.5 Kilometers

N

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Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 3.10-4

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Salinity

Figure 3.10-5, Potomac River Salinity Levels (1985-2006), depicts surface water salinity levels in the Lower Potomac River. The figure shows the seasonal average salinity levels for the spring and the fall, based on monthly average salinities at the MDNR monitoring stations. Table 3.10-4 shows the monthly surface water salinity at the MDNR stations.

Salinity Modifier	Salinity Range (ppt)
Hyperhaline	greater than 40
Euhaline	30.0 to 40
Mixohaline (Brackish)	0.5 to 30
Polyhaline	18.0 to 30
Mesohaline	5.0 to 18
Oligohaline	0.5 to 5
Fresh	less than 0.5

Source: Cowardin et al., 1979.

At all five stations, the mean salinity for each month is within the mixohaline or brackish range – between 0.5 and 30 ppt. Salinity levels increase in a downstream direction. At Station RET2.2, 8 NM upstream of the PRTR, mean salinities for each month are within the oligohaline range – 0.5 to 5 ppt. Between the UDZ and the MDZ, salinities vary between the oligohaline range and the mesohaline range – 5.0 to 18 ppt. In the LDZ and in the Chesapeake Bay, near the mouth of the Potomac River, mean salinities are within the mesohaline range.

Table 3.10-4
Surface Water Salinity (ppt)

Station ID		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RET2.2	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean	2.76	2.64	1.52	0.96	0.92	1.55	3.04	3.75	3.88	4.04	3.68	3.31
	Max	7.43	8.50	6.81	3.99	4.09	3.70	6.34	8.21	6.49	7.46	7.81	7.81
RET2.4	Min	0.00	0.32	0.00	0.04	0.34	0.49	1.98	2.37	1.09	2.74	1.51	0.26
	Mean	6.97	6.56	4.66	3.82	3.65	4.84	6.84	7.61	7.96	8.36	8.05	7.52
	Max	13.33	13.99	8.76	10.98	7.71	8.32	10.11	11.57	11.41	11.44	13.06	13.39
LE2.2	Min	5.10	4.00	2.98	3.36	3.10	4.20	7.26	6.11	7.12	7.01	7.26	5.02
	Mean	12.23	11.10	9.45	8.60	7.82	8.58	10.48	11.75	12.91	13.30	13.23	13.08
	Max	18.26	18.55	18.28	16.66	12.47	12.63	13.83	15.07	16.41	16.46	17.04	18.07
LE2.3	Min	7.74	9.40	7.18	6.71	6.06	7.30	9.11	9.28	10.37	7.87	9.59	8.25
	Mean	14.07	14.43	12.75	11.30	10.80	11.08	12.71	14.00	14.91	16.08	15.68	15.49
	Max	18.90	20.29	19.73	16.06	15.34	14.59	15.81	17.11	17.38	19.52	19.04	20.08
CB5.3	Min	7.81	8.89	8.73	7.34	7.50	8.12	10.04	10.47	11.87	11.02	10.95	9.91
	Mean	15.02	15.29	13.56	12.62	12.16	12.79	13.60	15.06	15.93	17.17	16.57	16.67
	Max	19.87	21.27	20.08	17.79	16.02	16.26	16.69	18.48	18.41	21.48	20.57	20.85

Notes: 1. Salinities are in parts per thousand (ppt).
2. Period of record is 1985 to 2009.
3. Min indicates minimum; Max indicates maximum.

Source: Based on MDNR, 2010.

At all five stations, salinity levels are seasonal, varying through the year depending on rainfall, and freshwater runoff and river flows. The relationship between river flows and salinity is strongest at the most upstream station – RET2.2 – and weakens downstream. The highest mean salinity levels occur in October. During the 1985 to 2009 period of record, polyhaline (18.0 to 30 ppt) water was recorded from October through March at Station LE2.3 in the LDZ, and from August through March in the Chesapeake Bay. Salinity levels decline from February through May, when snowmelt and increased

seasonal rainfall produce elevated freshwater discharges from streams and groundwater. The lowest mean salinity levels occur in May. Between the UDZ and the MDZ (at Station RET2.4), fresh water was recorded during the months of December through June, as evidenced by minimum salinities within the 0 to 0.5 ppt range. Salinity levels increase from the spring through the summer, when river flows are lowest.

Temperature

Table 3.10-5 shows the monthly surface water temperature at the monitoring stations. Temperatures are typically similar across the five monitoring stations, with only a 0.4- to 3.1-degree Fahrenheit (˚F) range of variation in monthly mean temperatures between the warmest station and the coolest station. The largest temperature variations between upstream and downstream stations occur from March through June, when the upstream stations are warmer, and from October to December, when the upstream stations are cooler. The mean temperatures at the five monitoring stations are most similar in September.

Table 3.10-5
Surface Water Temperature (˚F)

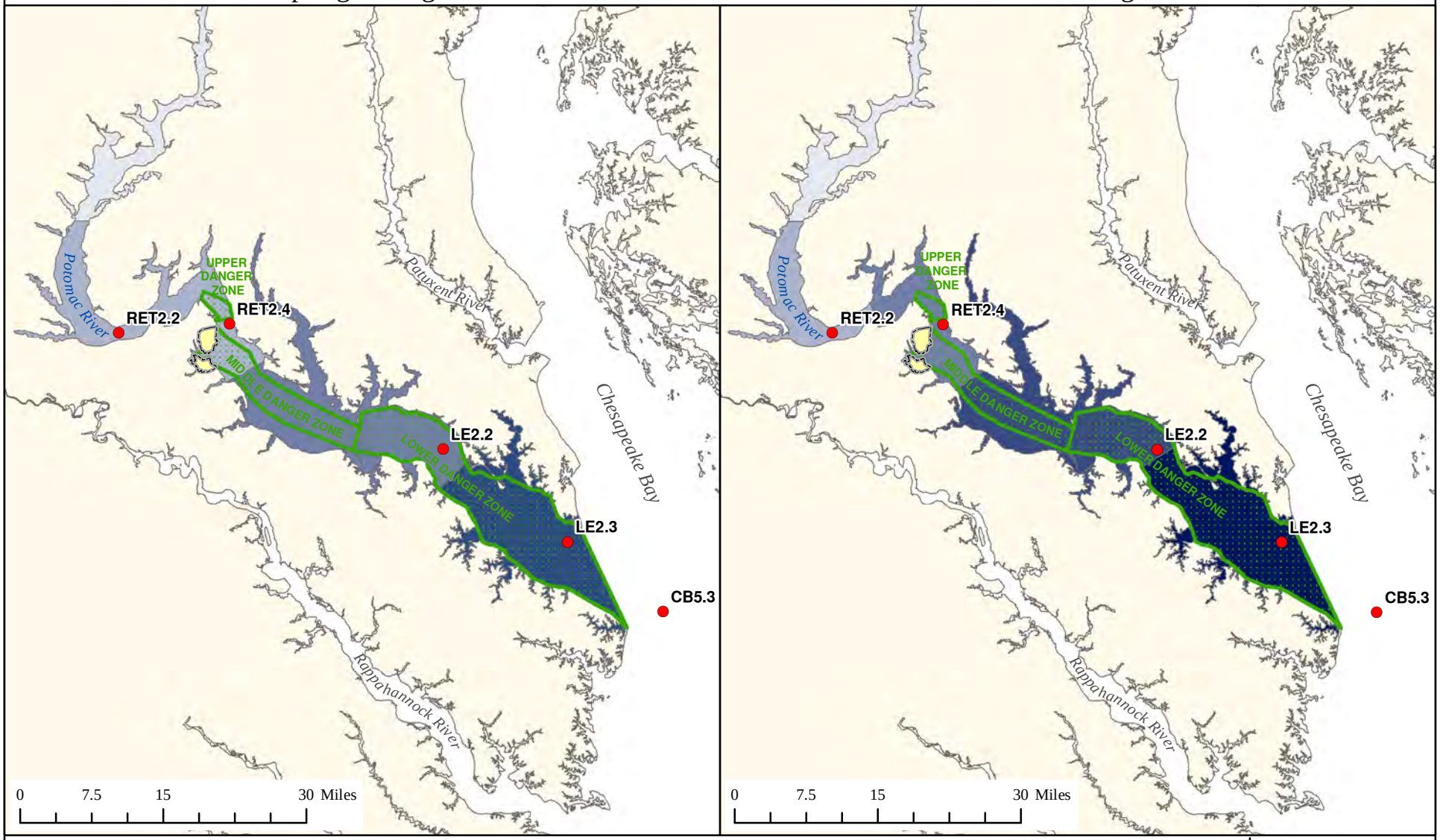
Station ID		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RET2.2	Min	33.62	33.62	37.04	50.81	60.44	68.90	79.16	77.99	71.69	57.02	46.40	37.22
	Mean	38.34	38.51	44.87	55.53	65.74	75.84	81.29	80.97	75.59	63.94	53.28	44.13
	Max	46.58	43.52	50.90	61.16	72.32	80.06	84.11	85.10	79.25	71.60	59.36	53.42
RET2.4	Min	34.70	33.44	36.50	48.56	60.71	67.64	78.26	77.72	72.86	57.20	47.84	39.02
	Mean	38.94	38.30	44.01	54.50	65.00	74.62	80.50	80.89	75.83	64.62	54.33	45.09
	Max	46.40	42.44	49.73	59.45	71.24	78.89	83.21	84.92	79.07	72.05	60.26	53.78
LE2.2	Min	35.06	35.96	36.86	50.54	60.71	68.18	77.18	76.46	72.41	60.35	48.74	39.02
	Mean	40.23	39.47	44.41	54.43	64.60	74.93	79.96	79.82	75.47	64.67	54.67	45.72
	Max	48.02	43.52	50.54	59.45	71.06	78.89	82.94	83.93	78.80	70.61	61.88	53.96
LE2.3	Min	33.98	31.82	36.32	49.37	59.18	64.76	77.18	77.54	71.24	60.26	50.90	40.64
	Mean	39.78	37.72	42.89	53.16	63.63	73.64	79.70	80.05	75.63	66.65	55.64	46.91
	Max	45.86	42.44	47.12	57.38	69.80	78.80	81.95	83.48	81.32	71.78	60.62	54.32
CB5.3	Min	34.34	31.46	36.68	49.46	58.64	63.32	77.27	76.82	71.60	61.34	50.90	40.64
	Mean	39.97	37.86	42.74	52.62	63.08	73.21	79.49	79.73	75.76	66.48	55.53	47.18
	Max	46.58	42.80	46.22	56.30	68.54	78.53	81.77	83.30	81.14	70.16	59.54	54.50

Notes: 1. Temperatures are in degrees Fahrenheit (˚F).
2. Period of record is 1985 to 2009.
3. Min indicates minimum; Max indicates maximum.
Source: Based on MDNR, 2010.

Over the year, the lowest mean temperatures occur in January and February and the highest mean temperatures occur in July and August. Station RET2.2 has the largest annual range between the minimum and maximum mean monthly temperatures – 43.0˚F. Station LE2.2 has the smallest annual variation in mean monthly temperatures, with a range of 40.5˚F. The low range in annual mean temperatures at LE2.2 results from comparatively high mean temperatures in January and February. Station LE2.2 is the warmest station in January, when downstream Stations CB5.3 and LE2.3 are the second and third warmest, respectively. Station LE2.2 also is the warmest station in February, when upstream Stations RET2.2 and RET2.4 are the second and third warmest.

Potomac River Salinity Levels (1985-2006)

Spring Average | Fall Average



MDNR Fixed Water Quality Monitoring Station

Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR)

Tidal Fresh < 0.5 parts per thousand (ppt)

Oligohaline 0.5 to 5.0 ppt

Low Mesohaline 5.0 to 9.3 ppt

Medium Mesohaline 9.3 to 13.7 ppt

High Mesohaline 13.7 to 18 ppt

Source: NSWCDD GIS (2008 - 2011); Based on Landwehr et al., 1999 and Maryland Department of Natural Resources (MDNR), 2007a.

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Figure 3.10-5

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The high mean temperatures at Station LE2.2 in January and February may result from discharges from the Morgantown Generating Station – located across the Potomac River from NSF Dahlgren – of water that is warmer than the receiving river water during the winter. The generating station uses a once-through cooling system, circulating on average 1.0 million gallons of river water per minute (Mirant Mid-Atlantic, LLC, 2006). The system employs a 1,833-ft-long discharge canal to cool water from the condenser and mix the discharge with river water (Maryland Power Plant Research Program, 2001).

Dissolved Oxygen

Table 3.10-6 shows the monthly bottom-water DO concentrations – i.e., the amount of oxygen dissolved in the water – at the MDNR monitoring stations. During all 12 months of the year except one, the highest mean DO concentrations occur at Station RET2.2, upstream of the PRTR. The highest mean DO concentration in March occurs at Station LE2.3 – in the LDZ near the mouth of the Potomac River – with Stations RET2.2 and LE2.2 having the second highest concentrations. From November through February, mean DO concentrations generally decrease in a downstream direction, with the highest concentrations at Station RET2.2 and the lowest concentrations at Station CB5.3 in the Chesapeake Bay. During the five-month period between May and September, however, the lowest mean DO concentrations occur in the LDZ at Stations LE2.2 and LE2.3.

Table 3.10-6
Bottom Water Dissolved Oxygen (mg/l)

Station ID		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RET2.2	Min	10.00	9.90	7.25	7.35	5.45	3.30	3.55	4.25	4.60	5.25	7.40	8.60
	Mean	11.46	12.23	10.53	8.97	7.25	5.63	5.50	5.63	6.23	7.20	9.14	10.33
	Max	13.20	14.10	12.60	10.05	8.55	9.10	7.55	7.90	7.15	8.65	10.60	12.70
RET2.4	Min	7.80	7.60	6.10	4.85	1.95	0.35	1.70	1.45	2.02	4.25	4.97	7.50
	Mean	10.93	11.09	9.64	7.72	4.73	2.57	2.68	3.29	4.84	6.24	8.19	9.57
	Max	12.70	14.30	12.00	9.80	7.15	3.85	4.75	4.75	6.50	7.90	10.30	12.20
LE2.2	Min	8.60	8.80	8.10	4.40	0.09	0.05	0.05	0.00	0.03	2.55	5.00	6.90
	Mean	10.27	11.12	10.54	7.22	3.13	0.75	0.47	0.72	2.50	5.35	7.72	9.08
	Max	14.00	16.10	12.85	9.55	7.30	2.60	2.90	3.45	6.20	7.45	9.60	10.80
LE2.3	Min	8.90	9.00	8.10	5.45	0.90	0.10	0.07	0.08	0.10	2.60	5.80	7.80
	Mean	10.34	10.86	10.66	8.05	3.99	1.46	0.37	0.79	3.22	5.89	7.88	9.42
	Max	11.70	12.14	12.50	11.40	6.85	7.30	1.33	3.31	6.13	8.20	9.50	11.50
CB5.3	Min	8.10	9.20	8.60	4.80	2.15	0.90	0.25	0.50	0.50	3.10	4.70	6.50
	Mean	9.78	10.53	9.98	7.57	4.74	2.61	1.12	1.63	3.48	5.54	7.27	8.65
	Max	11.10	11.80	11.50	9.55	6.82	6.10	2.20	2.90	5.70	7.90	8.90	10.50

Notes: 1. Dissolved oxygen concentrations are in milligrams per liter (mg/l).
2. Period of record is 1985 to 2009.
3. Min indicates minimum; Max indicates maximum.
Source: Based on MDNR, 2010.

The mean DO concentrations for the months from May through September and for the two monitoring stations in the LDZ are more variable than the concentrations for the remaining months of the year and for the other stations. From May through September, there is a 3.7- to 5.1-mg/l range of variation in monthly mean DO concentrations between the station with the highest concentration and the station with the lowest concentration. From October through April

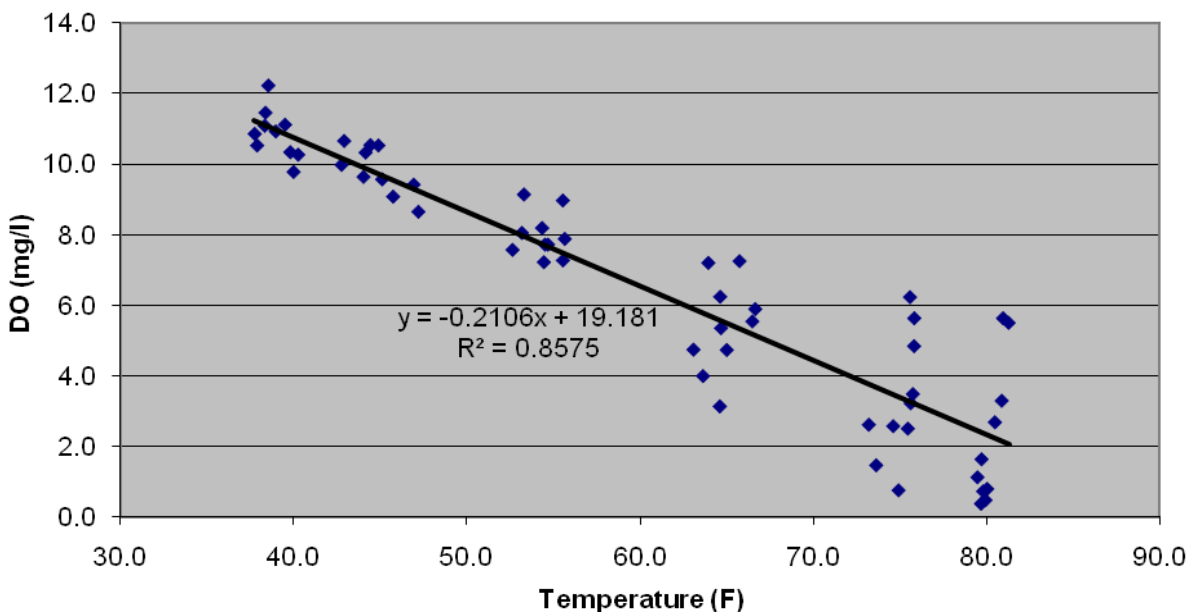
the ranges of variation are lower, with values between 1.0 and 1.9 mg/l. Over the course of a year, the ranges of variation for Stations LE2.2 and LE2.3 are 10.7 and 10.5 mg/l, respectively; whereas for the other stations the ranges of variation are between 6.7 and 9.4 mg/l.

DO concentrations are influenced by temperature and salinity, as the solubility of oxygen in water decreases with increasing temperature and salinity (NOAA, 2011a). Over the year, the highest mean DO concentrations in the vicinity of the PRTR occur in February, the month with the lowest mean surface water temperatures at four of the five stations. At Station RET2.2 the lowest mean surface water temperature occurs one month earlier, in January. The lowest mean DO concentrations occur in July (with the exception of Station RET2.4 which has its lowest mean DO occurring in June), and the highest mean surface water temperatures occurring in July and August.

Analysis of the surface water temperature and bottom water DO data for the five monitoring stations in the vicinity of the PRTR indicated a high correlation ($r^2 = 0.8575$) between the two parameters, as shown in Figure 3.10-6 (Temperature-DO Scatter-plot Diagram). The correlation is strongest at lower surface water temperatures (indicated by the clustering of data points) and weaker at higher temperatures. A similar analysis of surface water salinity and DO concentrations indicated a negligible correlation ($r^2 = 0.0293$) between these parameters[7].

> **r^2** is the square of the Pearson product-moment correlation coefficient. The r^2 value can be interpreted as the proportion of the variance in y attributable to the variance in x.

Figure 3.10-6
Temperature-DO Scatter-plot Diagram



[7] The 'high' and 'negligible' degrees of correlation are based on Table 6.3 in Schmidt, Marty J., 1975, *Understanding and Using Statistics: Basic Concepts*.

From May through September, the mean monthly DO concentrations for Stations RET2.4, LE2.2, LE2.3, and CB5.3 are all below 5 mg/l, with only Station RET2.2 maintaining mean monthly concentrations above this threshold. DO concentrations below 5 mg/l can stress some aquatic organisms in the river, such as some fish species, especially if exposed to these conditions for prolonged periods (MDNR, 2010). Although some bottom-dwelling organisms, such as worms, can survive at DO concentrations as low as 1 mg/l, many organisms will not survive exposure to concentrations below 1 mg/l for more than a few hours (MDNR, 2010). The June mean DO concentration for Station LE2.2 is below the 1-mg/l threshold, as are the July and August mean concentrations for both Station LE2.2 and Station LE2.3.

It is likely that low DO conditions are a natural feature of the lower Potomac River trench (USEPA, 2003), which extends from near Station LE2.2 to the mouth of the river, near Station LE2.3. The Potomac River trench is not connected to the mainstem Chesapeake Bay trench. Strong water-column stratification effectively isolates the trench waters from the surface waters, preventing the mixing of surface and bottom waters. Given the large size of the Potomac River basin, large amounts of organic matter potentially are transported from upriver to the waters of the trench. Decomposition of this organic matter could depress oxygen levels that are not readily replenished due to the presence of a pycnocline (the zone between waters with different densities). The high mean DO concentration in the LDZ, at Stations LE2.2 and LE2.3, in March – the month with the highest freshwater discharges – may result from high river flows rejuvenating the below-pycnocline waters of the Potomac River trench.

Turbidity

Water turbidity is a state of reduced clarity of the water caused by the presence of suspended matter. The greater the amount of total suspended solids (TSS) in the water, the higher the turbidity and the less light penetrates through the water. Increased turbidity can lead to reduced growth of submerged aquatic vegetation (SAV), reduced fish health, and, typically in association with dredging operations, burial of benthic organisms.

Excessive algal growth, runoff, shoreline erosion, pollution, resuspension of bottom sediments, and the mixing of fresh and salt water can increase turbidity. River discharge and turbidity data for the five monitoring stations in the vicinity of the PRTR were analyzed to determine the relationship between the two parameters in the Lower Potomac River. As river discharge data for the Potomac River were not available for a gage in the vicinity of the PRTR, data from the United States Geological Survey (USGS) monitoring station near Washington, DC (Station 01646502) were used in the analysis. The analysis indicated high correlation between discharge and turbidity for Station RET2.2 ($r^2 = 0.6966$) and moderate to high correlation for Station RET2.4 ($r^2 = 0.5422$); whereas, the analysis indicated negligible correlations between the two parameters for the three downstream stations – LE2.2, LE2.3, and CB5.3.

Secchi depth is measured using a Secchi disk, a circular plate that is divided into quarters, painted alternately black and white. The disk is lowered into the water and the Secchi depth, the depth at which the disk is no longer visible, is recorded. Low Secchi depth indicates high turbidity.

Table 3.10-7 shows the monthly turbidity – measured as Secchi depth – of the water at the MDNR monitoring stations. Throughout the year, mean water turbidity generally decreases in a downstream direction, with the highest turbidity (or lowest clarity) at Station RET2.2, and the lowest turbidity at Stations LE2.3 and CB5.3.

Table 3.10-7
Water Clarity or Turbidity (Secchi Depth) (m)

Station ID		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RET2.2	Min	0.10	0.20	0.20	0.25	0.25	0.35	0.35	0.45	0.15	0.30	0.05	0.10
	Mean	0.43	0.53	0.43	0.40	0.42	0.53	0.65	0.66	0.74	0.76	0.59	0.49
	Max	0.80	1.20	0.70	0.65	0.60	0.85	0.95	1.05	1.10	1.40	1.80	0.90
RET2.4	Min	0.10	0.30	0.30	0.20	0.40	0.35	0.50	0.60	0.35	0.50	0.21	0.20
	Mean	0.69	0.74	0.60	0.47	0.57	0.65	0.77	0.84	0.93	1.08	1.06	0.79
	Max	1.50	1.30	1.00	0.85	0.80	1.15	1.15	1.10	1.35	1.70	2.60	1.20
LE2.2	Min	1.00	0.70	0.70	0.40	0.35	0.60	0.70	0.95	0.95	0.95	1.10	0.50
	Mean	1.54	1.58	1.32	1.02	1.07	1.11	1.25	1.33	1.33	1.58	1.70	1.47
	Max	2.60	3.40	2.30	1.80	2.70	1.95	2.00	1.70	1.70	2.10	3.40	2.80
LE2.3	Min	1.10	1.40	1.10	0.85	1.00	1.00	0.85	1.20	1.00	1.30	1.30	1.10
	Mean	2.00	2.08	1.84	1.54	1.66	1.45	1.44	1.62	1.68	1.89	2.18	2.24
	Max	2.80	3.10	3.00	2.40	2.90	2.20	1.85	2.30	2.30	2.50	3.80	6.00
CB5.3	Min	1.50	1.00	0.80	0.70	1.00	0.85	0.90	1.20	1.30	1.00	1.20	1.20
	Mean	2.05	2.00	1.80	1.64	1.63	1.45	1.48	1.68	1.76	1.82	2.17	2.14
	Max	3.00	3.20	2.70	2.75	2.95	2.30	2.10	2.60	2.70	2.50	3.80	3.80

Notes: 1. As a measure of water clarity or turbidity, Secchi depths are in m.
2. Period of record is 1985 to 2009.
3. Min indicates minimum; Max indicates maximum.
Source: Based on MDNR, 2010.

At all five stations, turbidity is seasonal. The highest mean turbidity levels occur in April for the three upstream stations and in June or July for the downstream stations. For Stations RET2.2 and RET2.4, the lowest turbidity levels occur in October; whereas for the three stations downstream of RET2.4, the lowest turbidity levels occur in November or December.

pH – potential of hydrogen – is a measure of the acidity or alkalinity of a solution. The pH scale ranges from 0 to 14. A pH of 7 is neutral; below 7 is acidic and above 7 is alkaline or basic. The pH of water determines the amount that can be dissolved in the water (solubility) and the amount that can be utilized by aquatic life (biological availability) of chemical constituents, such as nutrients and heavy metals.

Buffering capacity is the ability of a solution to resist changes in pH. As a result of buffering, the pH in an estuary tends to remain fairly constant because the chemical components of seawater resist large changes in pH.

pH

Table 3.10-8 shows the monthly surface water pH at the monitoring stations. pH is variable across the five monitoring stations, with a 0.29 to 0.89 range of variation in monthly mean pH between stations. The largest variations between upstream and downstream stations occur in the spring and summer. The mean pH values at the five monitoring stations are most similar during the winter.

In the vicinity of the PRTR, pH generally increases in a downstream direction, as shown by Figure 3.10-7 (Mean Surface Water pH). Throughout the year, pH at the two upstream stations (RET2.2 and RET2.4) tends to be lower than that at the three downstream stations (LE2.2, LE2.3, and CB5.3). Counter to this tendency toward increasing pH downstream, Station LE2.2, in the upper portion of the LDZ, has the highest mean pH for eight months through the year. The annual range of variation of pH at the stations generally decreases in a downstream direction, likely as a result of buffering by seawater. However, Station RET2.4, between the UDZ and the MDZ, has the largest annual range of

variation. The high mean monthly pH values for Station LE2.2 and the large range of variation at Station RET2.4 may result from discharges from the Morgantown Generating Station.

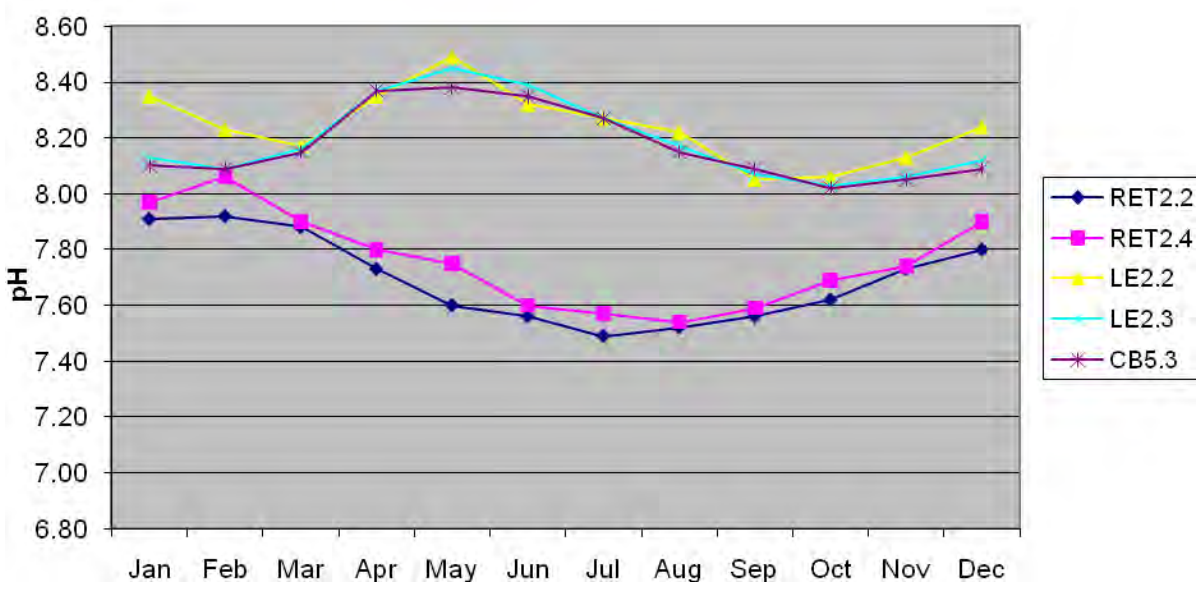
Table 3.10-8
Surface Water pH

Station ID		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RET2.2	Min	7.40	7.50	7.60	7.45	7.05	6.95	7.10	7.07	6.80	6.90	6.80	6.90
	Mean	7.91	7.92	7.88	7.73	7.60	7.56	7.49	7.52	7.56	7.62	7.73	7.80
	Max	8.30	8.30	8.35	8.05	7.90	8.00	7.70	8.30	8.60	7.90	8.20	8.20
RET2.4	Min	7.60	7.70	7.50	7.40	7.30	7.40	7.15	7.20	7.15	7.45	7.00	6.90
	Mean	7.97	8.06	7.90	7.80	7.75	7.60	7.57	7.54	7.59	7.69	7.74	7.90
	Max	8.40	8.50	8.40	8.30	8.20	7.85	7.75	7.95	7.90	7.95	8.10	8.40
LE2.2	Min	7.80	7.80	7.65	7.55	8.05	8.05	7.75	7.80	7.60	7.60	7.60	7.80
	Mean	8.35	8.23	8.17	8.35	8.49	8.32	8.27	8.22	8.05	8.06	8.13	8.24
	Max	9.40	8.70	8.85	9.00	9.00	8.60	8.65	8.75	8.35	8.45	8.60	8.70
LE2.3	Min	7.71	7.50	7.79	7.95	8.10	7.95	8.05	7.66	7.71	7.90	7.69	7.80
	Mean	8.13	8.09	8.16	8.37	8.45	8.39	8.27	8.17	8.07	8.03	8.06	8.12
	Max	8.70	8.40	8.44	8.84	8.80	8.60	8.45	8.60	8.30	8.50	8.30	8.40
CB5.3	Min	7.67	7.50	7.79	7.90	7.95	7.97	8.01	7.69	7.67	7.90	7.73	7.80
	Mean	8.10	8.09	8.15	8.37	8.38	8.35	8.27	8.15	8.09	8.02	8.05	8.09
	Max	8.60	8.40	8.50	8.78	8.75	8.60	8.60	8.55	8.40	8.30	8.30	8.50

Notes: 1. pH denotes 'potential of hydrogen' and is a measure of the acidity or alkalinity of a solution.
2. Period of record is 1985 to 2009.
3. Min indicates minimum; Max indicates maximum.

Source: Based on MDNR, 2010.

Figure 3.10-7
Mean Surface Water pH



Biological Indicators of Water Quality

The objective of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Biological or biotic integrity is "the capability of supporting and maintaining a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats of the region" (Karr and Dudley, 1981; Karr, 1991; USEPA, 2008b). As the numbers, diversity, and condition of living organisms present provides a direct and effective measure of the biological integrity of a specific waterbody, biological indicators are used to assess water quality. Biological indicators are measures, indices of measures, or models that characterize an ecosystem or one of its critical components (USEPA, 2008b). They are numerical values that are derived from actual measurements, have known statistical properties, and convey useful information for environmental decision making.

An index of biotic integrity (IBI) is used to determine the integrity of a biological community in a given waterbody. IBIs are comprehensive (i.e., they examine the subject community as a whole) and rapid bioassessment techniques that can be applied on a relatively large scale.

> An **index** is a ratio or other number derived from a series of observations and used as an indicator or measure.

In the Chesapeake Bay area, an estuarine benthic IBI (B-IBI) was developed by Weisberg et al. (1997) and Lacouture et al. (2006) developed a phytoplankton IBI (P-IBI). Both of these IBIs were developed for and are in use in the Chesapeake Bay and its tidal tributaries, including the Potomac River. IBIs for SAV (Dennison et al., 1993), zooplankton (Carpenter et al., 2006), and tidal fish (MDNR, 2008) also have been developed for use in the Chesapeake Bay and its tidal tributaries, but have not been implemented or are no longer active. The benthic and phytoplankton IBIs are discussed below. Fish kills are also discussed, as an additional indicator of water quality in the Lower Potomac River.

Benthic Index of Biotic Integrity (B-IBI)

Benthic (or bottom-dwelling) invertebrates are aquatic invertebrates, including insects, crustaceans, mollusks, and worms, that spend the majority of their life associated with the bottom in an aquatic ecosystem. The presence or absence of benthic invertebrates is regulated by several parameters, including organic input (i.e., carbon input), oxygen level, temperature, salinity, current strength, turbidity, substrate type, and inorganic input.

Unlike fish and other mobile species, many benthic invertebrates lack mobility and, as such, are more susceptible to stress, such as hypoxia, sedimentation, accumulation of contaminants, and other natural and anthropogenic impacts. Many studies have shown that the structure of benthic assemblages can be directly attributed to a response by the benthos – the organisms that live on or near the seabed or bottom, collectively – to a myriad of anthropogenic or natural impacts to the aquatic ecosystems (Weisberg et al., 1997). As a result of these characteristics, benthic invertebrates are reliable and sensitive indicators of habitat quality and environmental status, stress, and trends (Weisberg et al., 1997; Llansó et al., 2008).

> **Hypoxia/Hypoxic waters** are waters with dissolved oxygen concentrations of less than 2 parts per million, the level generally accepted as the minimum required for most marine life to survive and reproduce.
>
> **Source:** USEPA, 2008b.

Weisberg et al. (1997) developed a B-IBI for the Chesapeake Bay based on communities in ideal conditions, or conditions with little or no impairment. The B-IBI allows for comparison of relative condition between benthic invertebrate communities across habitat types. The Chesapeake Bay Long-Term Benthic Monitoring Program uses the B-IBI to assess the condition of the benthic community at each of its monitoring sites, including those in the Potomac River. The B-IBI is based on a scale of 1 to 5.

Metrics Used to Calculate the Chesapeake Bay B-IBI

- Shannon-Wiener species diversity index
- Total species abundance
- Total species biomass
- Percent abundance of pollution-indicative taxa
- Percent abundance of pollution-sensitive taxa
- Percent biomass of pollution-indicative taxa
- Percent biomass of pollution-sensitive taxa
- Percent abundance of carnivores and omnivores
- Percent abundance of deep-deposit feeders
- Tolerance score
- Tanypodinae-to-Choronomidae percent abundance ratio

Note: Two additional metrics are used only at fixed stations by the Virginia Benthic Monitoring Program, none of which are on the Potomac River.

Source: Llansó, 2002.

The Chesapeake Bay Long-Term Benthic Monitoring Program monitors benthic community conditions at fixed and probability benthic monitoring sites in the Chesapeake Bay and its tidal tributaries (Llansó, 2002; Llansó et al., 2007, 2008). Fixed sites are sampled twice a year, in May and in late August or September, to identify temporal trends in benthic community conditions. Probability sites are sampled once a year, in late August or September, to assess the geographic extent of degraded benthic community conditions. Benthic community condition is classified into four levels based on the B-IBI, as follows (Llansó et al., 2008):

- A score less than or equal to 2.0 is classified as severely degraded habitat
- A score from 2.0 to 2.6 is classified as degraded
- A score greater than 2.6 but less than 3.0 is classified as marginal
- A score of 3.0 or higher is classified as meeting the Chesapeake Bay benthic community restoration goals

Probability-based summer sampling at probability benthic monitoring sites was initiated in 1994, and the sampling intensity in the Potomac River was increased in 1995 and subsequent years (Llansó et al., 2007, 2008). Sampling of probability sites occurs at depths greater than 3.3 ft and up to 39.4 ft (Llansó et al., 2007). The probability sites are not sampled deeper than 39.4 ft because anoxia commonly occurs below that depth and samples are consistently azoic (i.e., without living organisms).

Analysis of the probability-based sampling data indicated that in terms of the condition of the health of the benthic communities, the Potomac River is in poor condition. The following findings are indicative of the condition of the river (Llansó et al., 2008):

For each year from 1995 to 2007, over half – ranging from 56 to 92 percent – of the bottom area of the Potomac River failed to meet the Chesapeake Bay benthic community restoration goals. Each year, 48 to 93 percent of the bottom area that failed to meet the restoration goals was severely degraded.

For the period 1996 through 2007, over 81 percent of sites in the Potomac River that failed to meet the restoration goals failed due to insufficient abundance or biomass of organisms (Llansó et al.,

2008). For the same period, 11 percent of the sites that failed to meet the restoration goals failed due to excess abundance or biomass.

In 2007, an estimated 80 percent of the bottom area of the Potomac River failed to meet the restoration goals. Among the 25 Potomac River probability sites sampled in 2007, 13 sites were azoic and 1 additional site was nearly azoic, with only 1 organism sampled.

Six fixed benthic monitoring sites, sampled since 1984, are located in the Lower Potomac River and are shown in Figure 3.10-4. A seventh Potomac River site – Site 36 – is located approximately 4.3 miles south of Washington, DC, near the Woodrow Wilson Bridge, and is not shown in Figure 3.10-4. Site 40, which is shown on Figure 3.10-4, is located upstream of the PRTR, in the vicinity of MDNR Monitoring Station RET2.2. For each of the seven Potomac River fixed sites, Table 3.10-9 shows the water depth at the site, the percentage of silt or clay in the substrate, and the B-IBI scores for four sampling periods.

Table 3.10-9
B-IBI Scores at Fixed Benthic Monitoring Sites

Site	Depth (ft)[1]	Percent Silt/Clay[1]	B-IBI Score				Trend Significance
			1985-1987	2002-2004	2004-2006	2005-2007	
36	≤ 16.4	≥ 40	3.14	2.28	3.22	2.89	NS
40	21-33	≥ 80	2.80	3.01	3.20	3.09	NS
43	≤ 16.4	≤ 30	3.76	3.58	3.58	3.58	NS
44	36-56	≥ 75	2.80	2.56	2.51	1.84	$p < 0.05$
47	≤ 16.4	≤ 30	3.89	3.40	3.89	4.02	NS
51	≤ 16.4	≤ 20	2.43	3.07	2.41	2.33	$p < 0.05$
52	30-43	≥ 60	1.37	1.22	1.04	1.11	NS

Notes: 1. ≥ indicates greater than or equal to; ≤ indicates less than or equal to.
2. NS indicates not significant.
Source: Llansó et al., 2007, 2008.

There is a strong correlation between hypoxia, depth, and sedimentation. Hypoxic events generally are more frequent as depth and sedimentation increase. B-IBI scores for the Potomac River benthic community likewise are correlated with depth and sedimentation, as well as hypoxia. The most severely degraded benthic monitoring sites in the PRTR portion of the Potomac River – and throughout the river – are Sites 44 and 52. As shown in Table 3.10-9, both sites are deep sites with high silt/clay content of the substrate, indicating a depositional environment with high sedimentation. Hypoxia influences benthic community condition at both Site 44 and Site 52 (Llansó et al., 2005). Conversely, the two benthic monitoring sites in the PRTR portion of the Potomac that have consistently met the Chesapeake Bay benthic community restoration goals – Sites 43 and 47 – are comparatively shallow and have low sedimentation (lower percentages of silt/clay). These two sites are less likely to experience hypoxic events than are Sites 44 and 52.

The B-IBI scores within the Potomac River that are marginal or that meet the Chesapeake Bay benthic community restoration goals are relatively low compared to scores within the rest of the Chesapeake Bay watershed. Overall, the Potomac and Patuxent Rivers, and Maryland's western shore, are in the poorest condition, based on B-IBI scores at fixed benthic monitoring sites. Among these three low-scoring areas, the Potomac River had the largest percentage of severely degraded conditions (Llansó et al., 2007).

For the period 1999 through 2003, in the PRTR portion of the Potomac River, the benthic habitats at 71 percent of the fixed sampling sites were degraded (Llansó et al., 2007). Upstream of the PRTR, the habitats at less than 50 percent of the sites were degraded. The high percentage of degraded sites in the PRTR portion of the river is due primarily to anoxic conditions (absence of oxygen) in the deeper – i.e., depths greater than 39 ft – water of the Lower Potomac River (Llansó et al., 2003). The reason anoxia is considered the primary reason for the high percentage of degraded sites in this portion of the river is that there is a strong relationship between B-IBI scores, DO levels, and depth (Llansó et al., 2003). Generally, dissolved oxygen decreases with depth, as do B-IBI scores. This relationship illustrates the enormous impact anoxia has on the benthic invertebrate community.

Significant ($p < 0.05$) trends have been observed at two fixed sampling sites in the PRTR portion of the Potomac River since sampling began – Sites 44 and 51 (Llansó et al., 2008). As shown in Table 3.10-9, the B-IBI score for Site 44 decreased from 2.80 for the initial condition (1985 to 1987) to 1.84 for the current condition (2005 to 2007), changing the rating for the site from marginal to severely degraded. The score for Site 51 also decreased, from 2.43 to 2.33, although the site rating in that case remained the same – degraded.

By contrast, despite their proximity to Site 44 (see Figure 3.10-4), Sites 43 and 47 have consistently met the Chesapeake Bay benthic community restoration goals. The lower scores and declining benthic community condition at Site 44 may result from the greater depth at the site and the site's location in a depositional environment, indicated by the high silt/clay content of the substrate. The site with the worst B-IBI scores throughout the last 22 years is Site 52, with scores consistently below 1.5, indicating a severely degraded benthic community condition. Site 52 is in deep water and is in a depositional area, both factors that likely contribute to the impoverishment of the benthic habitat.

Phytoplankton Index of Biotic Integrity (P-IBI)

A P-IBI based on reference phytoplankton communities – communities showing little or no impairment – was developed in order to characterize Chesapeake Bay and its tidal tributaries (Buchanan et al., 2005; Lacouture et al., 2006). The P-IBI serves as a quantitative scale to assess phytoplankton community status relative to water quality, and uses various metrics to characterize habitat conditions. Impaired areas generally have high DIN and PO_4 concentrations and low Secchi depths (high turbidity).

P-IBI ratings range from 1.0 to 5.0. The index classifies the phytoplankton community status as follows (Buchanan, 2006; Lacouture et al., 2006):

- A score from 1 to less than 2 is classified as Poor
- A score from 2 to less than 2.67 is classified as Poor to Fair
- A score from 2.67 to less than 3.33 is classified as Fair
- A score from 3.33 to less than 4 is classified as Fair to Good
- A score from 4 to 5 is classified as Good

A Good status is the recommended restoration goal for all Chesapeake Bay waters, including tidal tributaries such as the Potomac River, based on its correlation with attainment of the Chesapeake Bay water quality criteria and standards for dissolved oxygen and water clarity (Buchanan, 2006). A Good P-IBI rating is intended to correspond to the best attainable level of phytoplankton community integrity, not the level of integrity found in pristine estuaries (Buchanan, 2006).

Metrics Used to Calculate the Chesapeake Bay P-IBI

- Carbon:chlorophyll *a*
- Surface chlorophyll *a*
- Percent of total biomass composed of cryptophytes
- Cyanophyte biomass
- Diatom biomass
- Dinoflagellate biomass
- Dissolved organic carbon
- *Microcystis aeruginosa* abundance
- Pheophytin
- Picophytoplankton abundance
- *Prorocentrum minimum* abundance
- Total nano-micro phytoplankton biomass

Note: Carbon:chlorophyll a is the ratio of total nano-micro phytoplankton biomass to chlorophyll a in the above-pycnocline layer.

Source: Lacouture et al., 2006.

P-IBI parameters are monitored at two MDNR monitoring stations – Stations RET2.2 and LE2.2 – located in the vicinity of NSF Dahlgren and the PRTR (see Figure 3.10-4). Mean index scores based on data collected from 1985 to 2002 classify the oligohaline portion of the Potomac River – Station RET2.2, above the UDZ – as having a Poor P-IBI in spring (March to May) and a Fair P-IBI in summer (July to September), with average indices of 1.9 and 3.1, respectively (Buchanan, 2006; Lacouture et al., 2006). The mesohaline portion of the Potomac River – Station LE2.2, in the LDZ – was classified as having Fair phytoplankton communities in spring, and Poor to Fair communities in summer, with mean scores of 2.8 and 2.6, respectively (Buchanan, 2006; Lacouture et al., 2006).

Fish Kills

The MDE oversees the investigation of fish-kill incidents throughout the state, including the Lower Potomac River (MDE, 2011). Fish kills result from both natural and human-induced stresses. Based on data provided by the MDE (Luckett, pers. comm., February 9, 2010), 65 fish kills involving 12 or more fish occurred from 1984 through 2009 in the tidal Potomac River in Charles and Saint Mary's Counties, Maryland – i.e., from upstream of the UDZ to the mouth of the river.

The 65 incidents in the tidal Potomac River killed approximately 442,000 fish and shellfish, predominantly fish (finfish). Of the 65 fish kills, 14 probably were caused by low DO levels or by low DO in combination with other stresses:

- The statewide fish-kill response program designated low DO levels as the probable cause of nine of the incidents, killing approximately 114,000 fish, or about 25.8 percent of all the fish and shellfish killed in the 65 fish kills in the tidal Potomac River.
- Entrapment in combination with low DO was designated as the probable cause of an additional three incidents, and one other incident was attributed to entrapment in combination with low DO and/or a toxic algae bloom; combined, these four incidents killed approximately 11,500 fish, or 2.6 percent of the total.
- Toxic algae combined with low DO were designated as the probable causes of one incident, killing approximately 500 fish, or 0.1 percent of the total.

Review of the MDE data indicates that one species of fish – spot (*Leiostomus xanthurus*) – is particularly susceptible to low DO in the tidal Potomac River. Approximately 100,300 spot probably were killed by low DO resulting from storm-induced inversion during a single incident. The species represented at least 79.6 percent of the fish killed by the 14 low-DO-related incidents, and spot died in 8 of the 14 kills. Other susceptible species include Atlantic croaker (*Micropogonias undulatus*), summer flounder (*Paralichthys dentatus*), white perch (*Morone americana*), Atlantic menhaden (*Brevoortia tyrannus*), and striped bass (*Morone saxatilis*), together representing at least 11.2 percent of the fish killed. Six other species, along with fish of unidentified species, represent the remaining 9.2 percent.

Recent Potomac River Fish Kills

- A large fish kill occurred from June 2 to June 4, 2006 in the Lower Potomac River, in the vicinity of the MDZ and LDZ. Between 7,000 and 8,000 fish, comprising multiple species, washed ashore on the Virginia side of the river, between Colonial Beach and Coles Point (ICPRB, 2006). Algal toxin from a dinoflagellate bloom or the upwelling of anoxic (i.e., lacking oxygen) bottom waters, likely driven by strong westerly winds, may have been the proximal cause of the fish kill (ICPRB, 2006).
- During the summer of 2006, approximately 30,000 fish (multiple species) died off Cobb Island, on the Maryland side of the Lower Potomac in the vicinity of the MDZ (Pelton, 2007). Low dissolved-oxygen levels were the probable cause of the fish kill.
- In mid-February 2007, approximately 50,000 white perch and some striped bass died and washed ashore on the Maryland side of the river, near Swan Point in the vicinity of the MDZ, and near Tall Timbers in the vicinity of the LDZ (Pelton, 2007; Fahrenthold, 2007). It is likely that thermal shock resulting from severe cold killed the fish that were trapped in shallow water by strong winds and tides (Fahrenthold, 2007).

Several fish kills probably were caused by water quality conditions other than low DO levels. A single, very large fish kill was attributed to entrapment or disease. This incident killed an estimated 200,000 fish and shellfish, or about 45.2 percent of the fish killed in the 65 fish kills in the tidal Potomac River. Approximately 95 percent of the fish were Atlantic menhaden, but the kill also involved striped bass, oyster toadfish (*Opsanus tau*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), and blue crab (*Callinectes sapidus*). Other water-quality-related fish kills included the following:

- Three incidents attributed to cold stress killed over 50,500 fish, of which an estimated 50,250 were white perch; the remaining 250 or so individuals were individuals of five other finfish species.
- One incident attributed to the discharge of chlorine from the Morgantown Generating Plant killed approximately 8,000 gizzard shad (*Dorosoma cepedianum*).
- One incident attributed to toxic algae killed approximately 3,700 fish – predominantly hogchoker (*Trinectes maculatus*), spot, Atlantic silverside (*Menidia menidia*), and white perch, but also individuals of 11 other finfish species.
- One incident attributed to a natural die-off killed approximately 200 Asian clams (*Corbicula fluminea*).

The fish-kill response program designated commercial discards as the probable cause of 27 fish kills and recreational discards as the probable cause of 1 additional kill. Commercial and recreation discards killed approximately 15,000 fish. The causes of the remaining 16 fish kills, involving almost 39,000 fish, are not known.

3.10.1.3 Tributaries

Upper Machodoc Creek is approximately 3,000 ft wide at its mouth and 6 ft deep. Its total length is approximately 17.4 mi and its watershed encompasses approximately 47.2 sq mi. Gambo Creek is tidally influenced as far inland as NSF Dahlgren's northern boundary (NOAA, 1993; NSWCDD, 2001).

The Commonwealth of Virginia has jurisdiction over tributaries to the Potomac River on NSF Dahlgren. Under the Virginia Water Quality Standards (Virginia Regulation [VR] 680-21-00), Upper Machodoc Creek and its tidal tributaries are designated as Class IIa (NSF Dahlgren, 2006). This designation is applied to estuarine waters capable of propagating shellfish. Based on VDEQ water quality data, 0.4 sq mi of Upper Machodoc Creek are in impairment for bacteria (shellfish condemnation) and pH (aquatic life), and 0.8 sq mi were assessed as not supporting the fish consumption use goal due to exceedances of polychlorinated biphenyls (PCBs) in fish tissue (VDEQ, 2008). In addition, 13 to 17 percent of samples taken did not meet DO and fecal coliform criteria (VDEQ, 2008). A portion of the Williams Creek-Upper Machodoc Creek area also did not meet DO, pH, and bacteria goals (VDEQ, 2008).

The other tidal tributaries of the Potomac River on the installation are classified as Class IIb waters, which designates the waters as suitable for bathing and fishing, but taking shellfish is prohibited (NSF Dahlgren, 2006). This designation is applied to estuarine waters with Potomac embayment standards. The VDEQ assessed 0.2 sq mi of Gambo Creek as not supporting the shellfishing use goal in the 2004 water-quality assessment due to bacterial contamination (VDEQ, 2008).

3.10.1.4 Ponds

Both Beaver Pond and Lespedeza Pond are located north of Gambo Creek, in the north-central and northeast portions of Mainside, respectively. Two man-made ponds are also present on Mainside. Hideaway Pond, which is approximately 13 ac in size, is located in the Advanced Concepts Complex area in the northeast section of Mainside. Cooling Pond, which is approximately 10 ac in size, is located in the southern section of Mainside.

NOAA (1993) reported that surface water, sediment, and fish tissue samples were collected in Hideaway Pond and its two tributaries and analyzed for mercury. Mercury was not detected in any of the surface water samples (NOAA, 1993). However, although the detection limit of 0.10 micrograms per liter (µg/l) was below the current recommended criterion maximum concentration (CMC) of 1.4 µg/l, it was above the current recommended criterion continuous concentration (CCC) of 0.77 µg/l (USEPA, 2009). Half of the sediment samples contained mercury concentrations greater than or equal to 0.01 milligrams per kilogram (mg/kg) on a wet weight basis, although these concentrations were not directly comparable to the screening guideline, which is expressed in mg/kg on a dry weight basis (NOAA, 1993). Earlier studies detected mercury at a maximum concentration of 1.9 mg/kg in fish tissues collected from Hideaway Pond (Fred C. Hart

CMC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.

CCC is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

Source: USEPA, 2009.

Associates, Inc., 1983, as cited in NOAA, 1993). This concentration is an order of magnitude above the recommended criterion of 0.3 mg/kg methyl mercury for the protection of human health, based on a total fish consumption rate of 0.0386 lb per day (USEPA, 2009).

3.10.1.5 Stormwater Management

NSF Dahlgren follows three regulatory programs that are intended to protect water resources from degradation caused by stormwater runoff. The programs are the Virginia Stormwater Management Regulations (4 VAC 3-20), the Virginia Erosion and Sediment Control Regulations (4 VAC 50-30), and the Chesapeake Bay Preservation Act and Regulations. Subchapter 3.1.3 describes Virginia's Coastal Zone Management Program (as well as Maryland's).

The intent of Virginia's Chesapeake Bay Preservation Act (CBPA), Virginia Code 10.1-2100 et seq., and its implementing Chesapeake Bay Preservation Area Designation and Management Regulations, 9 VAC 10-20-10 et seq., is to protect certain lands, designated as Chesapeake Bay Preservation Areas, which if improperly developed could result in substantial damage to the water quality of the Chesapeake Bay and its tributaries. Chesapeake Bay Preservation Areas are divided into resource protection areas (RPAs) and resource management areas (RMAs).

RPAs include tidal wetlands; nontidal wetlands connected by surface flow and contiguous to tidal wetlands or water bodies with perennial flow, tidal shores, and 100-ft vegetated buffer areas located adjacent to and landward of the above three features, and along both sides of any water bodies with perennial flow (King George County, 2011). Development in RPAs is restricted to water dependent uses and redevelopment. RMAs include all other areas in King George County. Development performance criteria are applied to development within RMAs.

The CBPA is promulgated through county land ordinances; the DoD is a signatory to an agreement supporting the CBPA and partnering to conduct restoration of the Chesapeake Bay. It is Navy policy to comply to the extent possible, consistent with the military mission and budget constraints, with Virginia's Chesapeake Bay Preservation Act and its implementing regulations, maintained in accordance with the Virginia Erosion and Sediment Control Law (Virginia Code section 10.1-560) and the Virginia Stormwater Management Law (Virginia Code section 10.1-603, or an equivalent local program).

The quantity and quality of stormwater leaving the installation is controlled by a stormwater management system. The system consists of water retention ponds, gravity storm mains, laterals, drainage ditches, culverts, inlets, and catch basins. Most of the lines and culverts are reinforced concrete or corrugated metal, ranging in diameter from 4 to 60 inches (NSF Dahlgren, 2006). Natural features such as streams, wetlands, and floodplains also are part of the stormwater management system at NSF Dahlgren (NSWCDL, 1993, as cited in NSF Dahlgren, 2006). A Virginia Pollutant Discharge Elimination System (VPDES) permit covers small quantities of stormwater discharges into receiving water bodies.

3.10.2 Wetlands and Floodplains

3.10.2.1 Wetlands

Regulations

A number of federal laws, regulations, and policies regulate activities in wetlands, namely:

- Section 404 of the Clean Water Act, which directs the United States Army Corps of Engineers (USACE) to require permits for the discharge of dredged and fill material into "waters of the United States," a term that includes rivers, lakes, and most streams and wetlands.
- Executive Order 11990, *Protection of Wetlands*, which requires federal agencies to take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands.
- The North American Wetlands Conservation Act, 16 U.S.C. §4408, which requires the restoration, management, and protection of wetlands and habitats for migratory birds on federal lands.
- The Wetlands Resources Act, 16 U.S.C. §3901, which calls for intensifying cooperative efforts among federal, state, and local governments and private interests for the management and conservation of wetlands.

The USACE regulates development in jurisdictional wetlands under Section 404 of the Clean Water Act and regulations contained in 33 CFR, Parts 320-330. For regulatory purposes under the Clean Water Act, the USACE and the USEPA define wetlands as:

> "… those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas" (40 CFR § 230.3(t)).

Any action requiring a Section 404 Clean Water Act permit also requires a Section 401 water quality certification from the responsible state authority. Not every activity affecting wetlands requires a Section 404 permit/Section 401 water quality certification. Only those activities involving the discharge of dredged or fill material into a "water of the United States," including most wetlands, require these federal approvals.

The Commonwealth of Virginia regulates wetlands through a number of laws and provisions:

- The Virginia Wetlands Act of 1972 (Title 62.1 of the Code of Virginia), which protects tidal wetlands and regulates wetland development.
- Virginia Water Protection Regulations (VR 680-15-02), which regulate state waters and require a Virginia Water Protection Permit for activities involving wetlands under Section 404 of the Clean Water Act.

- Virginia Acts of Assembly Chapters 1054 (House) and 1032 (Senate), passed in the 2000 session, which amend existing wetland laws to require a Virginia Water Protection Permit for certain activities in non-tidal wetlands.

NSF Dahlgren Wetlands

Figure 3.10-8 (Wetlands - NSF Dahlgren) shows wetland areas at NSF Dahlgren, using National Wetland Inventory (NWI) descriptors. Wetlands at NSF Dahlgren are primarily associated with the Potomac River, Upper Machodoc Creek, Gambo Creek, Black Marsh Creek, and unnamed tributaries to these waterways. Wetlands within NSF Dahlgren are mostly estuarine emergent, palustrine forested, estuarine unconsolidated shore, and estuarine scrub-shrub wetlands. Wetlands outside the installation's boundaries are of similar type and distribution as those found within.

Table 3.10-10 provides a summary of the extent of wetlands on NSF Dahlgren, based predominantly on the estimated coverage of wetlands on the installation and to a lesser extent on field delineations of wetland limits. Estuarine and palustrine wetlands cover approximately 608 ac, or approximately 14 percent of the installation. The 608-ac total includes 90 ac of estuarine subtidal habitat, which is a deepwater habitat. Deepwater habitats are permanently-flooded lands that lie below the deepwater boundary of wetlands (Cowardin et al., 1979).

Table 3.10-10
Wetlands on NSF Dahlgren

Wetland Type	Area (ac)	Percentage of Total Acreage of NSF Dahlgren
Estuarine		
Intertidal	278	6.4
Subtidal	90	2.1
Total Estuarine	368	8.5
Palustrine		
Emergent	18	0.4
Forested (PFO)	183	4.2
Scrub-Shrub (PSS)	9	0.2
Unconsolidated Bottom	30	0.7
Total Palustrine	240	5.6
Total Wetlands	**608**	**14.1**

Note: Numbers may not total exactly due to rounding.
Source: NSF Dahlgren, 2007.

The wetlands on NSF Dahlgren along the Potomac River and Upper Machodoc Creek are predominantly estuarine, intertidal, emergent marsh, along with areas of scrub-shrub wetland and unconsolidated shores. Extensive estuarine wetlands border Gambo Creek. This brackish, intertidal, emergent marsh is dominated by saltmarsh cordgrass (*Spartina alterniflora*), marsh elder (*Iva frutescens)*, and pigweed (*Amaranthus cannabinus*) (NSWCDD, 2001). The wetland is well-buffered by mixed hardwood and pine forests. The downstream section of Black Marsh Creek is bordered by estuarine intertidal emergent marsh and unconsolidated shore. Further upstream, palustrine forested wetlands dominate.

There are approximately 92 ac of forested wetland swales in a designated special interest area (SIA) in the northwestern portion of Mainside. The swales drain toward the north end of the airfield. Tree species in the forested wetlands include red maple (*Acer rubrum)*, black gum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), white oak (*Quercus alba*), willow oak (*Quercus phellos*), and pin oak (*Quercus palustris*) (NSWCDD, 2001). The shrub layer is sparse to non-existent. The herb layer includes sedges (*Carex* spp.) and *Sphagnum* species (NSWCDD, 2001).

There is an approximately 6.1-ac constructed, non-tidal, seasonally-flooded emergent herbaceous wetland located in the southern section of Mainside. The wetland was constructed in 2001 as mitigation for remediation of the Pesticide Rinse Area (Solid Waste Management Unit 25) (NSF Dahlgren, 2006). The wetland was constructed by widening a narrow drainage way and associated wetlands that drain Cooling Pond, and then diverting flows from the pond across the widened area. The area was planted with wetland vegetation following excavation. The wetland is channelized at its downstream end and drains into tidal wetlands bordering Upper Machodoc Creek. Vegetation in the constructed wetland is characterized by black willow (*Salix nigra*), eastern baccharis (*Baccharis halimifolia*), woolgrass (*Scirpus cyperinus*), common rush (*Juncus effusus*), cattail (*Typha* spp.), strawcolored flatsedge (*Cyperus strigosus*), and common reed (*Phragmites australis*) (NSF Dahlgren, 2006).

3.10.2.2 Floodplains

Executive Order 11988, *Floodplain Management*, sets forth the responsibilities of federal agencies for reducing the risk of flood loss or damage to personal property, minimizing the impacts of flood loss, and restoring the natural and beneficial functions of floodplains. This order was issued in furtherance of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

> A floodplain is any land area susceptible to being inundated by floodwaters from any source. A **100-year floodplain** is an area susceptible to being inundated by the base flood – that is, the flood having a one percent chance of being equaled or exceeded in any given year.

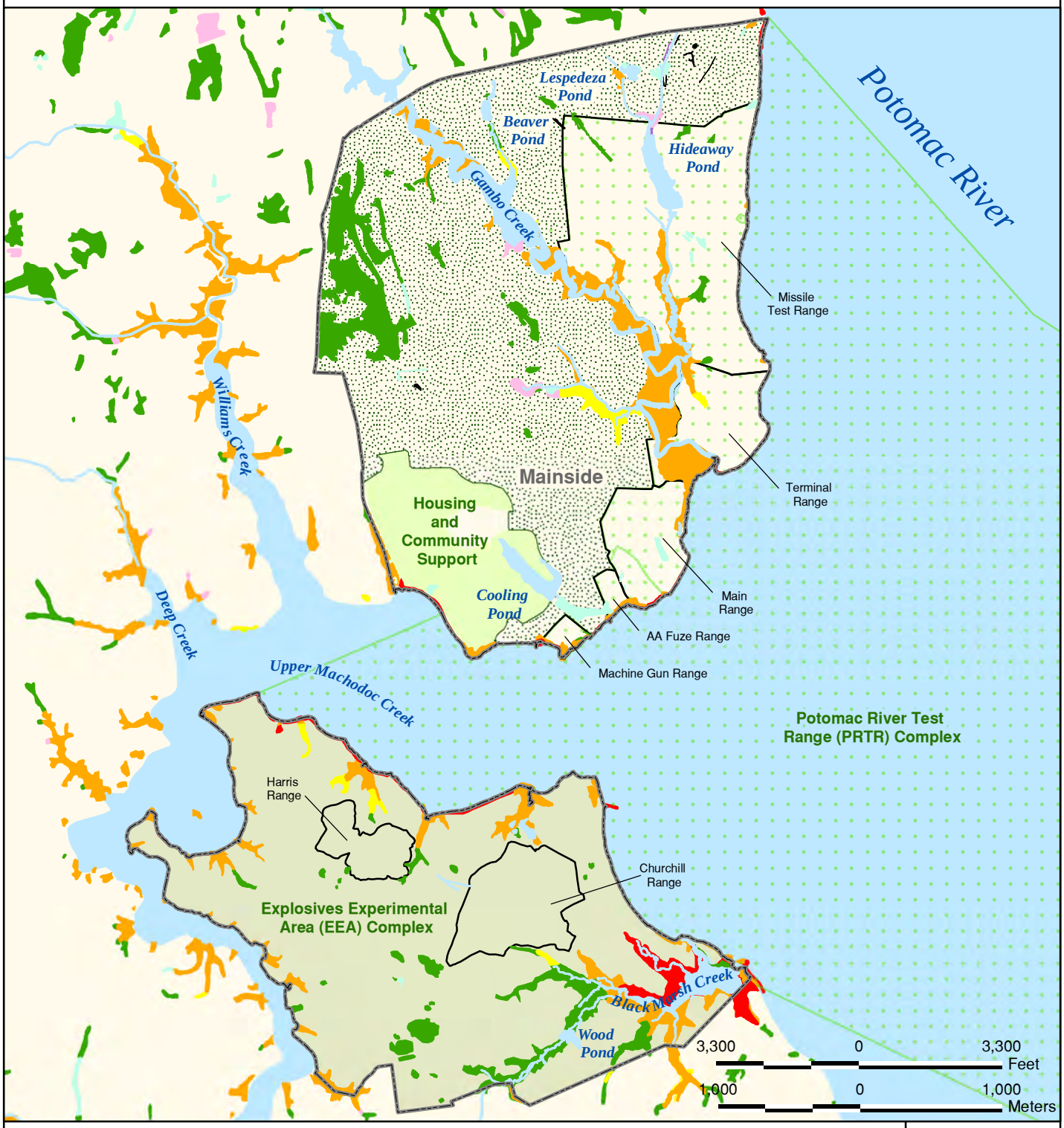
Federal Emergency Management Agency (FEMA) National Flood Insurance Program data show that NSF Dahlgren has approximately 391 ac of land that lies within the 100-year floodplain on Mainside and an additional 325 ac on the EEA Complex (Figure 3.10-9, Floodplains - NSF Dahlgren). The majority of the land on the installation that is within the floodplain is located on either side of Gambo Creek and along Black Marsh Creek. Floodplains also are located along the shores of Upper Machodoc Creek and the Potomac River.

3.10.3 Groundwater

3.10.3.1 Hydrogeology

On NSF Dahlgren, approximately 1,500 ft of unconsolidated sediments are present above the bedrock (Meng and Harsh, 1988). Based on Meng and Harsh (1988), Bell et al. (1994), Hammond and Bell (1995), Bell (1996), and Harlow and Bell (1996), these sediments are divided into the following seven hydrogeologic units, from the land surface downward:

Wetlands - NSF Dahlgren



Estuarine Intertidal Emergent (E2EM)
Estuarine Intertidal Scrub-Shrub (E2SS)
Estuarine Intertidal Unconsolidated Shore (E2US)
Palustrine Emergent (PEM)
Palustrine Forested (PF0)
Palustrine Scrub-Shrub (PSS)
Palustrine Unconsolidated Bottom (PUB)
Wetland Type – Not Specified
Mission Area
Naval Support Facility (NSF) Dahlgren

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Figure 3.10-8

Source: NSWCDD GIS (2008 - 2011), Wetland classes based on Cowardin et al., 1979.

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Floodplains - NSF Dahlgren

100-Year Floodplain

Mission Area

Explosives Experimental Area (EEA) Complex

Potomac River Test Range (RPTR) Complex

Naval Support Facility (NSF) Dahlgren

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 3.10-9

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- Columbia aquifer
- Upper confining unit
- Upper confined aquifer
- Nanjemoy-Marlboro confining unit
- Aquia aquifer
- Potomac confining unit
- Potomac aquifer

The following paragraphs describe the four aquifers that underlie NSF Dahlgren.

Columbia Aquifer

The Columbia aquifer underlies most of Mainside, but is absent in the stream valley of Gambo Creek in the northwestern part of Mainside (Harlow and Bell, 1996). The aquifer is present across the entire EEA Complex, where it varies from less than 8 ft to approximately 34 ft in thickness (Bell, 1996). On Mainside, the Columbia aquifer generally is 5 ft or more in thickness, and is thickest in the northeastern, central, and southeastern parts (Harlow and Bell, 1996).

Throughout most of NSF Dahlgren, the Columbia aquifer is underlain by the upper confining unit (Bell et al., 1994; Hammond and Bell, 1995; Bell, 1996), comprising deposits with relatively low permeability that restrict vertical groundwater movement between the Columbia aquifer and the underlying aquifers (Harlow and Bell, 1996; Agency for Toxic Substances and Disease Registry [ATSDR], 2006). However, the upper confining unit and upper confined aquifer are absent over an east-west trending band across the center of the EEA Complex, and the Columbia aquifer lies directly on the Nanjemoy-Marlboro confining unit (unpublished data on file in the Virginia district office of the USGS, as cited in Hammond and Bell, 1995; Bell, 1996).

The Columbia aquifer is recharged directly by precipitation across most of NSF Dahlgren (Bell, 1996; Harlow and Bell, 1996). Some groundwater enters the Columbia aquifer across portions of the installation boundary (Bell, 1996; ATSDR, 2006) and from the Nanjemoy-Marlboro confining unit, where the unit underlies the aquifer (Bell, 1996). On Mainside, groundwater flows from the northeast and northwest toward the wetlands along Gambo Creek, Upper Machodoc Creek, and the Potomac River (Harlow and Bell, 1996). On the EEA Complex, flow is generally from the western and central portion of the complex toward the Potomac River, Upper Machodoc Creek, Black Marsh, and other surface water features (Bell, 1996). Most water in the Columbia aquifer likely discharges to adjacent surface waterbodies (Harlow and Bell, 1996).

Upper Confined Aquifer

The unnamed, upper confined aquifer was discovered during hydrogeologic studies conducted by the USGS between 1992 and 1995 (Harlow and Bell, 1996). On Mainside, the upper confined aquifer ranges in thickness from 16 to 31 ft, being thickest in the northwestern part (Harlow and Bell, 1996). The aquifer is 0 to 35 ft thick on the EEA Complex (Bell, 1996).

The Nanjemoy-Marlboro confining unit underlies the upper confined aquifer (unpublished data on file in the Virginia District office of the USGS, as cited in Bell et al., 1994; Hammond and

Bell, 1995; Harlow and Bell, 1996) and impedes vertical groundwater flow between the upper confined aquifer and underlying aquifers (Harlow and Bell, 1996).

The upper confined aquifer is probably recharged by a combination of flow across the upper confining unit and the Nanjemoy-Marlboro confining unit (Bell, 1996). Groundwater flow in the upper confined aquifer is approximately northeast to southwest on Mainside (Harlow and Bell, 1996). On the EEA Complex, groundwater in the northern arm of the upper confined aquifer probably flows northward and eastward toward Upper Machodoc Creek and the Potomac River, whereas groundwater in the southern arm generally flows eastward-northeastward toward the Potomac River (Bell, 1996).

Aquia Aquifer

The recharge zone for the Aquia aquifer is approximately 25 miles west of NSF Dahlgren (Brown and Root Environmental, 1996, as cited in ATSDR, 2006). On Mainside, groundwater flow within the Aquia aquifer is approximately northwest to southeast (Harlow and Bell, 1996). The head –the difference in elevation between two points in a body of fluid – distribution observed during the USGS study was consistent with published maps of the Aquia aquifer that indicate a regional decline in water levels caused by withdrawals in Maryland (Harlow and Bell, 1996). Curtin et al. (2005) estimated that, in the vicinity of NSF Dahlgren, the water level of the Aquia aquifer declined approximately 20 ft between 1982 and 2003.

At the time of the USGS hydrogeologic study on Mainside (1995), there were no known withdrawals from the Aquia aquifer within or near Mainside (Harlow and Bell, 1996). However, according to the public health assessment for NSF Dahlgren (ATSDR, 2006), the Aquia aquifer provides water to many light industrial, small municipal, and domestic wells located around NSF Dahlgren.

Potomac Aquifer

The principal producing, confined aquifer underlying NSF Dahlgren is part of the Potomac Formation, which overlies the bedrock basement. This formation comprises three separate confined aquifers – the upper, middle, and lower Potomac aquifers – and associated confining units (Meng and Harsh, 1988). Most industrial and municipal wells in the general vicinity of NSF Dahlgren likely use the middle Potomac aquifer, sometimes in combination with the underlying, lower Potomac aquifer. Only the middle and lower Potomac aquifers underlie NSF Dahlgren (Meng and Harsh, 1988). These two aquifers are referenced collectively here as the Potomac aquifer.

The Potomac aquifer is recharged through a 253-sq-mi area approximately 25 mi west of NSF Dahlgren, along the Fall Line (NSWCDD, 2003). The Potomac aquifer is capable of supplying large quantities of groundwater and is the primary source of drinking water for NSF Dahlgren and the NSF Dahlgren municipal water system (ATSDR, 2006). Deep wells on the installation draw water from the aquifer (NSF Dahlgren, 2006). In the vicinity of NSF Dahlgren, the altitude of the top of the middle Potomac

> The **Fall Line** is a low, east-facing erosional scarp that parallels the Atlantic coastline from New Jersey to the Carolinas. It separates hard Paleozoic metamorphic rocks of the Appalachian Piedmont to the west from the softer, gently dipping Mesozoic and Tertiary sedimentary rocks of the Coastal Plain.
>
> **Source:** USGS, 2000.

aquifer is between approximately 260 and 280 ft below sea level (based on Meng and Harsh, 1988).

The middle Potomac confining unit overlies the Potomac aquifer and is between approximately 20 and 50 ft thick in the vicinity of NSF Dahlgren (based on Meng and Harsh, 1988). Studies indicate that the Potomac aquifer is not completely isolated from the overlying aquifers by a confining layer, and could be vulnerable to contamination from surface sources (Brown and Root Environmental, 1996, as cited in ATSDR, 2006). However, no evidence of contamination has been detected by the NSF Dahlgren drinking-water monitoring program (ATSDR, 2006).

3.10.3.2 Water Quality

Of the three shallow aquifers on Mainside, the mainly unconfined Columbia aquifer is most likely to be contaminated by surface sources (Harlow and Bell, 1996; ATSDR, 2006). During May 1993, water quality samples were collected once from 35 observation wells on Mainside, including 29 wells in the Columbia aquifer (Harlow and Bell, 1996). Water samples also were obtained from three wells in the upper confined aquifer and three wells in the Aquia aquifer. Due to anomalously high pH values measured in water samples from all three wells in the Aquia aquifer, chemical analyses of water from these wells were considered to not be representative (Harlow and Bell, 1996) and are not discussed here.

National secondary drinking water standards (NSDWSs) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

Source: USEPA, 2008a.

Dissolved solids and five inorganic constituents were present in water from the Columbia aquifer at concentrations that exceeded the national secondary drinking water standards (NSDWSs) for drinking water established by the USEPA (Harlow and Bell, 1996), as shown in Table 3.10-11. The concentration of dissolved solids exceeded the NSDWS of 500 milligrams per liter in 3 of 29 samples from the Columbia aquifer. An elevated concentration of sodium was present in one water sample, and elevated concentrations of chloride were present in two water samples.

Elevated concentrations of iron and manganese are the most extensive water-quality problems with regard to inorganic constituents in the Columbia aquifer. The concentration of dissolved iron exceeded the NSDWS in 10 water samples, and the concentration of manganese exceeded the NSDWS in 17 samples. High concentrations of iron and manganese at Mainside probably are the result of anoxic (severely deficient in oxygen) water conditions in parts of the Columbia aquifer (Harlow and Bell, 1996). Groundwater from two of the three wells in the upper confined aquifer on Mainside likewise had iron concentrations exceeding the NSDWS, and water from all three wells exceeded the NSDWS for manganese (Harlow and Bell, 1996). All other constituents measured were below the NSDWSs (Harlow and Bell, 1996).

On the EEA Complex, water-quality samples were collected from 28 wells – 20 wells in the Columbia aquifer, 4 wells in the Nanjemoy-Marlboro confining unit, and 4 wells in the upper confined aquifer – in June 1994 (Bell, 1996). Water in the upper confined aquifer and in some parts of the Columbia aquifer is anoxic and, as shown in Table 3.10-11, has high concentrations of dissolved iron and manganese (Bell, 1996). Concentrations of dissolved iron and manganese

exceeded the NSDWS in 9 and 11 of 20 water samples, respectively (Bell, 1996). High concentrations of these constituents indicate local anoxic conditions in the Columbia aquifer.

Table 3.10-11
Columbia Aquifer Water Quality

Constituent	Concentration			NSDWS	Number of Samples Exceeding NSDWS
	Maximum	Median	Minimum		
Mainside					
Aluminum (mg/l)	0.630	0.060	0.010	0.05 to 0.2	ND
Chloride (mg/l)	480	9.2	2.2	250	2
Fluoride (mg/l)	0.20	<0.10	<0.10	2.0	0
Iron (mg/l)	30	0.160	<0.010	0.3	10
Manganese (mg/l)	7	0.095	<0.010	0.05	17
pH (standard units)	6.9	5.3	4.7	6.5 to 8.5	26
Sulfate (mg/l)	85	14	<0.10	250	0
Total dissolved solids (mg/l)	1,190	110	49	500	3
EEA Complex					
Aluminum (mg/l)	1.700	0.020	<0.010	0.05 to 0.2	ND
Chloride (mg/l)	2,100	4.1	1.9	250	1
Fluoride (mg/l)	1.5	0.10	<0.10	2.0	0
Iron (mg/l)	40.000	0.230	0.009	0.3	9
Manganese (mg/l)	0.550	0.059	0.010	0.05	11
pH (standard units)	6.8	5.9	4.2	6.5 to 8.5	18
Sulfate (mg/l)	130	16	0.60	250	0
Total dissolved solids (mg/l)	4,510	106	37	500	1

Notes:
1. Results from 29 analyses were used to calculate all statistics for Mainside water quality. Results from 20 analyses were used to calculate all statistics for EEA Complex water quality, except results from 19 analyses were used to calculate statistics for aluminum.
2. NSDWS indicates National Secondary Drinking Water Standard.
3. mg/l indicates milligrams per liter.
4. ND indicates number of samples exceeding NSDWS was not determined because an NSDWS was not established for aluminum at the time of the study.
5. < indicates less than.

Source: Bell, 1996; Harlow and Bell, 1996; USEPA, 2008a.

3.11 Potomac River Aquatic Biological Resources

Biological resources in and around NSF Dahlgren can be divided into aquatic and terrestrial resources. Aquatic biological resources are concentrated in the Potomac River (Sections 3.11 and 3.12) and ponds, streams, and creeks at NSF Dahlgren (Section 3.13). Terrestrial resources are the land-based wildlife and vegetation resources of NSF Dahlgren and are described in Section 3.13. Rare, threatened, and endangered species that are either present or potentially found at NSF Dahlgren or the PRTR are discussed in Section 3.14.

As discussed in Section 3.10.1.2, the length of the tidal reach of the Potomac River is 114 mi. The river flows into the Chesapeake Bay about 43 NM south of NSF Dahlgren (see Figure 1-1). The PRTR is located within the estuarine portion of the Potomac River and extends from around Mathias Point to the mouth of the river (see Figure 1-2).

Plants and animals that live in the Potomac River are influenced by a number of factors, with salinity being one of the most important factors affecting their distribution and ecology. The tidal Potomac River can be divided into three segments by salinity regimes (see Figure 3.10-5) – tidal fresh, oligohaline, and mesohaline (Landwehr et al., 1999) – that delimit and characterize the segments:

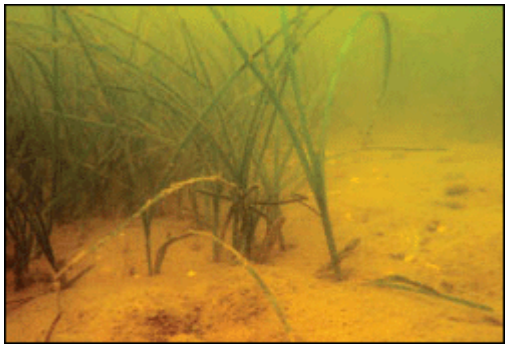
- Tidal fresh – includes the area of the tidal river above Quantico, Virginia. The water is fresh – salinity of less than 0.5 ppt – except in extremely dry years, and the net flow is seaward at all depths.
- Oligohaline – covers the transition zone between Quantico, Virginia, and the Harry Nice Bridge. The salinity is generally low, ranging from 0.5 to 5 ppt, except during drought. Extensive saltwater-freshwater mixing occurs in this segment.
- Mesohaline – extends from the Harry Nice Bridge to the mouth of the river. This segment has moderately brackish water, with salinities typically ranging from 5 to 18 ppt.

Oligohaline and mesohaline waters, along with the polyhaline waters (18-30 ppt) found in the lower part of the Chesapeake Bay below the mouth of the Potomac River, all fall under the terms “brackish” or “mixohaline” with a salinity range from 0.5 to 30 ppt. Ocean water, by comparison, generally has salinity levels of 30 to 35 ppt. Within the PRTR, the mean salinity of the Potomac ranges from approximately 4 to 8 ppt in the vicinity of NSF Dahlgren, to approximately 11 to 16 ppt around the downstream end of the LDZ (based on MDNR, 2010).

3.11.1 Vegetation

3.11.1.1 Submerged Aquatic Vegetation (SAV)

Submerged aquatic vegetation (SAV) is a critical component of the Potomac River ecosystem, providing important biological and physical functions (Rybicki and Landwehr, 2007). SAV forms an integral part of the food web in the Chesapeake Bay, providing shelter and nursery grounds for shellfish and finfish, as well as providing food for a diversity of waterfowl (Ruhl et al., 1999). In addition, the structure provided by SAV helps to stabilize bottom sediment.



Submerged aquatic vegetation

The Chesapeake Bay Program (CBP) has defined the three salinity segments of the lower river as Potomac tidal fresh (POTTF), Potomac oligohaline (POTOH), and Potomac mesohaline (POTMH) (Landwehr et al., 1999). The UDZ is in segment POTOH, and the MDZ and LDZ are in segment POTMH. The tidal fresh segment (POTTF) is upstream of the PRTR and, therefore, is not discussed further in this section.

Table 3.11-1 lists submerged aquatic plants of the tidal Potomac River, based upon surveys conducted by the USGS (Carter et al., 1983) and the Virginia Institute of Marine Science (VIMS) (e.g., Orth et al., 2004, 2005, 2006, 2007, 2011). Common species of SAV in the Potomac River include wild celery (*Vallisneria americana;* also called American eelgrass or tapegrass), coontail (*Ceratophyllum demersum)*, naiad (*Najas* spp.), and common elodea (*Elodea canadensis)* (Orth and Moore, 1984). Wild celery is one of the most abundant submerged aquatic plants found in the tidal Potomac River (Carter et al., 1983). It prefers fresh and slightly brackish water, with lower growth at salinities above 10 ppt (Doering et al., 2001). The growing season for SAV in the Potomac River extends from April through October (Carter et al., 1998).

Orth and Moore (1984) reviewed information on the historical distribution and abundance of SAV in the area of the Chesapeake Bay, of which the Potomac River is the largest tributary. In general, historical records indicate that SAV has been abundant over the last few hundred years, but they also show changes in abundance and species composition. SAV disappeared from the freshwater tidal Potomac River in the late 1930s (Carter et al., 1985). This decline in SAV was followed by an invasion of the exotic species Eurasian watermilfoil (*Myriophyllum spicatum*), from the late 1950s to the early 1960s. During this time period, there was also a significant expansion in SAV in many creeks on the Virginia side of the Potomac River (Moore et al., 2004).

In the 1960s and 1970s there was a decline of SAV in the Chesapeake Bay (Orth and Moore, 1984). The decline was first seen in local regions in the mid-1960s, but spread to all parts of the bay in the 1970s. The pace and extent of the decline increased after Tropical Storm Agnes in 1972 (Orth and Moore, 1984). These reductions were thought to be linked to high nutrient and sediment loads that decreased water clarity (Carter et al., 1998; Orth and Moore, 1984). In the early 1980s water quality improved with upgrades made to wastewater treatments plants, such as the Blue Plains wastewater treatment facility located above the Woodrow Wilson Bridge in the freshwater tidal section. Improvements in water quality led to the return of many species of SAV in the Potomac River (Carter et al., 1987).

Table 3.11-1
Submerged Aquatic Plants of the Tidal Potomac River

Common Name	Scientific Name
Wild celery	*Vallisneria americana*
Redhead grass	*Potamogeton perfoliatus*
Curly pondweed[1]	*Potamogeton crispus*
Coontail	*Ceratophyllum demersum*
Widgeon grass	*Ruppia maritima*
Sago pondweed	*Potamogeton pectinatus*
Slender pondweed	*Potamogeton pusillus*
Leafy pondweed	*Potamogeton epihydrus*
Eurasian watermilfoil[1]	*Myriophyllum spicatum*
Horned pondweed	*Zannichellia palustris*
Southern naiad	*Najas guadalupensis*
Slender naiad[2]	*Najas gracillima*
Naiad[1]	*Najas minor*
Northern or slender naiad	*Najas flexilis*
Stonewort	*Nitella* sp.
Muskgrass	*Chara* spp.
Common elodea	*Elodea canadensis Michx.*
(Brazilian) waterweed[1,2]	*Egeria densa Planch.*
Water stargrass	*Heteranthera dubia*
Hydrilla[1]	*Hydrilla verticillata*
Water chestnut	*Trapa natans*
Eelgrass	*Zostera marina*

Notes:
1. Invasive (non-native) species.
2. Predicted outside of NSF Dahlgren PTRC MDZ and LDZ study area, but may occur in the UDZ.

Sources: Carter et al. (1983); Orth et al. (2004, 2005, 2006, 2007, 2011); Rybicki et al. (2007).

USGS has monitored the distribution and composition of SAV beds in various segments of the Potomac River since 1978 using methods such as transect sampling (in the years 1978 to 1981, 1985 to 1987, and 2002) and shoreline surveys (from 1983 to 2004) (Rybicki et al., 2007). A USGS survey performed from 1978 to 1981 showed that the tidal river had few submerged aquatic plants, but that the greatest abundance and diversity were found in the transition zone of the estuary (Carter et al., 1985). In 1983, the USGS began a new study of the distribution and abundance of SAV that documented the return of many species of submerged aquatic plants to the tidal river (Carter et al., 1985).

Since the mid-1980s VIMS has estimated the annual SAV coverage for various Chesapeake Bay segments, inclusive of the Potomac River, using a combination of aerial photographs and on-site assessments (e.g., Orth et al., 1989, 1996, 2007, 2011). Using the results of these surveys, the changes in SAV coverage in the Potomac can be followed over time.

Data on SAV coverage from 1978 to 2010 were examined for the POTMH segment, which contains the majority of the PRTR, and for the Dahlgren MD-VA USGS quadrant. The total cover and annual change in cover for these areas are provided in Table 3.11-2.

Table 3.11-2
Changes in SAV Acreage in the Lower Potomac River (POTMH)

Year	SAV Acreage	Change from Previous Year	Dahlgren VA-MD Quad Acreage	Change from Previous Year
Historical[1]	4978	NA	NA	NA
1978	498	NA	183	NA
1984	148	-70%	11	-94%
1985	137	-8%	5	-57%
1986	107	-22%	6	22%
1987	123	15%	35	512%
1989[2]	249	103%	162	357%
1990	269	8%	128	-21%
1991	338	26%	144	13%
1992	239	-29%	84	-42%
1993	272	14%	71	-16%
1994	481	77%	77	9%
1995	591	23%	103	33%
1996	994	68%	139	36%
1997	1648	66%	230	65%
1998	1709	4%	406	77%
1999	2351	38%	453	12%
2000	1045	-56%	148	-67%
2001	1739	66%	236	60%
2002	2619	51%	4	-98%
2003	2484	-5%	16	286%
2004	3401	37%	57	253%
2005	3337	-2%	86	51%
2006	1689	-49%	38	-56%
2007	678	-60%	21	-45%
2008	396	-42%	28	35%
2009	336	-15%	39	36%
2010	207	-38%	54	39%

Source: Orth et al., 2011 except for [1] Moore et al. April 2004

Notes:
NA = Not applicable.
[1] Area not fully mapped.
[2] Area was not mapped in 1988.
Historical estimates of acreage may vary depending on the source.

As seen in this table, the amount of SAV coverage each year can vary substantially. In general, SAV coverage in the POTMH segment increased from 1984 to 2004 and has shown a steady decline to the current time (Orth et al., 2011). The SAV coverage in the USGS Dahlgren, VA-MD quadrangle shows a large percent variation in the annual SAV coverage, but generally reflects the trend of the POTMH river segment.

There have also been changes in SAV species distribution and abundance over time. Common species in the Dahlgren USGS quad area include wild celery, redhead grass, coontail, common elodea, widgeon grass, the invasive species Eurasian watermilfoil, and *Hydrilla verticillata* (hydrilla).

Hydrilla is an invasive species from Southeast Asia that grows rapidly and has the potential to outcompete some native species. It was first seen in the Potomac River in 1982 and within two years was fairly widespread in the upper freshwater tidal portion of the river. Hydrilla can grow very densely in shallow areas, where it interferes with boat traffic. As a consequence, the US Army Corps of Engineers (USACE) and local and state agencies began a harvesting program in 1986 to provide boaters with access through the hydrilla beds to boat moorings and marinas (Rybicki et al., 2007). Monitoring since the 1980s has shown that although hydrilla comprised more than 40 percent of the total abundance of vegetation in the Potomac River, it did not eliminate other species over time, and instead the proportion of native SAV has increased over time (USGS, 2010). The other common invasive species, Eurasian watermilfoil, has a greater presence in the oligohaline portion of the river, from Quantico, Virginia to the Nice Bridge (Rybicki et al., 2007), and is not abundant in areas of the PRTR with higher salinities.

3.11.1.2 Emergent Vegetation

Emergent vegetation is rooted in sediments underwater, but grows above – emerges from – the surface of the water. There are 219 ac of estuarine intertidal emergent wetlands on NSF Dahlgren, along the Potomac River, Upper Machodoc Creek, and other tributaries. These wetlands are dominated by saltmarsh cordgrass, marsh elder, and pigweed (NSWCDD, 2001). The wetlands on NSF Dahlgren are discussed in Section 3.10.2.

3.11.2 Plankton

Plankton refers to organisms that passively float or weakly swim in water. While planktonic organisms may have some locomotory ability and can swim vertically, they generally do not have enough power to counteract currents or turbulence or to control their horizontal movement in fresh or salt water. The majority of planktonic organisms are small, with a maximum size of less than an inch in length (less than two centimeters). There are two principal groups of plankton – phytoplankton (plant plankton) and zooplankton (animal plankton).

Common Phytoplankton *Ceratium lineatum*

3.11.2.1 Phytoplankton

Phytoplankton include microscopic algae such as diatoms (eukaryotic algae), dinoflagellates (unicellular protists), and cyanobacteria (blue-

green algae). Phytoplankton species composition and abundance are functions of interactions with environmental conditions including salinity, temperature, light, nutrients, turbulence, and water depth, in addition to other factors such as grazing, competition, and disease (Tango et al., 2005).

The spring bloom of phytoplankton in Chesapeake Bay is dominated by diatoms (Marshall et al., 2005). Spring dominance of diatoms is expected to also occur in the tidal Potomac River. The cell walls of diatoms are made from silica and most diatoms are unicellular. In oligohaline waters the major diatom species include *Skeletonema potamos*, *Skeletonema costatum*, *Cyclotella* spp., and a mixed assemblage of other centric (marine) diatoms less than one inch long. In mesohaline waters the most abundant taxa include *Cerataulina pelagica*, *Skeletonema costatum*, *Cyclotella* spp., *Dactyliosolen fragilissimus*, *Heterocapsa rotundata*, *Prorocentrum minimum*, and *Ceratium furca*. In summer, the phytoplankton community is more diverse, with a greater proportion of chlorophytes (a division of green algae) and cyanobacteria in the lower salinity (fresh and oligohaline) waters and diatoms and dinoflagellates in the higher salinity (mesohaline and polyhaline) waters (Marshall et al., 2006).

Increases in the amount of sediment and nutrients entering the Potomac River can increase algal growth or "blooms" and subsequently affect many other species. About 90 percent of the plankton community in a summer bloom consists of only one or two species, depriving higher trophic levels – organisms higher on the food chain – of valuable nutrition (ICPRB, 2004). Based on these characteristics, phytoplankton is considered a good indicator of water quality. The CBP has been monitoring plankton since the 1980s and has been developing plankton-based indicators of Chesapeake Bay health (ICPRB, 2008), which are described in Section 3.10.1.2.

3.11.2.2 Zooplankton

Zooplankton – animal plankton – provide the intermediate link between primary producers, such as phytoplankton, and secondary consumers, such as macroinvertebrates and fish. In the Potomac River, zooplankton are an important food source for fish, crabs, mussels, and other aquatic animals. Zooplankton include organisms that are entirely planktonic (e.g., copepods, cladocerans, and rotifers) and animals that spend only a portion of their life as plankton (e.g., larvae of benthic invertebrates, benthic chordates, and certain fish). Larval fish (ichthyoplankton) are discussed in Section 3.11.4.

Rotifer - a common zooplankton species

Species of zooplankton are distributed in the Chesapeake Bay based on factors including salinity and food (e.g., phytoplankton) (Reshetiloff, 2004). The Chesapeake Bay Water Quality Monitoring Program included zooplankton sampling from 1984 to 2002 at as many as 36 fixed monitoring stations in the main stem and tidal tributaries of the bay (CRC, 2005). Components of the sampling program included mesozooplankton (zooplankton greater than 202 micrometers [μm] in length), microzooplankton (between 20 and 202 μm long), and gelatinous zooplankton (CRC, 2005).

A Food Availability Index was developed to assess total zooplankton food availability for the larvae of migratory fish. Based on zooplankton data collected from 1999 to 2002, the Potomac River had a borderline minimal/below-minimal Food Availability Index. A comparison of zooplankton data from the beginning of the zooplankton sampling period – from 1984 to 1989 – with the latter part of the program – from 1999 to 2002 – showed decreases in zooplankton at most stations in mesohaline and polyhaline waters, while zooplankton increased in tidal fresh and oligohaline waters. For example, station RET2.2 in the oligohaline area (see Figure 3.10-3 for station location) showed a 33 percent increase in zooplankton, while station LE2.2 in the mesohaline area (see Figure 3.10-3 for station location) showed a 13 percent decrease (CRC, 2005).

Types of Zooplankton

- **Mesozooplankton**: hard-bodied zooplankton greater than 202 µm (based upon net size used in the CBP). This group includes copepods, cladocerans, benthic invertebrate larvae and other meroplankton (organisms that are only planktonic for a portion of their life cycles) (Johnson, 2007).
- **Microzooplankton**: hard-bodied zooplankton between 20 and 200 µm. In the CBP (Johnson, 2009), this group includes copepod nauplii, rotifers and protozoans. Microzooplankton are dominated by ciliated protozoans, rotifers, larval stages of copepods (nauplii), as well as larval stages of various other organisms.
- **Gelatinous Zooplankton**: soft-bodied zooplankton, including cnidarians (true jellyfish, hydromedusae) and ctenophores (comb-jellies). The ctenophore *Mnemiopsis leidyi* and the sea nettle *Chrysaora quinquecirrha* are dominant consumers in the Chesapeake Bay food web.

The Chesapeake Bay Water Quality Monitoring Program determined that the zooplankton status in the Chesapeake Bay area is generally not good, and that current zooplankton food levels for migratory fish larvae are inadequate in most major spawning/nursery areas (CRC, 2005). However, there are improving trends in selected regions of Chesapeake Bay and its tidal tributaries.

3.11.3 Aquatic Invertebrates

Invertebrate organisms are an extremely diverse group, making up over 95 percent of all known species of animals (Ruppert et al., 2003), including oysters, mussels, clams, crabs, sponges, jellyfish, sea anemones, worms, snails, sea slugs, whelks, squid, insects, and many lesser-known creatures. Although zooplankton are invertebrates, they are treated separately, in Section 3.11.2.

Common Aquatic Invertebrates
Midge larvae, snails, worms, and amphipods

In all their forms and diversity, invertebrates represent an important trophic link – a nutritional or energy link in a food web – in aquatic and terrestrial habitats by linking producers (algae and plants), decaying organic matter (hereafter, detritus), and vertebrate predators (fishes, birds, reptiles, and mammals). Many species of invertebrates consume detritus, and are in turn eaten by predators higher in the food web, such as fish, birds, sea turtles, and marine mammals. Detritus is formed by the decomposition of organic matter (decaying plant and animal material) which is facilitated

by microorganisms (bacteria and fungi). Aquatic and terrestrial invertebrates graze on microorganisms and detritus, releasing valuable nutrients back into the surrounding environment, nutrients which are also recycled back into the food chain. Moreover, many invertebrates produce large volumes of feces and pseudofeces, which can also increase nutrient availability and nutrition for plants and microorganisms. Without invertebrates, energy transformed by producers, or lost through decomposition, would not be recycled into the higher trophic levels of the food web.

3.11.3.1 Aquatic Invertebrate Habitats in the Lower Potomac River Estuary

Aquatic invertebrates can live in many different habitats in the Potomac River Estuary. The most common habitats utilized by aquatic invertebrates are:

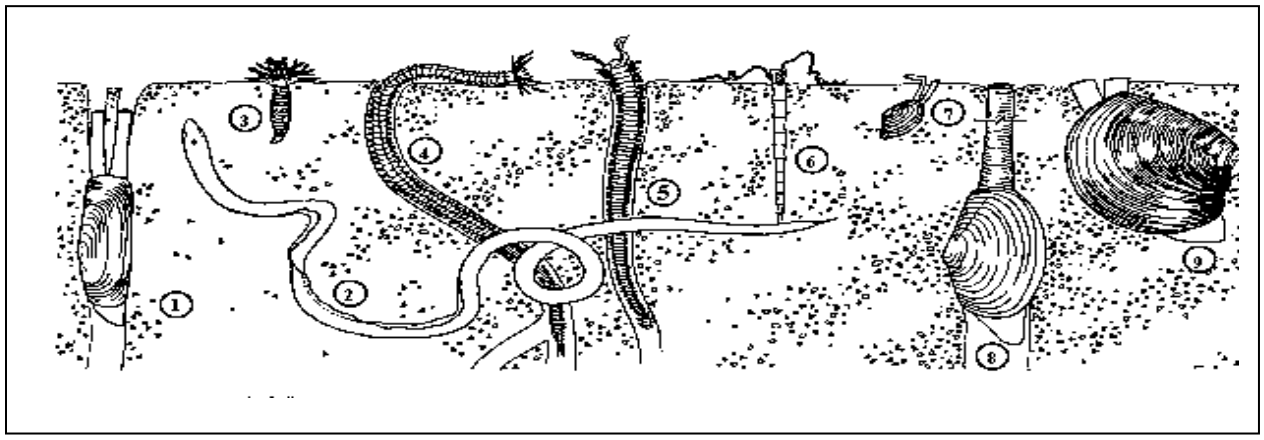
- **Benthic zone**. The bottom of the river forms the benthic zone. Organisms that live in the benthic zone are termed "benthos" or benthic organisms. Many aquatic invertebrates are benthic organisms, spending a majority of their lives living on the bottom of an aquatic ecosystem. The diversity and population size of benthic invertebrate species is controlled by the amount of detritus available, oxygen levels, temperature, salinity, current strength, turbidity, substrate type, and inorganic input.
- **Pelagic zone**. The pelagic zone, or open-water habitat, of the Potomac River Estuary is utilized by only a few groups of invertebrates (e.g., jellyfish, comb jellies, and zooplankton) on a permanent basis. It is underutilized because it usually lacks cover and protection from predators. Some invertebrate species utilize this zone only briefly, right before hatching into their adult form (e.g., aquatic insects). The invertebrates which utilize the pelagic zone the most are the zooplankton communities. Zooplankton can be found in very dense communities in the pelagic waters of the Potomac River Estuary; see Section 3.11.2.
- **Littoral zone**. The shallow edges of the river, which are the areas in the Potomac River Estuary shallow enough for rooted plants to grow, constitute the littoral zone. The habitats that encompass the littoral zone include the watery areas of wetlands, most piers and jetties, seagrass meadows, aquatic emergent plant beds, and oyster bars. In the Potomac River Estuary, the littoral zone is divided into two sections – the intertidal and subtidal zones. The intertidal zone, the zone closest to shore, can be temporarily exposed to air, and usually hosts an abundance of invertebrates. The subtidal zone is also abundant with invertebrate life, but is deeper than the intertidal zone and not often exposed to the air. The intertidal and subtidal zones share many of the same invertebrate groups, though there are some invertebrate species that are specific to each zone.

3.11.3.2 Potomac River Benthic Invertebrate Community Quality

Invertebrates are not only a diverse group that represent an important trophic link but are also important indicators of water and habitat quality, as described in Section 3.10.1.2. As noted in Section 3.10.1.2, the Potomac River benthic community has been rated "poor" overall since the mid-1980s, more so in the mesohaline region that in the tidal freshwater regions. Anoxia is considered the primary culprit for this rating (Llansó et al., 2007).

3.11.3.3 Invertebrate Species Found in the Lower Potomac River Estuary

Table 3.11-3 lists the groups of invertebrates found in the area of the Lower Potomac River Estuary where the PRTR danger zones are located. This list was assembled from data collected as part of the Maryland Department of Natural Resources (MDNR)'s Long-term Benthic Monitoring program (described in Section 3.10.1.2). MDNR has seven fixed long-term monitoring stations in the Potomac River (see Figure 3.10-4) ranging from tidal fresh waters to mesohaline waters. The program also collects random samples on a yearly basis (Llansó et al., 2007). The program samples invertebrate communities on soft mud and sand bottoms but not those on hard rocks or oyster reefs. Therefore, invertebrates that live on hard surfaces, such as Hydroids, some Anthozoans, Bryozoans, certain worms, and some mollusks, are either not well represented or not represented at all in the data collected by this long-term benthic monitoring program (Llansó, pers. comm., April 30, 2008). However, to make this list as complete as possible, the MDNR species list was augmented by data from the National Oceanic and Atmospheric Administration (NOAA)'s Estuarine Living Marine Resources (ELMR) program (Stone et al., 1994; Nelson and Monaco, 2000) and from Lippson & Lippson's (2006) overview of life in the Chesapeake Bay and its tributaries. Nonetheless, this list is probably still not complete, considering the vast diversity of invertebrates in aquatic ecosystems. For example, Tardigrades (or Water Bears) and Rotifer species may have been left out of sample inventories primarily because these organisms are microscopic and can easily be overlooked.



Common Benthic Invertebrates that may be found in the Lower Potomac River Estuary.
Source**:** (Llansó et al., 2007)

1. Stout razor clam *(Tagelus plebeius*)
2. Red ribbon worm (*Micrura leidyi*)
3. Burrowing anemone (*Ceriantheopsis americanus*)
4. Common clam worm (*Neanthes succinea*)
5. Red-gilled mudworm (*Marenzelleria viridis*)
6. Glassy tube worm (*Spiochaetopterus costarum*)
7. Baltic Macoma clam (*Macoma balthica*)
8. Soft-shelled clam (*Mya arenaria*)
9. Hard clam (*Mercenaria mercenaria*)

Table 3.11-3
Invertebrate Species Found in the Lower Potomac River Estuary

Invertebrate Group Taxonomy	Species Name[1] (Common Name)	Habitat[2]	Salinity Range	PRTR Zone	Common Predators	Common Prey
Hirudinea (Leeches)	Many species	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	fish, birds, aquatic insects, reptiles, mollusks and mammals	parasitic to mammals, fish, birds, crustaceans, reptiles
Oligochaete (Aquatic Earthworms)	Many species	Littoral, Benthic	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	fish, birds, aquatic insects, reptiles, mollusks and other invertebrates	detritus[3], protozoa, algae
Polychaete (Bristle Worms)	*Neanthes succinea; Heteromastus filiformis*	Littoral, Benthic	Brackish, Marine	MDZ, LDZ	fish, starfish, sea urchins, lobsters, skates, crabs, horseshoe crabs, birds	sponges, zooplankton, detritus
Coleoptera (Beetles)	*Dytiscus* spp.*; Gyrinus* spp.*; Cicindela doralis*	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	birds, invertebrates, fish	detritus, protozoa, algae
Collembola (Springtails)	*Anurida maritima* (Seashore springtail)	Littoral, Benthic	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	fish and invertebrates	detritus
Diptera (Flies, Midges)	*Aedes solicitans* (Saltmarsh mosquito larvae); *Chrysops* spp. (Deer Fly Larvae); *Tabanus americanus* (American horse fly larvae); *Chironomus* spp. *and Coelotanypus* spp. (Chironomid family); *Chaoborus* spp. (Chaoborus family)	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	fish, worms, large crustaceans, birds	small insect larvae, small crustaceans, zooplankton, mosquito larvae, annelids, fly larvae
Hemiptera (True Bugs)	*Corixa* spp. (Water boatmen); *Gerris* spp. (Water striders)	Littoral	Tidal Fresh, Oligohaline	UDZ	fish, worms, large crustaceans, birds	small crustaceans, aquatic insects, zooplankton, detritus, algae, protozoans, worms, mosquito larvae
Arthropod; Insecta; Odonata (Dragonflies, Damselflies)	*Anax junius* (Green darner); *Libellula puchella* (Twelve-spot skimmer); *Erythrodiplex berenice* (Seaside dragonlet)	Littoral	Tidal Fresh, Brackish	UDZ, MDZ, LDZ	fish, amphibians, large invertebrates, birds	mayfly larvae, small crustaceans, worms, odonata larvae, mollusks, zooplankton small fish, tadpoles
Trichoptera (Caddisflies)	*Oecetis* spp. (Longhorned case maker caddisfly)	Littoral, Pelagic	Tidal Fresh, Oligohaline	UDZ	fish and invertebrates	detritus, small crustaceans, zooplankton, small insect larvae, sponges
Amphipoda (Scuds, Sideswimmers)	*Gammarus* spp. (Scuds); *Ampelisca abdita* (Small four-eyed amphipod); *Leptocheirus plumulosus* (Common burrower amphipod	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, larger invertebrates, worms, birds	detritus, algae, protozoans

Table 3.11-3 (Continued)
Invertebrate Species Found in the Lower Potomac River Estuary

Invertebrate Group Taxonomy	Species Name[1] (Common Name)	Habitat[2]	Salinity Range	PRTR Zone	Common Predators	Common Prey
Cladocera (Giant Water Flea)	*Leptodora kindtii* (Giant water flea)	Littoral, Benthic, Pelagic	Tidal Fresh, Oligohaline	UDZ	fish and invertebrates	zooplankton, small invertebrates
Decapoda (Crayfish)	*Orconectes limosus* (Coastal plains river crayfish); *Cambarus diogenes* (Burrowing crayfish)	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish	UDZ, MDZ	fish, jellyfish, turtles, birds, mammals	clams, decapods, oysters, SAV, detritus, zooplankton, worms
Decapoda (Crab)	*Callinectes sapidus* (Blue crab); *Uca pugnax* (Marsh fiddler crab); *Rhithropanopeus harrisii* (White-fingered mud crab)	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, jellyfish, turtles, birds, mammals	clams, decapods, fish, oysters, SAV, detritus, zooplankton, worms
Decapoda (Shrimp)	*Crangon septemspinosa* (Sevenspine Bay shrimp); *Palaemonetes* spp. (Grass shrimps); *Farfantepenaeus aztecus* (Brown shrimp)	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, jellyfish, turtles, birds, mammals	detritus, zooplankton
Isopoda (Isopods)	*Cyathura polita* (Slender isopod); *Edotea triloba* (Mounded-back isopod); *Lironeca ovalis* (Fish-gill isopod)	Littoral, Benthic, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	invertebrates, fish, crustaceans, birds, mammals	detritus, blood from host, zooplankton, algae, protozoans
Mysidacea (Opossum Shrimp)	*Neomysis americana* (Opossum shrimp); *Americamysis* spp. (Americamysis family)	Benthic, Pelagic	Tidal Fresh, Mesohaline		fish and invertebrates	zooplankton, detritus, algae
Sessilia (Barnacles)	*Balanus eburneus* (Ivory barnacle); *Balanus improvisus* (Bay barnacle); *Balanus subalbidus* (White barnacle)	Littoral	Brackish, Marine	UDZ, MDZ, LDZ	Flatworms, sponges, byozoans, Sea Stars, Whelks	zooplankton, algae
Stomatopoda (Mantis Shrimp)	*Squilla empusa* (Mantis shrimp)	Littoral, Benthic	Mesohaline, Polyhaline	MDZ, LDZ	fish, crabs, mantis shrimp	shrimp, fish, crab
Merostomata (Horseshoe Crabs)	*Limulus polyphemus* (Horseshoe crab)	Littoral, Benthic	Mesohaline, Polyhaline, Marine	MDZ, LDZ	birds, fish, turtles	bivalves, annelid worms, small invertebrates
Pycnogonida (Sea Spiders)	*Callipallene brevirostris* (Long-necked sea spider)	Benthic	Mesohaline, Polyhaline, Marine	MDZ, LDZ	N/A	cnidarians, bryozoans, hydroids, sedentary polychaetes
Bryozoa (Bryozoans)	*Pectinatella* spp. (Freshwater Bryozoan); *Bowerbankia gracilis* (Creeping bryozoan); *Conopeum tenuissimum* (Lacy crust bryzoan)	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	Sea urchins and fish	bacteria, diatoms, algae
Chaetognatha (Arrow Worms)	*Sagitta* spp. (Arrow worms)	Littoral, Pelagic, Benthic	Polyhaline, Marine	MDZ, LDZ	fish and large invertebrates	zooplankton

Table 3.11-3 (Continued)
Invertebrate Species Found in the Lower Potomac River Estuary

Invertebrate Group Taxonomy	Species Name[1] (Common Name)	Habitat[2]	Salinity Range	PRTR Zone	Common Predators	Common Prey
Cephalochordata (Lancelets)	*Branchiostoma caribaeum* (Lancelet)	Benthic, Littoral	Mesohaline, Polyhaline, Marine	MDZ, LDZ	fish	detritus, zooplankton, algae
Uchordata (Sea Squirts)	*Molgula manhattensis* (Sea squirt)	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish	zooplankton, algae, small crustaceans
Anthozoa (Sea Anemone, Corals)	*Diadumene leucolena* (White anemone); *Edwardsia elegans* (Burrowing anemone); *Haliplanella luciae* (Green-striped anemone); *Leptogorgia virgulata* (Whip coral)	Littoral, Benthic	Brackish, Marine	UDZ, MDZ, LDZ	sea slugs, snails, fish, sea stars	fish, shrimp, isopods, amphipods, plankton
Hydrozoa (Hydroids)	*Cordylophora caspia* (Freshwater hydroid); *Dynamena disticha* (Horn garland hydroid); *Ectopleura crocea* (tube hydroid); *Garveia franciscana* (Rope grass)	Benthic, Littoral, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	Sea slugs	small crustaceans, insect larvae, annelid worms
Scyphozoa (Jellyfish)	*Chrysaora quinquecirrha* (Sea nettle); *Cyanea capillata* (Lion's mane jellyfish); *Craspedacusta sowerbii* (Freshwater jellyfish)	Pelagic	Mesohaline, Polyhaline, Marine	MDZ, LDZ	fish, sea turtles, mammals, crabs	fish, zooplankton, shrimp, small crustaceans
Ctenophora (Comb Jellies)	*Beroe ovata* (Pink comb jelly); *Mnemiopsis leidyi* (Sea walnut)	Pelagic	Brackish, Marine	UDZ, MDZ, LDZ	sea turtles, fish, sea birds, other comb jellies	plankton
Asteroidea (Sea Stars)	*Asterias forbesi* (Common sea star); *Micropholis atra* (Burrowing brittle star)	Littoral, Benthic	Polyhaline, Marine	MDZ, LDZ	fish, birds	sponges, bryozoans, and mollusks, detritus
Echinoidea (Sand Dollars)	*Echinarachnius* spp.	Littoral, Benthic	Mesohaline, Polyhaline, Marine	MDZ, LDZ	fish crabs and birds	detritus, plankton
Holothuroidea (Sea Cucumbers)	*Cucumaria pulcherrima* (Pale sea cucumber); *Thyone briares* (Common sea cucumber); *Leptosynapra tenuis* (White synapta)	Littoral, Benthic	Polyhaline, Marine	LDZ	crustaceans, gastropods, turtles, fish, mammals	detritus
Cephalopoda (Squid)	*Lolliguncula brevis* (Brief squid)	Pelagic	Mesohaline, Polyhaline, Marine	MDZ, LDZ	fish, squid	fish, crustaceans, squid
Gastropoda (Snails, Whelks, Sea Slugs)	Many species	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, birds, crabs, mammals	detritus, algae, protozoans

Table 3.11-3 (Continued)
Invertebrate Species Found in the Lower Potomac River Estuary

Invertebrate Group Taxonomy	Species Name[1] (Common Name)	Habitat[2]	Salinity Range	PRTR Zone	Common Predators	Common Prey
Pelycypoda (Bivalves: Oysters)	*Crassostrea virginica* (Eastern oyster)	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, echinoderms, crabs, birds, snails, mammals	plankton, detritus
Pelycypoda (Bivalves: Clams)	*Mya arenaria* (Soft-shelled clam); *Gemma gemma* (Gem clam); *Macoma* spp. (Macoma clams); *Corbicula fluminea* (Asian clam)	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, echinoderms, crabs, birds, snails, mammals	plankton, detritus
Pelycypoda (Bivalves: Mussels)	*Ischadium recurvum* (Hooked mussel)	Littoral, Benthic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, echinoderms, crabs, birds, snails, mammals	plankton, detritus
Polyplacophora (Chitons)	*Chaetopleura apiculata* (Common eastern chiton)	Benthic	Polyhaline, Marine	MDZ, LDZ	starfish, crabs, fish, sea anemones, birds	algae, detritus
Nemertea (Ribbon, Round, or Proboscis Worms)	Many species	Benthic, Littoral, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, crustaceans	detritus, mollusks, worms, small crustaceans, snails
Phoronida (Horseshoe or Phoronid Worms)	*Phoronis* spp. (Horseshoe worms)	Benthic, Littoral	Polyhaline, Marine	MDZ, LDZ	fish	small invertebrates, algae, detritus, plankton
Platyhelminthes (Flatworms)	*Euplana gracilis* (Slender flatworm); *Stylochus ellipticus* (Oyster flatworm)	Benthic, Littoral	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, worms, aquatic insect larvae	detritus, protozoans, small crustaceans, mollusks, barnacles, oysters, worms, algae
Porifera (Sponges)	*Cliona* spp. (Boring sponges); *Halichondria bowerbanki* (Crumb-of-bread sponge); *Haliclona* spp. (Eroded sponges	Benthic, Littoral, Pelagic	Tidal Fresh, Brackish, Marine	UDZ, MDZ, LDZ	fish, sea slugs, sea turtles	detritus, plankton

Sources:
Life in the Chesapeake Bay, Lippson and Lippson, 2006.
NOAA's Estuarine Living Marine Resources (ELMR) program, Stone et al., 1994; Nelson and Monaco, 2000.
(MDNR) Long-term Benthic Monitoring and Assessment Component of the Chesapeake Bay Water Quality Monitoring Program, Llansó et al., 2007.

Notes:
1. Lists the names of species most commonly known to occur in the Lower Potomac River Estuary; this list is not inclusive of every species in the estuary.
2. Habitat includes all stages of an organism's life that is associated with the river.
3. Detritus implies not only decaying organic matter but also bacteria and fungi, as these are the microorganisms primarily responsible for decomposition.

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While the invertebrates listed in Table 3.11-3 are ecologically important species, only blue crabs (*Callinectes sapidus)*, Eastern oysters (*Crassostrea virginica)*, and some clam species are economically important. The Chesapeake Bay and the Potomac River support a diverse commercial fishery, with blue crab yielding the largest financial return, at $45 million per year (Fahrenthold, 2007; Potomac River Fisheries Commission [PRFC], 2008). Historically, the Potomac River was a bountiful source of oysters and clams, but the catch has declined greatly. Clam harvesting in the Potomac River is minimal today.

Blue Crab

The blue crab in the Potomac River is both an ecologically and economically important crustacean. Blue crab habitat in the river ranges from tidal freshwater to the mesohaline waters at the mouth of the river. The blue crab utilizes SAV not only as protection from potential predators, but also to prey on other organisms and as a vital nursery for juvenile crabs (Lippson and Lippson, 2006). Blue crabs play a critical role in the healthy function of an ecosystem, for they are prey for economically important species such as striped bass (*Morone saxatilis*) and black and red drum (*Pogonias cromis* and *Sciaenops ocellatus*, respectively). In addition, they are also an important prey item for a myriad of other species, including loggerhead turtles (*Caretta caretta*), Kemp's ridley turtles (*Lepidochelys kempi*), mammals, and many bird species, such as herons and egrets (Lippson and Lippson, 2006). The blue crab is also important because it feeds on clams, fish, and other small invertebrate species. By doing so, the blue crab keeps these populations from exploding and over-reaching their habitat requirements.

Blue Crab
Callinectes sapidus

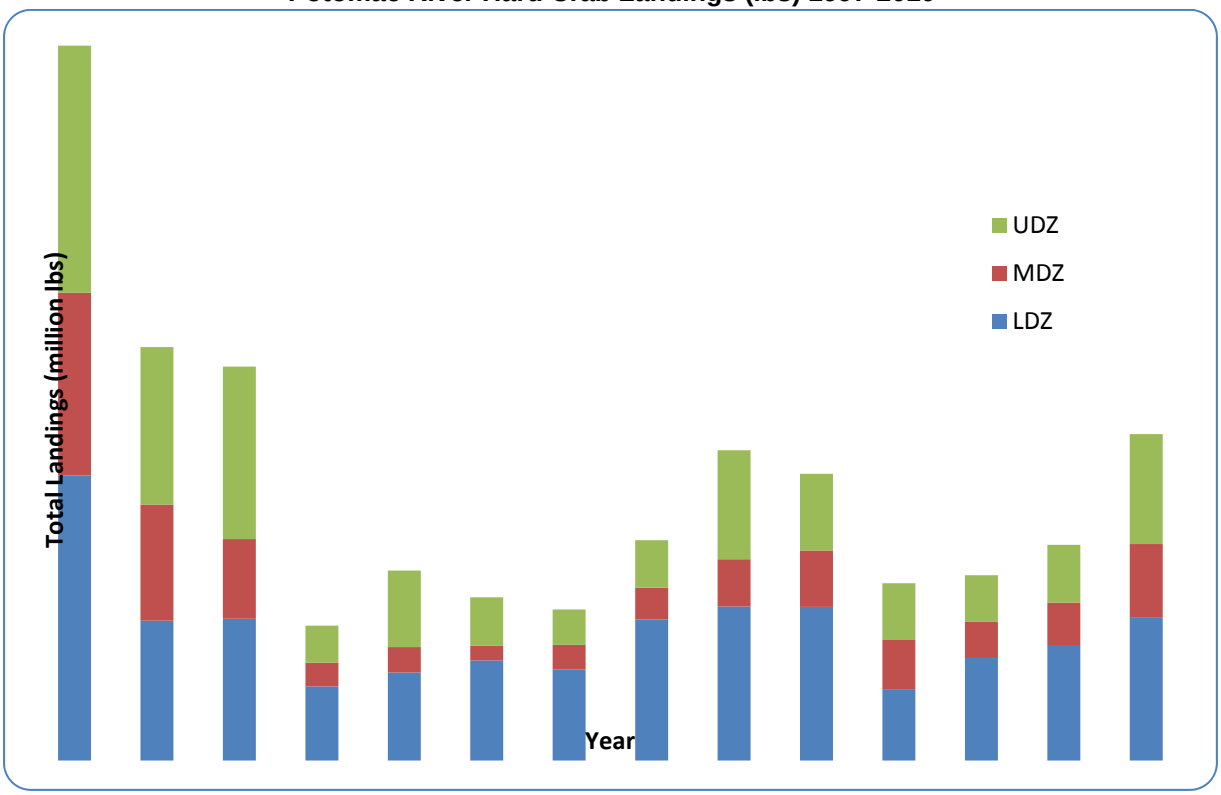
The blue crab population throughout the bay declined sharply in the last two decades, dropping 70 percent from an estimated 852 million in 1993 to 273 million in 2007 (Fahrenthold, 2008). The decline is variously attributed to overfishing; higher water temperatures and nitrogen levels, which contribute to algal blooms/die-offs and consequent low oxygen levels; and a decrease in SAV, which reduces nursery habitat (Fahrenthold, 2007). Figure 3.11-1 (Potomac River Hard Crab Landings (lbs) 1997-2010) illustrates the drop in total blue crab from Possum Point, Virginia to the mouth using landings of hard crabs data from the PRFC. For example, a decline in total annual harvest has been observed in the lower Potomac River (Possum Point, Virginia downstream to the mouth), including the UDZ, MDZ, and LDZ, where approximately 8.9 million pounds were harvested in 1997, but only 2.2 million pounds in 2007 (Cosby, PRFC, pers. comm., March 1, 2010). As a result, the states of Maryland and Virginia in

Hard Crabs

For a blue crab to grow larger, it must periodically shed its smaller shell through a process known as molting – or, more accurately, ecdysis. Early in its molting cycle, the crab begins to form a new, soft shell underneath its existing hard shell. Hard crabs are crabs with hard outer shells.

April 2008 moved to reduce the limit of female blue crabs allowed to be harvested in 2008 by 34 percent (Fahrenthold, 2008). The decrease in limits set by the two states has had a significant impact, as recent studies and landing data show that the crab population has nearly doubled in subsequent years (Fahrenthold, 2010; Cosby, PRFC, pers. comm., March 1, 2011). Current population estimate place the blue crab population at 658 million crabs bay-wide (Farenthold, 2010).

Figure 3.11-1
Potomac River Hard Crab Landings (lbs) 1997-2010



Source: Cosby, PRFC, pers. comm., March 1, 2011.

Eastern Oyster

The native eastern oyster can be found in nearly all coastal waters from Canada to Argentina, including the lower Potomac River. Oysters generally live in benthic and littoral areas, filtering plankton and detritus from the water column. What they do not eat they spit back out as waste, which is valuable to many other detritus consumers. When oysters were at their highest population levels in the 1800's, the oyster population could filter the entire Chesapeake Bay watershed, including the Potomac River, every three days (Newell, 1988). Today, it is estimated that the current oyster population would take a whole year to filter the same volume of water (Newell et al., 2005).

Oysters permanently cement themselves to a firm substrate. Once well-established, oysters and their shells form reefs that become complex ecosystems, offering a solid structure for other sessile organisms (e.g., barnacles, sea anemones) to attach to, and homes and hiding places for organisms to seek refuge from predation (e.g., blue crabs, oligochaetes, polychaetes). Oyster communities create spawning substrate for some species of fish, stabilize bottom sediments, concentrate food sources for predatory fish species, serve as breakwater and protection from erosion, and clarify the water column through their filtering behavior. Oysters are a food source for certain fish species, echinoderms, crabs, birds, snails, and mammals.

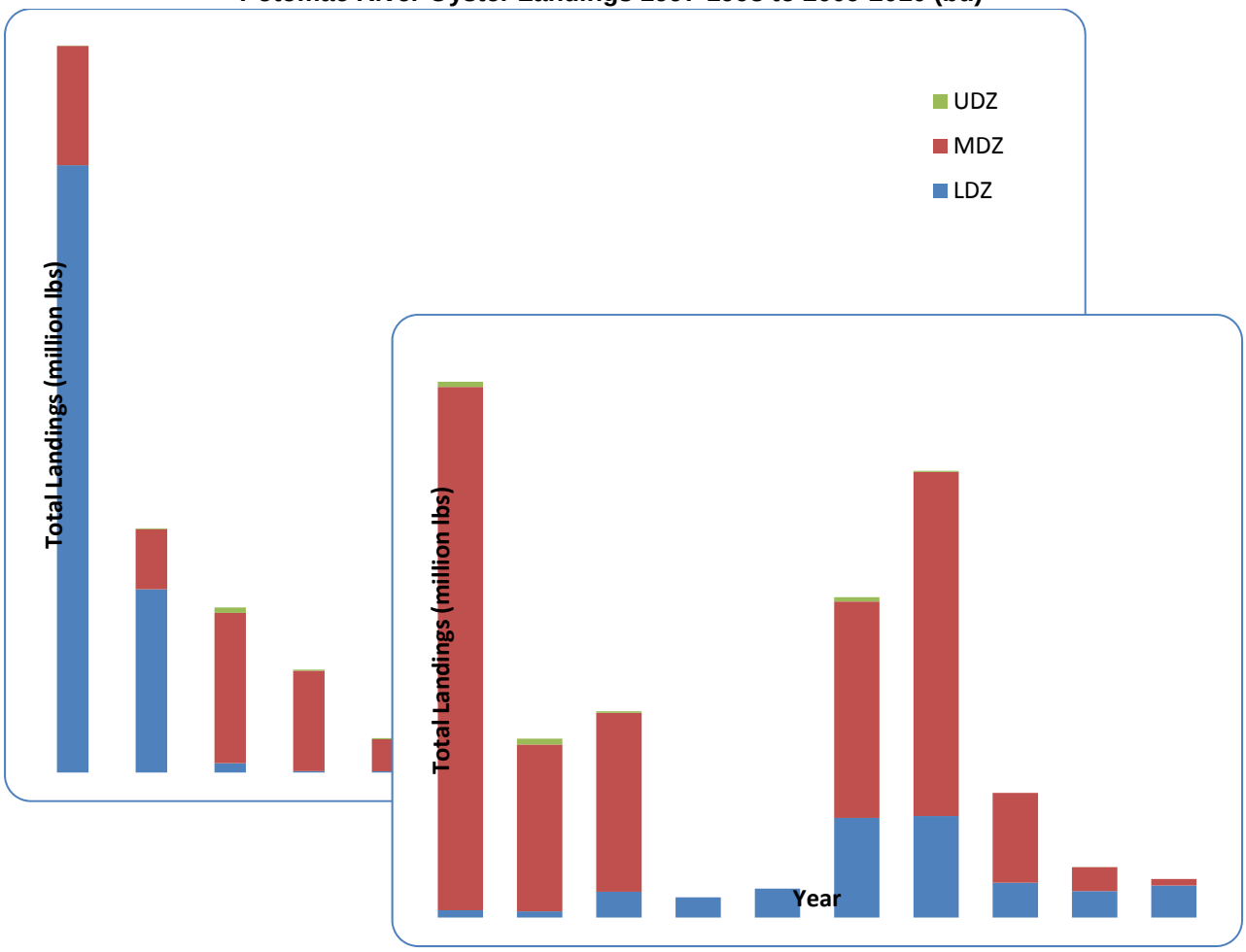
Eastern Oyster
Crassostrea virainica

The oyster population of the Chesapeake Bay and its tributaries has dropped precipitously since the later 1800s, when trade in Chesapeake Bay oysters boomed. By 1991, oyster populations were thought to be only four percent of the historical 19th-century levels (National Research Council and the Committee on Nonnative Oysters in the Chesapeake Bay, 2004). Although oysters are still harvested in the Potomac today, annual harvests continue to decline, as illustrated on Figure 3.11-2 (Potomac River Oyster Landings 1997-1998 to 2009-2010 (bu)). For example, in the 1997-1998 season, approximately 39,547 bushels (bu) were harvested from the Potomac River from Possum Point, Virginia to the mouth of the river, but the 2009-2010 season's harvest of 403 bu represented just 1 percent of the 1997-1998 landings (Cosby, PRFC, pers. comm., March 1, 2011).

The primary causes of oyster decline include overfishing, poor water quality (i.e., increased sedimentation), habitat loss, freshwater intrusion (i.e., decreased salinity levels), and disease. The most common disease in the Chesapeake Bay is Dermo Disease, which is caused by the protozoan parasite *Perkinsus marinus*, (VIMS, 2011). It is likely that the effectiveness and subsequent lethality of these diseases are the result of multiple stressors acting on the oyster population. For example, overfishing, poor water quality (i.e., increased sedimentation), habitat loss, and freshwater intrusion all add stress to the oyster population, decreasing its resistance to disease (Burreson, 1991).

As a result of the oyster decline, the oyster fishery in the Potomac River has been greatly diminished (Figure 3.11-2), and many of the oyster beds are currently off limits due to contamination. Figure 3.11-3 (Potomac River Oyster Bars) shows the boundaries of MDNR's natural oyster bars (NOBs) and historical oyster bars. NOBs are legally-defined locations where oyster bars are found in Maryland waters, which include most of the Potomac River. Since they are legal boundaries that were drawn to encompass potential oyster habitat, they may include some areas that do not support oyster growth. The NOB charts are based on surveys in 1928, 1975 through 1985, and 1994. The historical data show areas where oysters have been known to grow, but are not necessarily included as oyster bars on the current NOB charts (MDNR, 2008).

Figure 3.11-2
Potomac River Oyster Landings 1997-1998 to 2009-2010 (bu)



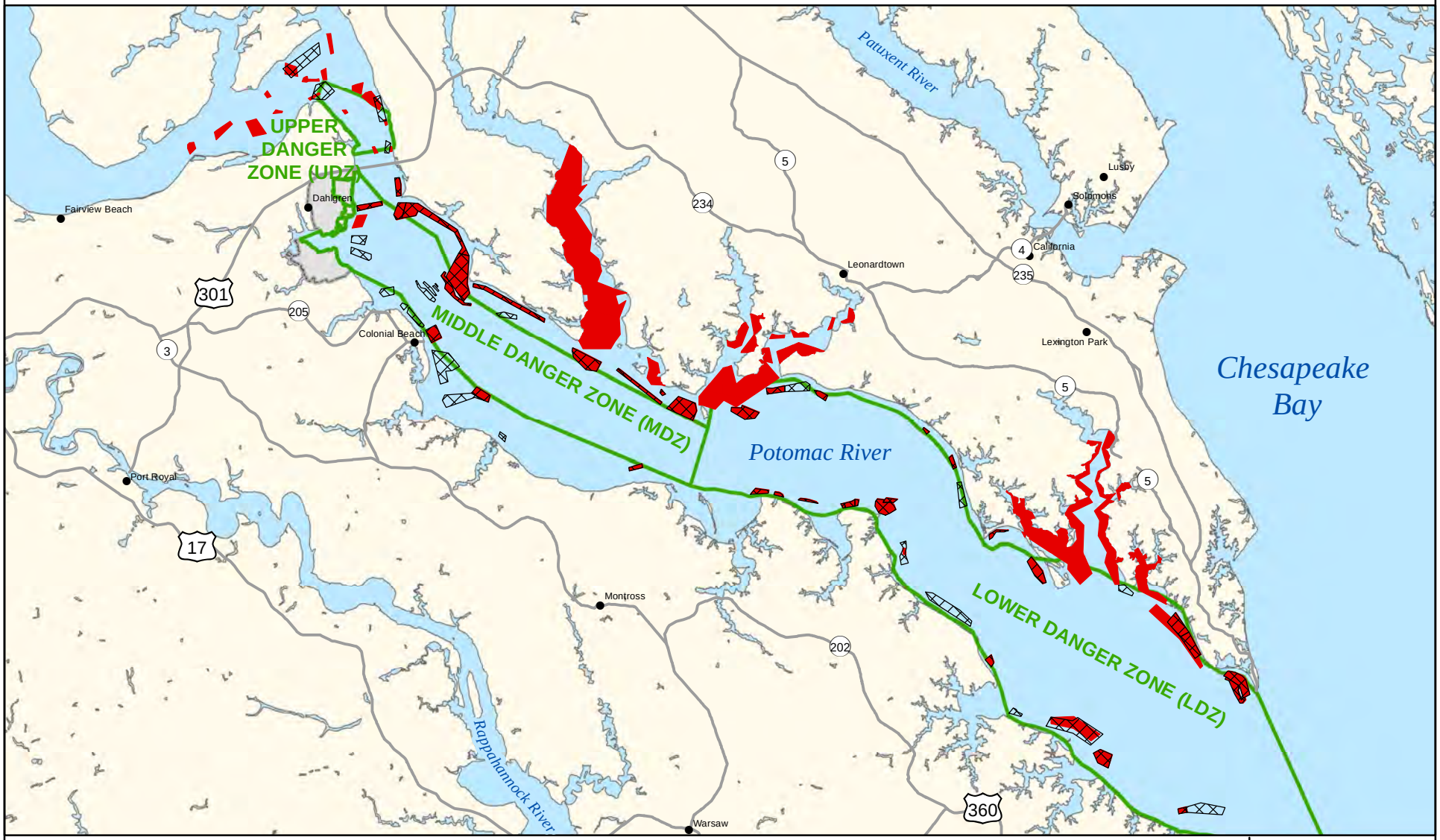
Source: Cosby, PRFC, pers. comm., March 1, 2011.

3.11.4 Fish

3.11.4.1 Distribution and Abundance

The structure of fish communities depends on abiotic (physical) factors, such as salinity, temperature, and dissolved oxygen, and on biotic (biological) factors, such as food availability, competition, predation, and habitat requirements. The PRTR portion of the Potomac River is characterized by strong tidal currents, moderate vertical stratification, and considerable longitudinal variation in salinity (Wilson, 1977). These characteristics underlie its ecological importance in providing adult, migratory, spawning, and nursery habitat for local and regional fish populations.

Potomac River Oyster Bars



MDNR Natural Oyster Bars (NOB) Data

Maryland's Historic Oyster Bottom (1976 - 1983)

Potomac River Test Range (PRTR) Complex

Naval Support Facility (NSF) Dahlgren

6 0 6 Miles

10 0 10 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011), Maryland Department of Natural Resources
Disclaimer: The Natural Oyster Bar/lease lines shown are for oyster management purposes only.
For the official boundaries consult the current official Natural Oyster Bar Chart.

Figure 3.11-3

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Table 3.11-4 presents a list of the approximately 90 fish species that are expected to occur in the PRTR portion of the Potomac River, ranging in abundance from rare – e.g., shortnose and Atlantic sturgeons, marsh and spotfin killifishes, and code and clown gobies – to highly abundant – e.g., hogchoker, rough and Atlantic silversides, bay anchovy, banded and striped killifishes, mummichog, and white perch. In chronological order, the principal sources of the information in Table 3.11-4 are briefly described below.

- Fish-sampling efforts in 1977 and 1978 identified 31 species within NSF Dahlgren and surrounding waters (NSWCDL, 1979). Seventeen species were captured in the Potomac River, mostly species that inhabit shallow waters near the shore. These included silversides, carp, bay anchovy, killifishes, white perch, striped bass, yellow perch, spot, and northern pipefish.

Atlantic Menhaden – *Brevoortia tyrannus*

- The *Environmental Atlas of the Potomac Estuary* (Lippson et al., 1981) is a compilation of data and information pertaining to the Potomac River Estuary. A review of the atlas, as well as of Lippson & Lippson's *Life in the Chesapeake Bay* (2006), suggests that approximately 70 species of fish are expected to occur in the PRTR portion of the river. The *Atlas* designates the occurrence of 20 of these species as abundant – i.e., common species found in large numbers – in the estuary: hogchoker, rough silverside, Atlantic silverside, alewife, Atlantic menhaden, bay anchovy, mummichog, naked goby, bluefish, striped bass, American eel, tidewater silverside, blueback herring, American shad, gizzard shad, banded killifish, striped killifish, white perch, yellow perch, and spot.
- In conjunction with a SAV study conducted between 1999 and 2002, the Alliance for the Chesapeake Bay and NSF Dahlgren conducted fish sampling at two stations on the Potomac River at NSF Dahlgren and four stations on Upper Machodoc Creek (Alliance for the Chesapeake Bay, Not Dated; NSF Dahlgren, 2007). A total of 24 fish species was collected at the Potomac River stations during these efforts (completed fish collection forms provided by Lou Etgen, Interim Director, Alliance for the Chesapeake Bay, November 17, 2008). The most abundant species collected were white perch and Atlantic silverside, comprising 51.0 and 30.0 percent of the total catch, respectively. Other species that represented at least 1.0 percent of the total catch were bay anchovy, banded killifish, mummichog, striped killifish, and striped bass. Additional species of recreational and commercial importance that were collected included American eel, gizzard shad, yellow perch, bluefish, and spot.
- More-recent studies and consultations – among them, NOAA, February 2008, and Cosby, PRFC, pers. comm., March 1, 2011 – provided information on additional species that are expected to occur, bringing the approximate total number of species to 100.

Table 3.11-4
Fish Species Expected to Occur in the PRTR Portion of the Potomac River

Common Name	Scientific Name	Habitat Characteristics[a]	Depth[a,b] (m)	Occurrence Data Source
Achiridae (American soles)				
Hogchoker	*Trinectes maculatus*	demersal · amphidromous · freshwater, brackish and marine	0 - 75	2, 3, 6, 7, 9, 10
Acipenseridae (sturgeons)				
Shortnose sturgeon	*Acipenser brevirostrum*	demersal · anadromous · freshwater, brackish and marine	NA	2, 9
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	demersal · anadromous · freshwater, brackish and marine	? - 46	2, 6, 9
Anguillidae (freshwater eels)				
American eel	*Anguilla rostrata*	demersal · catadromous · freshwater, brackish and marine	0 - 464	2, 5, 6, 7, 8, 9, 10
Atherinopsidae (neotropical silversides)				
Rough silverside	*Membras martinica*	pelagic · marine	NA	2, 9
Silversides	*Menidia* sp.			1, 3, 6, 10
Tidewater silverside (Inland silverside)	*Menidia beryllina*	pelagic · freshwater, brackish and marine	0 - ?	1, 2, 3, 5, 9, 10
Atlantic silverside	*Menidia menidia*	pelagic · oceanodromous · brackish and marine	0 - ?	1, 2, 3, 5, 7, 9, 10
Batrachoididae (toadfishes)				
Oyster toadfish	*Opsanus tau*	reef-associated · marine	NA	2, 6, 7, 9
Belonidae (needlefishes)				
Atlantic needlefish	*Strongylura marina*	reef-associated · freshwater, brackish and marine	1 - ?	2, 3, 5, 7[c], 9, 10
Blenniidae (combtooth blennies)				
Striped blenny	*Chasmodes bosquianus*	demersal · brackish and marine	? - 30	2, 9
Feather blenny	*Hypsoblennius hentz*	reef-associated · marine	NA	2, 9
Carangidae (jacks and pompanos)				
Blue runner	*Caranx crysos*	reef-associated · marine	0 - 100	2, 9
Carcharhinidae (Requiem sharks)				
Bull shark	*Carcharhinus leucas*	reef-associated · amphidromous · freshwater, brackish and marine	1 - 152	11
Centrarchidae (sunfishes)				
Sunfish	*Lepomis* sp.			10
Redbreast sunfish	*Lepomis auritus*	demersal · freshwater	NA	3, 10
Bluegill	*Lepomis macrochirus*	benthopelagic · freshwater	NA	5, 7
Largemouth bass	*Micropterus salmoides*	benthopelagic · freshwater	? - 7	5, 7
Black crappie	*Pomoxis nigromaculatus*	benthopelagic · freshwater	NA	1, 4
Clupeidae (herrings, shads, sardines, menhadens)				
	Alosa sp.			1, 3, 5, 7, 10
Blueback herring (blueback shad)	*Alosa aestivalis*	pelagic · anadromous · freshwater, brackish and marine	5 - 55	2, 6, 7, 8[d], 9
Hickory shad	*Alosa mediocris*	pelagic · anadromous · freshwater, brackish and marine	NA	2, 7, 9
Alewife	*Alosa pseudoharengus*	pelagic · anadromous · freshwater, brackish and marine	5 - 145	2, 6, 7, 9, 10
American shad	*Alosa sapidissima*	pelagic · anadromous · freshwater, brackish and marine	0 - 250	2, 6, 7, 8, 9

Table 3.11-4 (Continued)
Fish Species Expected to Occur in the PRTR Portion of the Potomac River

Common Name	Scientific Name	Habitat Characteristics[a]	Depth[a,b] (m)	Occurrence Data Source
Atlantic menhaden	*Brevoortia tyrannus*	pelagic · oceanodromous · brackish and marine	0 - 50	2, 3, 5, 6, 7, 8, 9
Gizzard shad (American gizzard shad)	*Dorosoma cepedianum*	pelagic · anadromous · freshwater, brackish and marine	? - 33	2, 3, 5, 7, 8, 9, 10
Hickory shad	*Alosa mediocris*	pelagic · anadromous · freshwater, brackish and marine	NA	2, 7, 9
Alewife	*Alosa pseudoharengus*	pelagic · anadromous · freshwater, brackish and marine	5 - 145	2, 6, 7, 9, 10
American shad	*Alosa sapidissima*	pelagic · anadromous · freshwater, brackish and marine	0 - 250	2, 6, 7, 8, 9
Atlantic menhaden	*Brevoortia tyrannus*	pelagic · oceanodromous · brackish and marine	0 - 50	2, 3, 5, 6, 7, 8, 9
Gizzard shad (American gizzard shad)	*Dorosoma cepedianum*	pelagic · anadromous · freshwater, brackish and marine	? - 33	2, 3, 5, 7, 8, 9, 10
Cynoglossidae (tonguefishes)				
Blackcheek tonguefish	*Symphurus plagiusa*	demersal · brackish and marine	0 - 183	2, 7[e], 9
Cyprinidae (minnows and carps)				
Carp (Common carp)	*Cyprinus carpio carpio*	benthopelagic · potamodromous · freshwater and brackish	NA	1, 3, 5, 7, 8
Unidentified shiner	*Notropis* sp.			1
Cyprinodontidae (pupfishes)				
Sheepshead minnow	*Cyprinodon variegates variegatus*	benthopelagic · non-migratory · freshwater, brackish and marine	NA	2, 6, 7, 9
Diodontidae (porcupinefishes [burrfishes])				
Striped burrfish	*Chilomycterus schoepfii*	reef-associated · marine	? - 11	2, 9
Engraulidae (anchovies)				
Striped anchovy (Broad-striped anchovy)	*Anchoa hepsetus*	pelagic · brackish and marine	1 - 70	2, 9
Bay anchovy	*Anchoa mitchilli*	reef-associated · amphidromous · brackish and marine	1 - 36	1, 2, 3, 5, 6, 7, 9, 10
Fundulidae (topminnows and killifishes)				
Killifishes	*Fundulus* spp.			1, 6, 10
Marsh killifish	*Fundulus confluentus*	benthopelagic · non-migratory · freshwater, brackish and marine	NA	2, 9
Banded killifish	*Fundulus diaphanous diaphanus*	benthopelagic · non-migratory · freshwater and brackish	NA	1, 2, 3, 5, 9, 10
Mummichog	*Fundulus heteroclitus heteroclitus*	benthopelagic · non-migratory · freshwater, brackish and marine	NA	1, 2, 3, 5, 7, 9, 10
Spotfin killifish	*Fundulus luciae*	benthopelagic · non-migratory · brackish and marine	NA	2, 9
Striped killifish	*Fundulus majalis*	benthopelagic · non-migratory · brackish and marine	NA	1, 2, 3, 5, 9, 10
Rainwater killifish	*Lucania parva*	pelagic · amphidromous · freshwater, brackish and marine	NA	2, 9
Gasterosteidae (sticklebacks and tubesnouts)				
Fourspine stickleback	*Apeltes quadracus*	benthopelagic · freshwater, brackish and marine	NA	2, 9
Threespine stickleback (Three-spined stickleback)	*Gasterosteus aculeatus aculeatus*	benthopelagic · anadromous · freshwater, brackish and marine	0 - 100	2, 9

Table 3.11-4 (Continued)
Fish Species Expected to Occur in the PRTR Portion of the Potomac River

Common Name	Scientific Name	Habitat Characteristics[a]	Depth[a,b] (m)	Occurrence Data Source
Gobiesocidae (clingfishes and singleslits)				
Skilletfish	*Gobiesox strumosus*	reef-associated · brackish and marine	0 - 33	2, 3, 9, 10
Gobiidae (gobies)				
Gobies	*Gobiosoma* spp.			6
Naked goby	*Gobiosoma bosc*	demersal · brackish and marine	NA	2, 9, 10
Seaboard goby	*Gobiosoma ginsburgi*	demersal · marine	? - 50	2, 9
Code goby	*Gobiosoma robustum*	demersal · brackish and marine	NA	2, 9
Clown goby	*Microgobius gulosus*	demersal · amphidromous · freshwater, brackish and marine	NA	2, 9
Green goby	*Microgobius thalassinus*	demersal · marine	NA	2, 9
Hemiramphidae (halfbeaks)				
Halfbeak (Common halfbeak)	*Hyporhamphus unifasciatus*	reef-associated · oceanodromous · brackish and marine	0 - 5	2, 9
Ictaluridae (North American freshwater catfishes)				
White catfish	*Ameiurus catus*	demersal · potamodromous · freshwater	10 - ?	7, 8
Yellow bullhead	*Ameiurus natalis*	demersal · freshwater	10 - ?	7
Brown bullhead	*Ameiurus nebulosus*	demersal · freshwater and brackish	? - 40	5, 7, 8
Channel catfish	*Ictalurus punctatus*	demersal · freshwater	15 - ?	5, 6, 7, 8
Labridae (wrasses)				
Tautog	*Tautoga onitis*	reef-associated · brackish and marine	1 - 75	2, 6, 9
Lepisosteidae (gars)				
Longnose gar	*Lepisosteus osseus*	demersal · freshwater and brackish	0 - ?	1, 7
Monacanthidae (filefishes)				
Orange filefish	*Aluterus schoepfii*	reef-associated · marine	3 - 900	2, 9
Moronidae (temperate basses)				
White perch	*Morone americana*	demersal · anadromous · freshwater, brackish and marine	10 - ?	1, 2, 3, 5, 6, 7, 8, 9, 10
Striped bass	*Morone saxatilis*	demersal · anadromous · freshwater, brackish and marine	30 - ?	1, 2, 3, 5, 6, 7, 8, 9, 10
Mugilidae (mullets)				
Mullets	*Mugil* spp.			6
Striped mullet (Flathead mullet)	*Mugil cephalus*	benthopelagic · catadromous · freshwater, brackish and marine	0 - 120	2, 9
White mullet	*Mugil curema*	reef-associated · catadromous · freshwater, brackish and marine	15 - ?	2, 9
Myliobatidae (eagle and manta rays)				
Cownose ray	*Rhinoptera bonasus*	benthopelagic · oceanodromous · brackish and marine	0 - 22	2, 6, 7, 9
Paralichthyidae (large-tooth flounders)				
Summer flounder	*Paralichthys dentatus*	demersal · oceanodromous · marine	10 - 183	2, 6, 7, 8, 9
Percidae (perches)				
Yellow perch	*Perca flavescens*	benthopelagic · freshwater and brackish	? - 56	1, 2, 3, 5, 6, 8, 9, 10
Petromyzontidae (lampreys)				
Sea lamprey	*Petromyzon marinus*	demersal · anadromous · freshwater, brackish and marine	1 – 2,200	2, 9

Table 3.11-4 (Continued)
Fish Species Expected to Occur in the PRTR Portion of the Potomac River

Common Name	Scientific Name	Habitat Characteristics[a]	Depth[a,b] (m)	Occurrence Data Source
Phycidae (phycid hakes)				
Spotted hake (Spotted codling)	*Urophycis regia*	demersal · non-migratory · marine	0 - 494	2, 9
Pleuronectidae (righteye flounders)				
Winter flounder	*Pseudopleuronectes americanus*	demersal · oceanodromous · marine	5 - 143	2, 6, 9
Poeciliidae (Poeciliids)				
Eastern mosquitofish	*Gambusia holbrooki*	benthopelagic · potamodromous · freshwater and brackish	NA	5
Pomatomidae (bluefishes)				
Bluefish	*Pomatomus saltatrix*	pelagic · oceanodromous · brackish and marine	0 - 200	2, 3, 6, 7, 8, 9, 10
Rachycentridae (cobia)				
Cobia	*Rachycentron canadum*	reef-associated · oceanodromous · brackish and marine	0 – 1,200	2, 9
Sciaenidae (drums and croakers)				
Silver perch	*Bairdiella chrysura*	demersal · freshwater, brackish and marine	NA	2, 9
Weakfish (Gray weakfish)	*Cynoscion regalis*	demersal · oceanodromous · brackish and marine	10 - 26	2, 6, 7, 8[f], 9
Spotted seatrout (Spotted weakfish)	*Cynoscion nebulosus*	demersal · brackish and marine	10 - ?	2, 3, 6, 8[g], 9
Spot (Spot croaker)	*Leiostomus xanthurus*	demersal · oceanodromous · brackish and marine	? - 60	1, 2, 3, 5, 6, 7, 8, 9, 10
Southern kingfish (Southern kingcroaker)	*Menticirrhus americanus*	demersal · oceanodromous · brackish and marine	? - 40	2, 9
Northern kingfish (Northern kingcroaker)	*Menticirrhus saxatilis*	demersal · brackish and marine	10 - ?	2, 6, 9
Atlantic croaker	*Micropogonias undulatus*	demersal · brackish and marine	? - 100	2, 6, 7, 8, 9
Black drum	*Pogonias cromis*	demersal · oceanodromous · brackish and marine	10 - ?	2, 6, 9
Red drum	*Sciaenops ocellatus*	demersal · oceanodromous · brackish and marine	10 - ?	2, 6, 9
Scombridae (mackerels, tunas, bonitos)				
Spanish mackerel	*Scomberomorus maculates*	reef-associated · oceanodromous · marine	10 - 35	8
Scophthalmidae (turbots)				
Windowpane flounder (Windowpane)	*Scophthalmus aquosus*	demersal · marine	55 - 73	2, 9
Serranidae (sea basses, groupers and fairy basslets)				
Black sea bass (Black seabass)	*Centropristis striata*	reef-associated · oceanodromous · marine	1 - ?	2, 6, 9
Stromateidae (butterfishes)				
Harvestfish	*Peprilus alepidotus*	benthopelagic · marine	NA	2, 3, 9
Butterfish (American butterfish)	*Peprilus triacanthus*	benthopelagic · oceanodromous · brackish and marine	15 - 420	2, 6, 9
Syngnathidae (pipefishes and seahorses)				
Lined seahorse	*Hippocampus erectus*	reef-associated · non-migratory · marine	1 - 73	2, 9
Dusky pipefish	*Syngnathus floridae*	demersal · marine	? - 22	2, 9
Northern pipefish	*Syngnathus fuscus*	demersal · amphidromous · freshwater, brackish and marine	5 - 366	1, 2, 3, 5, 6, 9, 10
Synodontidae (lizardfishes)				
Inshore lizardfish	*Synodus foetens*	reef-associated · brackish and marine	0 - 200	2, 9
Tetraodontidae (puffers)				
Northern puffer	*Sphoeroides maculatus*	demersal · brackish and marine	10 - 183	2, 7, 9

Table 3.11-4 (Continued)
Fish Species Expected to Occur in the PRTR Portion of the Potomac River

Common Name	Scientific Name	Habitat Characteristics[a]	Depth[a,b] (m)	Occurrence Data Source
Triglidae (searobins)				
Northern searobin	*Prionotus carolinus*	demersal · brackish and marine	15 - 170	2, 6, 9
Striped searobin	*Prionotus evolans*	reef-associated · brackish and marine	? - 180	2, 9
Uranoscopidae (stargazers)				
Northern stargazer	*Astroscopus guttatus*	demersal · marine	? - 36	2, 9

Habitat characteristics terms (based on Froese and Pauly, 2007 and National Marine Fisheries Service, March 2008):
Benthopelagic – living and feeding near the bottom as well as in midwaters or near the surface.
Demersal – living on or near the bottom.
Pelagic – living and feeding in midwaters or near the surface.
Reef-associated – living and feeding on or near coral reefs.
Amphidromous – regularly migrating between estuaries and coastal rivers and streams, usually associated with the search for food or refuge rather than the need to reproduce; can spawn in either freshwater or in a marine environment.
Anadromous – spending most of adult life in salt water and migrating into freshwater streams and lakes to reproduce.
Catadromous – spending most of adult life in fresh water and migrating to salt water to spawn.
Oceanodromous – migrating within oceans typically between spawning and different feeding areas.
Potamodromous – migrating within streams or in rivers.
Freshwater – broadly, all continental aquatic systems such as rivers and lakes; technically, water with salinity less that 0.5 ppt.
Brackish – water with salinity between that of fresh water and sea water; usually 0.5 to 30 ppt.
Marine – pertaining to the sea, from the open oceans to the high water mark and into estuaries.

Notes:
a. Available habitat characteristics and depth information based on Froese and Pauly, 2007.
b. NA indicates not available.
c. Species identified by the MDE (Luckett, pers. comm., February 12, 2008) as needlefish.
d. Species identified by the PRFC as herring.
e. Species identified by the MDE (Luckett, pers. comm., February 12, 2008) as tonguefish (sic).
f. Species identified by the PRFC as grey trout.
g. Species identified by the PRFC as spotted trout.
h. In addition to the species listed in this table, the MDE (Luckett, pers. comm., February 12, 2008) also identified blowfish, sea robin, skate, and sunfish sp. as having been involved in fish kills in the tidal Potomac River; however, these fish could not be identified by species.

Occurrence Sources:
1 – NSWCDL, 1979.
2 – Lippson et al., 1981.
3 – Alliance for the Chesapeake Bay, Not Dated.
4 – NSWCDD, 2001.
5 – NSF Dahlgren, 2007.
6 – NOAA, 2008.
7 – Luckett, pers. comm., February 12, 2008
8 –Cosby, PRFC, pers. comm., March 1, 2011.
9 – Lippson & Lippson, 2006.
10 – Completed fish collection forms from fish sampling conducted by Alliance for the Chesapeake Bay and NSF Dahlgren between 1999 and 2002, provided by Lou Etgen, Interim Director, Alliance for the Chesapeake Bay, November 17, 2008.
11 – Freedom du Lac, 2010.

3.11.4.2 Ecologically and Economically Important Fish

Estuarine Living Marine Resources (ELMR) Program

The NOAA ELMR program developed and maintains a database on the presence, distribution, relative abundance, and life history characteristics of ecologically and economically important fishes and invertebrates in the estuaries of the United States (Stone et al., 1994; Nelson and Monaco, 2000). The database is divided into five study regions, one of which is the Mid-Atlantic, which includes the Chesapeake Bay and the Potomac River. ELMR program staff selected species for inclusion in each

regional database based on the following four criteria, together with data availability (Stone et al., 1994; Nelson and Monaco, 2000):

- Commercial value
- Recreational value
- Indicator of environmental stress
- Ecological value

To develop the database, spatial and temporal distribution and relative abundance data were compiled from data sets, technical reports, and peer-reviewed literature.

The mixing salinity zone – defined by 0.5 to 25 ppt salinity – of the Potomac River approximately coincides with the PRTR portion of the river. Of the 51 species of fish included in the ELMR database for the Mid-Atlantic region, 34 species are present in the mixing salinity zone of the Potomac River; these species are shown in Table 3.11-5. Six are shallow-water species:

- Silversides
- Sheepshead minnow
- Bay anchovy
- Killifishes
- Gobies
- Northern pipefish

Ten others are pelagic species – fish that live and feed in midwaters or near the surface:

- Blueback herring
- Alewife
- American shad
- Atlantic menhaden
- White perch
- Striped bass
- Yellow perch
- Bluefish
- Black sea bass
- Butterfish

The remaining 18 are demersal species – fish that live on or near the bottom:

- Hogchoker
- Atlantic sturgeon
- American eel
- Oyster toadfish
- Channel catfish
- Tautog
- Mullets
- Cownose ray

- Summer flounder
- Winter flounder
- Weakfish
- Spotted seatrout
- Spot
- Northern kingfish
- Atlantic croaker
- Black drum
- Red drum
- Northern searobin

For 13 of these 34 species – the 13 that are highlighted in Table 3.11-5 – each of the five life stages is present in the zone at some point during the year. As indicated in the table, of these 13 species, five are shallow-water fishes, five are pelagic, and three are demersal. That is, of the six shallow-water species present in the mixing salinity zone, all but one of them make use of the zone for all five life stages, whereas only half of the 10 pelagic species and only one in six of the 18 demersal species do so.

The assemblages of fish occurring in the Potomac River vary seasonally, regulated primarily by temperature and salinity. Tables 3.11-6 through 3.11-10 summarize the relative abundance data for fish species life stages present in the mixing salinity zone of the Potomac River, based on the ELMR database. The abundance of a species life stage is ranked relative to that of the same life stage of other similar species – i.e., species having similar life modes and gear susceptibilities (susceptibility to capture by a type of fishing gear) (Stone et al., 1994; Nelson and Monaco, 2000). For each species, the life stage occurrence by month is categorized into the following relative abundance rankings by groups of similar species or guilds (Stone et al., 1994; Nelson and Monaco, 2000):

- **Not present** – Species or life stage is not found, questionable data as to identification of species, or recent loss or degradation of habitat suggests absence.
- **Rare** – Species is present, but not frequently encountered.
- **Common** – Species is generally encountered, but not in large numbers; distribution may be patchy.
- **Abundant** – Species is often encountered in substantial numbers relative to other species in a guild.[8]
- **Highly abundant** – Species is numerically dominant relative to other species within a guild.

Summer Flounder
Paralichthys dentatus

[8] Some species (e.g., striped bass and sheepshead minnow) designated as abundant in the Potomac estuary by Lippson et al., 1981 may not be designated as abundant based on the ELMR database. The differences in abundance ratings may be due to differences in the applied definitions of the abundance categories, differences in methodologies (e.g., the comparisons of life-stage occurrence by month within guilds used by the ELMR program), or changes in fish assemblages or occurrence records over time.

Table 3.11-5
Life Stages of Ecologically and Economically Important Species Present in Potomac River Mixing Salinity Zone

Common Name	Life Stages				
	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Shallow-Water Fishes					
Silversides	♦	♦	♦	♦	♦
Sheepshead minnow	♦	♦	♦	♦	♦
Bay anchovy	♦	♦	♦	♦	♦
Killifishes	♦	♦	♦	♦	♦
Gobies	♦	♦	♦	♦	♦
Northern pipefish		♦	♦	♦	♦
Pelagic Fishes					
Blueback herring	♦	♦	♦	♦	♦
Alewife	♦	♦	♦	♦	♦
American shad	♦	♦	♦	♦	♦
Atlantic menhaden			♦	♦	
White perch	♦	♦	♦	♦	♦
Striped bass			♦	♦	
Yellow perch	♦	♦	♦	♦	♦
Bluefish			♦	♦	
Black sea bass			♦	♦	
Butterfish			♦	♦	
Demersal Fishes					
Hogchoker	♦	♦	♦	♦	♦
Atlantic sturgeon			♦	♦	
American eel			♦		
Oyster toadfish	♦	♦	♦	♦	♦
Channel catfish			♦	♦	
Tautog			♦	♦	
Mullets			♦	♦	
Cownose ray			♦	♦	
Summer flounder			♦	♦	
Winter flounder	♦	♦	♦	♦	♦
Weakfish			♦	♦	
Spotted seatrout		♦	♦	♦	
Spot			♦		
Northern kingfish			♦	♦	
Atlantic croaker			♦	♦	
Black drum			♦	♦	
Red drum			♦	♦	
Northern searobin			♦	♦	

Notes: 1. Blank indicates species life stage is not present.
2. Green line indicates that all life stages are present for that species.
3. ♦ indicates species life stage is present.

Source: NOAA, 2008.

Table 3.11-6
Fish Egg Abundance in Potomac River Mixing Salinity Zone

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shallow-Water Fishes												
Silversides				A	H	H	H	H	A			
Sheepshead minnow				C	A	A	A	C	C			
Bay anchovy				R	A	A	H	A	C	R		
Killifishes				A	H	H	H	H	C			
Gobies				C	A	A	A	A	R	R		
Pelagic Fishes												
Blueback herring			R	C	C							
Alewife			C	C	R							
American shad				R	R							
White perch			C	C	C	R						
Yellow perch		C	C									
Demersal Fishes												
Hogchoker					A	H	H	H	A			
Oyster toadfish				C	C	C	C	C	C			
Winter flounder	R	R	R	R								R

Notes:
1. Blank indicates species life stage is not present.
2. R indicates species life stage is rare.
3. C indicates species life stage is common.
4. A indicates species life stage is abundant.
5. H indicates species life stage is highly abundant.

Source: Based on NOAA, 2008.

Table 3.11-7
Fish Larvae Abundance in Potomac River Mixing Salinity Zone

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shallow-Water Fishes												
Silversides				A	H	H	H	H	A			
Sheepshead minnow				C	A	A	A	C	C			
Bay anchovy				R	A	A	H	A	C	R		
Killifishes				A	H	H	H	H	C			
Gobies					C	A	A	A	R	R		
Northern pipefish				C	C	C	C	C	C	C		
Pelagic Fishes												
Blueback herring			R	C	C	C						
Alewife			C	C	R							
American shad				R	R							
White perch			C	C	C	R						
Yellow perch		C	C									
Demersal Fishes												
Hogchoker					A	H	H	H	A			
Oyster toadfish				C	C	C	C	C	C			
Winter flounder	R	R	R	R								R
Spotted seatrout				R	R	R	R					

Notes:
1. Blank indicates species life stage is not present.
2. R indicates species life stage is rare.
3. C indicates species life stage is common.
4. A indicates species life stage is abundant.
5. H indicates species life stage is highly abundant.

Source: Based on NOAA, 2008.

Table 3.11-8
Fish Juveniles Abundance in Potomac River Mixing Salinity Zone

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shallow-Water Fishes												
Silversides	H	H	H	H	H	H	H	H	H	H	H	H
Sheepshead minnow	A	A	A	A	A	A	A	A	A	A	A	A
Bay anchovy	H	H	H	C	A	H	H	H	H	H	H	H
Killifishes	H	H	H	H	H	H	H	H	H	H	H	H
Gobies					R	C	A	A	A	A	A	A
Northern pipefish	C	C	C	C	C	C	C	C	C	C	C	C
Pelagic Fishes												
Blueback herring					A	A	A	A	A	R		
Alewife					A	C	C	C	C	R		
American shad					C	C	C	C	C	C	R	
Atlantic menhaden	R	R	R	A	H	H	H	H	A	C	R	R
White perch	A	A	A	A	A	A	A	A	A	A	A	A
Striped bass	C	C	C	C	C	C	C	C	C	C	C	C
Yellow perch	C	C	C	C	C	C	C	C	C	C	C	C
Bluefish					R	C	A	A	C	R		
Black sea bass					R	R	R	R	R	R		
Butterfish						R	R	R	R	R		
Demersal Fishes												
Hogchoker	H	H	H	H	H	H	H	H	H	H	H	H
Atlantic sturgeon					R	R	R	R	R	R		
American eel	C	C	C	C	C	C	C	C	C	C	C	C
Oyster toadfish	C	C	C	C	C	C	C	C	C	C	C	C
Channel catfish	C	C	C	C	C	C	C	C	C	C	C	C
Tautog	R	R	R	R	R	R	R	R	R	R	R	R
Mullets						R	R	R	R	R		
Cownose ray						C	C	C	C	C		
Summer flounder	R	R	R	R	R	C	C	C	C	C	R	R
Winter flounder	R	R	R	R	R						R	R
Weakfish				C	C	C	C	C	C	C	R	
Spotted seatrout					C	C	C	C	C			
Spot					C	C	C	C	C	C	R	
Northern kingfish						R	R	R	R	R		
Atlantic croaker	C	C	C	C	C	C	C	C	C	C	R	R
Black drum					C	C	C	C	C	C		
Red drum						C	C	C	C	C	C	
Northern searobin				R	R	R	R	R	R	R		

Notes:
1. Blank indicates species life stage is not present.
2. R indicates species life stage is rare.
3. C indicates species life stage is common.
4. A indicates species life stage is abundant.
5. H indicates species life stage is highly abundant.

Source: Based on NOAA, 2008.

Table 3.11-9
Fish Adults Abundance in Potomac River Mixing Salinity Zone

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shallow-Water Fishes												
Silversides	H	H	H	H	H	H	H	H	H	H	H	H
Sheepshead minnow	A	A	A	A	A	A	A	A	A	A	A	A
Bay anchovy	H	H	H	H	H	H	H	H	H	H	H	H
Killifishes	H	H	H	H	H	H	H	H	H	H	H	H
Gobies	A	A	A	A	A	A	A	A	A	A	A	A
Northern pipefish	C	C	C	C	C	C	C	C	C	C	C	C
Pelagic Fishes												
Blueback herring			R	C	C	R						
Alewife		C	A	C	C							
American shad		R	C	C	C							
Atlantic menhaden					R	R	R	R	R	R		
White perch	A	A	A	A	A	A	A	A	A	A	A	A
Striped bass	R	R	C	C	C	C	C	C	C	C	R	R
Yellow perch	C	C	C	C	C	C	C	C	C	C	C	C
Bluefish					R	C	A	A	C	R		
Black sea bass					R	R	R	R	R	R		
Butterfish					R	R	R	R	R	R		
Demersal Fishes												
Hogchoker	H	H	H	H	H	H	H	H	H	H	H	H
Atlantic sturgeon				R	R	R						
Oyster toadfish	C	C	C	C	C	C	C	C	C	C	C	C
Channel catfish	C	C	C	C	C	C	C	C	C	C	C	C
Tautog					R	R	R	R	R			
Mullets						R	R	R	R	R		
Cownose ray						C	C	C	C			
Summer flounder					C	C	C	C	C	C	R	
Winter flounder	R	R	R	R	R						R	R
Weakfish					C	C	C	C	C	C	R	
Spotted seatrout			C	C	C	R	R	R	C	C		
Northern kingfish					R	R	R	R	R	R		
Atlantic croaker				R	R	R	R	R	R	R		
Black drum					C	C	C	C	C	C		
Red drum						C	C	C	C	C		
Northern searobin				R	R	R	R	R	R	R		

Notes:
1. Blank indicates species life stage is not present.
2. R indicates species life stage is rare.
3. C indicates species life stage is common.
4. A indicates species life stage is abundant.
5. H indicates species life stage is highly abundant.

Source: Based on NOAA, 2008.

Table 3.11-10
Fish Spawning Adults Abundance in Potomac River Mixing Salinity Zone

Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shallow-Water Fishes												
Silversides				A	H	H	H	H	A			
Sheepshead minnow				C	A	A	A	C	C			
Bay anchovy				R	A	A	H	A	C	R		
Killifishes				A	H	H	H	H	C			
Gobies				C	A	A	A	A	R	R		
Northern pipefish				C	C	C	C	C	C	C		
Pelagic Fishes												
Blueback herring			R	C	C							
Alewife			C	C	R							
American shad				R	R							
White perch			C	C	C	R						
Yellow perch		C	C									
Demersal Fishes												
Hogchoker					A	H	H	H	A			
Oyster toadfish				C	C	C	C	C	C			
Winter flounder	R	R	R	R								R

Notes:
1. Blank indicates species life stage is not present.
2. R indicates species life stage is rare.
3. C indicates species life stage is common.
4. A indicates species life stage is abundant.
5. H indicates species life stage is highly abundant.

Source: Based on NOAA, 2008.

Potomac River Fisheries Commission Landing Data

The PRFC (described later in this section) collects commercial fishing harvest data for three areas of the Potomac River (Figure 3.11-4, Potomac River Fisheries Commission Commercial Harvest Areas 1 through 3):

- Area 1, which extends upriver from mouth of the Potomac River to Hollins Marsh, Virginia/Colton's Point, Maryland and includes the LDZ. Salinity levels are in the low to high mesohaline range (Figure 3.10-4).
- Area 2, which extends upriver from Hollins Marsh, Virginia/Colton's Point, Maryland to the Harry Nice Bridge, and includes the MDZ. Salinity levels are in the oligohaline to medium mesohaline range.
- Area 3, which extends upriver from the Harry Nice Bridge to Possum Point, Virginia/Moss Point, Maryland, and includes the UDZ. Salinity levels vary from oligohaline to low mesohaline.

Table 3.11-11 displays commercial fishing harvest data for the years 2001 to 2010. The total weight of landings from the PRTR for this period was approximately 58.0 million lbs of fish (Cosby, PRFC, pers. comm., March 1, 2011). During this period, 89 percent of the total fish landings were in Area 1; the remaining 11 percent of landings came from Area 3 (7 percent) and Area 2 (4 percent). The high productivity of Area 1 relative to the other two areas is likely the result of the width of the river, which results in a large water area, and higher salinity levels. These conditions support many of the more sought-after commercial fish species, including summer flounder, blue fish, striped bass, croaker, spot, menhaden, and Spanish mackerel.

The fish species with the largest harvests by weight for the 2001 to 2010 period were: Atlantic menhaden (37.8 million lbs); croaker (8.2 million lbs); striped bass (6.4 million lbs); eel (1.0 million lbs); and spot (1.0 million lbs). Atlantic menhaden is a herring that moves in schools and is used to make fish meal for pet food and fish food. It's an important prey species for larger predators such as striped bass, bluefish, herons, and egrets, and concerns have recently been raised that overfishing of menhaden could lead to declines in species that depend on them. Striped bass is the premier sport fish in the bay, and its population has rebounded after being heavily overfished.

Striped bass
Morone saxatilis

Anadromous Fish

Anadromous fishes spend most of their lives in marine or estuarine waters but return to fresh water to spawn. Eleven anadromous species occur in the Potomac River. The anadromous species of the Potomac River comprise two sturgeons (shortnose sturgeon and Atlantic sturgeon), two herrings (blueback herring and alewife), three shad (hickory shad, American shad, and gizzard shad), threespine stickleback, white perch, striped bass, and sea lamprey. A brief

summary of the timing and location of spawning in the Potomac River for these species follows, based on Lippson et al., 1981, unless otherwise noted:

Shortnose sturgeon

- Optimal season from late March through April, when water temperatures are an ideal 48 to 64˚F (Federal Highway Administration, 2000).
- Lower nontidal portions of rivers or at the head of tide if passage into nontidal waters is not possible.
- Areas characterized by fast, turbulent currents and clean gravel/cobble and bounder substrates (Kynard et al., 2007).

Atlantic sturgeon

- Ascend tributaries in May or June when temperatures reach approximately 64˚F (MDNR, 2011a).
- Tidal fresh water (MDNR, 2011a).

Blueback herring

- Mid-April to mid-May (Lippson et al., 1981); late March through mid-May (MDNR, 2011a).
- Tidal fresh and low brackish waters.
- Mostly in tributaries, but also in the main stem upstream of Maryland Point (upstream of PRTR).

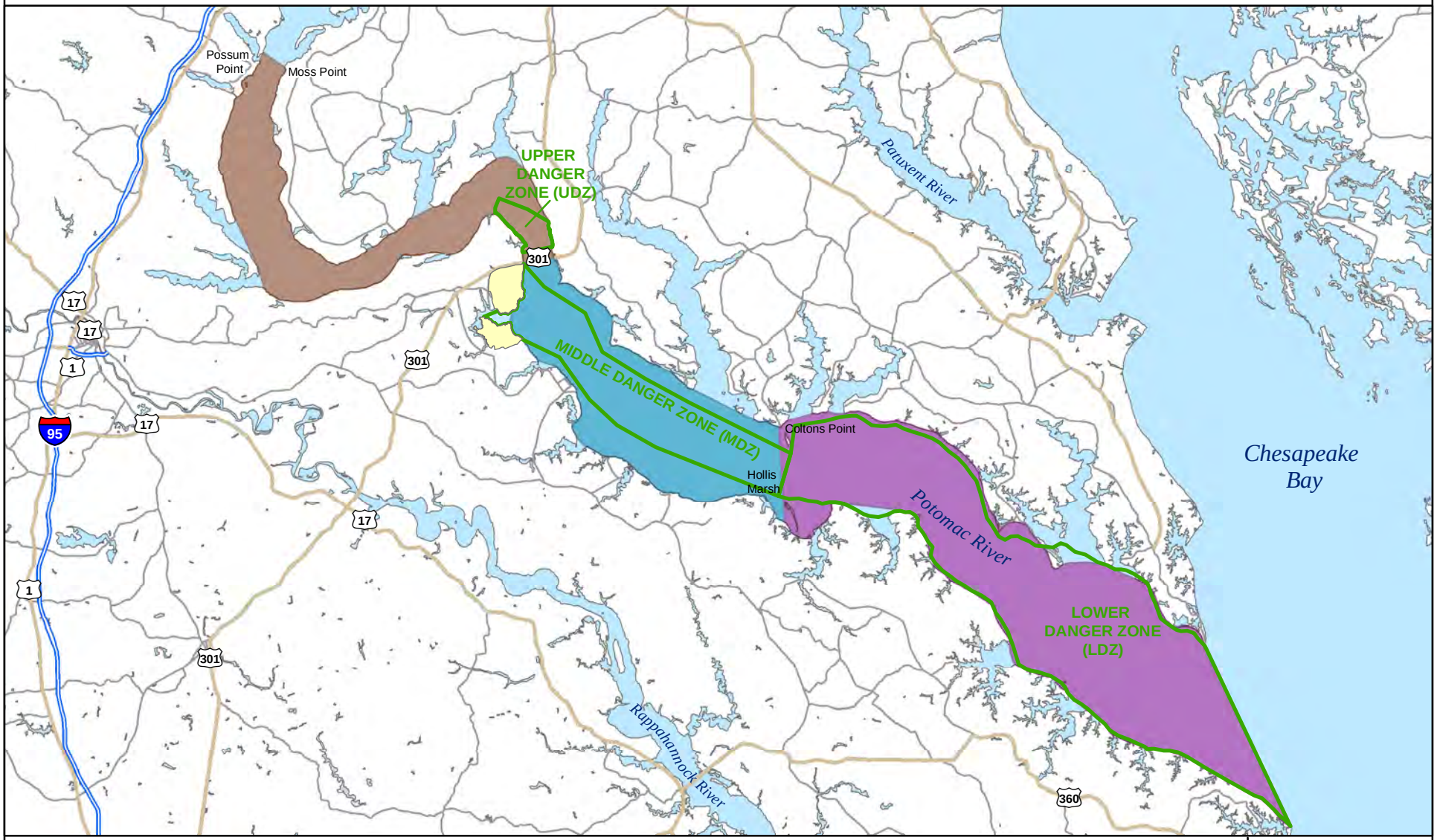
Alewife

- Late March through April (Lippson et al., 1981); late February through April (MDNR, 2011a).
- Tidal fresh and low brackish waters.
- Wide range of substrates, such as gravel, sand, detritus, and submerged vegetation (MDNR, 2011a).
- Mostly in tributaries, but also in the main stem upstream of Maryland Point (upstream of PRTR).

Hickory shad

- Peak mid-April through late May, with temperatures ranging from 54 to 72˚F (MDNR, 2011a).
- Peak temperature 59 to 66˚F (MDNR, 2011a).
- Tidal and nontidal fresh water (MDNR, 2011a).
- Main stem, as well as backwaters, sloughs, and tributaries (MDNR, 2011a).

Potomac River Fisheries Commission Commercial Harvest Areas 1 through 3



Area1
Area2
Area3
Potomac River Test Range (PRTR)
Naval Support Facility (NSF) Dahlgren

8 0 8 Miles

13 0 13 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: Based on Cosby PRFC, pers. comm., February 19, 2008.

Figure 3.11-4

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Table 3.11-11
Potomac River Fisheries Commission (PRFC) Landings Data
Finfish Landings (lbs.)

Species	PRFC Area	Year										Totals
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
American Eel	3	149,334	109,213	71,814	33,444	33,327	9,883	11,910	34,045	18,315	4,535	475,820
	2	51,981	17,844	35,657	62,524	43,157	54,882	52,659	15,469	28,882	32,220	395,275
	1	12,125	1,538	12,454	12,100	25,294	17,530	32,792	22,040	11,630	23,011	170,514
	TOTAL	**213,440**	**128,595**	**119,925**	**108,068**	**101,778**	**82,295**	**97,361**	**71,554**	**58,827**	**59,766**	**1,041,609**
American Shad (buck)	3	5		34	45	60	15	3	38	81	6	287
	2							40				40
	1	1,487	1,035	1,114	598	716	409	942	467	532	95	7,395
	TOTAL	**1,492**	**1,035**	**1,148**	**643**	**776**	**424**	**985**	**505**	**613**	**101**	**7,722**
American Shad (roe)	3	323	24	458	500	483	343	773	285	677	17	3,883
	2				206	456	78	1,586	92	108	5	2,531
	1	3,162	1,703	6,628	3,995	5,105	3,824	5,691	6,215	3,816	3,799	43,938
	TOTAL	**3,485**	**1,727**	**7,086**	**4,701**	**6,044**	**4,245**	**8,050**	**6,592**	**4,601**	**3,821**	**50,352**
Blue Catfish	3			1,382	12,101	7,953	15,220	38,730	58,895	67,216	163,067	364,564
	2			14	239	250	23	2,704	991	10,233	5082	19,536
	1			120	637	167	177	1,792	244	1,178	4,403	8,718
	TOTAL	**0**	**0**	**1,516**	**12,977**	**8,370**	**15,420**	**43,226**	**60,130**	**78,627**	**172,552**	**392,818**
Bluefish	3	150						1,916	1,617	1,955	10	5,648
	2	83	89		4		586			275	163	1,200
	1	127,619	97,459	23,879	58,643	89,967	44,720	78,262	82,892	32,413	51,339	687,193
	TOTAL	**127,852**	**97,548**	**23,879**	**58,647**	**89,967**	**45,306**	**80,178**	**84,509**	**34,643**	**51,512**	**694,041**
Bullhead	3	18,927	9	6,377	8,352	14,304	204	21,281	22,714	25,791	21,972	139,931
	2	30		693			74	187	644	145	60	1,833
	1											
	TOTAL	**18,957**	**9**	**7,070**	**8,352**	**14,304**	**278**	**21,468**	**23,358**	**25,936**	**22,032**	**141,764**
Carp	3	420	2	395	10	25	22	8,018	28		66	8,986
	2		11	181	155	110	16	194	154	39	105	965
	1	113	20	316	629	612	60		23			1,773
	TOTAL	**533**	**33**	**892**	**794**	**747**	**98**	**8,212**	**205**	**39**	**171**	**11,724**

Table 3.11-11 (Continued)
Potomac River Fisheries Commission (PRFC) Landings Data
Finfish Landings (lbs.)

Species	PRFC Area	Year										Totals
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Catfish (mixed)	3	72,049	54,804	27,240	1,654	413	888	16,845				173,893
	2	716	48	258		137	37					1,196
	1	89	28	1,100	15							1,232
	TOTAL	**72,854**	**54,880**	**28,598**	**1,669**	**550**	**925**	**16,845**	**0**	**0**	**0**	**176,321**
Channel Catfish	3			39,068	74,424	57,347	44,186	15,087	25,363	31,216	52,327	339,018
	2				67	270	180	197	645	2957	2174	6,490
	1			474	4,346	4,749	502	980	2,023	187	1,451	14,712
	TOTAL	**0**	**0**	**39,542**	**78,837**	**62,366**	**44,868**	**16,264**	**28,031**	**34,360**	**55,952**	**360,220**
Croaker	3	948	6,465	2,277	24,081	786	1,862	138	30,947	19,986	886	88,376
	2	2,543	171	154	325	52	89,328	1,501	9	182	1,105	95,370
	1	1,959,803	1,414,458	1,125,572	1,607,190	481,074	572,493	186,925	293,751	210,570	161,380	8,013,216
	TOTAL	**1,963,294**	**1,421,094**	**1,128,003**	**1,631,596**	**481,912**	**663,683**	**188,564**	**324,707**	**230,738**	**163,371**	**8,196,962**
Gizzard Shad	3	36,031	32,653	78,202	75,377	51,241	30,278	29,622	6,657	16,167	225	356,453
	2	130	242	2,270	4,800	7,565	790	2,906	8,024	1,115	2,340	30,182
	1	66,523	69,730	47,619	30,098	48,915	8,436	18,723	26,972	35,168	14,847	367,031
	TOTAL	**102,684**	**102,625**	**128,091**	**110,275**	**107,721**	**39,504**	**51,251**	**41,653**	**52,450**	**17,412**	**753,666**
Grey Trout	3											
	2	2										2
	1	44,217	57,818	5,273	1,986	974	689	20	74	17	80	111,148
	TOTAL	**44,219**	**57,818**	**5,273**	**1,986**	**974**	**689**	**20**	**74**	**17**	**80**	**111,150**
Hickory Shad	3			90	162						150	402
	2											
	1											
	TOTAL	**0**	**0**	**90**	**162**	**0**	**0**	**0**	**0**	**0**	**150**	**402**
Menhaden	3	55	1,455		77,580	7,845	22,440	201,600	173,367	256,922	7,800	749,064
	2		30	45	102	140	35,520	1,290	1,080	7,761	2,838	48,806
	1	3,328,980	3,120,565	2,438,745	5,333,361	4,751,920	3,244,437	4,834,376	4,416,451	2,746,742	2,780,090	36,995,667
	TOTAL	**3,329,035**	**3,122,050**	**2,438,790**	**5,411,043**	**4,759,905**	**3,302,397**	**5,037,266**	**4,590,898**	**3,011,425**	**2,790,728**	**37,793,537**

Table 3.11-11 (Continued)
Potomac River Fisheries Commission (PRFC) Landings Data
Finfish Landings (lbs.)

Species	PRFC Area	Year										Totals
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
River Herring	3	5,799	1,730	423	3,208	170	95			1,980		13,405
	2		3,320	65								3,385
	1	29,924	50,036	19,644	16,531	8,337	6,724	6,011	5,476	6,947	928	150,558
	TOTAL	**35,723**	**55,086**	**20,132**	**19,739**	**8,507**	**6,819**	**6,011**	**5,476**	**8,927**	**928**	**167,348**
Spanish Mackerel	3											
	2											
	1	25,970	14,922	21,267	917	2,725	2,019	4,915	3,198	470	68	76,471
	TOTAL	**25,970**	**14,922**	**21,267**	**917**	**2,725**	**2,019**	**4,915**	**3,198**	**470**	**68**	**76,471**
Spot	3						1	3	70	567		641
	2	197	38				136			183	35	589
	1	176,349	140,738	227,430	131,605	95,350	40,575	70,511	29,720	62,714	43,990	1,018,982
	TOTAL	**176,546**	**140,776**	**227,430**	**131,605**	**95,350**	**40,712**	**70,514**	**29,790**	**63,464**	**44,025**	**1,020,212**
Spotted Sea Trout	3											
	2		14									14
	1	1,380	1,910	103	419	71	134	24	31	33	8	4,113
	TOTAL	**1,380**	**1,924**	**103**	**419**	**71**	**134**	**24**	**31**	**33**	**8**	**4,127**
Striped Bass	3	168,586	179,861	118,536	120,301	135,494	137,313	110,171	131,699	103,818	110,146	1,315,925
	2	158,744	86,088	155,055	292,321	88,651	129,302	173,333	186,207	215,800	188,013	1,673,514
	1	324,026	245,084	401,377	346,085	305,488	401,037	310,654	280,973	398,530	374,988	3,388,242
	TOTAL	**651,356**	**511,033**	**674,968**	**758,707**	**529,633**	**667,652**	**594,158**	**598,879**	**718,148**	**673,147**	**6,377,681**
Summer Flounder	3				59		80	495	312	1,106	117	2,169
	2	19	12				222					253
	1	32,034	40,930	28,194	35,565	23,308	29,367	21,574	26,445	23,844	22,270	283,531
	TOTAL	**32,053**	**40,942**	**28,194**	**35,624**	**23,308**	**29,669**	**22,069**	**26,757**	**24,950**	**22,387**	**285,953**
White Catfish	3			1,907	3,100	1,859	3,110	5,328	3,564	18,812	42	37,722
	2			6	434	333	718	1,314	1901	502	2552	7,760
	1			119	172	817	47	1,105	165	87	90	2,602
	TOTAL	**0**	**0**	**2,032**	**3,706**	**3,009**	**3,875**	**7,747**	**5,630**	**19,401**	**2,684**	**48,084**

Table 3.11-11 (Continued)
Potomac River Fisheries Commission (PRFC) Landings Data
Finfish Landings (lbs.)

Species	PRFC Area	Year										Totals
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
White Perch	3	15,513	8,725	7,722	11,212	9,338	7,122	4,501	5,131	3,361	2,050	74,675
	2	1,181	345	484	278	233	298	1,514	1,233	1,191	486	7,243
	1	17,400	7,257	23,401	23,870	30,775	26,246	23,934	9,652	3,532	9,620	175,687
	TOTAL	**34,094**	**16,327**	**31,607**	**35,360**	**40,346**	**33,666**	**29,949**	**16,016**	**8,084**	**12,156**	**257,605**
Winter Flounder	3											
	2											
	1	113	788	151		28		59		15	21	1,175
	TOTAL	**113**	**788**	**151**	**0**	**28**	**0**	**59**	**0**	**15**	**21**	**1,175**
Yellow Perch	3	961	4,199	990	2,274	1,396	676	128	115	366	168	11,273
	2	5	2			3					3	13
	1	259		46	1,530	591	1,865	558	655		27	5,531
	TOTAL	**1,225**	**4,201**	**1,036**	**3,804**	**1,990**	**2,541**	**686**	**770**	**366**	**198**	**16,817**

Source: Cosby, PRFC, pers. comm., March 1, 2011.

American shad	♦ Peak from mid-April to mid-May (Lippson et al., 1981); peak from mid-April through early June, with temperatures ranging from 55 to 68˚F (MDNR, 2011a). ♦ Peak temperature 64˚F (MDNR, 2011a). ♦ Tidal fresh waters over shallow flats (Lippson et al., 1981); usually gently sloping areas with fine gravel or sandy bottoms (MDNR, 2011a). ♦ Main stem between Mattawoman and Piscataway Creeks, and sometimes upstream to Broad Creek; marginal spawning may occur as far downstream as Maryland Point (upstream of the PRTR).
Gizzard shad	♦ April to June (Lippson et al., 1981), with peak in May (Lippson et al., 1981; MDNR, 2011a). ♦ Primarily tidal fresh waters. ♦ Most of the large tributaries above Maryland Point and the upper freshwater region of the main stem down to approximately Douglas Point (above the PRTR); presumably upper Wicomico River and Nanjemoy Creek; Mattawoman and Piscataway Creeks apparently locations of the most intensive spawning.
Threespine stickleback	♦ April and May. ♦ Shallow weedy areas. ♦ Main stem downstream of the mouth of the Wicomico River (downstream portion of the MDZ and the LDZ).
White perch	♦ Begins when water temperatures reach 46 to 50˚F, and inhibited above 59˚F; optimal temperatures 54 to 57˚F. ♦ Optimal temperatures from first part of April to the end of May; sporadic spawning has been observed at the end of March and into the first week of June. ♦ Fresh to low-salinity waters over fine gravel or sand (MDNR, 2011a). ♦ Shallow waters along the shores preferred, often under overhanging banks. ♦ Main-stem spawning concentrated from Indian Head upstream to Broad Creek and in the bend around Maryland Point (upstream of the PRTR).

Striped bass

- Water temperatures from 50 to 73˚F, with peak between 57 to 59˚F.
- Usually early April to end of May, with peak beginning mid-to-late April.
- Peak in tidal fresh waters in region 15 to 20 nm above Maryland Point (upstream of the PRTR); may shift upstream or downstream depending on freshwater river flow.

Sea lamprey

- Begins at water temperature 52˚F, peaks at 57 to 59˚F, and completed by the time water temperatures reach 75˚F.
- Rapidly flowing water over gravel bottoms.
- Non-tidal waters, or tidal waters if passage is blocked.

3.11.4.3 Management of Fish Resources in the Tidal Potomac River

Fish resources of the tidal Potomac River from the Maryland-Washington, DC boundary line near the Woodrow Wilson Bridge to the mouth of the river, including the PRTR portion of the river, are regulated by the PRFC (PRFC, 2008). The Maryland and Virginia Potomac River Compact of 1958 created the commission and charged it with the establishment and maintenance of a program to conserve and improve the fishery resources of the tidewater portion of the river. The commission regulates all recreational and commercial fishing, crabbing, oystering, and clamming in the main stem of the tidal Potomac River and issues licenses for those activities.

The PRFC coordinates regulations with the MDNR, the Virginia Marine Resources Commission, and the Virginia Department of Game and Inland Fisheries (VDGIF). Additionally, the management of coastal and migratory species is coordinated through the Atlantic States Marine Fisheries Commission (ASMFC). Maryland, Virginia, and other coastal states participate in the Commission process to manage the shared fishery resources.

At the federal level, the Magnuson-Stevens Fishery Conservation and Management Act (MSA) of 1976 (16 U.S.C. §1801 *et seq*.), as amended, is the primary law governing marine fisheries management in US federal waters. The MSA developed ten national standards for fishery conservation and management. The first national standard states that "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry" (16 U.S.C. §1851(a)(1)). The MSA established eight regional fishery management councils to promote conservation through preparation of fisheries management plans (FMPs), which are documents that set rebuilding goals and regulations. There are three councils on the East Coast: New England Fishery Management Council (NEFMC), Mid-Atlantic Fishery Management Council (MAFMC), and South Atlantic Fishery Management Council (SAFMC). Due to the migratory nature of fish, all three councils as well as the ASMFC manage one or more of the species occurring in the Potomac River. As part of the fisheries management process, NMFS fisheries science centers coordinate with the councils by researching and analyzing fish populations to assess the status of federally-managed fish stocks.

In the northeast, the Northeast Fisheries Science Center coordinates two stock-assessment programs, referred to as the Northeast Regional Stock Assessment Workshop (SAW) and the

Groundfish Assessment Review Meeting (GARM). These are formal scientific peer-review processes for evaluating and presenting stock-assessment results to managers. The SAW prepares and reviews assessments for fish stocks in offshore US waters of the northwest Atlantic; GARM focuses on 19 groundfish[9] stocks managed under the Northeast Multispecies FMP. Assessments that are prepared by SAW working groups (federally-led assessments), or ASMFC technical assessment committees (state-led assessments) are reviewed by an independent panel of stock-assessment experts called the Stock Assessment Review Committee (SARC). GARM follows a similar protocol. In the southeast, the Southeast Fisheries Science Center coordinates a third stock-assessment program, the SouthEast Data, Assessment, and Review, which is a cooperative Fishery Management Council process initiated to improve the quality and reliability of fishery stock assessments in the south Atlantic, Gulf of Mexico, and US Caribbean.

Table 3.11-12 provides an overview of the status of federally-managed species or stocks that are known to occur in the PRTR portion of the Potomac River. The table identifies the council that manages each species, the stock-assessment program that performed the review, whether or not each species has been overfished historically, whether overfishing is still occurring, and the species' current status. The terms "overfishing" and "overfished" signify "a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis" (16 U.S.C. §1802(34)).

Unless otherwise noted, Table 3.11-12 provides coast-wide stock status. Individual states also conduct surveys in inland and state waters to determine abundance of certain species locally. These estimates may differ from the coast-wide status determinations listed in Table 3.11-12. For example, while the coast-wide status of spot is unknown, juvenile abundance indices have generally declined in Maryland's portion of the Chesapeake Bay and consistent declines in juvenile abundance have occurred in Virginia's portion of the Chesapeake Bay since 1992 (Fabrizio and Montane, 2007).

As mentioned previously, the PRFC, MDNR, and VDGIF coordinate fisheries management in the Potomac River and/or the Chesapeake Bay. These organizations, as well as the Virginia Institute of Marine Science (VIMS), survey the Chesapeake Bay and its tributaries to determine abundance estimates and develop local stock- assessment reports. Depending on the organization responsible for the study, the results may be in the form of juvenile abundance indices or long-term trends. Information is available for approximately half of the federally-managed species. Due to the technical nature of the juvenile abundance indices, this section only summarizes information on long-term trends. One report, Estimating Relative Juvenile Abundance of Ecologically Important Finfish and Invertebrates in the Virginia Portion of Chesapeake Bay, August 2007, prepared by VIMS, provides long-term relative juvenile abundance trends for several species, as shown in Table 3.11-13 (Fabrizio and Montane, 2007). VIMS conducts a trawl survey in the lower Chesapeake Bay, and James, York, and Rappahannock rivers to collect these data. While the Potomac River is not included in their survey area, these trends are likely to be representative of the status of species that occur in the Potomac.

[9] Groundfish is a term used to define bottom-dwelling fish, such as flounder or cod.

Table 3.11-12
Status of Federally-Managed Fish Species Occurring in the PRTR

Species	Fishery Council	Year and Source of Most Recent Stock Assessment	Historically Overfished?	Is Overfishing Occurring?	Status
American Shad	ASMFC	2007 (ASMFC)	Depleted	Unknown[1]	Depleted
Atlantic Sturgeon	ASMFC	1998 (ASMFC)	Yes	No[2]	Unknown
American Eel	ASMFC	2006 (ASMFC)	Unknown	Unknown	Unknown
Atlantic Croaker	ASMFC	2010 (ASMFC)	Unknown	No	Healthy
Atlantic Menhaden	ASMFC	2010 (ASMFC)	No	Yes	Stable/ Unchanged
Black Sea Bass	ASMFC, MAFMC	2006 (SAW) 2008 (DPSWG[3])	No	No	Healthy
Bluefish	ASMFC, MAFMC	2005 (SAW)	No	No	Healthy
Red Drum	ASMFC	2009 (SEDAR[4])	Unknown	No	Stable/ Unchanged
River Herring	ASMFC	1990 (ASMFC)	Unknown	Unknown[5]	Unknown
Spanish Mackerel	ASMFC, SAFMC	2003 (MSAP[6])	Unknown	No	Rebuilding
Spotted Seatrout	ASMFC	N/A	Unknown	Unknown	Unknown
Spot	ASMFC	N/A	Unknown	Unknown	Unknown
Striped Bass	ASMFC	2007 (SAW)	No	No	Healthy
Summer Flounder	ASMFC, MAFMC	2011 (NEFSC[7])	No	No	Healthy
Tautog	ASMFC	2005 (ASMFC)	Yes	Yes	Depleted
Weakfish	ASMFC, SAFMC	2006 (ASMFC) 2008 (SAW)	Depleted	No	Depleted
Winter Flounder (Southern New England/Mid-Atlantic stock complex)	NEFMC	2008 (GARM)	Yes	No	Depleted

Notes:

1. Amendment 3 to the Interstate FMP for shad and river herring establishes a 2013 moratorium unless sustainability can be documented.
2. Amendment 1 to the Atlantic sturgeon FMP mandated all Atlantic coastal states to enact a moratorium on harvest and possession of Atlantic sturgeon.
3. DPSWG indicates Northeast Data Poor Stocks Working Group.
4. SEDAR indicates Southeast Data, Assessment, and Review.
5. Amendment 2 to the Interstate FMP for shad and river herring establishes a 2012 moratorium unless sustainability can be documented.
6. MSAP indicates Mackerel Stock Assessment Panel.
7. NEFSC indicates NOAA Fisheries Service Northeast Fisheries Science Center.

Sources: ASMFC, 2012a, 2012c; MAFMC, 2012.

Table 3.11-13
Relative Juvenile Abundance Trends in Virginia Waters of the Chesapeake Bay

Species	Random Stratified Index[1] Sample Years	Trend
American Eel	1988-2007	Declining
Atlantic Croaker	1988-2006	No
Atlantic Menhaden	2006-2007[2]	Slight increase
Black Sea Bass	1988-2006	Slight decline
Spot	1988-2006	Negative
Striped Bass	1988-2006	Negative
Summer Flounder	1988-2006	No substantial trend (potential slight decline)
Weakfish	Early 1990s - 2006	Slight increase

Notes:
1. The Random Stratified Index survey method allows sampling stations to be chosen at random, including location and water depth.
2. The index for Atlantic Menhaden is new, thus data to estimate long-term trends are unavailable.

Source: Fabrizio and Montane, 2007.

3.11.4.4 Essential Fish Habitat Assessment

Magnuson-Stevens Act

The MSA establishes management authority over all fishing within the United States Exclusive Economic Zone (EEZ); all anadromous fish throughout their migratory range; and all fish on the continental shelf. The MSA established the requirement to describe and identify essential fish habitat (EFH) for each federally-managed fishery in the corresponding FMP. EFH is defined as "...those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." National Marine Fisheries Service (NMFS) regulations further define the following terms (NMFS, 1999a; NMFS, 2002):

- **Waters** – Aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate.
- **Substrate** – Sediment, hard bottom, structures underlying the waters, and associated biological communities.
- **Necessary** – The habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem.
- **Spawning, breeding, feeding, or growth to maturity** – Stages representing a species' full life cycle.

As required by the MSA, federal agencies must consult with NMFS Habitat Conservation Division on any proposed federal action that may adversely affect EFH. In addition to EFH designations, areas called habitat areas of particular concern (HAPCs) are designated to provide additional focus for conservation efforts; they represent a subset of designated EFH that are especially important ecologically to a species/life stage or are vulnerable to degradation (50 CFR

§§ 600.805-600.815). Although categorization as an HAPC does not confer additional protection or restriction to the designated area, these areas are fully considered below.

Designated Essential Fish Habitat

EFH has been designated in the Potomac River for one or more life stages of cobia, king mackerel, Spanish mackerel, and red drum (NOAA, 2012c). EFH also has been designated in the mixing water/brackish salinity zone (greater than 0.5 to less than 25.0 ppt salinity) of the Potomac River for the windowpane flounder, summer flounder, and bluefish. In addition, HAPCs in the Potomac River have been designated for red drum and summer flounder. Table 3.11-14 provides a listing of the species and their life stages for which EFH has been designated in the Potomac River, as well as designated HAPCs. Table 3.11-15 identifies the fisheries management plans that designated EFH in the Potomac River and the fishery management council that manages each of the species for which EFH has been designated.

Table 3.11-14
Species Identified as Having EFH in the Potomac River

Species	Egg	Larvae	Juvenile	Adult	HAPC
Cobia	♦	♦	♦	♦	
King Mackerel	♦	♦	♦	♦	
Spanish Mackerel	♦	♦	♦	♦	
Red Drum	♦	♦	♦	♦	♦
Windowpane Flounder			♦	♦	
Summer Flounder			♦	♦	♦
Bluefish			♦	♦	

Notes:
1. ♦ indicates EFH has been designated for species life stage or HAPC has been designated for species.
2. Blank indicates EFH has not been designated for species life stage or HAPC has not been designated for species.

Source: NOAA, 2012c.

Table 3.11-15
Fishery Management Plans Designating Essential Fish Habitat in the Potomac River

Species	Fishery Management Plan	Fishery Management Council
Cobia	Coastal Migratory Pelagics (SAFMC, 2012)	SAFMC
King Mackerel	Coastal Migratory Pelagics (SAFMC, 2012)	SAFMC
Spanish Mackerel	Coastal Migratory Pelagics (SAFMC, 2012)	ASMFC, SAFMC
Red Drum	Red Drum (ASMFC, 2012b)	ASMFC
Windowpane Flounder	Northeast Multispecies (Groundfish) (NEFMC, 2012)	NEFMC
Summer Flounder	Summer Flounder, Scup, and Black Sea Bass (MAFMC, 2011b)	ASMFC, MAFMC
Bluefish	Bluefish (MAFMC, 2011a)	ASMFC, MAFMC

The following discussions describe the species and life stages for which EFH has been designated in the Potomac River, emphasizing the species' habitat, seasonal range, feeding, and

life history in the Chesapeake Bay or in the river, as possible based on available information. The sources for each species discussion are cited once at the end of the description. A summary of the EFH utilized by the life stages designated in the Potomac River follows each species discussion.

Cobia

Cobia are migratory, coastal pelagic, warm-water fish that prefer water temperatures greater than 68°F. In the Chesapeake Bay, cobia live in the bay's deep, open waters, and are often found in the shade of wrecks, buoys, and pilings. They are found in the lower Chesapeake Bay from May through October, and can move as far north as Tangier Sound and the mouth of the Potomac River. In the lower Potomac River estuary, cobia are found in the regions closest to the mouth of the river. Around October, cobia migrate out of the Chesapeake Bay to warmer southern waters.

Cobia are opportunistic hunters with a broad diet. They eat mostly crabs and shrimp, but also will feed on squid and small fish. Cobia spawn from June through mid-August in estuarine waters near the mouth of the Chesapeake Bay or just offshore. Eggs collect near the surface of the water.

Sources: Lippson et al., 1981; CBP, 2012; NOAA, 2012a

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Cobia

Eggs Larvae Juveniles Adults	♦ Sandy shoals of capes and offshore bars, high-profile rocky bottom and barrier island ocean-side waters from the surf zone to the shelf break, but from the Gulf Stream shoreward. ♦ All coastal inlets. ♦ All state-designated nursery habitats of particular importance to coastal migratory pelagics. ♦ High-salinity bays, estuaries, and seagrass habitat. ♦ Water temperatures greater than 68˚F. ♦ Salinities greater than 25 ppt.

King Mackerel

King mackerel are highly-migratory, coastal epipelagic fish that are found near shore or far out to sea over the continental shelf. Temperature and salinity are believed to be the most important determinants of their distributions; king mackerel usually inhabit waters with temperatures greater than 68°F and salinities between 32 and 36 ppt. In the Chesapeake Bay, king mackerel live near the surface of the bay's open waters, close to shore, and around wrecks, reefs, and other hard structures. While migrating along the Atlantic coast, they occasionally visit the lower bay between June and October, peaking in September. Although EFH has been designated for king mackerel in the Potomac River, due to its preference for higher-salinity, estuarine and coastal oceanic habitats, king mackerel are not expected to occur in the Potomac River, as indicated by the species' absence from Table 3.11-4. If king mackerel do visit the Potomac River, it is expected that their occurrence would be limited to the regions closest to the mouth of the river.

King mackerel eat mostly fish, such as menhaden and anchovies, but also feed on shrimp and squid. They spawn from July through September over the Atlantic continental shelf. Larvae are found near or off the continental shelf, near the Gulf Stream, in waters with temperatures between 22 to 28°C.

Sources: Collette and Nauen, 1983; Godcharles and Murphy, 1986; CBP, 2012; NOAA, 2012a

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

King Mackerel

Eggs Larvae Juveniles Adults	♦ Sandy shoals of capes and offshore bars, high-profile rocky bottom and barrier island ocean-side waters from the surf zone to the shelf break, but from the Gulf Stream shoreward. ♦ All coastal inlets. ♦ All state-designated nursery habitats of particular importance to coastal migratory pelagics. ♦ Water temperatures greater than 68˚F. ♦ Salinities greater than 30 ppt.

Spanish Mackerel

Like king mackerel, Spanish mackerel are highly-migratory, coastal epipelagic fish that are found near shore or far out to sea over the continental shelf. Temperature and salinity are believed to be the most important determinants of their distributions. Spanish mackerel usually prefer waters with temperatures between 70 and 81°F, rarely occurring in waters cooler than 64°F, and salinities between 32 and 36 ppt. Spanish mackerel usually avoid freshwater or low salinities near river mouths, although exceptions have been reported.

In the Chesapeake Bay, they usually live near the surface of the bay's open waters, close to shore. Spanish mackerel are found in the lower and middle bay, extending at least to the Patuxent River, and are most common along Virginia's western shore. They migrate from off Florida to the Chesapeake Bay in spring, entering the bay by May and leaving in autumn. As shown in Table 3.11-11, Potomac River commercial fishing harvest data indicate that Spanish mackerel landings from PRFC Area 1, which includes the LDZ, were reported each year from 2002 through 2010. No landings of Spanish mackerel were reported from Areas 2 and 3, which include the MDZ and UDZ, respectively.

Like king mackerel, Spanish mackerel eat mostly fish, such as menhaden and anchovies, but also feed on shrimp and squid. Spanish mackerel spawn off the Virginia and North Carolina coasts from late spring through late summer, and spawn in lower Chesapeake Bay in mid June. Most juvenile Spanish mackerel remain in high-salinity, nearshore ocean waters, although some use estuaries as nursery grounds.

Sources: Collette and Nauen, 1983; Godcharles and Murphy, 1986; Cosby, PRFC, pers. comm., March 1, 2011; CBP, 2012; NOAA, 2012a

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Spanish Mackerel

Eggs
Larvae
Juveniles
Adults

- Sandy shoals of capes and offshore bars, high-profile rocky bottom and barrier island ocean-side waters from the surf zone to the shelf break, but from the Gulf Stream shoreward.
- All coastal inlets.
- All state-designated nursery habitats of particular importance to coastal migratory pelagics.
- Water temperatures greater than 68˚F.
- Salinities greater than 30 ppt.

Red Drum

Red drum are estuarine-dependent fish. Juvenile and adult red drum can tolerate wide ranges of salinities (euryhaline) and temperatures (eurythermal). Juveniles have been found in waters with salinities of 0 to 50 ppt and temperatures of 55 to 82°F. Adults are most abundant in waters with salinities of 30 to 35 ppt, and have been found in waters with temperatures from 36 to 95°F. Larger juveniles and adults are more susceptible to the effects of winter cold waves than are small red drum.

In the Chesapeake Bay, adult red drum most often are found near the shoreline and school near the water surface. Juveniles are common in the bay's shallows and move up the bay as far as the Patuxent River. Red drum visit the Chesapeake Bay from May through November; adults are most common near the mouth of the bay during spring and autumn. Red drum occur sporadically in the Potomac River estuary, generally from June to October, with young fish remaining into late fall. Large adults are seldom caught in the river, except at the mouth, although young fish may be caught upstream or in the lower tributaries.

Juvenile red drum eat zooplankton and small invertebrates; adults feed on smaller fish such as anchovies and menhaden, as well as crabs and shrimp. In the Chesapeake Bay, red drum spawn in nearshore waters in late summer and autumn. After spawning, adults spend more time in the ocean and less in the bay. Larvae are found in vegetated and unvegetated bottoms in estuaries. Young-of-the-year red drum appear in the bay in August and September, and move into shallow, fresher waters, protected from wave action. In fall and winter, after their first year, red drum move into deeper bays and marine littoral areas, and return to the estuary in the spring.

Sources: Lippson et al., 1981; Buckley, 1984; CBP, 2012; NOAA, 2012a

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Red Drum

Larvae

- Estuarine wetlands especially important.
- Flooded saltmarshes, brackish marshes, tidal creeks, mangrove fringe, seagrasses.
- Water temperatures from 36 to 91˚F.
- Low salinity.

- Water depths less than 164 ft.

Juveniles

- Utilize shallow backwaters of estuaries as nursery areas and remain until they move to deeper water portions of the estuary associated with river mouths, oyster bars and shell banks, and front beaches.
- Found throughout Chesapeake Bay from September through November.
- Water temperatures from 36 to 91˚F.
- Salinities from 20 to 40 ppt.
- Water depths less than 164 ft.

Adults

- Concentrate around inlets, shoals, and capes along the Atlantic coast – shallow bay bottoms or oyster reef substrate preferred.
- Nearshore artificial reefs.
- Found in Chesapeake Bay in spring and fall, and also along eastern shore of Virginia.
- Water temperatures from 36 to 91˚F.
- Salinities from 20 to 40 ppt.
- Water depths less than 164 ft.

HAPC

- All coastal inlets, and adjoining channels, sounds, and outer bars.
- All state-designated nursery habitats of particular importance to red drum.
- Documented sites of spawning aggregations in North Carolina, South Carolina, Georgia, and Florida, and other identified spawning areas in the future.
- Habitats identified for SAV, especially seagrass beds or SAV prevalent in the Chesapeake Bay.
- Barrier islands and passes between barrier islands into estuaries.

Windowpane Flounder

Windowpane flounder are shoal-water benthic fish that inhabit estuaries, nearshore waters, and the continental shelf. Although windowpane flounders show some small-scale seasonal inshore-offshore movement, they do not undertake extensive migrations seasonally or for spawning. They generally inhabit shallow waters, less than 360 ft deep, with sand to sand/silt or mud substrates, and are most abundant at depths of 3.3 to 6.6 ft. Windowpane flounder are eurythermal and euryhaline. In most bays and estuaries south of Cape Cod, they can be found throughout the year at a wide range of depths and temperatures. Windowpane flounder may move as far up the Chesapeake Bay as the Potomac River.

Windowpane flounder feed mostly on polychaetes, small crustaceans, mysids (various small, shrimp-like, chiefly marine crustaceans of the order Mysidacea), and small fish. In the southern

Mid-Atlantic Bight, both juveniles and adults may migrate to nearshore or estuarine habitats in the autumn.

Sources: Bigelow and Schroeder, 1953; Lippson et al., 1981; Morse and Able, 1995; NMFS, 1999c; NOAA, 2012a

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Windowpane Flounder

Juveniles
- Bottom habitats with a substrate of mud or fine-grained sand.
- Water temperatures less than 77˚F.
- Salinities from 5.5 to 36 ppt.
- Water depths from 3.3 to 328 ft.

Adults
- Bottom habitats with a substrate of mud or fine-grained sand.
- Water temperatures less than 80.2˚F.
- Salinities from 5.5 to 36 ppt.
- Water depths from 3.3 to 246 ft.

Summer Flounder

Summer flounder are bottom-dwelling fish that inhabit shallow estuarine waters and the outer continental shelf. Juveniles use a variety of estuarine habitats, including estuarine marsh creeks, which serve as important nursery habitat, and seagrass beds, mud flats, and open bay areas. In the Chesapeake Bay, young-of-the-year occupy tidal creeks with salinities greater than 15 ppt. Some juvenile summer flounder prefer mixed or sandy substrates, whereas others use mud and vegetated habitats. Although reportedly adult summer flounder prefer sandy habitats, they also occupy various habitats with both mud and sand substrates, including marsh creeks, seagrass beds, and sand flats.

Summer flounder exhibit strong seasonal inshore-offshore movements. Generally, adults inhabit shallow coastal and estuarine waters during warmer months and remain offshore during the fall and winter. Juveniles remain inshore and in estuaries during spring, summer, and fall, and may move to deeper waters offshore during colder winter months.

Summer flounder visit the Chesapeake Bay from spring through autumn; most remain in the lower to middle bay, although some move as far north as the Gunpowder River. They usually enter the Potomac River in April and leave by November, but may arrive in March and leave in December. Young summer flounder have been found as far upstream as Indian Head, upriver from the UDZ, but most remain in the lower reaches of the estuary. Commercial fishing harvest data indicate that summer flounder landings from PRFC Area 1, which includes the LDZ, were reported each year from 2002 through 2010, as shown in Table 3.11-11. Landings from Area 1 accounted for 99 percent of the total landings by weight from the PRTR portion of the river during this period, with landings from Areas 2 and 3, which include the MDZ and UDZ, accounting for the remaining 1 percent.

Summer flounder are bottom feeders. Juveniles eat mostly mysid shrimp and adults feed mostly on fish, shrimp, squid, and polychaetes. Summer flounder spawn in shallow coastal waters and in estuaries along the Atlantic Coast.

Sources: Lippson et al., 1981; NMFS, 1999b; Cosby, PRFC, pers. comm., March 1, 2011; CBP, 2012; NOAA, 2012a; 2012b

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Summer Flounder

Juveniles
- Demersal waters, muddy substrate but prefer mostly sand.
- Lower estuaries in mudflats, channels, saltmarsh creeks, and seagrass beds, and open bay areas.
- Water temperatures greater than 52˚F.
- Salinities from 10 to 30 ppt.
- Water depths from 1.6 to 16 ft in estuary.

Adults
- Demersal waters.
- Estuaries.
- Water depths from 0 to 82 ft.

HAPC
- Within adult and juvenile EFH, all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes in any size bed as well as loose aggregations.

Bluefish

Bluefish are highly-migratory, pelagic fish that inhabit open waters and migrate seasonally. They occur in a wide range of conditions, but prefer warmer waters, at least 57 to 61ºF, and high salinities. Adults are found at much deeper depths than juveniles, ranging from 3 to 1,300 ft. Juvenile bluefish use a variety of pelagic habitats in estuaries, which they use as nursery areas, bays, and the coastal ocean. They usually occupy waters near shorelines or in tidal creeks during the day and occupy open bay or channel waters at night. Although juveniles prefer sandy substrates, they also can be found over silt and clay bottoms. They prefer waters with salinities between 23 and 33 ppt, but can tolerate salinities as low as 3 ppt. Adult bluefish occur in the open ocean, large embayments, and estuaries.

Bluefish visit Chesapeake Bay open waters from spring through autumn. They spawn offshore and juveniles enter the bay in late summer. Bluefish are abundant in the lower bay, but most years also are common in the upper bay as far north as Baltimore. In the Chesapeake Bay, most bluefish are found where DO levels are between 6 and 9 mg/l. In early autumn, bluefish migrate out of the bay and all stages of bluefish have left the estuary by mid November. Adult bluefish start to enter the Potomac River shortly after they enter the Chesapeake Bay, in March or April. Although there are records of their occurrence near Washington, DC, adult bluefish are seldom found above Mathias Point, at the upriver end of the UDZ. Juveniles may be found as far upriver as Liverpool Point, upriver from the UDZ.

Bluefish are opportunistic predators that feed on a wide variety of fish and invertebrates; over 70 species of fish have been found in their stomach contents. Bluefish may be the most voracious predator in the Chesapeake Bay, feeding on squid and schooling fish, such as menhaden, silversides, and anchovies. Juveniles feed on small forage fish found in nearshore habitats.

Sources: Lippson et al., 1981; NMFS, 2006; ASMFC, 2011; NOAA, 2011a, 2011b

Habitat Associations by Life Stage (NOAA, 2012a, 2012b)

Bluefish

Juveniles
- Pelagic waters.
- Estuaries.
- Water temperatures from 66 to 75˚F.
- Salinities from 23 to 36 ppt.

Adults
- Pelagic waters.
- Estuaries.
- Water temperatures from 57 to 61˚F.
- Salinities greater than 25 ppt.

Composition of Essential Fish Habitat in the Potomac River

Based on the above descriptions of the species and life stages for which EFH has been designated and resulting estimates of actual habitat utilization, the composition of EFH in the PRTR is as follows:

- UDZ – juvenile and adult summer flounder and bluefish
- MDZ – juvenile and adult summer flounder and bluefish
- LDZ – juvenile and adult cobia, king and Spanish mackerel, red drum, windowpane and summer flounder, and bluefish

Adverse Nonfishing Activity Effects Described in Fishery Management Plans

Collectively, the FMPs for each of the species for which EFH has been designated in the Potomac River identify multiple nonfishing activities that have the potential to adversely affect EFH quantity or quality (Gulf of Mexico Fishery Management Council and SAFMC, 1983; ASMFC, 1984; NEFMC, 1985; MAFMC, 1987; MAFMC and ASMFC, 1989, 1998; ASMFC, 1991). The identified activities may result, directly or indirectly, in the absolute loss or long-term degradation of the general aquatic environment or specific aquatic habitats, including EFH (NMFS Northeast Fisheries Center, 1985).

In 2005, the Northeast Region Essential Fish Habitat Steering Committee hosted the *Technical Workshop on Impacts to Coastal Fishery Habitat from Nonfishing Activities* to convene scientists, resource managers, and other marine resource professions to review and evaluate existing information on nonfishing impacts for the purpose of updating, as necessary, fishery management plans under the New England and Mid-Atlantic Fishery Management Councils

(NMFS Northeast Regional Office, 2008). Among the specific goals/tasks of the workshop were the following:

- Identify all known and potential adverse effects for each category of nonfishing activity by life history strategies or stages (i.e., benthic/demersal and pelagic) and ecosystem type or strata (i.e., riverine, estuarine/nearshore, and marine/offshore).
- Create a matrix of nonfishing impacts and score the relative severity of each impact using a semiquantitative scoring system.

Table 3.11-16 summarizes the results of the workshop scoring for the estuarine ecosystem strata for those categories of nonfishing activities that, in terms of the nature of the activities and the character of their potential adverse effects on EFH, may be similar to the RDT&E activities evaluated in this EIS.

The potential impacts to the designated EFH in the Potomac River that would result from implementing the alternatives considered in this EIS are assessed in the relevant subsections of Section 4.11 in Chapter 4.

Table 3.11-16
Estuarine/Nearshore Habitat Impact Severity Index Scores

Activity Type/Potential Effect	Benthic/Demersal Stages	Pelagic Stages
Marine Debris		
Entanglement	medium	medium
Ingestion	medium	medium
Contaminant releases	medium	medium
Introduction of invasive species	medium	medium
Introduction of pathogens	medium	medium
Conversion of habitat	medium	medium
Operation and Maintenance of Vessels		
Impacts to benthic habitat	high	medium
Resuspension of bottom sediments	medium	medium
Erosion of shorelines	medium	medium
Contaminant spills and discharges	high	high
Underwater noise	medium	medium
Derelict structures	medium	low
Increased air emissions	low	low
Release of debris	medium	low
Military/Security Activities		
Exclusion of organisms to habitat	low	medium
Noise impacts	medium	medium
Chemical releases	high	medium
Impacts to tidal/intertidal habitats	medium	medium
Blasting injuries from ordnance	medium	medium
Electromagnetic Fields		
Changes to migration of organisms	medium	medium
Behavioral changes	medium	medium
Changes in predator/prey relationships	medium	medium
Source: NMFS Northeast Regional Office, 2008.		

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3.12 Potomac River Birds

3.12.1 Migratory Birds

Migratory birds are a large, diverse group of birds that typically fly north to breed in the temperate or Arctic summer, and return to wintering grounds in warmer regions to the south. In the Western Hemisphere, migratory birds commonly nest in North America and spend the winter in southern North America, Central and South America, the West Indies, and the Caribbean.

All migratory birds are protected under the Migratory Bird Treaty Act (MBTA) (16 U.S.C. §§ 703-712). The MBTA prohibits the taking, killing, or possessing of migratory birds unless permitted by regulation. However, the 2003 National Defense Authorization Act provides that the Secretary of the Interior shall exercise his/her authority under the MBTA to prescribe regulations to exempt the Armed Forces from incidental taking of migratory birds during military readiness activities authorized by the Secretary of Defense. The final rule authorizing the DoD to take migratory birds during military readiness activities (50 CFR Part 21, published February 28, 2007) provides that the Armed Forces must confer and cooperate with the US Fish and Wildlife Service (USFWS) on the development and implementation of conservation measures to minimize or mitigate adverse effects of a military readiness activity if it determines that it may have a significant adverse effect on a population of a migratory bird species. Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, provides additional protection for migratory birds on federal properties and stresses incorporating bird conservation principles in agency management plans.

The Potomac River is located off the main Atlantic flyway, which follows the Atlantic coast. Millions of migratory birds, including waterfowl, shorebirds, and songbirds, use the Atlantic flyway to travel between their summer breeding grounds and winter feeding grounds. Most species of waterfowl that use the flyway are from the northeastern United States and eastern Canada. There are sub-flyways off the main Atlantic flyway that follow major rivers – including the Potomac – and their tributaries. Waterfowl and other birds stop for food and shelter in coves and marshes along the flyway. Chesapeake Bay and the surrounding area serve as a wintering area for variety of ducks, geese, swans, and other migratory birds.

Many species of migratory birds frequent the shoreline and waters of the Potomac River, including waterfowl, raptors, shorebirds, and neotropical migrant birds, as described in the following sections.

3.12.2 Waterfowl

Waterfowl include birds in the family Anatidae (order Anseriformes). Potomac River waterfowl fall into four categories: dabbling ducks, diving ducks, geese, and swans (see text box). All have webbed feet and short legs, and most have wide, flattened bills. Most species migrate seasonally and use aquatic vegetation beds, wetlands, agricultural areas, and shoreline areas for food and nesting habitat. Dabbling ducks are generally found in shallow areas, such as near shallow wetlands and aquatic vegetation. In contrast, diving ducks generally occur in deeper open-water and are likely to be found in the river range. Dabbling ducks can spring into the air and fly away, but diving ducks have to run across the water flapping their wings in order to become airborne.

Large rafts (i.e., several hundred to several thousand) of diving ducks are observed annually on the Potomac River stretching from the Harry Nice Bridge into the mouth of Upper Machodoc Creek. Canvasback, lesser scaup, and ruddy ducks are the major species comprising these rafts.

Six high priority species, as defined by the Atlantic Coast Joint Venture, a partnership of federal, regional and state agencies and organizations focused on the conservation of habitat for native bird species in the Atlantic Flyway from Maine to Puerto Rico, use the lower Potomac River for wintering and migration habitat (Atlantic Coast Joint Venture, 2005). These priority species include the black duck, mallard, pintail, greater and lesser scaup, and the Southern James Bay population of Canada goose. Dabbling duck species (see text box above) and Canada geese utilize flooded marshes and the adjacent waterbodies to feed on invertebrates, plants and seeds. Scaups are diving ducks and use open-water to feed on SAV and invertebrates.

Potomac River Waterfowl

- **Dabbling ducks** feed primarily on water plants, which they obtain by tipping forward or dabbling in the shallows. They feed on submerged grasses, seeds, and other plant material. Their legs are positioned close to the middle of their bodies, allowing them to walk easily but inhibiting their diving ability. Common dabbling ducks include mallard (*Anas platyrhynchos*), black duck (*Anas rubripes*), pintail (*Anas acuta*), and wood duck (*Aix sponsa*).
- **Diving ducks** feed by diving to the bottom in deep water. Their legs are positioned towards the rear of their bodies, allowing them to dive but making it awkward to walk on land. Some diving ducks prefer plants such as wild celery and pondweed, but most consume a mixed diet consisting of small fish, mollusks, crustaceans, worms, and/or insects. Common diving ducks include canvasback *(Aythya valisineria*), redhead (*Aythya americana*), bufflehead (Bucephala albeola), lesser scaup (*Aythya affinis*), greater scaup (*Aythya marila*), ruddy duck (*Oxyura jamaicensis*), and red-breasted merganser (*Mergus serrator*).
- **Geese** are large, heavy-bodied waterfowl intermediate in size and build between large ducks and the swans. Geese feed on grain, grasses, and aquatic plants. Common geese include Canada geese (*Branta canadensis*), snow geese (*Chen caerulescens*), and Atlantic brant geese (*Branta bernicla*).
- **Swans** are the largest waterfowl species of the family Anatidae. Swans feed on aquatic plants, seeds, and field grain. The native tundra swan (*Cygnus columbianus*) is the most common swan found in the area, followed by the introduced mute swan (*Cygnus olor*).

Sources: Chesapeake Bay Gateways Network, 2009, Chesapeake Bay Program, 2009, USGS, 2011).

Fall migrants and overwintering waterfowl are very common in the creeks and bays that empty into the lower Potomac River. For example, NOAA's National Ocean Service (NOS) Environmental Sensitivity Index Maps, which are compiled from a number of databases, indicate that black duck, American coot *(Fulica americana*), American widgeon (*Anas americana)*, bufflehead, Canada goose, gadwall *(Anas strepera)*, and mallard – all except bufflehead are dabbling ducks – overwinter in creeks, such as Gambo Creek, along the river from October to April. Creeks with larger bays and more open water, such as Upper Machodoc Creek, Mattox Creek, Currioman Bay, and Nomini Bay, provide refuge from October to April for

Ruddy Duck
Oxyura jamaicensis

bufflehead, canvasback, common goldeneye (*Bucephala clangula*), red-breasted merganser, mute swan, ruddy duck, lesser scaup, scoter *(Fuligula americana)*, and tundra swan, many of which are divers (NOS, 2005, Environmental Sensitivity Index map VA-116).

MDNR (2010) has estimated the number of waterfowl overwintering in the Chesapeake Bay area to range between about 500,000 and 900,000 birds (Table 3.12-1). Much of the Chesapeake Bay is considered to be a waterfowl concentration area, portions of which extend to the lower Potomac River. Many species of waterfowl – but especially geese, swans, and diving ducks – tend to return year after year to the same wintering and staging areas. MDNR maps of waterfowl concentration or staging areas indicate that several overlap the PRTR, particularly in the upper portion of the LDZ, as shown in Figure 3.12-1 (Waterfowl Concentration Areas) (MDNR, 2010).

Table 3.12-1
Maryland Midwinter Chesapeake Bay Waterfowl Survey
Numbers from 2003 to 2007

Species	2003	2004	2005	2006	2007
Mallard	39,000	48,200	52,800	32,500	39,700
Black duck	22,500	31,700	23,600	13,300	13,800
Gadwall	3,700	2,500	1,400	1,200	1,400
Widgeon	800	6,000	2,000	300	400
Green-winged teal	1,000	1,200	1,000	400	3,300
Shoveler	0	100	100	0	100
Pintail	1,300	4,600	1,900	2,500	500
Total Dabbling Ducks	**68,300**	**94,300**	**82,800**	**50,200**	**59,200**
Redhead	5,100	6,100	9,300	1,800	1,100
Canvasback	40,000	30,800	39,400	33,800	13,700
Lesser scaup	66,600	106,300	189,800	79,500	25,700
Ring-necked	300	200	1,000	500	900
Golden-eye	2,100	1,000	3,000	700	700
Bufflehead	13,100	9,800	22,000	11,800	12,000
Ruddy duck	42,700	34,000	36,100	12,100	19,800
Mergansers	6,500	18,700	5,100	7,000	1,700
Scoters	2,300	8,100	40,600	10,000	2,100
Long-tailed duck	100	400	4,100	700	500
Total Diving Ducks	**178,800**	**215,400**	**350,400**	**157,900**	**78,200**
Brant geese	1,500	1,300	1,700	2,400	500
Snow goose	75,600	93,900	54,900	49,200	46,600
Canada goose	452,900	355,200	383,400	305,400	285,700
Tundra swan	15,100	17,900	13,200	8,200	8,700
Total Geese and Swans	**545,100**	**468,300**	**453,200**	**365,200**	**341,500**
Total Waterfowl	**792,200**	**778,000**	**886,400**	**573,300**	**478,900**

Source: MDNR, 2010.

Over the last century, the number of waterfowl present in the Chesapeake Bay area has declined due to habitat deterioration, increased human activities, and loss of wetlands (Chesapeake Bay Gateways Network, 2009). Some waterfowl feed on the benthic invertebrates that are abundant in SAV beds, and other birds feed directly on below-ground buds and tubers (Rybicki and Landwehr, 2007). Species that are dependent on native SAV, such as the canvasback, are more

sensitive to fluctuations in SAV abundance (see Section 3.11.1) than birds like Canada geese and snow geese, which have adapted their diets to feed on grass and agricultural grain. Another factor contributing to the year-to-year variation in the number of waterfowl wintering in the area is the warm winter temperatures over the last few decades, which has resulted in waterfowl remaining north of traditional wintering areas (MDNR, 2010). The temperatures in the Chesapeake Bay region have increased by about 2°F (1°C) since 1960 (Duffy, 2008).

3.12.3 Raptors

3.12.3.1 Bald Eagle

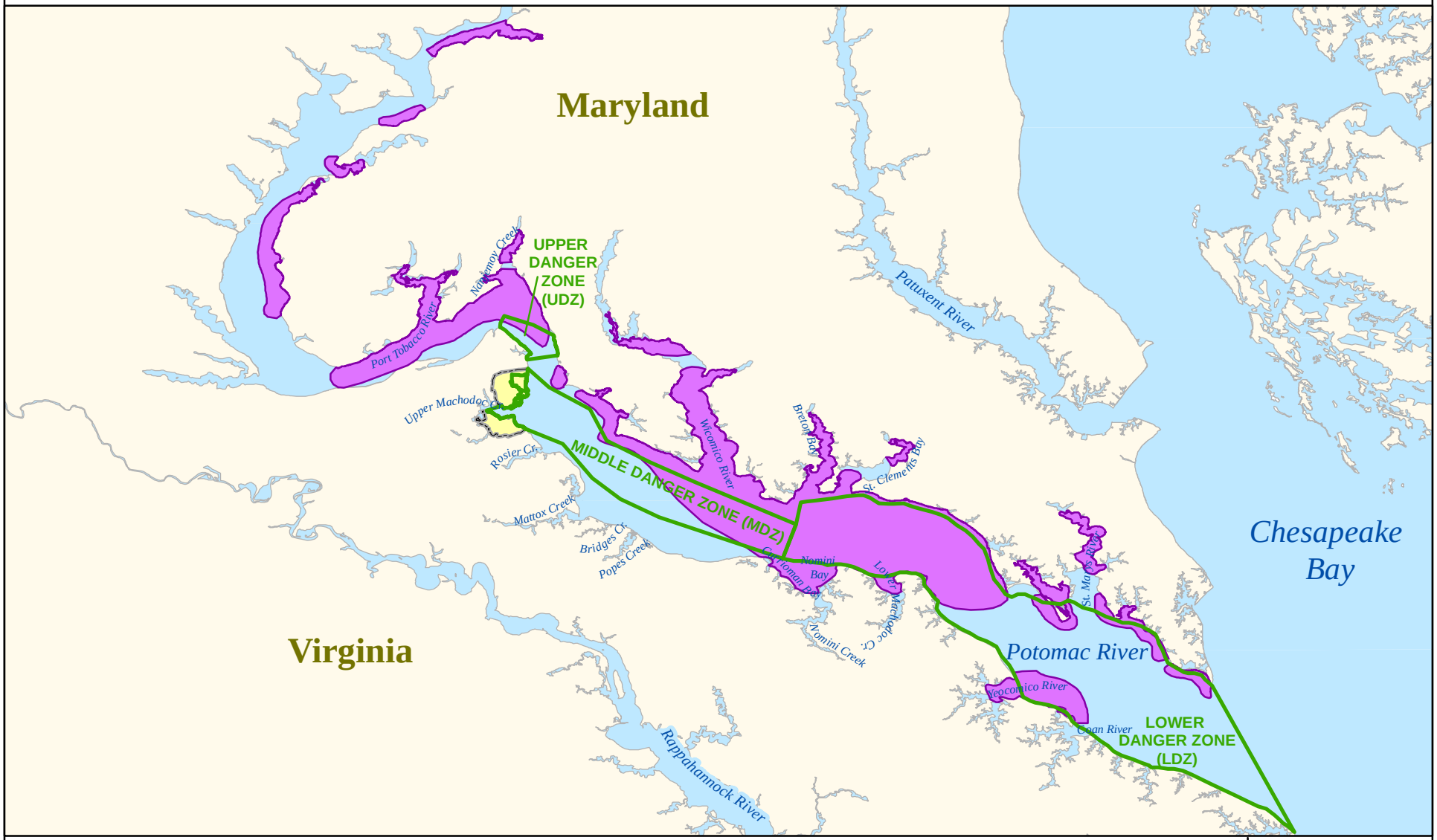
Bald eagles (*Haliaeetus leucocephalus*) are typically found in coastal areas or along the margins of rivers and lakes throughout North America. The bald eagle was originally listed as an endangered species south of the 40th parallel in 1967. On July 4, 1976, it was listed as a national endangered species under the Endangered Species Act (ESA). Its status in the lower 48 states was upgraded to threatened in July 1995, due in large part to increases in eagle populations following a ban on the use of dichlorodiphenyl trichloroethane (DDT). The bald eagle was delisted from the federal threatened and endangered species list on July 28, 2007. It is primarily protected under the Bald and Golden Eagle Protection Act of 1940 (BGEPA) (16 U.S.C. §§ 668-668d), which prohibits taking, possession, and commerce of eagles. It is also protected by the Migratory Bird Treaty Act (16 U.S.C. §§ 703-712). The bald eagle remains listed as a state "threatened" species under Virginia law and VDGIF regulations (USFWS and VDGIF, 2001; VDGIF, 2007). The Lacey Act of 1900 (18 U.S.C. §§ 43-44) and subsequent amendments to the act also protect bald eagles (along with other plants and animals) by making it a federal offense to take, possess, transport, sell, import, or export their nests, eggs and parts that are taken in violation of any state, tribal, US, or foreign law.

Bald eagles feed primarily on fish, but, as opportunistic feeders, their diet also includes waterfowl, other shore and sea birds, small mammals, turtles, and carrion (USFWS, 2007). Bald eagles frequently scavenge for dead or dying fish, waterfowl, and mammals, or steal prey from other smaller birds, such as osprey (VDGIF, 2011). Because they are visual hunters, eagles typically locate their prey from a conspicuous perch or soaring flight, then approach their prey in a shallow glide and grab it with a quick swipe of their talons. Eagles feed by holding the catch in one claw and tearing the flesh with the other claw.

Bald Eagle
Haliaeetus leucocephalus

Bald eagles generally nest near water bodies (e.g., coastlines, rivers, lakes, or streams) that can provide an adequate food supply (USFWS, 2007). Eagles frequently nest in old-growth or tall trees, or structures that include at least one perch with a clear view of the water for foraging (USFWS, 2007). Eagles forage in open water, including the PRTR portion of the Potomac River. Breeding in the Chesapeake Bay area starts in November and can last through mid-July, with most eggs laid mid-January to late February (VDGIF, 2011).

Waterfowl Concentration Areas



Waterfowl Concentration Area

Potomac River Test Range (PRTR) Complex

Naval Support Facility (NSF) Dahlgren

10 0 10 Miles

16 0 16 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: Maryland Department of Natural Resources (MDNR). 2010.

Figure 3.12-1

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The Potomac River is a major nesting and migration area for the bald eagle. The Chesapeake Bay region bald eagle population is divided into two distinct groups – one of individuals that migrate to the Chesapeake Bay region, but do not breed there; the other a population of year-round residents that breed in the area (Buehler et al., 1991). The migratory bald eagles come from three geographically-isolated breeding populations in the northeastern, southeastern, and mid-Atlantic regions of the United States, providing both summer and winter migrants.

The bald eagle population in the Chesapeake Bay region has experienced a recovery similar to that seen in many other areas of the United States. In 1962, there were estimated to be 150 breeding pairs in the Chesapeake Bay; the number fell over the next eight years to an estimated low of 80 to 90 pairs in 1970 (Watts and Byrd, 2011). Since then, bald eagles have experienced a dramatic recovery in the region, with an estimated population of more than 2,000 eagles in the Chesapeake Bay region (MDNR, 2000). Bald eagle nesting success in the lower Chesapeake Bay is one of the highest on record in North America, with 74 percent of occupied territories producing at least one young annually since 1995 (Watts and Byrd, 2011). The availability of undeveloped waterfront property is considered to be a major limiting factor for bald eagles in the Chesapeake Bay (Watts and Byrd, 2011).

The number of bald eagles in Maryland has increased since surveys began. The MDNR began eagle surveys in 1977 and documented only 44 occupied nests. By 2004, this number had grown to 390 occupied nests (MDNR, 2004). The Maryland mid-winter bald eagle survey has shown that the number of bald eagles wintering at concentration areas in Maryland has grown from 44 in 1979 to 303 in 2008 (MDNR, 2008). An increasing number of eagles are also nesting – and successfully producing chicks (one to three per nest) – along the Virginia side of the Potomac River (Table 3.12-2). In 2011 there were 726 occupied bald eagle territories recorded in Virginia (Watts and Byrd, 2011). The Potomac River area has shown one of the highest bald eagle population increases in Virginia (Watts and Byrd, 2007, 2008).

Table 3.12-2
Bald Eagle Nesting Along the Potomac River in Virginia from 2005 to 2011

	2005	2006	2007	2008	2009	2010	2011
Number of territories occupied	95	98	123	139	151	141	156
Number of active nests	92	97	117	132	136	137	134(131)
Number of chicks produced	131	136	160	211	205	183	199(103)
Mean number of chicks per active nest	1.49	1.46	1.33	1.67	1.59	1.43	1.52
Mean number of chicks produced per nest	1.72	1.72	1.74	1.91	1.78	1.78	1.93

Notes:
A breeding territory is considered to be "occupied" if a pair of birds is observed in association with the nest and there is evidence of recent nest maintenance.
Nests are considered to be "active" if a bird is observed in an incubating posture or if eggs or young are detected in the nest.
Source: Watts and Byrd, 2006, 2007, 2008, 2010, 2011.

The VDGIF and the USFWS have defined a Potomac River Bald Eagle Concentration Area that includes most of the Virginia shoreline between Pohick Creek and the Harry Nice Bridge (Wetland Studies and Solutions, 2006) – areas adjacent to the UDZ. Figure 3.12-2 (Bald Eagle Concentration Areas and Great Blue Heron Nests/Pairs) shows the areas along the river where bald eagle nests are most concentrated.

Both migratory and residential breeding populations inhabit NSF Dahlgren and its surrounding area year-round (NSF Dahlgren and NAVFAC Washington, 2007; NSF Dahlgren, 2007). The installation's proximity to open water and the presence of forested habitats, combined with an upswing in the bald eagle population throughout the region and a loss of suitable habitat in the areas surrounding the installation, have resulted in an increase in the resident bald eagle population. Between 1983 and 2009 the number of nests documented at NSF Dahlgren went from 1 to 12, and 6 of these nests were active in 2009 (Figure 3.12-3, Bald Eagle Nests).

3.12.3.2 Osprey

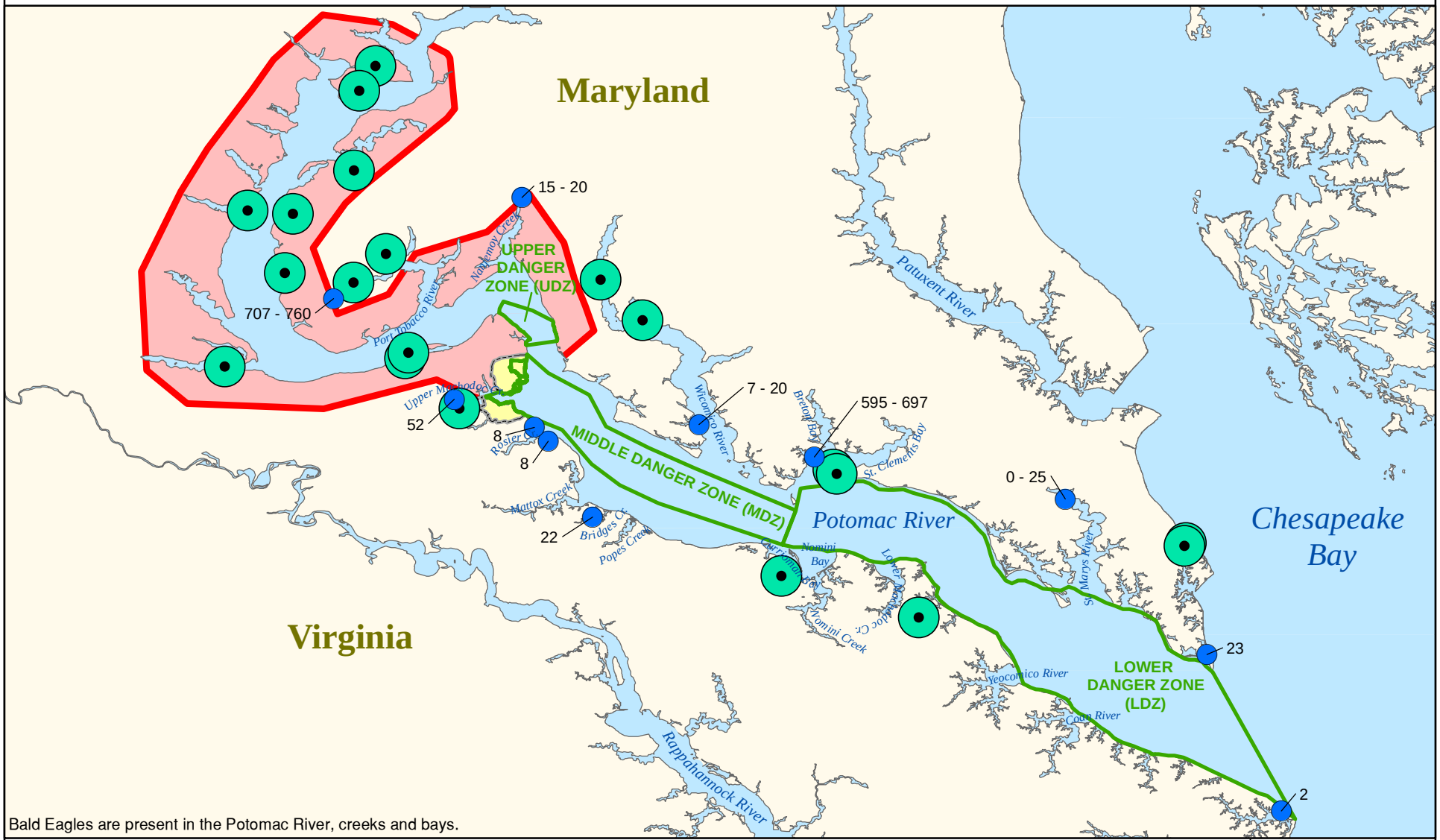
The Chesapeake Bay region is also home to a large population of another raptor – the osprey (*Pandion haliaetus*). The osprey is also known as the "fish eagle" or "fish hawk" and feeds almost exclusively on fish. North American ospreys are migratory, except for the populations of South Florida, Baja California, and the Pacific Coast of Mexico (Vana-Miller, 1987).

Osprey
Pandion haliaetus

Ospreys hunt by soaring over open water and scanning the surface for fish (USFWS, 2008). An osprey spots its prey above the water, after which the bird hovers momentarily, then plunges feet first into the water, accessing only the top 3 ft of water (Poole, et al., 2002). This fishing technique restricts them to catching surface schooling fish and fish in the shallows. The PRTR area of the Potomac provides suitable foraging habitat for ospreys.

Ospreys return to the Chesapeake Bay every spring, usually around the beginning of March, and usually leave by late July to August (USFWS, 2011). During the spring breeding season, more than 2,000 nesting pairs can be found near the Chesapeake Bay (Reshetiloff, 2004). Ospreys regularly forage along the Potomac River and its larger tributaries, such as Gambo and Upper Machodoc Creeks. When fish abundance is low, osprey nestling survival decreases, but when fish are abundant, survival increases to about 50 to 100 percent (State of Maryland Office of Attorney General, 2007). More than 20 active osprey nests are found within the NSF Dahlgren boundaries each year, and a greater number can be found in the installation's vicinity (NSWCDD, 2001). NSF Dahlgren has a program in place to install, monitor, and maintain nesting boxes for eastern bluebirds and wood ducks and nesting platforms for ospreys.

Bald Eagle Concentration Areas and Great Blue Heron Nests/Pairs



Bald Eagles are present in the Potomac River, creeks and bays.

22 Number of Heron Nests / Pairs

Heron Nests / Pairs

Bald Eagle Communal Roosts

Bald Eagle Concentration Areas

Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR) Complex

7 0 7 Miles

11 0 11 Kilometers

N

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NAVSEA WARFARE CENTERS DAHLGREN

Source for Heron Data: National Ocean Service Environmental Sensitivity Index Maps VA-(116,115,111 & 95) , 2005; MD-(54, 52, 44, 43, 29 & 21), 2007.
Source for Bald Eagle Data: Center for Conservatin Biology, 2008.

Figure 3.12-2

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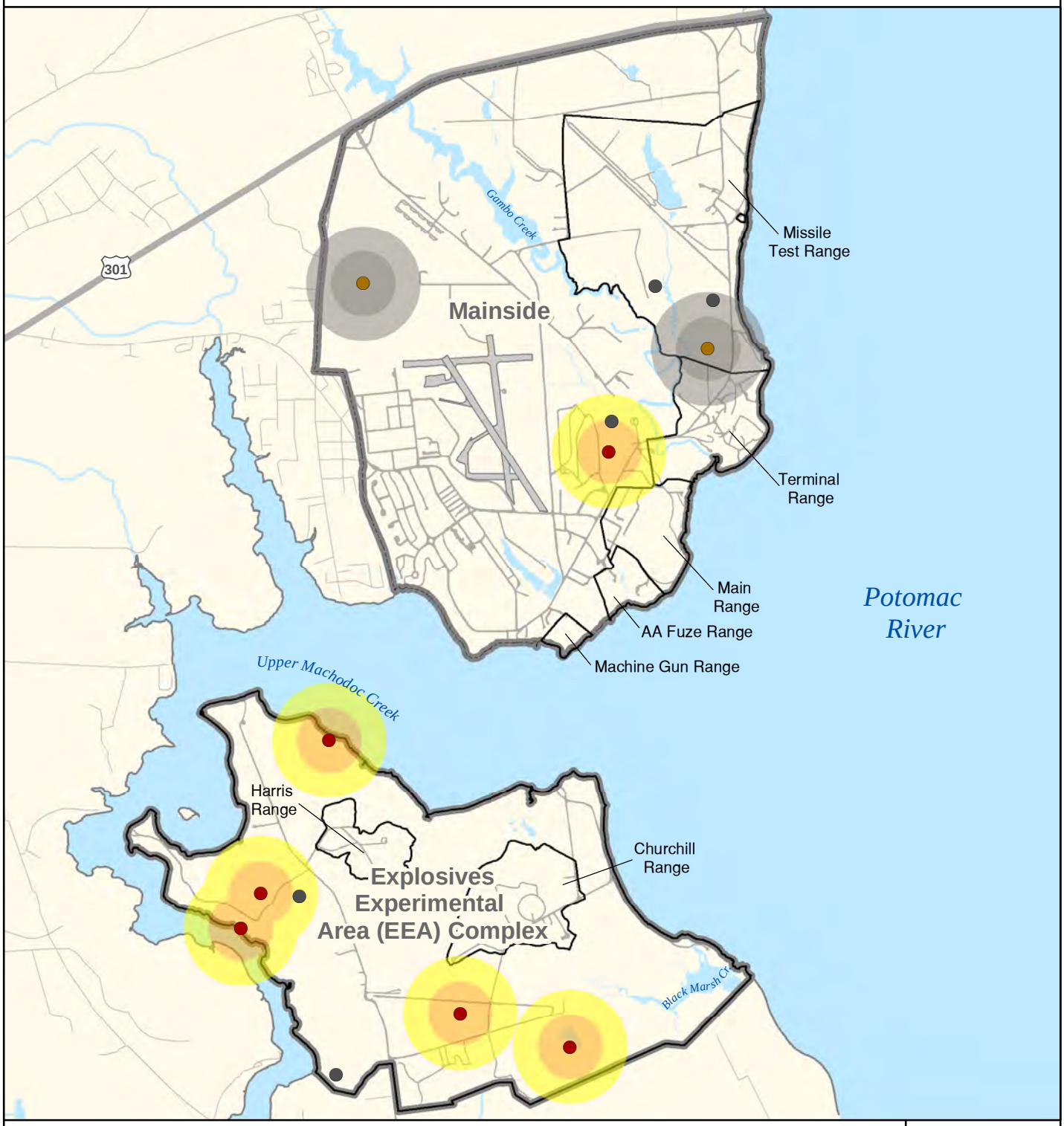
Bald Eagle Nests



Bald Eagle Nesting Site
- Active
- Historic
- Inactive

- 750 Foot - Active
- 1,320 Foot - Active
- 750 Foot - Inactive
- 1,320 Foot - Inactive
- Naval Support Facility (NSF) Dahlgren

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 3.12-3

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3.12.4 Wading Birds, Gulls, and Shorebirds

Open-water habitats are also important feeding areas for a number of other migratory species of water birds. The great blue heron (*Ardea herodias*), great egret (*Casmerodius albus*), green heron (*Butorides virescens*), herring gull (*Larus argentatus*), and ring- billed gull (*Larus delawarensis*) regularly feed along the edges of open-water habitats, both within and outside NSF Dahlgren (NSWCDD, 2003). All these species are protected under the MBTA; however, similar to the bald eagle, there are year-round and breeding populations of these species in the area.

Great Blue Heron
Ardea herodias

Piscivorous (fish-eating) birds in the area include the great blue heron, the largest heron in the region, with a wing-span of 6 ft. The Potomac River and the surrounding area comprise the main area for this species in Virginia (Watts, 2004). Most great blue herons breed in localized colonies (called rookeries or heronries) of sometimes hundreds of nesting pairs (CBP, 2011a). Two of the largest colonies within the mid-Atlantic region are located along the Potomac River (see Figure 3.12-2) on the headwaters of Nanjemoy Creek – a tributary of the Potomac River – in Charles County about 14 mi (as the heron flies) west-northwest of the Main Range at NSF Dahlgren. The largest colony is found at the Nanjemoy Creek Preserve, which is run by the Nature Conservancy, and has an average of more than 700 nesting pairs annually. The other colony is located on St. Clement's Bay, about 2 mi northeast of the PRTR's MDZ and approximately 14 mi east-southeast of Main Range, with an average of more than 600 nesting pairs annually (NOS, 2007). A smaller rookery which had 52 nests in 2005 (NOS, 2005) is located near NSF Dahlgren on the headwaters of Upper Machodoc Creek, 3 mi from the mouth of the creek and about 2 mi west of NSF Dahlgren.

The great egret and green heron are found along the Potomac River from spring to fall. The great egret feeds on fish, amphibians, and aquatic invertebrates. It returns to the Chesapeake Bay area to breed from mid-March to May (CBP, 2011b). The green-backed heron feeds on small fish, amphibians, and aquatic invertebrates. It returns to the Chesapeake Bay area to breed from April to May (CBP, 2011c).

Herring gulls are a common species seen around landfills, beaches, piers, and many other waterfront areas on the Chesapeake Bay and its tidal rivers. They live in the Chesapeake Bay watershed year-round, but are more common from fall through spring than in the summer (CBP, 2011d). Ring-billed gulls are the bay's most abundant winter gull, but in summer they are less common around the bay and more abundant on freshwater lakes and rivers (CBP, 2011d).

During the spring and fall migration periods, large numbers of shorebirds feed along the shoreline of the Potomac River and its tributaries. These shorebirds include lesser yellowlegs (*Tringa flavipes*), greater yellowlegs (*Tringa melanoleuca*), killdeer (*Charadrius vociferus*), and semipalmated sandpipers (*Calidris pusilla*) (NSWCDD, 2001).

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3.13 NSF Dahlgren's Biological Resources

This section describes the biological resources of the NSF Dahlgren base that have the potential to be affected by the Proposed Action. Because the potential for impacts on off-base terrestrial animals and plants is negligible, these resources are not addressed. Birds found at NSF Dahlgren are considered to be able to move freely on- and off-base.

The main source of information for this section (unless otherwise noted) is the *Integrated Natural Resources Management Plan, Naval Support Facility Dahlgren, Dahlgren, Virginia* (NSF Dahlgren, 2007). Every DoD installation that has suitable habitat for conserving and managing natural ecosystems is required to prepare, maintain, and implement an Integrated Natural Resources Management Plan (INRMP). An INRMP is a long-term planning document that guides implementation of the natural resources program to ensure support of the installation's mission while protecting and enhancing the installation's natural resources for multiple use, sustainable yield, and biological integrity. NSF Dahlgren's INRMP documents the installation's mission; the baseline condition of natural resources; the impacts of the mission on natural resources; the management approaches to conserve and enhance natural resources; and specific projects aimed at protecting and enhancing existing natural resources.

3.13.1 NSF Dahlgren's Ponds, Streams, and Creeks

Aquatic resources other than the Potomac River associated with NSF Dahlgren include ponds, streams, and creeks within the installation. These water bodies include Upper Machodoc Creek, Gambo Creek, and Black Marsh Creek; two natural ponds – Beaver Pond and Lespedeza Pond; and two manmade freshwater impoundments – Hideaway Pond and Cooling Pond (Figure 3.10-1, Surface Water Resources - Dahlgren).

Upper Machodoc Creek is approximately 17 mi long, approximately 3,000 ft wide at the mouth, and about 6 ft deep. SAV is present most years in Upper Machodoc Creek near the mouth of Williams Creek (e.g., Orth et al., 2005, 2006, 2007), west of Gambo Creek. Prior to 2002, SAV was also generally found in the more upstream reaches of the creek (e.g., Orth et al., 2005, 2006, 2007). Species found include wild celery, common elodea, coontail, and the invasive Eurasian watermilfoil.

The Alliance for the Chesapeake Bay and NSF Dahlgren conducted fish sampling at two stations on the Potomac River and four stations on Upper Machodoc Creek in conjunction with a SAV study conducted between 1999 and 2002 (NSF Dahlgren, 2007). A total of 27 fish species was collected at the Upper Machodoc Creek stations during these efforts (completed fish collection forms provided by Lou Etgen, Interim Director, Alliance for the Chesapeake Bay, November 17, 2008). The most abundant species were white perch and Atlantic silverside. These species comprised 54.8 and 18.0 percent of the total catch, respectively. Other species that represented at least 1.0 percent of the total catch were Atlantic menhaden, gizzard shad, bay anchovy, banded killifish, mummichog, striped killifish, and striped bass. Additional species of recreational and commercial importance included channel catfish, yellow perch, bluefish, spotted seatrout, and spot.

In addition to the species collected, anadromous fish species, such as striped bass, hickory shad, American shad, alewife, and white perch, use wetlands associated with Upper Machodoc Creek and Gambo Creek for nursery areas.

Gambo Creek is tidally influenced as far inland as the northern boundary of the installation. The creek is bordered by extensive tidal wetlands dominated by saltmarsh cordgrass and big cordgrass (*Spartina cynosuroides*).

Many waterfowl use the creeks and ponds at NSF Dahlgren. Dabbling ducks are common winter inhabitants in the tidal creeks and in Hideaway Pond (NSF Dahlgren, 2007). Tundra swans are a common sighting just offshore in Upper Machodoc Creek, as well as in the Potomac River, and the flock numbers 10 to 15 swans.

Large groups of 30 to 50 black ducks are often seen in Gambo Creek Marsh, and the total wintering population is estimated at 100 to 150 individuals. Three of the five Mainside bald eagle nests are in this area, one of which was active during the 2009 nesting season (see Figure 3.12-2). The area also provides important roosting and foraging habitat for eagles, ospreys, and other birds; nursery habitat for fish; and habitat for uncommon dragonflies, such as the blue-faced meadowhawk (*Sympetrum ambiguum*) and the unicorn clubtail (*Arigomphus villosipes*). The Gambo Creek area has been categorized as a Special Interest Area (SIA) due to its unique ecological characteristics and high-quality rare species' habitat (Figure 3.13-1, Special Interest Areas).

Blue-faced Meadowhawk
Sympetrum ambiguum

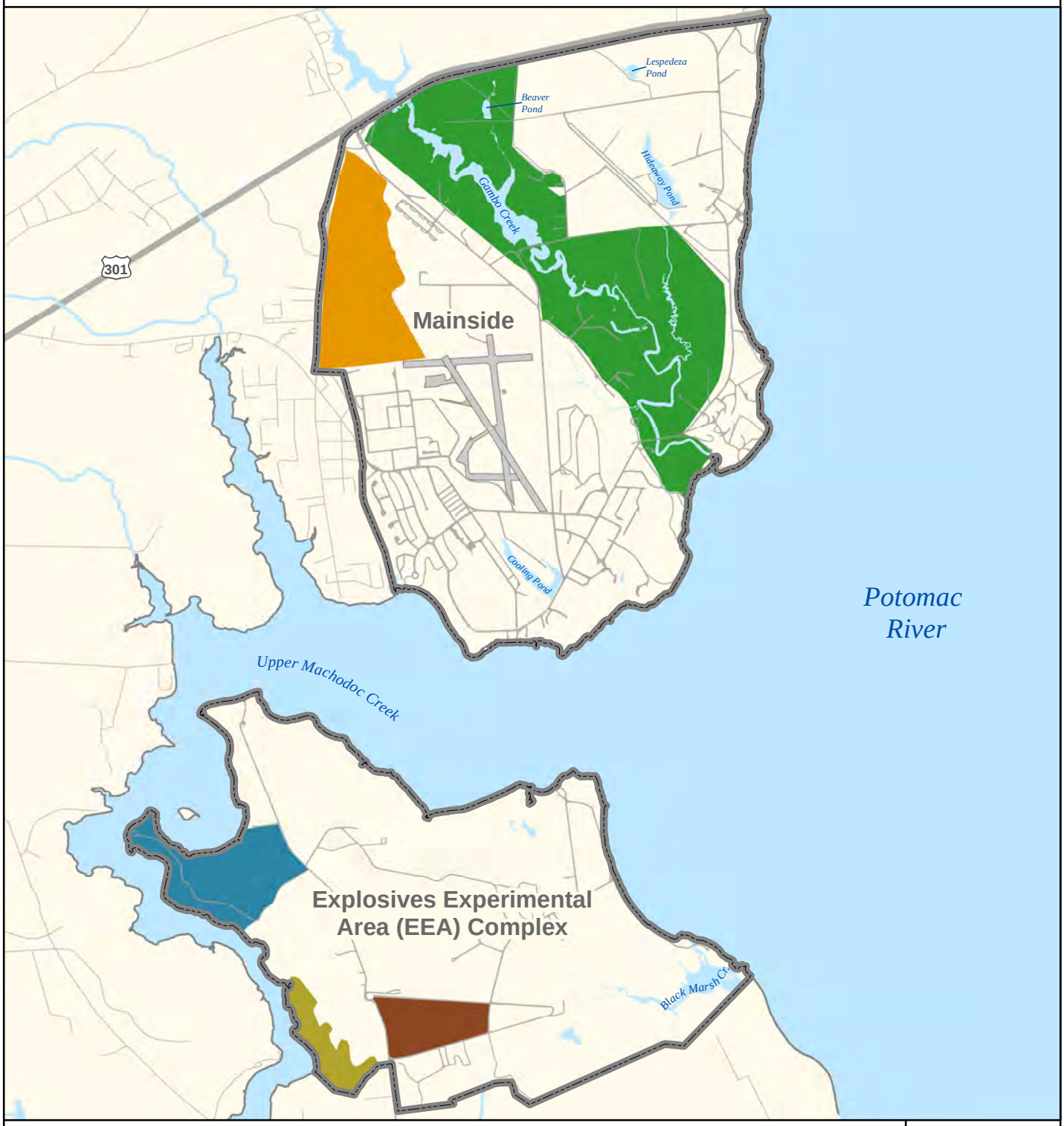
Four ponds are present on NSF Dahlgren. Hideaway Pond, an impoundment of approximately 13 ac, was created along a marshy drainage area flowing into Gambo Creek, and is located in a relatively isolated area on Mainside (see Section 3.10.1.4). Cooling Pond, which is approximately 10 ac in size, is located in the community support area of NSF Dahlgren. Beaver Pond is located north of Gambo Creek in the north central portion of Mainside. Lespedeza Pond is located at the C-Gate area (NSF Dahlgren, 2006).

Common freshwater fish found in Hideaway Pond and Cooling Pond include largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), and channel catfish (NSF Dahlgren, 2007). Both ponds are managed as a catch-and-release fishery (ATSDR, 2006). The 1978 floral and faunal survey identified a total of 32 species of fish in the following water bodies: Gambo Creek, Black Marsh, Hideaway Pond, and Cooling Pond (NSWCDL, 1979).

3.13.2 NSF Dahlgren's Vegetation

NSF Dahlgren is about 28 percent developed. A little more than half – 52 percent – of the installation is forested. Wetlands account for 14 percent of NSF Dahlgren's land (see Section 3.10.2), while grasslands or early successional fields make up about 6 percent.

Special Interest Areas



Gambo Creek
Forested Wetland Swale
Tetotum Flats North
Tetotum Flats South
Tetotum Flats East
Naval Support Facility (NSF) Dahlgren

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 3.13-1

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Forests at NSF Dahlgren are of three basic types: mixed pine-hardwood; hardwood; and pine. Figure 3.13-2 (Forest Cover Types) shows the distribution of forest types on the installation.

- **Mixed Pine-Hardwood Forest** – This is the predominant forest-cover type at NSF Dahlgren, comprising approximately 31 percent of the installation. Mixed forests are considered transitional between pine and various hardwood types; in the absence of disturbance, succession will strongly favor hardwoods. Site index and hydrologic regime strongly influence the hardwood component of the forest. On moist sites, sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), and tulip poplar (*Liriodendron tulipifera*) colonize the site, along with loblolly pine (*Pinus taeda*). In such stands, hardwoods grow quickly and form a single stratum canopy with the pines. On drier sites, several oak species, including southern red oak (*Quercus falcata*) and white oak (*Q. alba*), may invade areas that were first colonized by pines and, over time, become their canopy co-dominants. Understories are varied, and depend on site conditions.
- **Hardwood Forests –** Hardwood forests comprise 14 percent of NSF Dahlgren. On poorly-drained sites, common overstory species include blackgum (*Nyssa sylvatica*), red maple, willow oak (*Q. phellos*), and water oak (*Q. nigra*). On drier sites, oaks such as black oak (*Q. velutina*), southern red oak, and chestnut oak (*Q. prinus*), along with hickories (*Carya alba* and *C. ovata*), dominate the overstory. Understories often include American holly (*Ilex opaca*), flowering dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), Virginia creeper (*Parthenocissus quinquefolia*), partridgeberry (*Mitchella repens*), blueberry (*Vaccinium* spp.), and ground pine (*Lycopodium* spp.).
- **Pine Forests –** Pine forests comprise 7 percent of NSF Dahlgren. Such forests are indicative of disturbance or intensive maintenance. Dominant overstory species include loblolly pine and Virginia pine (*Pinus virginiana*), with lesser amounts of tulip poplar and sweetgum. Older pine stands may support an understory with oak (*Quercus* spp.) and other hardwood seedlings. The shrub and herbaceous components of pine forests are often sparse, but may include Japanese honeysuckle (*Lonicera japonica*), trumpet creeper (*Campsis radicans*), poison ivy (*Toxicodendron radicans*), Virginia creeper, and blueberry.

All NSF Dahlgren forested areas are managed for the production of timber, wildlife habitat, and outdoor recreation by the Navy Natural Resources Conservation Program.

Grasslands and early successional fields are occupied by shrubs, grasses, and herbaceous vegetation typically mowed less than twice a year. The exact vegetative composition of these communities is highly variable, and is influenced by previous land use and adjacent ecological communities. Various native warm-season grasses, such as broomsedge (*Andropogon virginicus*), big bluestem (*Andropogon gerardii*), and switchgrass (*Panicum virgatum*), as well as perennials, such as goldenrods (*Solidago* spp.), bonesets (*Eupatorium* spp.), partridge pea (*Cassia fasciculata*), and bushclovers (*Lespedeza* spp.) are common in these areas.

Both the Virginia and Maryland shorelines of the river outside NSF Dahlgren are characterized by similar habitats, except that a greater percentage of the cover is made up of agricultural fields, with crops including corn, tobacco, small grains, and hay.

3.13.3 NSF Dahlgren's Wildlife

Wildlife surveys conducted in 1978 documented 16 amphibian, 16 reptilian, 157 avian, and 20 mammalian species at NSF Dahlgren (NSWCDL, 1979). A complete list of wildlife species present on the installation is included in the INRMP (NSF Dahlgren, 2007).

3.13.3.1 Amphibians and Reptiles

NSF Dahlgren's wetlands, ponds, and wooded areas provide habitat for a number of common amphibians and reptiles. Frogs and toads comprise the largest group of the amphibians in the area. Common frogs and toads found on the installation include the American toad (*Bufo americanus*), green frog (*Rana clamitans*), southern leopard frog *(Rana sphenocephala*), spring peeper *(Pseudacris crucifer*), green tree frog (*Hyla cinerea*), and upland chorus frog (*Pseudacris triseriata feriarum*).

Green Tree Frog
Hyla cinerea

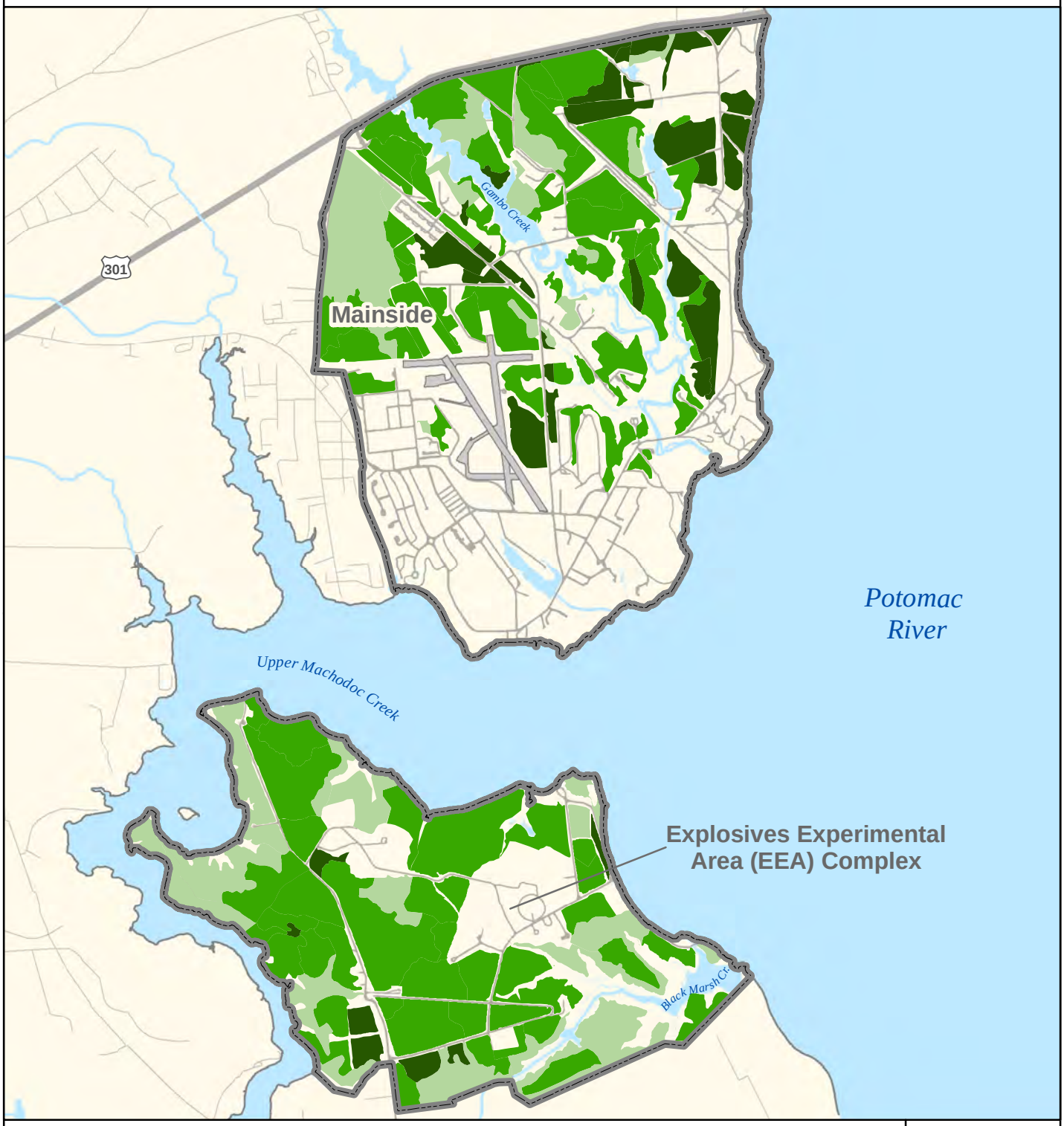
Reptiles found on the installation include snakes, turtles, and lizards. Common snakes include the northern water snake (*Nerodia s. sipedon*), black rat snake (*Elaphe obsoleta*), and northern black racer (*Coluber constrictor constrictor*). Turtles include the common snapping turtle (*Chelydra serpentina*), red-bellied turtle (*Pseudemys rubriventris*), eastern mud turtle (*Kinosternon subrubrum*), and eastern box turtle (*Terrapene carolina*). Lizards found on the installation include ground skinks (*Scincella lateralis*) and five-lined skinks (*Eumeces fasciatus*).

3.13.3.2 Birds

The avian population at and near NSF Dahlgren is particularly diverse, and includes a large number of migratory birds and waterfowl that over-winter in the area (see Section 3.12.1 and 3.12.2) as well as many neotropical migrant birds, which nest in the region or farther north and overwinter in the Caribbean or South America. The hardwood forests found on the installation and along the Potomac River are strategically important for local breeding populations of neotropical migrants and as stopover areas for northern populations moving through the region in the fall. These forests make the installation a stopover ground during migrations for many species and a nesting area for some. Forest-dwelling neotropical migrant birds include the brown thrasher (*Toxostoma rufum*), wood thrush (*Hylocichla mustelina*), ovenbird (*Seiurus aurocapillus*), black and white warbler (*Mniotilta varia*), red-eyed vireo (*Vireo olivaceous*), white-eyed vireo (*Vireo griseus*), common yellowthroat (*Geothlypis trichas*), scarlet tanager (*Piranga olivacea*), summer tanager (*Piranga rubra*), and various woodpeckers. Also found in the forests are the red-shouldered hawk (*Buteo lineatus)*, sharp-shinned hawk (*Accipiter striatus*), barred owl (*Strix varia*), and screech owl (*Megascops asio*).

Common yellowthroat
Geothlypis trichas

Forest Cover Types



Hardwood

Pine and Hardwood

Pine

Naval Support Facility (NSF) Dahlgren

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 3.13-2

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Although detailed seasonal waterfowl surveys have not been conducted at NSF Dahlgren, incidental observations by the Natural Resources Manager and sportsmen suggest that common species found in on-base and nearby waters include the following: mallard, black duck, canvasback, lesser scaup, ruddy duck, and tundra swan. Less common species include blue-winged teal (*Anas discors*), wood duck, red-breasted merganser, ring-necked duck (*Aythya collaris*), common goldeneye (*Bucephala clangula*), and bufflehead.

In accordance with the MBTA and Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, natural resources management at NSF Dahlgren supports conservation objectives identified by Partners in Flight (PIF). PIF is a consortium of state, federal, and private organizations dedicated to the conservation and management of neotropical migratory birds and their habitats. PIF identified bird species and habitats most in need of conservation and outlined conservation objectives in its *Bird Conservation Plan for the Mid-Atlantic Coastal Plain* (Watts, 1999). PIF conservation objectives that are applied to natural resources management at NSF Dahlgren include:

- Identifying and maintaining significant blocks of mixed upland forest and considering the value of hardwood-dominated forests in management decisions.
- Preventing any loss of forested wetlands.
- Avoiding the conversion of mixed forests or hardwood-dominated forests to pine monoculture.
- Using open spacing for planting and conducting multiple thinnings in pine stands to delay canopy closure and promote understory vegetation.
- Monitoring and controlling infestations of common reed in salt, freshwater, and brackish marshes.

In addition to these measures, migratory bird nesting habitat has been improved on NSF Dahlgren by the installation, monitoring, and maintenance of nesting boxes for eastern bluebirds and wood ducks. These efforts help to support regional goals under the North American Waterfowl Management Plan (NAWMP) and the Joint Agreement of Cooperation to Perpetuate North American Waterfowl Populations, which was signed by the USFWS and the DoD in 1988.

The DoD has established bird conservation regions that include bird species of concern in that region (DoD, 2009). As a list for NSF Dahlgren has not been finalized, the list for Fort AP Hill in Caroline County, Virginia (adjacent to King George County) was used to determine which bird species observed at NSF Dahlgren (NSF Dahlgren, 2007) may be considered species of concern based on being listed on one or more of the following eight different priority lists (DoD, 2009):

- Birds of Conservation Concern (BCC)
- Game Birds Below Desired Condition
- Non-migratory Bird Species of Concern
- North American Waterbird Conservation Plan
- North American Waterfowl Management Plan (NAWMP)
- Partners in Flight (PIF)
- US Shorebird Conservation Plan (SCP)
- Threatened and Endangered Species (50 CFR § 17.11)

Table 3.13-1 lists these bird species and identifies the priority list(s) with which they are associated.

Table 3.13-1
Bird Species of Concern Observed at NSF Dahlgren

Order & Scientific Name	Common Name	Priority List(s)
Order Ciconiiformes		
Botaurus lentiginosus	American Bittern	PIF
Egretta thula	Snowy Egret	NAWCP
Order Anseriformes		
Anas discors	Blue-winged Teal	NAWMP
Bucephala albeola	Bufflehead	NAWMP, PIF
Branta canadensis	Canada Goose	NAWMP
Aythya valisineria	Canvasback	BCC, NAWMP, PIF
Bucephala clangula	Common Goldeneye	NAWMP
Aythya affinia	Lesser Scaup	BCC, NAWMP, PIF
Anas platyrhynchos	Mallard	BCC, NAWMP
Mergus serrator	Red-breasted Merganser	NAWMP
Aythya americana	Redhead	NAWMP, PIF
Aythya collaris	Ring-necked Duck	BCC, NAWMP
Oxyura jamaicensis	Ruddy Duck	NAWMP
Cygnus columbianus	Tundra Swan	NAWMP
Aix sponsa	Wood Duck	BCC, NAWMP
Order Galliformes		
Colinus virginianus	Northern Bobwhite	NMBSC
Order Falconiformes		
Falco sparverius	American Kestrel	BCC, PIF
Buteo lineatus	Red-shouldered Hawk	PIF
Order Charadriiformes		
Scolopax minor	American Woodcock	BCC, PIF, SCP
Chilidonias niger	Black Tern	BCC
Gallinago gallinago	Common Snipe	PIF, SCP
Sterna hirundo	Common Tern	BCC
Tringa melanoleuca	Greater Yellowlegs	SCP
Charadrius vociferous	Killdeer	PIF
Tringa flavipes	Lesser Yellowlegs	SCP

Table 3.13-1 (Continued)
Bird Species of Concern Observed at NSF Dahlgren

Order & Scientific Name	Common Name	Priority List(s)
Order Podicipediformes		
Podiceps auritus	Horned Grebe	PIF
Order Columbiformes		
Zenaida macroura	Mourning Dove	BCC
Order Cuculiformes		
Strix varia	Barred Owl	PIF
Coccyzus americanus	Yellow-billed Cuckoo	PIF
Order Apodiformes		
Chaetura pelagica	Chimney Swift	PIF
Order Caprimulgiformes		
Caprimulgus carolinensis	Chuck-will's-widow	BCC, PIF
Order Coraciiformes		
Ceryle alcyon	Belted Kingfisher	PIF
Order Piciformes		
Melanerpes carolinus	Red-bellied Woodpecker	PIF
Order Passeriformes		
Empidonax virescens	Acadian Flycatcher	PIF
Dendroica virens	Black-throated Green Warbler	BCC, PIF
Polioptila caerulea	Blue-gray Gnatcatcher	PIF
Guiraca caerulea	Blue Grosbeak	PIF
Cyanocitta cristata	Blue Jay	PIF
Toxostoma rufum	Brown Thrasher	PIF
Poecile carolinensis	Carolina Chickadee	PIF
Thryothorus ludovicianus	Carolina Wren	PIF
Tyrannus tyrannus	Eastern Kingbird	PIF
Sturnella magna	Eastern Meadowlark	PIF
Pipilo erythrophthalmus	Eastern Towhee	PIF
Contopus virens	Eastern Wood-pewee	PIF
Spizella pusilla	Field Sparrow	PIF
Corvus ossifragus	Fish Crow	PIF
Ammodramus savannarum	Grasshopper Sparrow	PIF
Dumetella carolinensis	Gray Catbird	PIF
Myiarchus crinitus	Great Crested Flycatcher	PIF
Wilsonia citrinia	Hooded Warbler	PIF
Lanius ludovicianus	Loggerhead Shrike	PIF

Table 3.13-1 Continued)
Bird Species of Concern Observed at NSF Dahlgren

Order & Scientific Name	Common Name	Priority List(s)
Seirus aurocapillus	Louisiana Waterthrush	PIF
Cistothorus palustris	Marsh Wren	PIF
Parula Americana	Northern Parula	BCC
Order Passeriformes (Cont'd)		
Icterus spurius	Orchard Oriole	BCC, PIF
Dendroica palmarum	Palm Warbler	PIF
Dendroica pinus	Pine Warbler	PIF
Dendroica discolor	Prairie Warbler	BCC, PIF
Euphagus carolinus	Rusty Blackbird	PIF
Piranga rubra	Summer Tanager	PIF
Cistothorus platensis	Sedge Wren	PIF
Melospiza georgiana	Swamp Sparrow	PIF
Vireo griseus	White-eyed Vireo	PIF
Hylocichla mustelina	Wood Thrush	BCC, PIF
Helmitheros vermivorus	Worm-eating Warbler	PIF
Icteria virens	Yellow-breasted Chat	PIF
Vireo flavifrons	Yellow-throated Vireo	PIF

Key to Priority Lists:
Birds of Conservation Concern (BCC)
North American Waterfowl Management Plan (NAWMP)
Partners in Flight (PIF)
US Shorebird Conservation Plan (SCP)

Sources: DoD, 2009; NSF Dahlgren, 2007.

3.13.3.3 Mammals

The only large mammal species that has been documented at NSF Dahlgren is white-tailed deer (*Odocoileus virginianus*). Medium and small mammals include red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), eastern cottontail (*Sylvilagus floridanus*), eastern gray squirrel (*Sciurus carolinensis*), raccoon (*Procyon lotor*), groundhog (*Marmota monax*), beaver (*Castor canadensis*), opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), river otter (*Lontra canadensis*), muskrat (*Ondatra zibethicus*), mink (*Mustela vison*), and long-tailed weasel (*Mustela frenata*). A number of small rodents and insectivores are also found at NSF Dahlgren.

3.13.4 Special Interest Areas (SIAs)

Five SIAs totaling approximately 1,033 ac have been established at the installation (Figure 3.13-1). SIAs are areas with unique ecological characteristics and/or high quality habitat for rare species. Of the five, two are wetland areas on Mainside that possess unique ecological characteristics and high-

quality rare species habitat; the remaining three are areas on the EEA that provide nesting habitat for bald eagles.

Forested Wetland Swale SIA – This 167-ac SIA is located in the northwestern portion of Mainside. It consists of several parallel, seasonally-flooded low troughs in a flat topography. It includes an extensive forested wetland and herbaceous wetlands along firebreaks. Tree species in the forested wetland include red maple, black gum, willow oak, and pin oak (*Quercus palustris*). The shrub layer is sparse to non-existent. The herbaceous layer includes sedges and peat moss (*Sphagnum* spp.). Coyle's purse-web spider (*Sphodros coylei*), a funnel-web spider listed on Virginia's Natural Heritage watch list, was documented in this area during Virginia Department of Conservation and Recreation, Division of Natural Heritage surveys conducted in 1991 and 1992 (NSF Dahlgren, 2007).

Gambo Creek SIA - This SIA is approximately 643 ac in size and consists of a brackish-intertidal emergent marsh community along Gambo Creek. The extensive marshes along Gambo Creek are dominated by saltmarsh cordgrass (*Spartina alterniflora*), marsh elder (*Iva frutescens*), and pigweed (*Amaranthus cannabinus*). The area is well-buffered by mixed hardwood and pine forests. In addition to providing valuable wetland habitat, three of the five known Mainside bald eagle nests are in this area; one of the nests was active during the 2008 nesting season. The area also provides important roosting and foraging habitat for eagles, ospreys, and other birds; nursery habitat for fish; and habitat for uncommon invertebrates.

Tetotum Flats North SIA - This SIA includes approximately 124 forested acres adjacent to Upper Machodoc Creek. Bald eagles have nested in this area intermittently since 1983 and have utilized at least two separate nest sites.

Tetotum Flats South SIA - The Tetotum Flats South SIA is in the southwestern corner of the EEA, adjacent to Upper Machodoc Creek. It consists of approximately 44 forested acres and has also supported an active bald eagle nest site.

Tetotum Flats East SIA - This SIA is in the interior portion of the EEA and includes approximately 55 forested acres. Bald eagles have consistently nested at this site since 1997.

3.13.5 Hunting and Fishing

NSF Dahlgren's diverse forests, grasslands, wetlands, ponds, and creeks provide habitat for flourishing wild game and fish populations that support recreational hunting and fishing activities. The NSF Dahlgren Natural Resources Manager is responsible for managing base fish and wildlife populations, as well as for overseeing hunting and fishing activities as a recreational activity. The goal of the Outdoor Recreation Program is to enhance quality of life for the NSF Dahlgren community by allowing for maximum natural resources-based recreational use in a manner that does not interfere with the military mission. Because of NSF Dahlgren's mission, general public access to the installation is not permitted. However, active and retired military personnel, current and retired NSA South Potomac civilian government employees, NSA South Potomac residents and their dependents, and NSA South Potomac on-installation contractors – as well as the guests of any of the above, except those of retired civilian employees – may hunt and fish (NSA South Potomac Instruction 5090.2). Because of activities on the ranges and the presence of UXO in some areas, as well as for natural resource management purposes, access to

recreational areas for specific activities is limited based on time of day, day of the week, and time of year (NSA South Potomac, October 2009a, October 2009b). Proper credentials are required for access, and state and base user permits are required for hunting, trapping, and fishing.

3.13.5.1 Hunting

Primary game species include white-tailed deer, wild turkey, quail, rabbit, dove, and squirrel. Deer, wild turkey, waterfowl, and small-game hunting areas on NSF Dahlgren are shown in Figure 3.13-3 (Hunting Areas). Mainside is divided into nine hunting compartments and the EEA is divided into four compartments. Areas open to hunting are subject to change based on range testing schedules and bald eagle nesting activities. Designated bow and gun areas within these compartments are delineated in base hunting and fishing instructions. Hunting compartments on Mainside are located throughout the northern and eastern portions of the installation (the ranges and Mission Area), but the base community support area to the south is off limits to hunting. EEA's hunting compartments are located along the southern and western borders. The entire northern and eastern portions of the EEA are off limits to hunting because of potential UXO contamination and range activities. Wildlife populations are monitored as part of the Fish and Wildlife Management Program, and this information is used to determine management activities, particularly for white-tailed deer.

White-tailed Deer

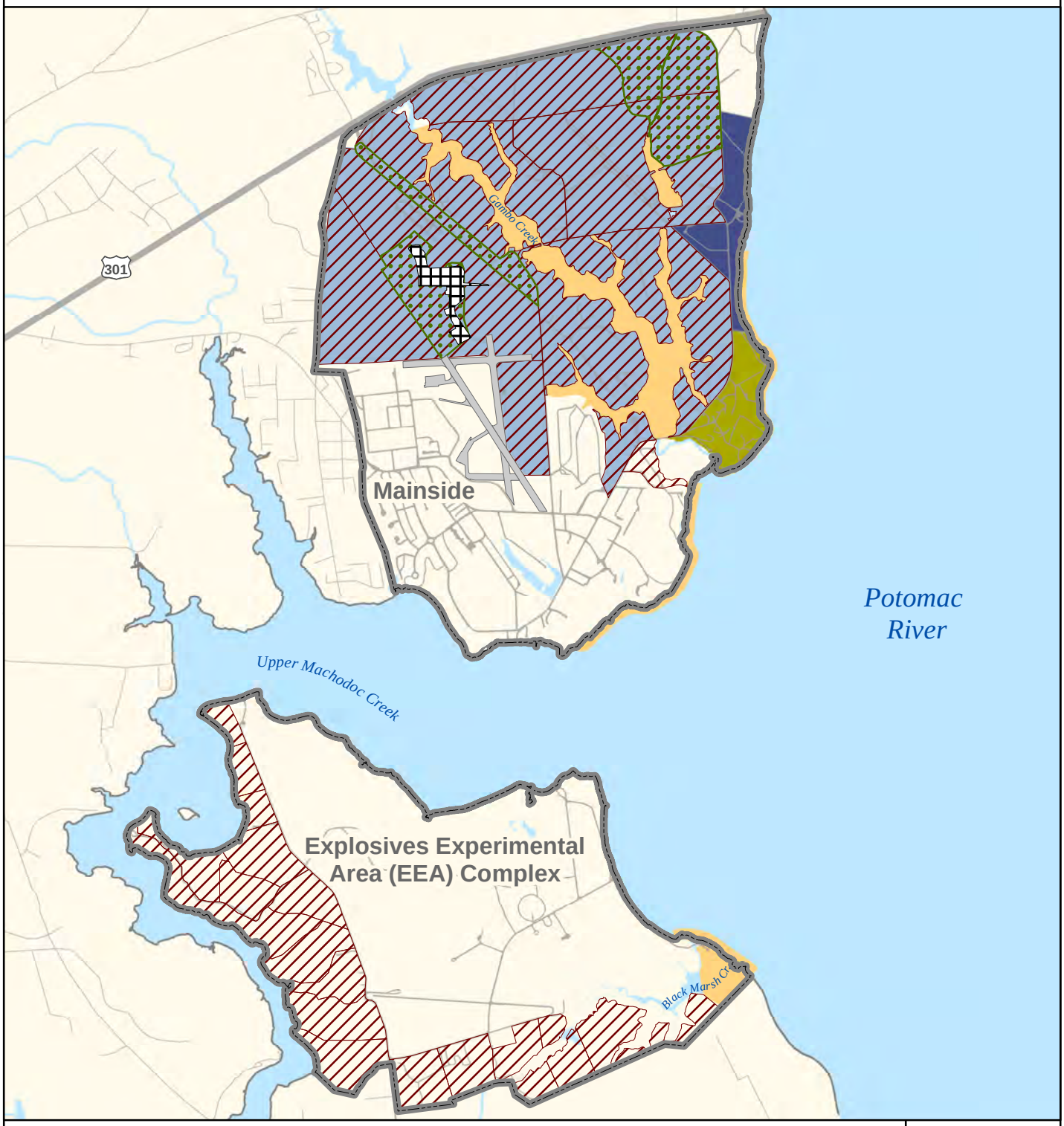
White-tailed deer are common throughout Virginia, including NSF Dahlgren. They are a very adaptable species and thrive in a variety of habitats, including those with high levels of human activity. Over the past 25 years, white-tailed deer populations have increased to unprecedented levels in many parts of the animal's range. When predation and other losses are low and food is plentiful, deer populations can double every two to three years. High deer populations cause concerns about impacts to native plant communities, wildlife habitat, deer-human interactions, and deer herd health. These concerns have been studied and documented and the need to manage them is well recognized.

White-tailed Deer
Odocoileus virginianus

NSF Dahlgren's regulated deer hunting program started during the 1980/81 hunting season as a means to control the resident deer population. The hunting program has continued as the primary means of managing the deer herds. Seasons and bag limits comply with those set for Virginia.

Available deer habitat on Mainside and the EEA is about 1,600 and 1,530 ac, respectively. Rough post-hunting season population estimates since 1995/96 have ranged from 100 to 150 animals for Mainside and 110 to 150 for the EEA. Based on an optimal density of one deer per 20 ac – which would place the desired populations on Mainside and the EEA at about 80 and 77, respectively – the estimates suggest that the population is above the desired level. Since the hunting program began, total deer harvests on Mainside have ranged from 20 to 60, with an average of 37 deer per year; the corresponding numbers for the EEA are 23 to 65, with an

Hunting Areas



Turkey Compartment
Small Game Area-1
Small Game Area-2
Waterfowl Area
Naval Support Facility (NSF) Dahlgren
Bow Only
Deer
No Access

3,300 0 3,300 Feet

1,000 0 1,000 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011)

Figure 3.13-3

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average of 39 per year. In order to reduce the deer population to carrying capacity, the 2007/2008 harvest objective was to double the total harvest at each site.

Wild Turkey

Observations and harvest data indicate that wild turkeys are abundant on Mainside and the EEA. Turkey hunting is permitted in designated areas on Mainside during the Fall Season and Spring Gobbler Season established by the state. On the EEA, turkey hunting is permitted in the fall during the Firearms Season and during the Spring Gobbler Season. Approximately four or five birds are harvested annually on Mainside and one or two birds are harvested annually on the EEA.

Small Game

The installation supports a variety of small game animals. All legal game species may be harvested in accordance with state seasons and bag limits. However, the most-often-hunted species are the bobwhite quail (*Colinus virginianus*), mourning dove (*Zenaida macroura*), eastern cottontail, and eastern gray squirrel. A few sportsmen also hunt American woodcock (*Philohela minor*). Furbearers at NSF Dahlgren include beaver, river otter, muskrat, mink, red fox, gray fox, raccoon, striped skunk, long-tailed weasel, and opossum. Trapping is permitted at the installation; however, demand is low, and very little trapping actually occurs.

Waterfowl

Waterfowl hunting is permitted along the Mainside Potomac River and Upper Machodoc Creek shorelines, along Gambo Creek, and near the mouth of Black Marsh Creek. Gambo Creek Marsh has been designated as an SIA based in part on its value as wintering waterfowl habitat.

3.13.5.2 Fishing

Recreational fishing is permitted at Hideaway Pond, Cooling Pond, Gambo Creek, and portions of the Potomac River and Upper Machodoc Creek shorelines on Mainside. The EEA is closed to fishing because of the presence of UXO and range activities. Open fishing areas receive low to moderate fishing pressure. Largemouth bass, bluegill, brown bullhead, and channel catfish are present in both ponds. Hideaway Pond and Cooling Pond are catch-and-release fisheries only. Fish caught from the ponds may be kept for mounting purposes only, due to potential health risks from high levels of mercury. Flat-bottomed boats are available for use on Hideaway Pond. Personal boats may be used, but gasoline-powered boats are prohibited on NSF Dahlgren ponds.

Management of Potomac River fisheries is primarily the responsibility of the Potomac River Fisheries Commission. However, many of the management practices implemented under NSF Dahlgren’s Land Management Program support Potomac River fisheries management through habitat and water quality protection.

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3.14 Protected Species

3.14.1 Laws and Regulations

The Endangered Species Act (ESA) of 1973 (16 U.S.C. § 1531 et seq.; 50 CFR Part 17, Subpart I, and 50 CFR Part 402) and subsequent amendments provide for the conservation of threatened and endangered species of animals and plants, and the habitats in which they are found. The ESA prohibits jeopardizing endangered and threatened species or adversely modifying critical habitats essential to their survival without specific authorization from the USFWS or the National Marine Fisheries Service (NMFS) depending on the species and the area within which it occurs. A species is considered "endangered" if it is in danger of extinction throughout all or a significant portion of its range, and "threatened" if it is likely to become endangered in the foreseeable future due to any of the following factors (Section 4(a) (1) (A-E), 1982 amendment):

- The present or threatened destruction, modification, or curtailment of its habitat or range
- Overutilization for commercial, recreational, scientific, or educational purposes
- Disease or predation
- The inadequacy of existing regulatory mechanisms
- Other natural or manmade factors affecting its continued existence

Section 7(a) (2) of the ESA requires federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed endangered or threatened species or result in the destruction or adverse modification of designated critical habitat. Federal agencies are required to consult with the USFWS or NMFS if an action may affect a listed species. The Navy ensures that consultations are conducted according to guidance provided in the Navy *Environmental Resources Program Manual* (OPNAVINST 5090.1C).

In Virginia, the statutes under Article 6, Endangered Species, of the Wildlife and Fish Laws prohibit the taking, transportation, possession, sale, or offer for sale within the commonwealth of species listed on the federal endangered species list or any other species designated by the state board (Code of Virginia §§ 29.1-563-570). The Maryland law that covers threatened and endangered species is the Nongame and Endangered Species Conservation Act (Code of Maryland §§ 10-2A-01-09). Under this act, any species designated under the federal ESA is deemed an endangered species, as are other species designated by the state secretary based on habitat and population factors.

The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §§ 1361-1421h) establishes a federal responsibility to conserve marine mammals, with management vested in the Department of Commerce's NMFS for whales, dolphins, porpoises, seals, and sea lions. The Department of the Interior's USFWS is responsible for all other marine mammals (i.e., manatees, polar bears, sea otters, and walruses). The act prohibits the "taking" of marine mammals in the United States or on the high seas, subject only to limited exceptions. The term "take," as defined in Section 3 (16 U.S.C. § 1362) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of "harassment" – Level A (potential injury) and Level B (potential disturbance).

The National Defense Authorization Act of fiscal year 2004 (Public Law 108-136) amended the definition of harassment as applied to military readiness activities or scientific research activities

conducted by or on behalf of the federal government, consistent with Section 104(c)(3) [16 U.S.C. § 1374 (c)(3)]. For military readiness activities the relevant definition of harassment is any act that:

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment"), or
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") [16 U.S.C. § 1362 (18)(B)(i)(ii)].

Section 101(a)(5) of the MMPA directs the Secretary of the Department of Commerce (NOAA) to allow, upon request, the incidental (but not intentional) taking of marine mammals by US citizens who engage in a specified activity (exclusive of commercial fishing), if certain findings are made and regulations are issued. Authorization will be granted by the Secretary for the incidental take of marine mammals if the taking will have a negligible impact on the species or stock and will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses.

Appendix G contains the correspondence exchanged to date with federal and state fish and wildlife resources agencies as part of the ESA Section 7 coordination effort for this EIS. In response to Section 7, a Biological Assessment evaluating the impacts of the Proposed Action on species listed on or proposed for listing on the ESA was prepared and is included as Appendix H of this EIS. Table 3.14-1 lists the protected species found, or potentially found, within four miles of NSF Dahlgren or within the PRTR. Species include fish, sea turtles, birds, and plants, described below.

3.14.2 Fish

Two federally-listed endangered fish species – the shortnose sturgeon (*Acipenser brevirostrum*) (also state-listed) and the Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) are found in the PRTR section of the Potomac River.

The USFWS listed the shortnose sturgeon as endangered throughout its range in 1967 under the Endangered Species Preservation Act of 1966. The NMFS took over jurisdiction of the shortnose sturgeon in 1974, following the enactment of the ESA of 1973. Maryland and Virginia also list it as an endangered species. There are 19 Distinct Population Segments (DPSs) of shortnose sturgeon in 25 river systems. The Chesapeake Bay DPS includes shortnose sturgeon that occur in the Potomac River in Maryland and Virginia.

The Atlantic sturgeon was listed under the ESA on February 6, 2012. The Atlantic sturgeon is comprised of five DPSs that are listed as endangered or threatened. The Chesapeake Bay DPS which includes Potomac River Atlantic sturgeon is listed as endangered.

Table 3.14-1
Federal and State Status of Protected Species Potentially Found within Four Miles of NSF Dahlgren or within the PRTR

Federal Status	Virginia Status	Maryland Status	Common Name	Scientific Name
Fish				
FE	SE	SE	Shortnose sturgeon	*Acipenser brevirostrum*
FE			Atlantic sturgeon	*Acipenser oxyrhynchus*
Sea Turtles and Terrestrial Reptiles				
FT/FE[1]	ST	ST	Loggerhead turtle	*Caretta caretta*
FT/FE[2]	SE	SE	Kemp's ridley turtle	*Lepidochelys kempii*
FT	ST	ST	Green turtle	*Chelonia mydas*
FS			Northern diamondback terrapin	*Malaclemys terrapin terrapin*
Birds				
FS	ST	SE	Loggerhead shrike*	*Lanius ludovicianus*
FS		SE	Black rail	*Laterallus jamaicensis*
FS			Cerulean warbler	*Dendroica cerulean*
FS	ST		Bald eagle*	*Haliaeetus leucocephalus*
	ST	SE	Upland sandpiper	*Bartramia longicauda*
	SSC		Winter wren*	*Troglodytes troglodytes*
	SSC		Little blue heron	*Egretta caerulea caerulea*
	SSC	ST	Least tern	*Sterna antillarum*
	SSC		Northern harrier*	*Circus cyaneus*
	SSC		Tricolored heron	*Egretta tricolor*
	SSC		Yellow-crowned night heron	*Nyctanaa violacea violacea*
	SSC		Barn owl	*Tyto alba pratincola*
	SSC	SE	Sedge wren*	*Cistothorus platensis*
	SSC		Brown creeper	*Certhia americana*
	SSC		Forster's tern	*Sterna forsteri*
	SSC		Dickcissel	*Spiza americana*
	SSC		Great egret*	*Ardea alba egretta*
	SSC		Purple finch*	*Carpodacus purpureus*
	SSC		Golden-crowned kinglet*	*Regulus satrapa*
	SSC	SI	Common moorhen	*Gallinula chloropus cachinnans*
	SSC		Magnolia warbler*	*Dendroica magnolia*
	SSC		Red-breasted nuthatch	*Sitta Canadensis*
	SSC		Caspian tern	*Sterna caspia*
	SSC		Hermit thrush	*Catharus guttatus*
Plants				
FT	SE	SE	Swamp pink	*Helonias bullata*
	ST		Narrow-leaved spatterdock	*Nuphar sagittifolia*
FE	SE	SE	Harperella	*Ptilimnium nodosum*
	ST	SE	New Jersey rush	*Juncus caesariensis*
FT	ST	SE	Sensitive joint-vetch	*Aeschynomene virginica*
	SE		Tropical water hyssop	*Bacopa innominata*

Notes: FE = Federal Endangered; FT= Federal Threatened; FS= Federal Species of Concern; SE = State Endangered; ST = State Threatened; SSC = State Species of Special Concern; SI = State In Need of Conservation.

[1]Nine distinct population segments of loggerhead turtles were recently identified within the global population. The only distinct population segment that occurs within Study Area of this EIS—the Northwest Atlantic Ocean distinct population segment—is listed as threatened.[2] As a species, the green turtle is listed as threatened, but the Florida and Mexican Pacific coast nesting populations are listed as endangered. Green turtles found in the Study Area might not all be from the Florida population.

* Species observed at NSF Dahlgren.

Sources: NSF Dahlgren, 2007; Townsend, 2009; NMFS, 2011; MDNR, 2010; VDGIF, 2011; USFWS, 2011; NFS, 2011; NOAA, 2012; USFWS, January 21, 2013.

3.14.2.1 Shortnose Sturgeon

The shortnose sturgeon inhabits large coastal rivers of eastern North America, ranging from the Saint John River in New Brunswick, Canada, to the Saint Johns River in northeastern Florida (NMFS, 1998).

Shortnose Sturgeon
Acipenser brevirostrum

The shortnose and the Atlantic sturgeon share many characteristics – both are long-lived, late-maturing, estuarine-dependent, anadromous (ascending rivers from the sea to spawn) species. The shortnose sturgeon is the smaller of the two sturgeon species that occur in the Chesapeake Bay. The shortnose sturgeon rarely exceeds three to four feet in length and its mouth is broader than that of the Atlantic sturgeon. The shortnose sturgeon is a demersal (living on or near the bottom) omnivore that uses its flattened snout to search through bottom sediments and its sensitive barbels (whisker-like tactile organs) to find crustacea, insects, worms, and small mollusks, which it sucks into its mouth.

The shortnose sturgeon spends most of its life in slow-moving tidal rivers or in nearshore marine waters, then moves upstream to fresh waters to spawn. Shortnose sturgeon spawn at or above the head-of-tide (the farthest point upstream affected by tidal fluctuations) in most rivers. Mature adults migrate to spawning areas in the spring.

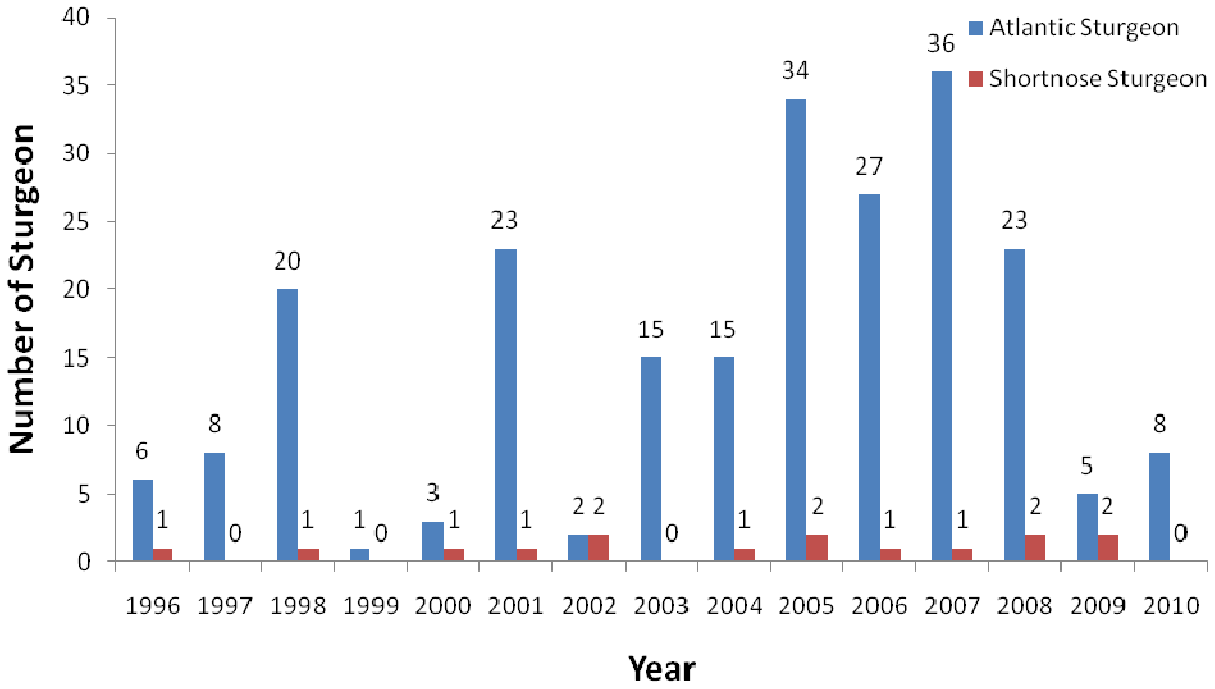
The area immediately downstream from Little Falls on the Potomac River just above Washington, DC would likely be their primary potential spawning area on the Potomac River. Below Little Falls Dam, which is 117 mi upstream from the mouth of the Potomac River and 1.5 mi above the head of tide, appears to offer suitable habitat for spawning. However, there are no records of shortnose sturgeon spawning in the Potomac River, despite detailed tracking of two tagged females with late stage eggs (Kynard et al., 2007, 2009).

After hatching, the young-of-the-year remain in freshwater for about one year before moving downstream to the zone where fresh and salt water interface. This interface is located generally in and upstream of the upper MDZ in the spring and upstream of the UDZ in the fall. Juveniles (three to ten years of age) occur at the fresh-saline water interface in most rivers, where they shift slightly upstream in spring and summer and downstream in fall and winter. Adults are generally found upstream while spawning in the spring and spend the remainder of the year at the fresh and saltwater interface.

There is little scientific evidence that an historic shortnose sturgeon population lived in the Potomac River with the exception of one capture recorded in 1876. A small number of shortnose sturgeon have been found in the Potomac River over the last 15 years. From 1996 to 2010, 15 shortnose sturgeon were documented in the river primarily as a result of the USFWS's Atlantic Sturgeon and Shortnose Sturgeon Reward Program carried out by the USFWS in cooperation with the Chesapeake Bay Program and the MDNR Sturgeon Reward Program, but also as the result of other research. Under the Reward Capture Program, commercial fishermen reported sturgeon captures and received a cash reward. The fish were held by the fishermen until scientists arrived to inspect them and then were released back into the river. Figure 3.14-1

(Sturgeon Captures in the Potomac River 1996-2010) shows the number of shortnose and Atlantic sturgeon captured annually and Figure 3.14-2, Potomac River Shortnose Sturgeon Captures (1996-2010), shows the locations of captures.

Figure 3.14-1
Sturgeon Captures in the Potomac River (1996-2010)



Note: Total includes recaptured sturgeon.
Source: Eyler, USWFS, pers. comm., January 11, 2011.

Shortnose sturgeon were found by commercial fishermen and scientists at the following locations (Eyler, pers. comm., January 11, 2011):

- Three at the mouth of Potomac Creek, which is approximately 5 NM (8 km) upriver from the PRTR UDZ (one on May 17, 1996 and two on March 8, 2002).
- Four near the mouth of the river around Ophelia, Virginia (caught on May 3, 2000; March 26, 2001; December 10, 2004; and May 22, 2005) where the Potomac River enters the bay.
- One at the mouth of the Saint Mary's River (April 12, 1998) in the PRTR LDZ.
- One near Craney Island (September 20, 2005), which is well upstream of the UDZ.
- One near the mouth of Popes Creek, along the PRTR MDZ (March 22, 2006).
- Three captures around Cobb Bar (near Cobb Island in the MDZ); one of which was a fish that was captured twice within a few days (March 14 and 17, 2008).
- One near Colonial Beach, also in the MDZ (March 13, 2009).
- One near Cole's Point in the LDZ (April 9, 2009).

The reward program operated year round from 1996 through 2005. However, beginning in 2006 the USFWS discontinued the program from May 31st to October 1st due to concern that the water temperatures in the summer months were too high for sturgeon to be held safely by fishermen while awaiting inspection by scientists, especially with the large numbers of Atlantic sturgeon being reported in 2006 (Eyler and Mangold, pers. comm., January 11, 2011). USFWS has continued to shut down the reward program in the summer months to protect sturgeon from the stress of being held during warm weather, with no reward offered from June 1st through September 30th. However, it is likely that sturgeon are present during the summer months in the Potomac River based on information collected when the reward program operated from June through September (Eyler and Mangold, pers. comm., January 11, 2011).

The locations of the sturgeon collected by the reward program are based on where fishermen are setting their fishing gear (Eyler and Mangold, pers. comm., January 11, 2011). Therefore, the sturgeon captures on the Potomac River may or may not reflect areas preferred by sturgeon more of the time.

3.14.2.2 Atlantic Sturgeon

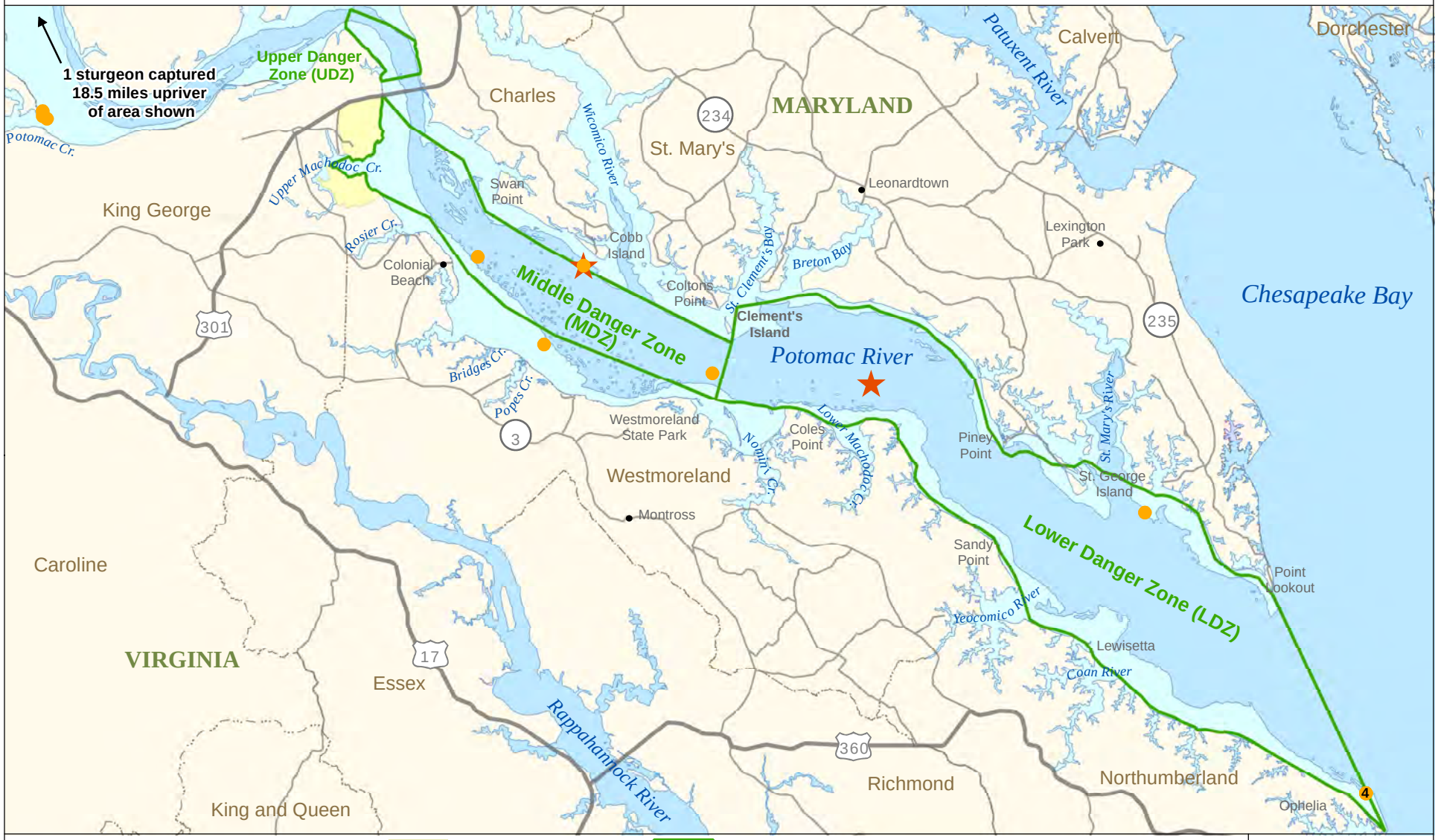
The range of the Atlantic sturgeon extends farther north – to Hamilton Inlet on the coast of Labrador – than the shortnose sturgeon, but they share the southern extent of their range at the Saint Johns River in Florida (Atlantic Sturgeon Status Review Team [ASSRT], 2007).

Atlantic Sturgeon
Acipenser oxyrhynchus

The Atlantic sturgeon has long been an important commercial species in North America, beginning with Jamestown, the first successful English colony in the Americas founded in 1607 on the James River, Virginia (Smith, 1624). The early colonists survived by dining on sturgeon when other food was scarce. Later, pickled sturgeon and caviar roe (eggs) became one of the first exports from the New World (Roberts, 2007). Records from the 1700s and 1800s continued to document large numbers of sturgeon in many rivers along the Atlantic coast, and in 1870 a caviar market was established (ASSRT, 1997; Smith and Clugston, 1997). Both the shortnose sturgeon and Atlantic sturgeon were of commercial importance along the eastern shores of North America in the 1800s because of the quality and taste of their flesh and caviar.

During the late 1800s, the Chesapeake Bay supported the second largest caviar fishery in the eastern United States. However, in the early 1900s sturgeon populations collapsed as a result of overfishing (Murawski and Pacheco, 1977, as cited in ASSRT, 1997). The remaining sturgeon fishery switched in the 1900s to targeting sturgeon for flesh, rather than caviar. Continued overfishing prompted the Atlantic States Marine Fisheries Commission to impose a coast-wide moratorium for fisheries targeting Atlantic sturgeon in 1998 (ASSRT, 2007; NFS, 2011). Factors other than overfishing, such as deterioration of habitat and blockage of spawning runs, have also contributed to the decline or extirpation of Atlantic sturgeon populations (Stevenson and Secor, 1999).

Shortnose Sturgeon Reward Captures in the Potomac River (1996-2010)



Shortnose Sturgeon Original Capture
(Minimum of one capture)

Shortnose Sturgeon Recapture
(Minimum of one recapture)

Note: Number in circle represents number of captures/ recaptures at location, if more than one.

NSF Dahlgren

Depth of less than 18 ft

Potomac River Test Range (PRTR)

County Boundaries

6 0 6 Miles

10 0 10 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: Eyler, USFWS, 2011.

Figure 3.14-2

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Atlantic sturgeon, like shortnose sturgeon, are demersal omnivores. Although these two species occur in the same geographic areas, they usually do not compete for food (ASSRT, 2007). Several studies in the Northeastern US found that shortnose and Atlantic sturgeon feeding activity generally does not overlap except for brief periods, likely because the two species occur in different river stretches/salinity zones, at different water depths, and seeking different prey (Haley and Bain, 1997; Kahnle and Hattala, 1988; both as cited in ASSRT, 2007).

Atlantic sturgeon are primarily marine and spend less of their time in fresh or brackish water than do shortnose sturgeon. Atlantic sturgeon spawning is thought to take place between the salt front and fall line of large rivers. In the Potomac River, this area is located below Little Falls Dam and extends up to Great Falls, which is 10 miles upriver of Little Falls, well above the Proposed Action area. However, there are no records of Atlantic sturgeon spawning in the Potomac River. Juvenile Atlantic sturgeon primarily stay within freshwater but move progressively seaward as they age. In general, juveniles remain within the riverine system for one to six years before migrating to the coast and out to the continental shelf where they grow to maturity.

In the Potomac River, a total of 226 Atlantic sturgeon have been reported, primarily through the Sturgeon Reward Program (Eyler, pers. comm., January 11, 2011). As shown in Figure 3.14-3 (Potomac River Atlantic Sturgeon Captures (1996 - 2010)), most Atlantic sturgeon have been captured below the Nice Bridge in the areas covered by the MDZ and LDZ. The number reported varies annually and was highest from 2005 to 2008 (Figure 3.14-1). The yearly fluctuations in the number of captures are thought to reflect changes in the sturgeon population, not the participation of commercial fishermen in the reward program. There seem to be stronger year classes of sturgeon that move up into the Chesapeake Bay in certain years but not others (Eyler and Mangold, pers. comm., January 11, 2011).

3.14.3 Sea Turtles and Terrestrial Reptiles

3.14.3.1 Sea Turtles

All sea turtle species are protected under the ESA. The ESA and the protection it affords to sea turtles are discussed above in Section 3.14.1. Five of the seven species of sea turtles existing in the world today occur in coastal and inland Virginia waters (VIMS, 2011): loggerhead (*Caretta caretta*), green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), and – although infrequently – hawksbill (*Eretmochelys imbricata*). Sea turtles are observed in Virginia's inshore and nearshore waters from May to November (VDGIF, Not Dated). During winter months, sea turtle distribution shifts either south or offshore, where water temperatures are warmer and prey is more abundant (e.g., Epperly et al., 1995a; 1995b). The lower Chesapeake Bay, its tributaries, and the Atlantic coastline provide important developmental habitat for immature sea turtles because of SAV beds and a rich diversity of bottom-dwelling fauna that afford cover and forage. Occasionally, adult females use Virginia's ocean-facing beaches as nesting sites.

Approximately 5,000 to 10,000 sea turtles enter the Chesapeake Bay each spring/summer as water temperatures rise (VIMS, 2011). Sea turtles use the bay and its tributaries as a feeding ground because of the abundance of SAV and benthic prey. The majority of these turtles are

either juvenile loggerhead or Kemp's ridley sea turtles that use the bay seasonally as a feeding ground.

3.14.3.2 Sea Turtles in the Potomac River

Three sea turtle species are known to occur in the lower Potomac River based on reported stranding and/or incidental capture records: loggerhead turtle, Kemp's ridley turtle, and green sea turtle, as described below.

Loggerhead Turtle

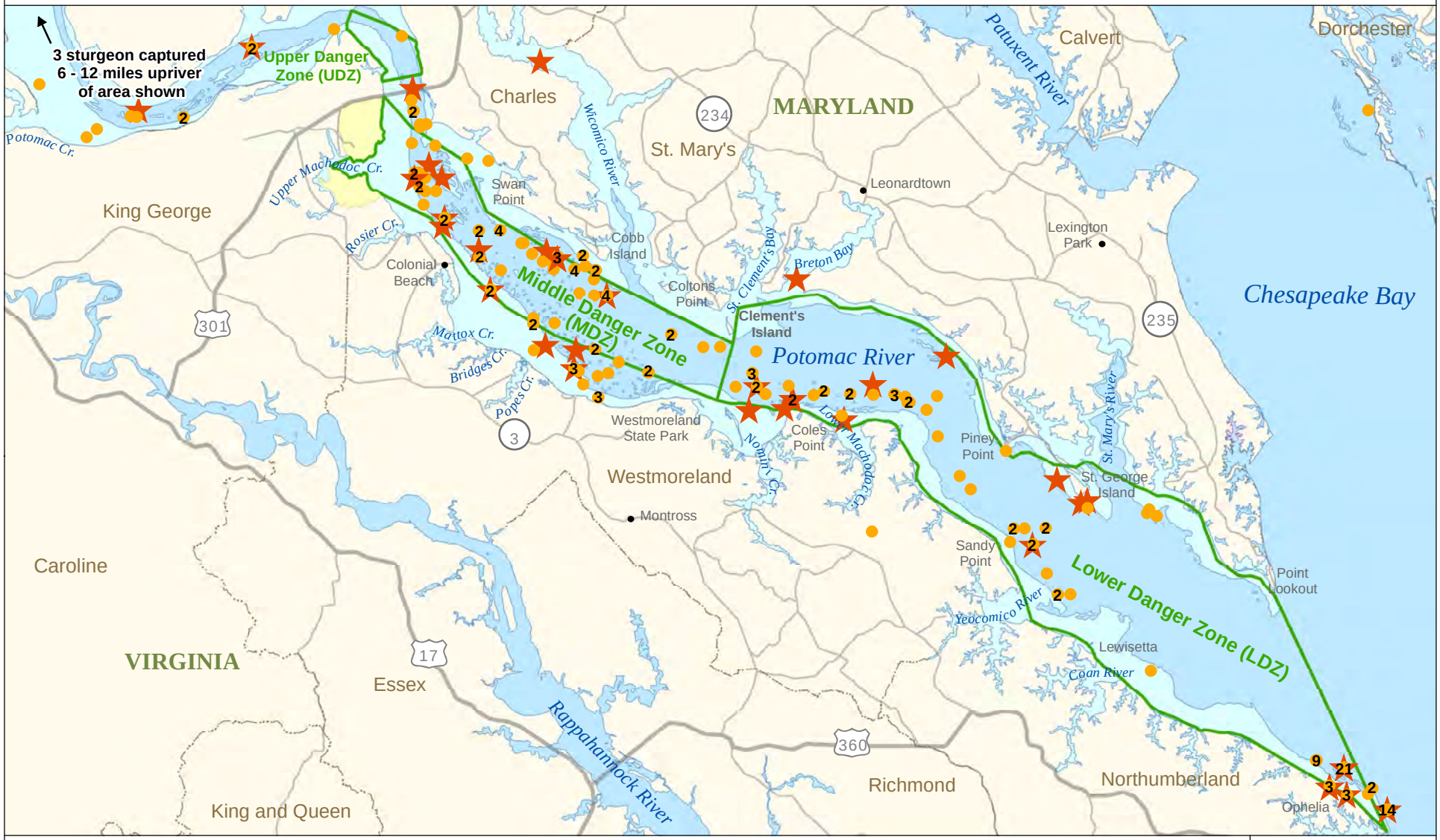
Loggerhead Sea Turtle
Caretta caretta

The loggerhead turtle is a large, hard-shelled sea turtle that is named for its disproportionately large head. The head supports powerful jaws that enable it to feed on hard-shelled prey (NFS, 2011). The average straight carapace length (SCL) of an adult loggerhead is about 3 ft and the average weight is 250 lbs (Ehrhart and Yoder 1978 as cited in NMFS and USFWS, 2008)). Adults are mainly reddish-brown in color on top and yellowish underneath. The diet of loggerhead turtles changes with age and size. Very little is known of the diet of oceanic juveniles, but they are thought to be primarily carnivorous, consuming mainly sea jellies and other invertebrates (NMFS and USFWS, 2008). Between the ages of 7 to 12 years, oceanic juveniles migrate to coastal waters (NFS, 2011). Juvenile loggerhead turtles are omnivorous and feed on a wide variety of organisms inhabiting coastal waters. Although they may forage on pelagic (free swimming) crabs, mollusks, jellyfish, and vegetation captured at or near the surface, benthic (bottom dwelling) invertebrates such as mollusks, and benthic crabs comprise the majority of their diet (Dodd, 1988; NMFS and USFWS, 2008).

The waters off the Virginia and North Carolina coasts are important transitional habitat for juvenile sea turtles. Juvenile sea turtles along the US Atlantic Coast exhibit seasonal foraging movements, migrating north along the coast in the early spring to coastal development habitats and south in the fall (Morreale and Standora, 2005). Coastal waters of Virginia, particularly the Chesapeake Bay, serve as developmental habitat for juvenile loggerhead and Kemp's ridley sea turtles, which take up residency during the summer months (Lutcavage and Musick, 1985). The presence of juvenile sea turtles in the Chesapeake Bay area and in Virginia coastal waters peaks from May through October (VIMS, 2011). As waters cool in the fall, most sea turtles migrate out of the Chesapeake Bay and Virginia coastal waters to travel southward at least as far as Cape Hatteras, North Carolina to avoid cold stunning[10]. Along the US coast loggerheads successfully nest from Texas to Virginia with the majority of nests – about 80 percent – occurring in six Florida counties (NMFS and USFWS, 2008). There are no records of nesting in the Chesapeake Bay or its tributaries.

[10] Cold stunning is the state that turtles enter when they are suddenly exposed to cold water of less than 50°F (less than 10 °C). In this circumstance, they may become lethargic and begin to float on the surface of the water, making them susceptible to predators, accidental boat strikes, and even death if water temperatures continue to drop (Witherington and Ehrhart, 1989).

Atlantic Sturgeon Reward Captures in the Potomac River (1996-2010)



Atlantic Sturgeon Original Capture (Minimum of one capture)

Atlantic Sturgeon Recapture (Minimum of one recapture)

NSF Dahlgren

Depth of less than 18 ft

Potomac River Test Range (PRTR)

County Boundaries

Note: Number in circle or star represents number of captures/ recaptures at location, if more than one.

Source: Eyler, USFWS, 2011.

6 0 6 Miles

10 0 10 Kilometers

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Figure 3.14-3

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Kemp's Ridley Turtle

Kemp's ridleys are considered the smallest marine turtle in the world with a SCL of approximately 2.0 to 2.3 ft (with shell length and width being nearly equal) and weight of about 100 lbs (NMFS, USFWS, and SEMARNAT, 2010; NFS, 2011). The carapace is round to somewhat heart-shaped and the coloration changes from grey-black in hatchlings to the lighter grey-olive top and cream-white or yellowish bottom of adults (NMFS, USFWS, and SEMARNAT, 2010).

Kemp's ridleys range includes the US Atlantic seaboard from New England to Florida, and the Gulf of Mexico. Kemp's ridleys share a general life history pattern similar to other sea turtles, such as the loggerhead (NMFS, USFWS, and SEMARNAT, 2010). Feeding grounds and developmental areas are found on the Atlantic and Gulf coasts of the US. Young Kemp's ridley hatchlings and small juveniles feed on the macroalgae *Sargassum* and associated floating species in habitats of the North Atlantic Ocean. Kemp's ridleys move as large juveniles and adults to benthic, nearshore feeding grounds along the US. Atlantic and Gulf coasts (Morreale and Standora, 2005).

Next to loggerheads, the Kemp's ridley is the second most abundant sea turtle in mid-Atlantic waters. Young Kemp's ridleys may forage during warmer months in the Chesapeake Bay area, generally heading southward out of Chesapeake Bay by early November (Lutcavage and Musick 1985, Keinath, 1993). Kemp's ridley sea turtles feed primarily on crabs and blue crabs and rock crabs comprise most of their diet in the Chesapeake Bay area (Burke et al., 1994). During the winter, Kemp's ridleys migrate south to warmer waters in Florida (Marquez, 1994).

Nesting is limited to the beaches of the western Gulf of Mexico (NMFS, USFWS, and SEMARNAT, 2010).

Green Sea Turtle

The green turtle is the largest hard-shelled sea turtle, with adults reaching an SCL of 3.3 ft and 300 to 350 lbs in weight and a maximum size of 4.0 ft and 440 lbs in weight (NMFS and USFWS, 1991; NFS, 2011; USFWS, 2011). The adult ranges in color from solid black to gray, yellow, green, and brown on top, while the bottom is yellowish white (NFS, 2011). The common name refers to the color of the green turtle's fat.

Very young green turtles (hatchlings) eat a variety of plants and animals, but adult green turtles feed mainly on seagrasses and marine algae (USFWS, 2011). While offshore, green turtles are not obligate herbivores and may consume invertebrates (NMFS and USFWS, 2007). Important adult feeding areas are found in Florida, where seagrasses are abundant.

In US Atlantic and Gulf of Mexico waters, green turtles are found in inshore and nearshore waters from Texas to Massachusetts, and are also found around the US Virgin Islands and Puerto Rico (NMFS and USFWS, 1991; NFS, 2011). The green sea turtle has only been recorded twice in Maryland waters as of 2001 (Litwiler, 2001), making it an infrequent visitor to the area. Green turtles also share a general life history pattern similar to other sea turtles, using three types of habitat – oceanic beaches (for nesting), convergence zones in the open ocean, and benthic feeding grounds in coastal areas (NFS, 2011).

Similar to the loggerhead and Kemp's ridley sea turtles, post-hatchling and early-juvenile green turtles are found in the open ocean (NMFS and USFWS, 1991; NFS, 2011; USFWS, 2011). Green turtles grow slowly (NMFS and USFWS, 1991). Once they reach a carapace length of

about 7.9 to 9.8 in, they migrate to shallow, nearshore areas (<164 ft in depth) where they tend to remain. The optimal developmental habitats for late juveniles and foraging adults are warm, shallow waters (10 to 16 ft in depth), with an abundance of submerged aquatic vegetation, close to nearshore reefs or rocky areas that are used by green turtles for resting.

Juvenile green turtles use estuaries along the Atlantic coast as summer developmental habitat, including Chesapeake Bay (Epperly et al., 1995a, 1995b). Adults are predominantly tropical and are only occasionally found north of southern Florida. Green turtles mainly nest from North Carolina south, with most of the primary nesting beaches occurring in a six-county area in east central and southeastern Florida (NMFS and USFWS, 1991). In August 2011 a green sea turtle nested at Cape Henlopen State Park, Delaware (Delaware Department of Natural Resources and Environmental Control, 2011). The eggs were moved in October 2011 to a climate-controlled room at the University of Delaware, as the temperature was getting too low for survival. Six turtles hatched and were taken to Morehead City, North Carolina where they were released into warmer waters (Delaware Department of Natural Resources and Environmental Control, 2011).

Sea Turtle Strandings and Incidental Captures in the Potomac River

The Virginia Institute of Marine Science (VIMS) and MDNR record sea turtle strandings and incidental captures in commercial fishing nets in Virginia and Maryland; data are then provided to NMFS. Figure 3.14-4 (Sea Turtle Strandings in the Potomac River (1991-2010)) shows locations of sea turtle strandings in the Potomac River and Figure 3.14-5 (Incidental Captures of Sea Turtles in the Potomac River (1991-2010)) depicts locations where sea turtles were incidentally captured in fishing nets. In recorded strandings, the sea turtle is often found dead or in poor condition. Therefore, strandings data provides the location where the turtle was found and not necessarily the location where the mortality occurred in the case of dead turtles. Some degree of transport may have occurred prior to the turtle's washing up at the stranding site.

Tables 3.14-2 and 3.14-3 list sea turtle strandings and incidental takes, respectively, in the Potomac River from 1991 through 2010 (VIMS, 2011; Tulipani, pers. comm., March 4, 2009 and January 7, 2010; Schofield, pers. comm., December 4, 2009; Testa, pers. comm. January 11, 2011; Trapani, pers. comm., January 11, 2011). Data are based on sea turtles records from St. Mary's County, Maryland and Northumberland County, Virginia. Both these counties front both the Potomac River and the Chesapeake Bay (see Figures 3.14-4 and 3.14-5), but only occurrences of turtles in the Potomac River are presented here. No sea turtles have been recorded from the Potomac River upriver of St Mary's and Northumberland Counties.

Seventy-two percent of recorded incidents (69 of 96) have been incidental captures of sea turtles in fishing nets, with the remaining 28 percent (27 of 96) consisting of strandings. The majority (84 percent) of turtles found in the Potomac River have been loggerheads, with Kemp's ridley comprising most of the remaining turtles (13 percent), but with one green turtle captured incidentally (Tables 3.14-2 and 3.14-3).

Most sea turtle occurrences in the Potomac River were recorded from May through July, with a few incidents later in the year. The presence of juvenile sea turtles in the Chesapeake Bay area is highest during warmer months (Coles, 1999; Tulipani, VIMS, pers. comm., March 4, 2009 and January 7, 2010; Schofield, MDNR, pers. comm., December 4, 2009; Testa, pers. comm., January 11, 2011; Trapani, Virginia Aquarium, pers. comm., January 11, 2011). These observations confirm that the Chesapeake Bay area serves as developmental habitat for juvenile loggerhead and Kemp's ridley sea turtles and rarely for green sea turtles.

Table 3.14-2
Sea Turtle Strandings in the Potomac River

Species	Loggerhead	Kemp's ridley	Green	Leatherback	Unidentified
1991*	1	0	0	0	0
1992*	0	0	0	0	0
1993*	0	0	0	0	0
1994*	0	0	0	0	0
1995*	1	0	0	0	0
1996*	1	0	0	0	0
1997	6	1	0	0	0
1998	2	0	0	0	0
1999	6	0	0	0	1
2000	1	0	0	0	0
2001	0	1	0	0	0
2002	0	0	0	0	0
2003	0	0	0	0	0
2004	0	0	0	0	0
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	3	0	0	0	0
2008	1	0	0	0	0
2009	0	0	0	0	0
2010	2	0	0	0	0
Total	24	2	0	0	1

Notes: * Only Maryland data.

Numbers represent total from Maryland and Virginia shorelines. Only sea turtles found in the Potomac River are listed here. The only counties where sea turtles were recorded are St. Mary's County, Maryland and Northumberland County, Virginia.

Sources: Tulipani, VIMS, pers. comm., March 4, 2009 and January 7, 2010; Schofield, MDNR, pers. comm., December 4, 2009; Testa, MDNR, pers. comm. January 11, 2011; Trapani, Virginia Aquarium, pers. comm., January 11, 2011.

Table 3.14-3
Sea Turtle Incidental Captures in the Potomac River

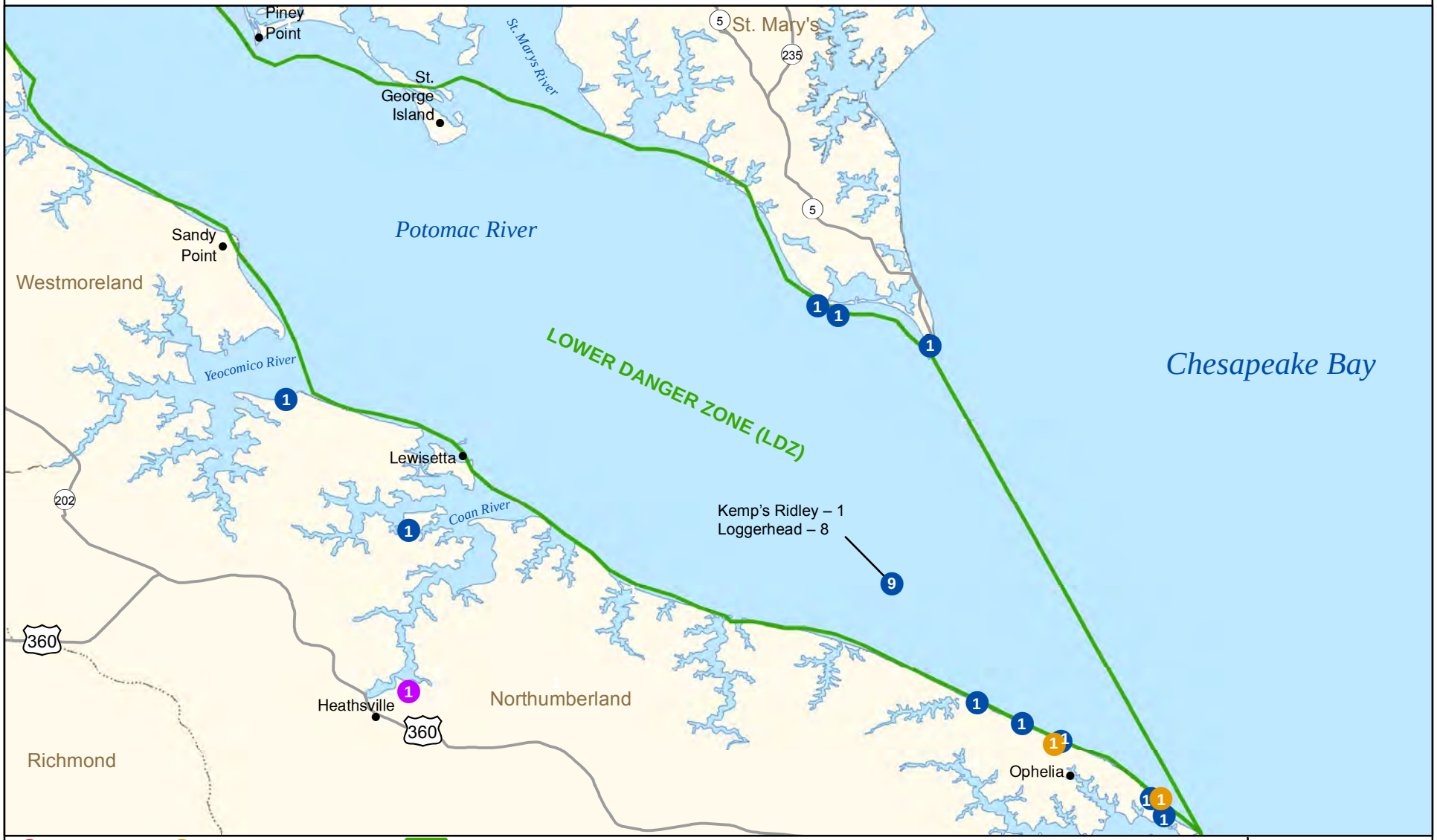
Species	Loggerhead	Kemp's ridley	Green	Leatherback	Unidentified
1991*	0	0	0	0	0
1992*	0	0	0	0	0
1993*	0	0	0	0	0
1994*	0	0	0	0	0
1995*	0	0	0	0	0
1996*	0	0	0	0	0
1997	23	2	0	0	0
1998	11	1	0	0	0
1999	12	2	0	0	0
2000	2	1	0	0	0
2001	3	3	1	0	0
2002	6	1	0	0	1
2003	0	0	0	0	0
2004	0	0	0	0	0
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	0	0	0
2009	0	0	0	0	0
2010	0	0	0	0	0
Total	57	10	1	0	1

Notes: * Only Maryland data.

Numbers represent total from Maryland and Virginia shorelines. Only sea turtles found in the Potomac River are listed here. The only counties where sea turtles were recorded are St. Mary's County, Maryland and Northumberland County, Virginia.

Sources: Tulipani, VIMS, pers. comm., March 4, 2009 and January 7, 2010; Schofield, MDNR, pers. comm., December 4, 2009; Testa, MDNR, pers. comm. January 11, 2011; Trapani, Virginia Aquarium, pers. comm., January 11, 2011.

Sea Turtle Strandings in the Potomac River (1991-2010)



Kemp's Ridley
Loggerhead, Kemp's Ridley
Potomac River Test Range (PRTR)
Unidentified
Loggerhead

Note: Number in circles indicates number of strandings at location.

Sources: Tulipani, VIMS, 2009, 2010; Schofield, MDNR, March 2009, December 2009, January, 2011; Trapani, Virginia Aquarium Stranding Response Program, 2011.

3 0 3 Miles

5 0 5 Kilometers

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Figure 3.14-4

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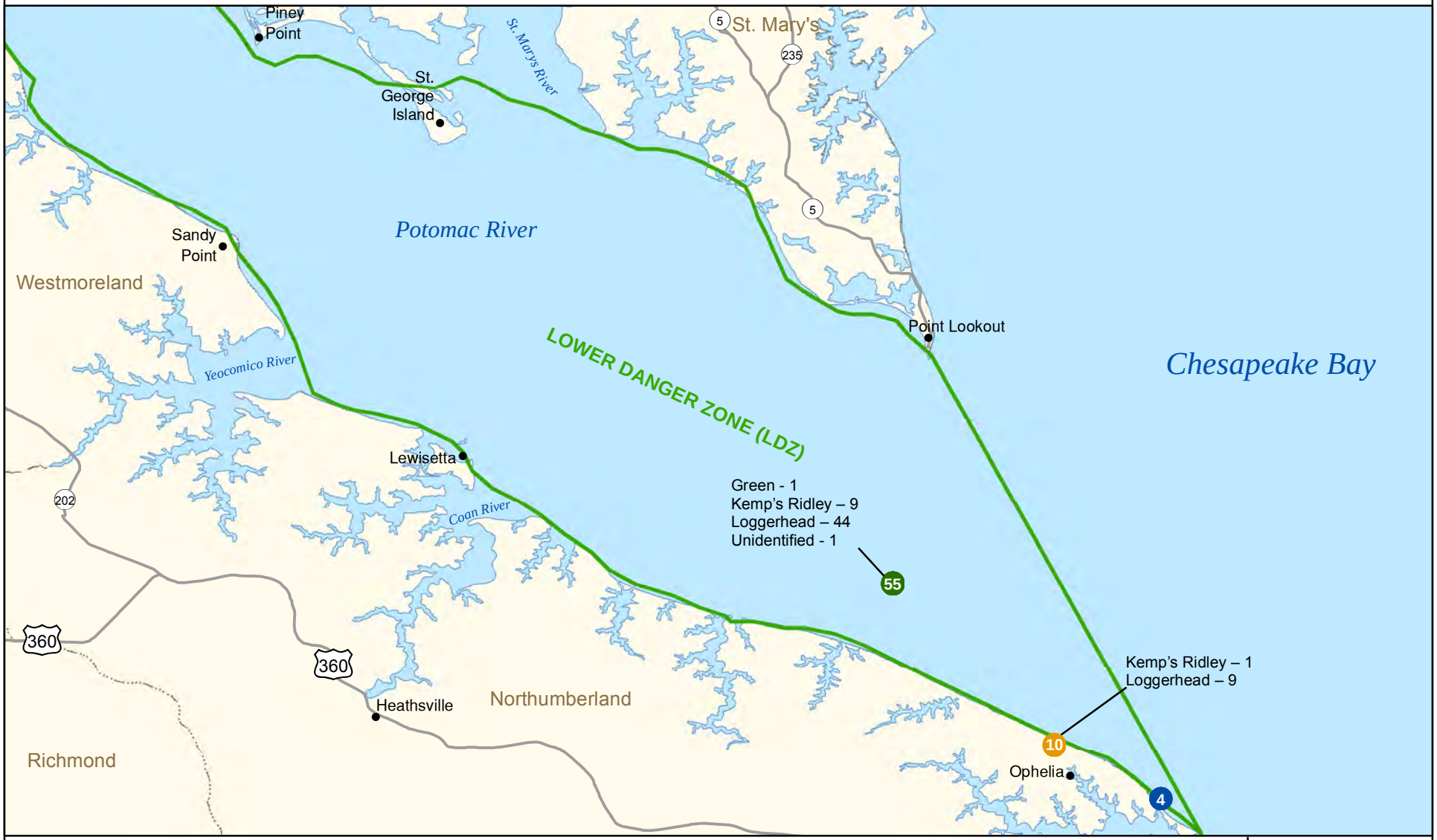
Incidental Captures of Sea Turtles in the Potomac River (1991-2010)



Loggerhead

Green, Kemp's Ridley, Loggerhead, Unidentified

Loggerhead, Kemp's Ridley

Potomac River Test Range (PRTR)

Note: Number in circles indicates number of incidents at location.

Sources: Tulipani, VIMS, 2009, 2010; Schofield, MDNR, March 2009, December 2009, January, 2011; Trapani, Virginia Aquarium Stranding Response Program, 2011.

3 0 3 Miles

5 0 5 Kilometers

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Figure 3.14-5

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The number of sea turtle strandings and incidental captures has decreased from its peak in the late 1990s. Almost 70 percent (67 turtles) of incidental captures/strandings were recorded in a three-year period from 1997 to 1999.The large number of turtles recorded in 1997 and 1999 reflect the numerous turtles that were captured or stranded at one location near the mouth of the river between Ophelia and Point Lookout, as shown in Figures 3.14-4 and 3.14-5. Many turtles were incidentally captured by fishing boats at this location. Most of the turtles stranded at this location were live turtles that were released back into the water. Excluding the large number of sea turtles captured/stranded in 1997 to 1999, there has been an average of less than two (1.4) sea turtle strandings or incidental captures per year in the Potomac River.

The reduction in the number of turtles recorded since the early 2000s may be due to a recovery in crab populations, thus reducing turtle foraging on fish caught in nets; less fishing activity in the Lower Potomac River; use of turtle exclusion devices by fishing boats; lower reporting of sea turtle incidents, fewer sea turtles in the area due to reduced prey abundance; or a combination of these and perhaps other factors.

The MDNR studied sea turtles in the Maryland portion of Chesapeake Bay from 2001 to 2007 (Kimmel, 2004, 2007). Fifty-four loggerheads, 19 Kemp's ridleys and 4 green turtles were examined as part of a sea turtle tagging and health-assessment study from July 2001 to August 2006 (MDNR, 2011). These turtles were reported by pound netters with nets at various locations throughout Maryland's Chesapeake Bay, including Herring Bay, Fishing Bay, and the Pocomoke River. In the Potomac River, the most upriver sea turtle stranding recorded during this time period was slightly above Piney Point in the LDZ (Kimmel, 2004).

Sea turtles have not been sighted in the PRTR MDZ by NSF Dahlgren's range control boat operators, who are present there five days a week (Patteson, pers. comm., August 4, 2008). Although sea turtles spend only a fraction of their time at the surface, the lack of sightings combined with other information on their distribution indicates that they are unlikely to be found upriver from the lower LDZ.

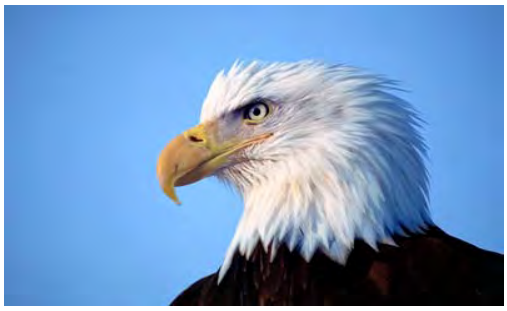
Based upon stranding, incidental capture, and tracking data, sea turtles are considered to be restricted to the lower part of the Potomac River, rarely venturing farther upstream than Piney Point/Sandy Point in the lower section of the LDZ.

3.14.3.3 Terrestrial Reptiles

One terrestrial reptile – the northern diamondback terrapin (*Malaclemys terrapin terrapin*) – is a federal species of concern that may occur within a four-mile radius of the installation, based on information from the *Atlas of Amphibians and Reptiles in Virginia* (Mitchell and Reay, 1999) and the VDGIF database (NSF Dahlgren, 2007). The diamondback terrapin is known to occur statewide in Virginia, and prefers quiet salt and brackish tidal waters, though it is also found in mud flats, shallow bays, coves, and tidal estuaries. Terrapins are occasionally observed in the Chesapeake Bay and in the Atlantic Ocean, and potentially could occur in the Potomac River on occasion (Roble, pers. comm., March 31, 2011).

The brackish marshes, creeks, and riverbanks associated with the Potomac River and the areas around NSF Dahlgren are suitable habitat for the terrapin. However, during the last reptile survey effort at NSF Dahlgren, an attempt was made to focus on rare and threatened reptiles, and the diamondback terrapin was not observed (Buhlmann and Mitchell, 1997). No diamondback terrapins have been observed on the installation to date.

3.14.4 Birds



Bald Eagle

Historically, the bald eagle is the only species of bird known to occur at NSF Dahlgren that was protected by the ESA. Bald eagles have been known to nest at NSF Dahlgren since 1983. As discussed in Section 3.12.3, the bald eagle was removed from the ESA list of threatened or endangered species in 2007 and is no longer covered under the ESA, but remains protected by the Bald and Golden Eagle Protection Act (BGEPA), the Migratory Bird Treaty Act, and the Lacey Act. It is also protected as a state-listed threatened species under Virginia law. Coordination with the USFWS Virginia Field Office online process for compliance with the BGEPA is included in Appendix G.

As discussed in Section 3.12.3, bald eagles use NSF Dahlgren for nesting and foraging (see Figure 3.12-3 for active nests). NSF Dahlgren's bald eagle management practices are outlined in the installation's *Bald Eagle Management Plan* (NSF Dahlgren and NAVFAC Washington, 2007) and are implemented in cooperation with VDGIF and USFWS to ensure protection of the species and compliance with the BGEPA. Management includes the protection of documented nesting and foraging habitat, the monitoring of nesting activity and success, and the enforcement of the Bald Eagle Protection Guidelines for Virginia developed by the USFWS and VDGIF (USFWS and VDGIF, 2001) and National Bald Eagle Guidelines (USFWS, 2007). Requests for deviations from these guidelines must be approved by USFWS and VDGIF.

NSWCDD RDT&E activities at NSF Dahlgren have the potential to disturb bald eagles due to human activity, aircraft operation, and loud noises generated by explosives. However, aircraft use and ordnance testing at the ranges is intermittent, has a historic presence, is consistent with past practices, and bald eagles have demonstrated tolerance for these activities at NSF Dahlgren. Therefore, these activities are allowed to proceed during the bald eagle nesting season, as specified in the National Bald Eagle Management Guidelines (USFWS, 2007). Guidelines in the NSF Dahlgren *Bald Eagle Management Plan* (NSF Dahlgren and NAVFAC Washington, 2007) require that, when prudent, the USFWS be consulted if the following circumstances occur:

- A bald eagle builds a nest within a quarter-mile of existing test ranges, if testing was not routinely conducted at the time of nest establishment.
- A given test on an existing range is significantly different from those conducted historically.
- A new testing area is proposed.

Currently, approximately 408 ac on Mainside and 552 ac on the EEA are constrained by bald eagle protection zones (PZs) around active bald eagle nests. The first PZ – PZ1 – extends from the nest tree to a radius of 750 ft, and the second zone – PZ2 – extends from 750 ft to 1,320 ft (a quarter-mile) in radius (NSF Dahlgren and NAVFAC Washington, 2007). Historical nesting sites are assumed to be inactive unless aerial or ground surveys document otherwise. PZs remain in place while the nest is active and for three consecutive nesting seasons after the last season

during which the nest was occupied (USFWS and VDGIF, 2001; NSF Dahlgren and NAVFAC Washington, 2007).

Federal avian species of concern that may occur within a four-mile radius of the installation include three species – the loggerhead shrike (*Lanius ludovicianus*), the black rail (*Laterallus jamaicensis*), and the cerulean warbler (*Dendroica cerulean*) (Table 3.14-1) (NSF Dahlgren, 2007). In addition, a number of avian species that are listed as state species of special concern may be potentially found in or near NSF Dahlgren (Table 3.14-1) (NSF Dahlgren, 2007). Nine bird species listed as state threatened or state species of special concern[11] have been observed at NSF Dahlgren (NSF Dahlgren, 2007).

3.14.5 Marine Mammals

Marine mammals, including pinnipeds (sea lions, seals, and walruses), otters, polar bears, cetaceans (whales, dolphins, and porpoises), dugongs, and manatees are protected species under the jurisdiction of NMFS and USFWS through the MMPA. Some marine mammals are also threatened or endangered species; however, none of the marine mammals that are known to occur in the Potomac River are threatened or endangered species. Therefore, their protection is afforded by the MMPA, but not by the ESA.

Information on marine mammals in the Potomac River and Chesapeake Bay is limited primarily to strandings and sighting reports by individuals. Systematic survey data are not available. It is likely that marine mammals found in the Chesapeake Bay are feeding on the many fish species that are available, such as silversides, anchovies, and menhaden, as well as shellfish (crabs), which are abundant in the bay.

A bottlenose dolphin (*Tursiops truncatus*) breaches the water

Since 1995 four species of marine mammal have been sighted or stranded in the Potomac River: the bottlenose dolphin (*Tursiops truncatus*), the harbor porpoise (*Phocoena phocoena*), Risso's dolphin (*Grampus griseus*), and the minke whale (*Balaenoptera acutorostrada*). These species are not ESA-listed, nor are they considered depleted under the MMPA.

In addition, there are two historical records of the West Indian manatee's (*Trichechus manatus*) being sighted in the Potomac River, with the most recent sighting occurring in August 1980 when a single manatee was sighted in the river at Washington, DC (Rathburn and Bonde, 1982, as cited in DoN, 2009).

Table 3.14-4 provides a list of marine mammal strandings in the Potomac River since 1995. The marine mammal was found dead all these stranding, usually in a state of moderate or advanced decomposition. Therefore, strandings data provides the location where the marine mammal was found and not necessarily the location where the mortality occurred. Some degree of transport is likely to have occurred prior to the marine mammal washing up at the stranding site.

[11] Maryland state status categories include threatened, endangered, and in need of conservation (not a legal status) Virginia state status categories include threatened, endangered, and special concern (not a legal status).

The only marine mammal regularly sighted in the Potomac River is the bottlenose dolphin. NOAA's NOS ESI maps (2005) indicate that marine mammals are found in the lower Potomac River from the mouth to Sandy Point, Virginia (the same part of the river where sea turtles are observed). NSF Dahlgren's range control boat operators, who are on the river in the PRTR MDZ five days a week, confirm that marine mammals are not sighted in this most active part of the river range (Patteson, pers. comm., August 4, 2008).

Table 3.14-4
Potomac River Marine Mammal Strandings 1995 - 2011

Observation Year	Common Name	Stranding State	Stranding County
1995	Minke Whale	MD	St. Mary's
1995	Bottlenose Dolphin	MD	St. Mary's
1996	Bottlenose Dolphin	MD	St. Mary's
1999	Harbor Porpoise	MD	St. Mary's
2000	Bottlenose Dolphin	MD	St. Mary's
2001	Bottlenose Dolphin	VA	Northumberland
2002	Risso's Dolphin	MD	Charles
2002	Bottlenose Dolphin	VA	Northumberland
2003	Harbor Porpoise	MD	St Mary's
2003	Bottlenose Dolphin	VA	Northumberland
2004	Bottlenose Dolphin	MD	St. Mary's
2009	Bottlenose Dolphin	VA	Northumberland
2010	Bottlenose Dolphin	VA	Northumberland
2010	Unidentified Delphinid	VA	Northumberland

Notes: Only years with strandings are listed. No marine mammal strandings were reported in the Potomac River in 2011.
Sources: Collins-Payne, NMFS, pers. comm., March 23, 2006, May 23, 2007, and October 13, 2009; Swingle et al., 2011, 2012.

Marine mammal species that have been sighted or stranded in the lower Potomac River are described below.

Bottlenose Dolphin

Bottlenose dolphins are large and robust, with adult body lengths ranging from 8 to 12 ft, depending on habitat (American Cetacean Society, 2004a). They are opportunistic feeders that use many feeding strategies to prey on fish primarily, and sometimes squid and crustaceans (American Cetacean Society, 2004a). In the US Atlantic, the bottlenose dolphin is distributed along the coast from Long Island, New York to the Florida Keys (NOAA, 1994). North of Cape Hatteras, North Carolina, there are concentrations of dolphins found nearshore in embayments and within several miles of the coast, as well as concentrations offshore near the continental shelf margin, about 37 to 124 mi from the coast (NOAA, 1994). Two ecotypes (forms) of bottlenose dolphins are recognized in the western North Atlantic Ocean: the nearshore (coastal) and offshore stock (NMFS, 1997). The dolphins in the Chesapeake Bay form a part of the Western North Atlantic coastal migratory stock.

In Virginia, bottlenose dolphins occur along the entire ocean coast, within one mile of shore, and in the Chesapeake Bay and its tributaries from late spring into the winter. In the Chesapeake Bay

area and its tributaries, nearshore bottlenose dolphins are found from April to November (VDEQ, 1997). Since 1995, nine bottlenose dolphin strandings and one unidentified delphinid stranding have been reported in the Potomac River (Table 3.14-4).

Bottlenose dolphins are most likely attracted to the Chesapeake Bay area because of the abundant sources of food. These dolphins feed on a variety of prey, including eels, catfish, menhaden, shrimp, and crabs, all of which are abundant in the bay. The Virginia Marine Science Museum Stranding Program is permitted by NMFS and the state to manage the Virginia Marine Mammal Stranding Network. In Maryland waters, the MDNR Cooperative Oxford Laboratory responds to marine mammal strandings.

In 1987, an apparent disease epidemic broke out, caused by a poisoning by brevetoxin, a neurotoxin produced by *Ptychodiscus brevis* – the dinoflagellate responsible for Florida's red tide (NOAA, 1994; Litwiler, 2001). This poisoning led to infection by bacterial and viral pathogens, resulting in the death of about half of the coastal migratory stock of bottlenose dolphins between Florida and New Jersey (NOAA, 1994). As a result, in 1993 NMFS listed the coastal migratory stock of bottlenose dolphins as depleted under the MMPA and required that a conservation plan be developed. The number of bottlenose dolphins in the northern migratory management unit stretching from New Jersey to Virginia is estimated at about 17,466 individuals (Waring et al., 2007). The population size of bottlenose dolphins in the Chesapeake Bay has not been quantified.

Harbor Porpoise

Harbor porpoises are the smallest cetaceans in the North Atlantic, with a maximum length of 6 ft and a maximum weight of 200 lbs (American Cetacean Society, 2004b). In the North Atlantic they feed on a variety of small, schooling clupeoid (herring-like) and gadoid (cod-like) non-spiny fish, including herring, cod, whiting, and sardines, consuming approximately 10 percent of their body weight each day (American Cetacean Society, 2004b). Harbor porpoises are normally found in subpolar to cool-temperate waters of the northern hemisphere (American Cetacean Society, 2004b, Culik, 2010). The harbor porpoise is an inshore species inhabiting shallow, coastal waters (American Cetacean Society, 2004b).

The best estimate of abundance for the Gulf of Maine and Bay of Fundy stock is 89,700 individuals (Waring et al., 2007). Their occurrence in the Chesapeake Bay area is seasonal and is in small numbers. There are two relatively recent records – one in 1999, the other in 2003 – of harbor porpoise strandings in the Maryland portion of the Lower Potomac River near Leonardtown and Scotland in St. Mary's County (Table 3.14-4) (NMFS, 2007).

Risso's Dolphin

Risso's dolphin is a moderately large, robust animal, with an average length of 10 ft and a maximum length of approximately 12.5 ft (American Cetacean Society, 2004c). They primarily feed on cephalopods, such as squid and octopus (Culik, 2010). It is a widely-distributed species, found in the western North Atlantic from Newfoundland southward to the Gulf of Mexico, throughout the Caribbean, and around the equator (Culik, 2010). Risso's dolphins are pelagic, mostly occurring seaward of the continental slope and in deep oceanic waters from 1,312 to 3,281 ft (Culik, 2010). The best estimate of abundance for the western North Atlantic stock is 20,479 individuals (Waring et al., 2007). Based on their depth preferences, they are unlikely to

be found in the Potomac River and, in general, strandings in Virginia are rare (Blaylock, 1985). There is one record of stranding in Charles County, Maryland (Table 3.14-4) (NMFS, 2007).

Minke Whale

The minke whale is a small baleen whale, reaching an adult length of about 26 ft, with a maximum length of about 33 ft (American Cetacean Society, 2004d). In the western North Atlantic, minke whales feed primarily on small schooling fish, such as sand lance, capelin, herring, cod, and mackerel, as well as on krill (American Cetacean Society, 2004d). Minke whales are distributed in polar, temperate, and tropical waters, but are less common in the tropics than in cooler waters, resulting in greater abundance in New England waters than in the mid-Atlantic (Waring et al., 2007). Minke whales off the eastern coast of the US are considered to be part of the Canadian East Coast stock that ranges from the eastern half of the Davis Strait (between Greenland and Baffin Island) to the Gulf of Mexico, and is estimated to consist of 3,312 individuals (Waring et al., 2007).

Minke Whale
Balaenoptera acutorostrata

The southernmost sighting in recent NMFS shipboard surveys was of one individual offshore of the mouth of Chesapeake Bay, in waters with a bottom depth of 11,400 ft (Mullin and Fulling, 2003). There is one record of a stranding in the Potomac River in 1995 near Piney Point, Maryland (Table 3.14-4); however as this individual was dead and in a moderate state of decomposition when found, it is uncertain where it died.

West Indian Manatee

The West Indian manatee is found along the coast of Florida and in the Caribbean (USFWS, 2008). Most adult manatees are about 10 ft long and weigh 800 to 1,200 lbs (USFWS, 2008). West Indian manatees are classified as endangered under the ESA.

Manatees are herbivores that feed opportunistically on a wide variety of marine, estuarine, and freshwater plants (USFWS, 2013). They prefer large, slow-moving rivers, river mouths, and shallow coastal areas such as coves and bays (USFWS, 2008). Their range is generally restricted to the southeastern United States with individuals occasionally ranging as far north as Massachusetts and as far west as Texas (USFWS, 2013).

Based on the manatee's sensitivity to cold waters, they are unlikely to occur in the Chesapeake Bay during the winter months, and all sightings in the northern three-quarters of the Chesapeake Bay are from the summer (DoN, 2009). When ambient water temperatures drop below 68°F manatees aggregate within the confines of natural and artificial warm-water refuges or move to the southern tip of Florida (USWFS, 2001). The mean surface water temperature of the PRTR is below 68°F for eight months of the year, from October through May (Table 3.10-5), limiting the time when manatees could be present. As there have been no manatee sightings in the Potomac

River for more than 30 years and the temperature of the water in the PRTR is too cold for manatees most of the year, the presence of manatees on the PRTR is considered highly unlikely.

3.14.6 Insects

The northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*) is listed under the ESA as a threatened species and has been identified by USWFS as potentially occurring in the area (USFWS, January 21, 2013). Their habitat includes open, undisturbed beaches, sand flats, dunes, water edges, woodland paths, and sparse grassy areas (USFWS, 1994). Adult beetles are usually active along the water's edge on bright, clear, sunny days; and eggs are usually deposited below the surface of the sand, above the high-tide mark (Lippson and Lippson, 2006).

The beetle has been observed on beaches along the lowest reaches of the Virginia side of the Potomac River – along the lower PRTR LDZ. Potomac River northeastern beach tiger beetle populations were surveyed in 1998 and again in 2004 (Knisley, pers. comm., September 24, 2008). Populations of tiger beetles were observed between Hull Creek and the mouth of the Little Wicomico River, along the LDZ, 25 mi south of the MDZ's downriver boundary (Figure 3.14-6, Northeastern Beach Tiger Beetle Occurrences). Although the MDNR's database indicates that the beetle occurs on St. Mary's County's shores, populations no longer exist on the Maryland beaches of the Potomac River (Knisley, pers. comm., September 24, 2008).

3.14.7 Plants

In 2004, a rare-plant survey was completed by ESA, Inc. for state-listed and federally-listed rare, threatened, and endangered plant species that are known to occur in the vicinity of NSF Dahlgren (DoN, 2004). Surveyors searched for swamp pink (*Helonias bullata*), narrow-leaved spatterdock (*Nuphar sagittifolia*), small whorled pogonia (*Isotria medeoloides*), harperella (*Ptilimnium nodosum*), New Jersey rush (*Juncus caesariensis*), sensitive joint-vetch (*Aeschynomene virginica*), and water hyssop (*Bacopa innominata*). None of the target species or any other rare plants were found on the installation (DoN, 2004).

The sensitive joint-vetch has been identified by USFWS as potentially occurring in the area (USFWS, January 21, 2013). However, even if this species occurs somewhere on the installation, it is unlikely to be present in the range areas. Sensitive joint-vetch occurs in fresh to slightly brackish tidal river systems, within the intertidal zone, typically occurring at the outer fringe of marshes or shores (USFWS, 1999).

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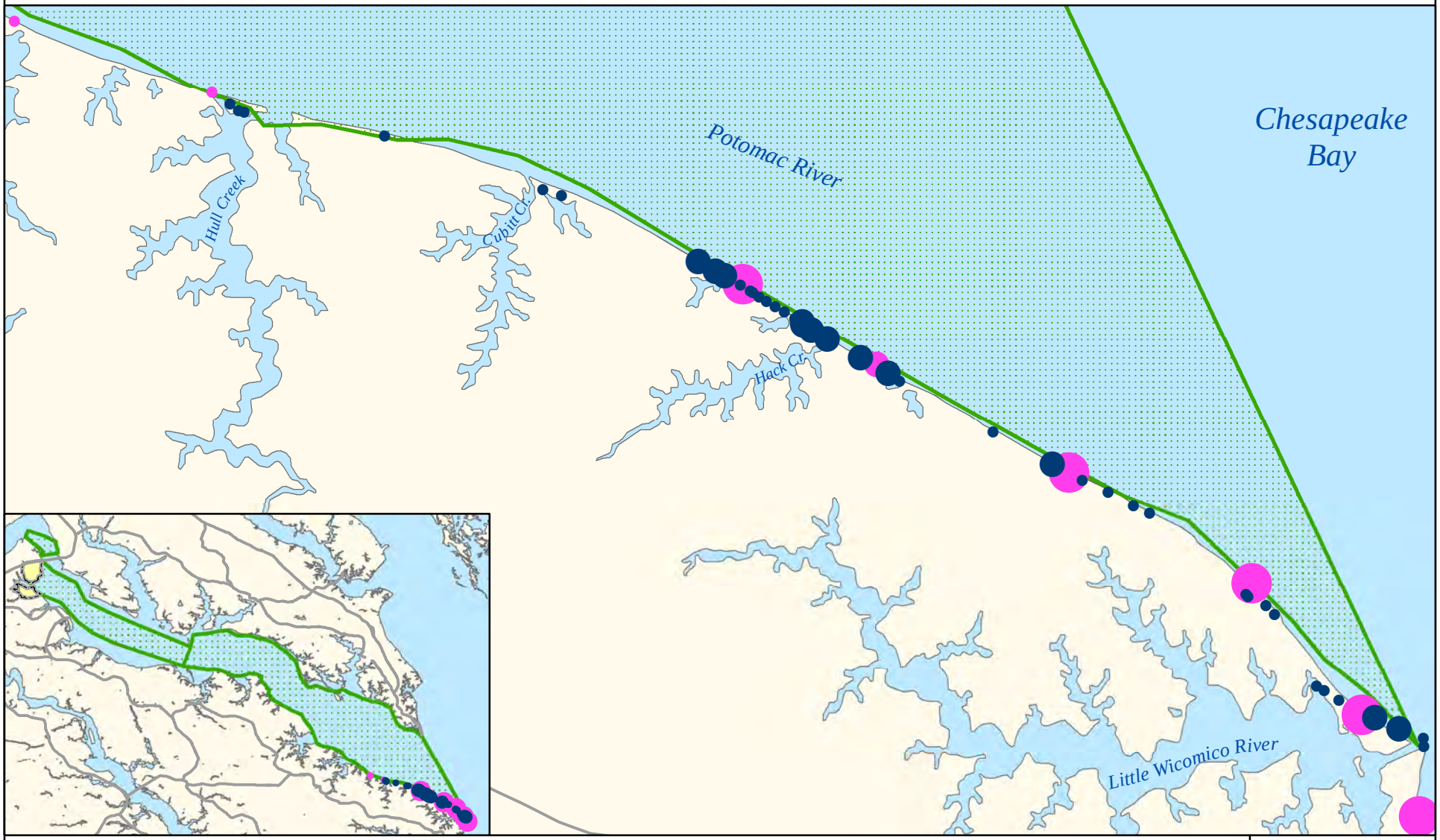
Northeastern Beach Tiger Beetle Occurrences



Tiger Beetles 1998:
Tiger Beetles 2004:

Potomac River Test Range (PRTR)

1,001 - 5,000
51 - 1,000
1 - 50

0 0.5 1 2 Miles

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011) and Knisley, 2008.

Figure 3.14-6

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4 ENVIRONMENTAL IMPACTS

This chapter provides an assessment of the potential environmental impacts that would result from implementing the alternatives considered in this EIS. Each alternative was evaluated for its potential to produce environmental impacts. Chapter 4 is organized like Chapter 3, by resource area.

For the purposes of this EIS, the terms “impacts” and “effects” are used interchangeably; they are synonymous. Impacts can be described as having several distinct attributes. The following defines the impact attributes that were used to assess potential impacts:

- **Context –** Context refers to the geographic, social, and environmental circumstances within which a proposed action may have effects on an environmental resource. An action in a disturbed urban area may have little effect compared to one in an old growth forest. Context also refers to the scale of the impact; i.e., the size of the area affected by the action.
- **Intensity –** Intensity refers to the severity of the impacts – the degree to which a proposed action would affect an environmental resource. Intensity is rated as negligible, minor, moderate, or major, in accordance with the framework presented below.
- **Short-term or Long-term –** Impacts can be short-term (noise and dust during the construction of a building) or long-term (destroying a historic structure to make way for a new building). These characteristics are determined on a case-by-case basis and do not refer to any rigid time period. In general, short-term impacts are those that would occur only with respect to a particular discontinuous activity or for a finite period, or only during the time required for installation activities. Long-term impacts are those that are more likely to be persistent and chronic.
- **Direct or Indirect –** Impacts can also be direct (filling wetlands to build a new road) or indirect (population growth induced by the new road). A direct impact is caused by a proposed action and occurs contemporaneously at or near the location of the action. An indirect impact is caused by a proposed action but might occur later in time or be farther removed in distance but still be a reasonably foreseeable outcome of the action.
- **Positive or Negative –** Impacts of a proposed action can be positive (more jobs from a new factory) or negative (cutting down trees to build a factory). A positive impact is one having beneficial outcomes on an environmental resource. A negative impact is one having adverse, unfavorable, or undesirable outcomes. A single action might result in positive impacts on one environmental resource and negative impacts on another resource.

The following scale is the qualitative framework used in this EIS to evaluate the intensity of impacts:

- **No Impacts** – No change to the environmental resource.
- **Negligible Impacts** – Impacts either are non-detectable or, if detected, are well within natural or normal variability and do not appreciably affect the extent or value of the environmental resource. Adverse impacts are easily absorbed by the natural or human environment without mitigation or long-term consequences.
- **Minor Impacts** – Impacts are clearly detectable but they approximate natural or normal variability and do not appreciably affect the extent or value of the resource. If needed to offset adverse impacts, mitigation is simple and mitigation success is likely.
- **Moderate Impacts** – Impacts exceed natural or normal variability; impacts appreciably affect the value or extent of the resource, but do not affect its viability. Although mitigation typically would be needed for the environment to absorb adverse impacts without long-term deterioration, mitigation success is likely.
- **Major Impacts** – Impacts exceed natural or normal variability and likely affect the viability of the resource or, as the impacts are highly uncertain or involve unique or unknown risks, the future viability of the resource is in question. Full mitigation of adverse impacts may not be possible or mitigation success is not likely, and some long-term deterioration of the environment may be unavoidable.

4.1 Land Use, Plans, and Coastal Zone Management

4.1.1 No Action Alternative

Under the No Action Alternative, outdoor RDT&E activities at NSF Dahlgren would continue at the existing level into the foreseeable future. There would be no increase in the average annual number of such activities, as described in Table 2-1.

4.1.1.1 NSF Dahlgren

Existing land uses at NSF Dahlgren, described in Section 3.1.1, reflect and support current operations, including outdoor RDT&E activities. Implementation of the No Action Alternative, under which outdoor RDT&E activities would continue to be conducted as at present, would neither cause nor require any changes in land use. The EEA and PRTR range complexes and their associated infrastructure, which currently support NSWCDD's outdoor RDT&E activities, would continue to be used and maintained as they are now. Outdoor RDT&E activities would continue to be conducted on the ranges and Mission Area (Figure 1-4), but not in the Sailor and Family Support Area (see Figure 3.1-1). Impacts on land use at NSF Dahlgren result from the need to divert non-RDT&E-related uses, such as recreation and installation travel, during some outdoor RDT&E activities to ensure the safety of personnel. Consequently, travel times on the installation may be longer during certain operations, or personnel may need to reschedule their outdoor recreational activities, such as jogging. These negative impacts on other NSF Dahlgren land uses would be negligible, short-term, and direct. There would be no indirect impacts.

Generally, continuation of outdoor RDT&E activities at the current level would be consistent with the plans that have been developed to guide the development of NSF Dahlgren and Naval District Washington (NDW), which include the *Naval Surface Warfare Center Dahlgren Site Area Development Plans: Warfare Systems Complex, Weapons Development Complex, and Advanced Concepts Complex* and the *NDW Regional Shore Infrastructure Plan* (RSIP) (see Sections 3.1.1.2 and 3.1.1.3, respectively). However, by not allowing for future increases in NSWCDD's outdoor RDT&E activities, and thus restricting its potential to accommodate new and emerging RDT&E needs and requirements, the No Action Alternative would not fully support the recommendation from the RSIP to "recognize NDW as an RTD&E center" that stands out among other regions (see Section 3.1.1.3), as the extent of RTD&E would be limited.

4.1.1.2 Dahlgren Area and Potomac River Shoreline

Existing land uses near NSF Dahlgren and along the Potomac River shoreline on either side of the PRTR, described in Section 3.1.2.1, are the cumulative result over time of a wide range of factors, including geography, demographic conditions, economic conditions, and local and state land use and development policies, along with the corresponding regulatory requirements. The presence of the Navy at Dahlgren since 1918 also has been a factor, as have other features, such as the presence of the Potomac River, the proximity of Washington, DC, and the state and federal transportation infrastructure.

Historically, the two aspects of NSF Dahlgren most likely to have had a significant influence in shaping existing land use patterns are (1) the installation's role as a major employment center, creating a demand for nearby housing and supporting commercial uses, and (2) the installation's

role as a center for outdoor RDT&E activities, with associated noise impacts (see Section 4.5) and occasional restrictions on river use. While the former can be expected to have made the area around NSF Dahlgren more attractive to residential development, the latter, to the contrary, may be expected to have made it less so, though it is not possible to ascertain to what degree, especially since so many other factors have also been, and continue to be, at play.

However, the No Action Alternative would cause no change to any of the multifarious factors that have created existing land use patterns. In particular, it would not affect those aspects of NSF Dahlgren most likely to influence surrounding land uses: NSF Dahlgren would remain a major employment center, though no significant increase in personnel is expected; and the environmental impacts of the outdoor RDT&E activities conducted at the installation would remain the same as well.

One possible foreseeable consequence of increased population encroachment with no economic affiliation to NSF Dahlgren is the potential for a growing negative reaction to the Navy's activities, and particularly to the noise associated with them. Increases in noise complaints can be expected, not from an increase in Navy activity, but rather from a changing population with little relationship to NSF Dahlgren. Conceivably, dissatisfaction with NSF Dahlgren as a neighbor could nominally dampen the rate of future residential development and affect land use patterns.

However, to monitor and control noise from its outdoor RDT&E activities and, thereby, reduce noise complaints from surrounding communities, NSWCDD has developed and implemented a noise management process, which is summarized in Section 3.5.3.5 and reproduced in full in Appendix C. Implementation of the noise management process is expected to minimize noise impacts and noise complaints resulting from NSWCDD's outdoor RDT&E activities, and substantially preclude noise-related effects on future residential development and land use.

The land use plans and policies of the five counties included in the study area for this EIS as well as those of the Town of Colonial Beach would continue to guide future development, in combination with demographic and economic conditions. These plans and policies are briefly characterized in Section 3.1.2.2 and are described in more detail in Appendix B. Continuation of the current level of outdoor RDT&E activities at NSF Dahlgren, as would occur under the No Action Alternative, would be consistent with the plans, which all have been developed relatively recently and, therefore, can be expected to have taken the installation and its on-going activities into account.

Therefore, under the No Action Alternative, current development patterns can be expected to evolve as envisioned by the different comprehensive plans developed by the jurisdictions making up the study area. No significant new factors that could unexpectedly and substantially alter the character or density of development near the installation or along the Potomac River would be introduced as a result of this alternative. (Although unforeseen demographic or economic changes may intervene and significantly alter land use patterns, such potential changes are independent from the Navy's decision with respect to the Proposed Action evaluated in this EIS.) Thus, the No Action Alternative would have no direct or indirect impact on land use near NSF Dahlgren and along the Potomac River shoreline because it would not change factors such as noise and river use, which are already incorporated into existing land use patterns.

The No Action Alternative would have no direct or indirect impact on existing access to the Potomac River for either commercial or recreational purposes (commercial navigation is addressed in Section 4.2.1.2). As is currently the case, portions of the river, mostly within the

MDZ but also occasionally including the upper LDZ, would continue to be restricted on average a total of 750 hours per year to allow for the safe performance of RDT&E activities in the PRTR. This impact would continue to be minimized, as is done at present, through the procedures described in Section 3.8.1.1, including advance notice of any restrictions and reasonable efforts to minimize inconvenience by taking advantage of any lulls in operations (e.g., for equipment adjustments and the like) to allow watercraft to move through the affected area. Shallow-draft boats (which most recreational vessels are) can always pass by hugging the Maryland shore of the river.

The No Action Alternative would not result in any direct or indirect impacts on the ongoing projects described in Section 3.1.2.5. The projects' owners can be expected to have taken the presence of and activities at NSF Dahlgren into account in their planning. Under the No Action Alternative, no new factors or impacts would be introduced that could affect the economic or operational viability of any of those projects.

4.1.1.3 Special-Use Airspace

Under the No Action Alternative, NSWCDD's designated special-use airspace (SUA) at NSF Dahlgren would continue to operate as it does today and as is described in Section 3.1.3. Commercial operators would continue to fly along long-established routes that avoid the SUA, and general aviation operators would continue to avoid the SUA at all times as a matter of course. They would also continue to have the option of checking Notices to Airmen (NOTAMs) and communicating with air traffic control at NAS Patuxent River in case they want or need to fly through the SUA. However, as noted in Section 3.1.3, such an occurrence is, and is expected to remain, very rare. There would be no change to existing conditions and no direct or indirect impact on non-military airspace users.

4.1.1.4 Coastal Zone Management

Pursuant to Coastal Zone Management Act (CZMA) § 307(c)(1) and 15 CFR Part 930, Sub-part C, Federal Coastal Consistency Determinations (CCDs) for the Proposed Action evaluated in this EIS (including the No Action Alternative and Alternatives 1 and 2) were prepared to evaluate the consistency of the Proposed Action with the coastal zone management programs of Virginia and Maryland, respectively. These documents, contained in Appendix I of this EIS, were submitted for review to the Virginia Department of Environmental Quality (VDEQ) and the Maryland Department of the Environment (MDE) along with the DEIS when it was published.

Based on the impact analyses contained in the EIS, the Navy concludes in the CCDs that the Proposed Action, under any of the alternatives considered, including the No Action Alternative, is consistent to the maximum extent practicable with the enforceable policies of the coastal zone management programs of Virginia and Maryland. VDEQ responded to the Navy's conclusion in a letter dated October 18, 2012 (reproduced on page A-69 in Appendix A; consistency determination conclusion on page A-82) that "Based on our review of the Navy's consistency determination, and the comments and recommendations submitted by agencies administering the enforceable policies of the VCP [Virginia Coastal Program], DEQ concurs that the proposed actions are consistent, to the maximum extent practicable, with the VCP."

MDE did not respond within 60 days to the Navy's consistency determination nor ask for an extension, so under the provisions of the CZMA, the state has waived its consistency rights,

stating neither that it concurs with nor objects to the Navy's consistency determination. The Maryland Department of Natural Resources' (MDNR's) comments on the DEIS (documented on pages A-64 and A-65) included a section entitled "Consistency with the Coastal Zone Management Act," with three comments:

- Navigational comments focus on the noise policy.
- Charles County notes a potential use conflict with a marina and development project.
- Proposed increased training and testing activities may conflict with other activities in the Potomac River, such as recreational and commercial fishing, recreational boating and War of 1812-related 200th Anniversary commemoration events in the Potomac River.

MDNR also asked that "General Comments" be considered when assessing the consistency of the proposed activities with Maryland's enforceable coastal zone management policies. These comments concern:

- Bald eagles
- Waterfowl concentration and staging areas
- Noise impacts on residents
- Terrapin and horseshoe crab spawning habitat
- Largemouth bass habitat and shoreline erosion control projects
- Submerged aquatic vegetation
- Increased exclusion of commercial and recreational boaters
- Natural oyster bars
- Sea-level rise
- Striped bass, Atlantic sturgeon, and anadromous fish spawning sites
- Need to consult US Coast Guard for mainstem boating modifications
- Fish and shellfish tissue analysis
- Point and non-point pollution
- Potential effects on wildlife due to magnetic and electric field exposure

Responses to comments S004.3 through S004.19 in the DEIS comment matrix in Appendix A address MDNR's issues and describe their resolution.

4.1.2 Alternative 1

Under Alternative 1, NSWCDD's RDT&E activities would increase relative to baseline (existing and no action) conditions as shown in Table 2-2.

4.1.2.1 NSF Dahlgren

Under Alternative 1, while there would be an increase in the annual average number of outdoor RDT&E activities performed at NSF Dahlgren, there would be no change in the type of activities

(with the exception of the use of biological simulants for chem/bio testing, as only chemical simulants are used under existing conditions and would be used under the No Action Alternative). This quantitative increase would not require new or different facilities than those that currently exist or are being built. No new military construction (MILCON) is included in the Proposed Action. The facilities now supporting NSWCDD's RDT&E work, including the two range complexes, would continue to be used and maintained as they are now. RDT&E activities would continue to be conducted within the ranges and the mission area, where they are already performed. Likewise, outdoor RDT&E activities would continue to be conducted typically during normal operating hours (8 am to 5 pm on weekdays), with infrequent activities outside normal hours, as would be the case under the No Action Alternative. However, under Alternative 1, EM energy, laser, and chem/bio sensor activities outside the normal operating hours would occur at greater frequency than is the case now. None of these differences would affect land use patterns at the installation. However, an increased number of outdoor operations requiring restrictions on land range access would increase the inconvenience to other land uses, such as travel around the installation and recreation, resulting in negligible, short-term, direct, negative impacts and no indirect impacts during some outdoor RDT&E activities.

Alternative 1 would be consistent with the plans that have been developed to guide the development of NSF Dahlgren and NDW, including the *Naval Surface Warfare Center Dahlgren Site Area Development Plans: Warfare Systems Complex, Weapons Development Complex, and Advanced Concepts Complex* and the NDW RSIP (see Sections 3.1.1.2 and 3.1.1.3). Unlike the No Action Alternative, Alternative 1 would support the recommendation from the RSIP to promote NDW as an RTD&E center that stands out among other regions, since it would allow NSWCDD to better accommodate new and emerging RDT&E needs and requirements. Because it would result in NSWCDD's making better use of its facilities at NSF Dahlgren, Alternative 1 would also support the RSIP's recommendation to maximize existing facilities for highest and best use.

4.1.2.2 Dahlgren Area and Potomac River Shoreline

As explained in Section 4.1.1.2, existing land uses near NSF Dahlgren and along the shores of the Potomac River on either side of the PRTR are the cumulative result of a number of factors, including, though to an unknown degree, the influence of NSF Dahlgren as both a major employment center and the location of various outdoor RDT&E activities, with impacts on noise levels and river use. Continuation of the current levels of outdoor RDT&E activities (the No Action Alternative) would have no direct or indirect impact because it would not change factors such as noise and river use, which are already incorporated into existing land use patterns, current plans, and on-going projects.

Conversely, an increase in the number of RDT&E activities, as would occur under Alternative 1, could potentially have an impact on land use patterns, existing land use plans and policies, and ongoing projects if it affects those NSF Dahlgren-related factors most likely to have an influence on land use, namely noise and river use. For instance, a significant increase in noise levels could create incompatibilities with land uses or projects requiring a reasonably quiet environment, such as residential developments, parks, or historic properties. Similarly, a significant increase in the number and/or duration of river range restrictions might create incompatibilities with water-based recreational or commercial uses. Potential impacts would not necessarily be adverse. For instance, an increase in noise levels, which might discourage future waterside residential

development, could indirectly further land use policies aiming to preserve as much as possible of the shoreline in an undeveloped state for environmental conservation and recreational purposes.

As shown by the noise analysis for Alternative 1 (Section 4.5.2), the alternative is expected to result in minor, long-term, direct, negative noise impacts. The noisiest activities (large gun activities and detonations) would either not increase (large guns), increase negligibly (detonations), or be contained within the installation (small arms). The greater use of UAVs for EM or laser testing also may result in some additional noise, but given the small size of many of the UAVs used and their associated modest noise levels, as well as the altitude at which they fly (2,000 to 3,000 ft; sometimes more), noise from flights is expected to be negligible. Increased use of the upper LDZ as a target area for large-gun firing would extend the area affected by large-gun noise downriver more frequently than the occasional use made of this area in recent years. With the exception that noise levels would be higher downriver in the vicinity of the upper LDZ up to ten days a year, noise levels in the study area under Alternative 1 would not substantially vary from noise levels under existing and no action conditions. Because greater use of the upper LDZ would take place at most ten days a year and the rounds fired may be inert, which would not increase noise levels in the target area, current or future land use patterns, including ongoing residential projects such as the Villages at Swan Point Project (see Section 3.1.2.5), are not likely to be affected.

With respect to river access, under Alternative 1, some part of the PRTR would be in use on average for 870 hours a year, as opposed to 750 hours a year under existing and no action conditions – an increase of 120 hours during which a portion of the Potomac River and its tributary Upper Machodoc Creek may not be accessible to commercial or recreational boaters or may require that vessels go around the edge of the range when it is restricted. In addition to the relatively modest size of the increase (16 percent), the impact on recreational boating (the most relevant factor when dealing with land use, as it may more directly affect the desirability of waterside property; potential impacts on commercial boating are addressed in Section 4.2.1.2 and would be minimal) would be small because for the most part, access restrictions would still be limited to approximately 8 am to 5 pm on weekdays (set-up for testing may begin before 8 am and activities may continue after 5 pm on some days), whereas pleasure boating is predominantly a weekend or evening activity.

Restriction of the MDZ often covers only part of the MDZ – not all of it – allowing vessels to move freely in the unrestricted part. When firing is taking place, a larger part or even the whole of the MDZ or upper LDZ, depending on the location of the target area, may be restricted. While under Alternative 1 activities requiring water access restrictions may take place on weekends – EM energy, HE laser, or chem/bio defense, but no gun firing – such occasions would typically be those when the specific weather conditions needed for a test are present, but such weather conditions – often involving fog or wet weather – are also those most likely to keep pleasure boaters home. Activities could also take place during the week outside normal working hours, at dawn, dusk, or during the night. Again, in addition to the relatively low frequency of such cases, these are hours when recreational use of the water is at a minimum, with the possible exception of recreational fishing from boats, but anglers are often not limited to one spot and, if needed, may relocate with little trouble.

These impacts would not be distributed evenly throughout the river range. Under existing and no action conditions, all or part of the MDZ and the upper LDZ (to 40,000 yds from firing) are restricted for range activities, but not the UDZ or lower LDZ. This would change under

Alternative 1. Access to all or part of the UDZ and/or the LDZ would be restricted approximately two days a year for operations involving vessels and aircraft. Access to the upper LDZ to 40,000 yards from the firing line would be restricted approximately ten days a year. Restricting public access to these areas has been infrequent in recent years, so the inconvenience to other river users would be more noticeable to them than to users accustomed to the regular restrictions imposed on the MDZ.

Another area that would sustain more impact is the mouth of Upper Machodoc Creek. The increased impact would be in large part a direct result of the more frequent HE laser and other directed energy tests that would be conducted across the creek to and from the Navy Directed Energy Center (NDEC) and the Counter Explosives Test Facility (CETFAC), located on the northern and southern shores of the creek, respectively (see Figure 1-8). HE laser and directed energy testing would require restricting public access to the mouth of the creek while the test is in progress more often than is currently the case or would be the case under the no action conditions. A substantial number of such tests would take place at either dawn or dusk, which are times when boats docked on the creek's shores may be on their way to or back from Potomac waters. (Tests would also take place occasionally at night, but few, if any, recreational boaters are likely to be affected by this.)

However, several factors contribute to minimizing this localized adverse impact. First, as is the case with all river range restrictions, information on the time and duration of each test would be made available in advance on the web and via a toll-free number (see Sections 1.6 and 3.8.1.1). Second, by their nature, activities involving lasers and directed energy are intermittent and include long periods during which boats would be allowed to pass under controlled conditions, through the restricted test area, consistent with NSWCDD's policy to make all reasonable efforts to minimize public inconvenience. Finally, inevitable delays are expected to be 10 minutes on average, and, in the worst case, are not expected to exceed 30 minutes. For these reasons, the impact on boat traffic across the mouth of Upper Machodoc Creek is expected to be minor.

More generally, any impact on river use would continue to be minimized, as is done at present, through the procedures described in Section 3.8.1.1, including issuance of advance notice of any restrictions and reasonable efforts to limit inconvenience by taking advantage of any lulls in testing to allow watercraft to move through the affected area. Shallow-draft vessels, which most recreational craft are, would continue to be able to pass by the range by hugging the Maryland shore of the river. Thus, impacts on water access would be negligible and not sufficient to noticeably affect present or future land use patterns.

The increased outdoor laser, EM energy, and chem/bio defense RDT&E activities that would take place under Alternative 1 would have no impacts likely to affect land use patterns in the study area, as they would remain within the confines of the ranges or the mission area (potential effects relating to noise and water access are addressed in the preceding paragraphs).

Under Alternative 1, as under the No Action Alternative, current development patterns can be expected to evolve as envisioned by the different comprehensive plans developed by the jurisdictions in the study area. No significant new factors that could unexpectedly and substantially alter the character or density of development near the installation or along the Potomac River would be introduced as a result of this alternative. (Although unforeseen demographic or economic changes may intervene and significantly alter land use patterns, such potential changes are independent from the Navy's decision with respect to the Proposed Action

evaluated in this EIS.) However, the increase in the number of RDT&E activities under Alternative 1 and the resulting adverse noise and river use effects potentially would nominally affect land use patterns, existing land use plans and policies, and ongoing projects. Thus, Alternative 1 would have no direct impacts and negligible, long-term, indirect, negative impacts on land use, land use planning, and ongoing development projects.

4.1.2.3 Special-Use Airspace

The increased use of the SUA for NSWCDD's RDT&E activities that would occur under Alternative 1, compared to existing and no action conditions, would have negligible, short-term, direct, negative impacts and no indirect impacts on non-military airspace users for the following reasons:

The lower tier (surface to 7,000 or 40,000 ft) of the SUA above NSF Dahlgren and the PRTR is normally in effect every non-holiday weekday from 8 am to 5 pm and the higher tier (40,000 to 60,000 ft) is used as needed, in which case a NOTAM is issued. A NOTAM is also issued when the lower tier of airspace is needed outside the normal weekday hours. When, conversely, it is not needed during the normal weekday hours, it is released to FAA control for potential use by civilian aviation. This would continue to be the case under Alternative 1. Since, under Alternative 1, the SUA would be used more than under existing conditions (the No Action Alternative), the hours during which it is potentially open to civilian aircraft would be reduced. However, as explained in Section 3.1.3, both commercial and general aviation operators in fact normally stay out of the SUA at all times. Commercial airliners fly along long-established routes that do not cross the SUA, and general aviation pilots, although they do have the option of checking whether the SUA is in effect when planning their flights, very rarely do so; as a matter of course, they consider the SUA to be off-limits at all times.

In the event of an emergency, any commercial or general aviation aircraft may contact ground control and request and be granted permission to fly through the controlled air space. This would not change under Alternative 1. In addition to being very rare, such emergency situations would not be affected by an increase in NSWCDD activities within the SUA.

4.1.2.4 Coastal Zone Management

Pursuant to CZMA § 307(c)(1) and 15 CFR Part 930, Sub-part C, Federal CCDs for the Proposed Action evaluated in this EIS (including the No Action Alternative and Alternatives 1 and 2) were prepared to evaluate the consistency of the Proposed Action with the coastal zone management programs of Virginia and Maryland. These documents, contained in Appendix I of this EIS, were submitted for review to the VDEQ and the MDE along with the DEIS when it was published.

Based on the impact analyses contained in the EIS, the Navy concludes in the CCDs that the Proposed Action, under any of the alternatives considered, including Alternative 1, is consistent to the maximum extent practicable with the enforceable policies of the coastal zone management programs of Virginia and Maryland. VDEQ responded to the Navy's conclusion in a letter dated October 18, 2012 (reproduced on page A-69 in Appendix A; consistency determination conclusion on page A-82) that "Based on our review of the Navy's consistency determination, and the comments and recommendations submitted by agencies administering the enforceable

policies of the VCP [Virginia Coastal Program], DEQ concurs that the proposed actions are consistent, to the maximum extent practicable, with the VCP."

MDE did not respond within 60 days to the Navy's consistency determination nor ask for an extension, so under the provisions of the CZMA, the state has waived its rights to concur with or object to the Navy's consistency determination. MDNR comments on the DEIS (documented on pages A-64 and A-65) included a section entitled "Consistency with the Coastal Zone Management Act," described in Section 4.1.1.4. Responses to comments S004.3 through S004.19 in the DEIS comment matrix in Appendix A address MDNR's issues and describe their resolution.

4.1.3 Alternative 2

4.1.3.1 NSF Dahlgren

The difference between Alternative 2 and Alternative 1 is almost entirely quantitative: under Alternative 2, the same RDT&E activities are proposed but the average annual number of events would be roughly 16 percent higher than under Alternative 1. Therefore, Alternative 2 would have no direct or indirect impact on present or future land use patterns at NSF Dahlgren for the same reasons that Alternative 1 would have no impact (see Section 4.1.2.1). Because of the increase in events on land ranges above no action and Alternative 1 levels, however, Alternative 2 would have no indirect impacts and negligible, short-term, direct, negative impacts on other land uses, such as recreation and travel on the installation, as a result of increased use of land ranges and an increase in access restrictions during some operations. Another difference between the alternatives is that by making greater use of NSF Dahlgren's facilities, Alternative 2 would better support the recommendations of the RSIP to promote NDW as an RTD&E center that stands out among other regions and maximize existing facilities for the highest and best use than would Alternative 1.

4.1.3.2 Dahlgren Area and Potomac River Shoreline

Like Alternative 1 (see Section 4.1.2.2), Alternative 2 could have effects on existing and future land use patterns as well as ongoing development projects and current land use plans and policies if it resulted in a change in noise levels or river use great enough to affect the desirability of land in the study area for different types of use.

With regard to noise, as explained in Section 4.5.3, implementation of Alternative 2 is expected to result in minor, long-term, direct, negative noise impacts. The noisiest activities would either not increase in number (large gun activities), increase slightly (detonations), be largely contained within the installation (small arms), or generate negligible noise levels (UAV flights). For the most part, noise levels outside NSF Dahlgren under Alternative 2, as under Alternative 1, would not substantially vary from noise levels under existing and no action conditions. The one exception to this is that firing into the upper LDZ would increase and, if live rounds are used, higher noise levels would extend downriver. Because this would take place no more than ten days a year, and inert projectiles may be used, this change is unlikely to affect land use.

With regard to river access, impacts under Alternative 2 would be greater than under Alternative 1: on average, part of the PRTR would be restricted for 1,000 hours a year, as opposed to 870

hours under Alternative 1 and 750 hours under existing and no action conditions. The adverse impacts from the resulting river closures (in the PRTR's MDZ and Upper Machodoc Creek; restrictions in the UDZ and LDZ would be the same as under Alternative 1: an average of two days a year for the whole of the UDZ and LDZ plus 10 days a year for firing into the upper LDZ to 40,000 yards from the installation) would be more noticeable than under Alternative 1. However, the same mitigating factors noted in Section 4.1.2.2 would contribute to minimizing them. As explained in Section 4.2.3.2, impacts on commercial river traffic would be minor. Impacts on recreational river traffic would be limited, especially since, compared to commercial vessel operators, pleasure boaters can often more readily change their route or destination and, using mostly shallow-draft vessels, would remain able to pass by the range by remaining close to the Maryland shore of the river. Restriction of the MDZ may cover only part of the MDZ—not all of it—allowing vessels to move freely in the unrestricted part. Overall, impacts on river use are expected to be minor and not sufficient to noticeably affect existing or future land use patterns.

Like under Alternative 1, the increased outdoor laser, EM energy, and chem/bio defense RDT&E activities that would take place under Alternative 2 would have no impacts likely to affect land use patterns in the study area, as they would remain within the confines of the ranges or the mission area (potential effects relating to noise and water access are addressed in the preceding paragraphs).

Under Alternative 2, as under the No Action Alternative and Alternative 1, current development patterns can be expected to evolve as envisioned by the different comprehensive plans developed by the jurisdictions in the study area. No significant new factors that could unexpectedly and substantially alter the character or density of development near the installation or along the Potomac River would be introduced as a result of this alternative. (Although unforeseen demographic or economic changes may intervene and significantly alter land use patterns, such potential changes are independent from the Navy's decision with respect to the Proposed Action evaluated in this EIS.) However, the increase in the number of RDT&E activities under Alternative 1 and the resulting adverse noise and river use effects potentially would nominally affect land use patterns, existing land use plans and policies, and ongoing projects. Thus, Alternative 2 would have no direct impacts and negligible, long-term, indirect, negative impacts on land use, land use planning, and ongoing development projects.

4.1.3.3 Special-Use Airspace

Under Alternative 2, as under Alternative 1 and the No Action Alternative, the lower tier (surface to 7,000 or 40,000 ft) of the SUA would remain in effect every non-holiday weekday from 8 am to 5 pm and the higher tier (40,000 to 60,000 ft) would be used as needed, in which case a NOTAM would be issued. A NOTAM would also be issued when the lower tier of airspace is needed outside the normal weekday hours. When, conversely, it is not needed during the normal weekday hours, it would be released to FAA control for potential use by civilian aviation. Since, under Alternative 2, the SUA would be used more than under the other alternatives, the hours during which it is potentially open to civilian aircraft would be reduced. However, as explained in Section 3.1.3, both commercial and general aviation operators in fact already normally remain out of the SUA at all times. Commercial airliners fly along long-established routes that do not cross the SUA and general aviation pilots, although they do have

the option of checking whether the SUA is in effect when planning their flights, very rarely do so; as a matter of course, they consider the SUA to be off-limits at all times.

In the event of an emergency, any commercial or general aviation aircraft may contact ground control and request and be granted permission to fly through the controlled air space. This would not change under Alternative 2. In addition to being very rare, such emergency situations would not be affected by an increase in NSWCDD activities within the SUA.

For these reasons, the increased RDT&E activities that would occur under Alternative 2, compared to existing and no action conditions, would have negligible, short-term, direct, negative impacts and no indirect impacts on non-military airspace users.

4.1.3.4 Coastal Zone Management

Pursuant to CZMA § 307(c)(1) and 15 CFR Part 930, Sub-part C, Federal CCDs for the Proposed Action evaluated in this EIS (including the No Action Alternative and Alternatives 1 and 2) were prepared to evaluate the consistency of the Proposed Action with the coastal zone management programs of Virginia and Maryland, respectively. These documents, contained in Appendix I of this EIS, were submitted for review to the VDEQ and the MDE along with the DEIS when it was published.

Based on the impact analyses contained in the EIS, the Navy concludes in the CCDs that the Proposed Action, under any of the alternatives considered, including Alternative 2, is consistent to the maximum extent practicable with the enforceable policies of the coastal zone management programs of Virginia and Maryland. VDEQ responded to the Navy's conclusion in a letter dated October 18, 2012 (reproduced on page A-69 in Appendix A; consistency determination conclusion on page A-82) that "Based on our review of the Navy's consistency determination, and the comments and recommendations submitted by agencies administering the enforceable policies of the VCP [Virginia Coastal Program], DEQ concurs that the proposed actions are consistent, to the maximum extent practicable, with the VCP."

MDE did not respond within 60 days to the Navy's consistency determination nor ask for an extension, so under the provisions of the CZMA, the state has waived its rights to concur with or object to the Navy's consistency determination. MDNR comments on the DEIS (documented on pages A-64 and A-65) included a section entitled "Consistency with the Coastal Zone Management Act," described in Section 4.1.1.4. Responses to comments S004.3 through S004.19 in the DEIS comment matrix in Appendix A address MDNR's issues and describe their resolution.

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4.2 Socioeconomics

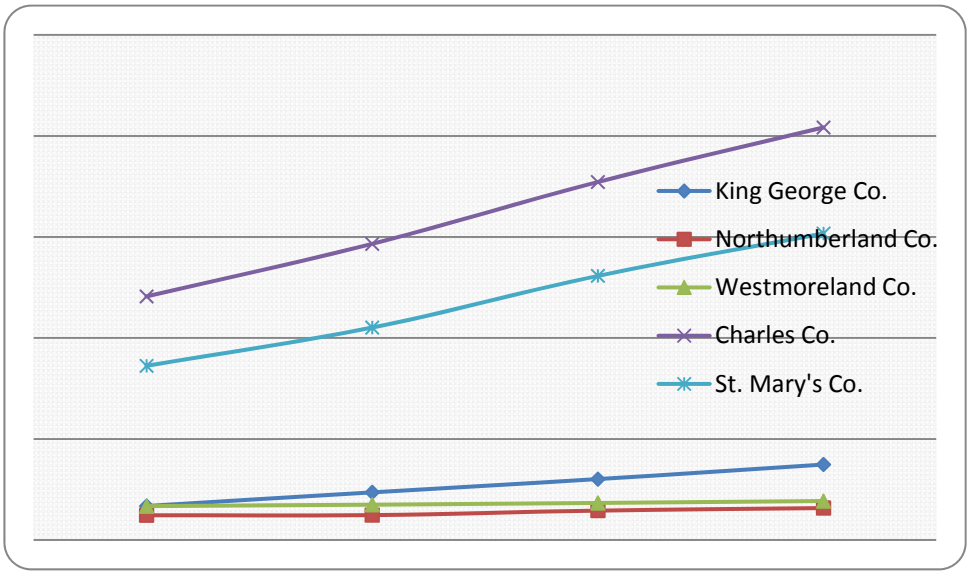
4.2.1 No Action Alternative

The No Action Alternative assumes that the existing baseline conditions describing NSWCDD's activities in Chapter 1 would continue for the foreseeable future. No significant increase in NSWCDD RDT&E personnel is anticipated, and, consequently, NSWCDD's proposed activities would not be a factor driving any changes to the surrounding region's future socioeconomic characteristics.

4.2.1.1 Demographics

Baseline demographic conditions are described for the five-county study area and the two states in Section 3.2.1. Table 3.2-1 notes population trends through 2010, and Table 3.2-2 presents population projections for the study area through 2020. Additional county and state population projection data through 2030 are shown in Table 4.2-1. Figure 4.2-1, Population Projections 2000-2030, presents the data graphically for the five counties of the study area.

Figure 4.2-1
Population Projections 2000-2030



These data reveal that, in numerical terms, the two Maryland counties account for the highest projected population growth, with Charles County accounting for 47.6 percent of the growth in the study area and St. Mary's for 37.2 percent. The three Virginia counties together account for only 15.2 percent of the study area's projected growth, of which King George County accounts for 11.7 percent. Although numerically King George County has a relatively small share of the study area's growth, its percentage increase from 2000 to 2030 is high, at 122.4 percent, larger than Charles County, at 69.4 percent, and St. Mary's, at 76.0 percent (Table 4.2-1).

Table 4.2-1
Population Projections 2000-2030

Jurisdiction	Population				Change 2000-2030			Percentage of 2030 Study Area Population	Percentage of 2000 Study Area Population
	2000	2010	2020	2030	Growth	Percentage Growth	Percentage of Study Area's Growth		
King George Co.	16,803	23,584	30,126	37,365	20,562	122.4	11.7	8.7	6.7
Northumberland Co.	12,259	12,330	14,587	15,821	3,562	29.1	2.0	3.7	4.9
Westmoreland Co.	16,718	17,454	18,336	19,261	2,543	15.2	1.4	4.5	6.6
Charles Co.	120,546	146,551	177,200	204,200	83,654	69.4	47.6	47.7	47.7
St. Mary's Co.	86,211	105,151	130,750	151,700	65,489	76.0	37.2	35.4	34.1
Study Area	252,537	305,070	370,999	428,347	175,810	69.6	100	100	100
Maryland	5,296,486	5,773,552	6,339,290	6,737,750	1,441,264	27.2	-	-	-
Virginia	7,078,515	8,001,024	8,917,396	9,825,019	2,746,504	38.8	-	-	-

Source: US Census Bureau, 2011, Census 2000, DP-1 Profile of General Demographic Characteristics 2000; Census 2010, DP-1 Profile of General Population and Housing Characteristics 2010; Virginia Employment Commission, 2011; Maryland Department of Planning, 2008.

Westmoreland County has the smallest projected growth in both absolute and relative terms. Northumberland County's and Westmoreland County's growth rates are below that of the state; all other counties of the study area exceed the projected growth rate of their respective state.

The No Action Alternative is unlikely to affect these population projections and would have no direct or indirect impact on demographics. The future patterns generally reflect recent demographic trends, mostly attributable to regional migration and population dispersal from the center of the Washington, DC metropolitan area to its periphery. The two Maryland counties in the study area are closer to and better served by highways to the metropolitan core than the three counties in Virginia's Northern Neck. Thus, the Maryland counties are more accessible from the employment centers of the region. In addition, the Maryland counties already have larger population bases and a wider choice of amenities, and so are more appealing to households used to these choices than the quieter, more rustic Virginia counties.

4.2.1.2 Economic Impacts

As previously noted, under the No Action Alternative, existing employment conditions at NSWCDD would continue into the foreseeable future. While the Navy at NSF Dahlgren is presently one of the largest employers in the region, no significant increase in outdoor RDT&E employment related to the Proposed Action is anticipated. Consequently, NSWCDD outdoor RDT&E activities would not be a factor causing any changes to the surrounding region's future economic character.

The projected growth in population in the study area (discussed in the previous section) will, however, likely increase employment and earnings there. As a consequence, more vacant land will be developed for housing, business, and institutional use. To some extent, these growth activities will also increase population in proximity to NSF Dahlgren and the range complexes. It is apparent that current activities at NSF Dahlgren have not deterred new development along the Potomac River – e.g., several major residential development projects initiated over the last few years in Colonial Beach on the Virginia shore not far from the installation. The No Action Alternative would have no direct or indirect impacts on economic conditions in the study area because it would not change factors such as noise and river use, which are already incorporated into existing economic activities.

Marine-Related Economic Activity

The Navy shares the use of the Potomac River with others, including commercial and industrial vessels (e.g., fuel and sand and gravel barges), commercial fishing, and recreational users.

Marine Freight

As discussed in Section 3.2.2.3, navigation of the Potomac River south of Washington, DC is limited by its relatively shallow depth at a number of locations, but the river still is active in waterborne commerce with a total of 6,332 vessel trips up or down the Potomac River below Washington, DC in 2008 (USACE, 2008). Deeper draft vessels, such as those carrying freight or passengers, must use the main navigation channel, which the US Army Corps of Engineers dredges in places to maintain sufficient depth. The main navigation channel passes through the UDZ, MDZ, and LDZ closer to the Maryland shoreline than the Virginia shoreline. There are currently approximately 122 vessels per week transiting the Potomac River below Washington, DC. However, because the data indicate only port of departure, it is not clear that all of these

vessels pass through the PRTR – some may be going from one port to another above the PRTR or going from a port far downriver out into the bay, barely passing through the PRTR (USACE, 2008).

NSWCDD's Range Operations Center (ROC) maintains two marine radio channels. While smaller vessels can skirt around the Maryland side of the range when the whole MDZ is restricted, larger vessels needing to pass through the main channel, which is within the MDZ, must call ROC to let it know of their approach. ROC in turn notifies them when they are allowed to pass. Vessels either slow down or stop until allowed through. A typical wait is less than 30 minutes, with a maximum delay of about an hour. Smaller fishing boats also radio ROC for permission to cross the range.

The Mirant Morgantown coal-fired power plant has constructed facilities that allow it to supplement the importation of coal by rail to include an estimated four to five 20,000-ton barges per week, with each taking about 16 hours to unload, day and night. Actual coal deliveries vary and are very limited at this time – the majority of coal deliveries are by rail and, based on current market conditions, likely will remain so for the foreseeable future (Allen, pers. comm., June 3, 2010). The barges – typically 485 ft long with a beam of 80 ft and sitting approximately 20 ft above water – will have to traverse the MDZ and LDZ in the main channel to reach the unloading facility. The coal barges for the Mirant plant would add at most four or five barges a week to this total, so that the new average for vessels passing through the PRTR would be 126 or 127 vessels per week – an increase of about four percent or less.

The Navy reached an operating agreement with Mirant and its barge-unloading facility (McGettigan and Smith, pers. comm., April 24, 2007). Mirant has agreed where feasible to schedule barge traffic through the PRTR outside the range's normal operating hours of Monday to Friday, 8 am to 5 pm and to coordinate alternate schedules with the Navy when PRTR activities would pose undue hardship to barge shipments.

Commercial Fishing

Commercial fishing in the Potomac River involves fishing, crabbing, and, less frequently, oystering. Section 3.2.2.3 discusses employment, citing available data from the 2000 Census and noting that the occupational category of *Farming, Fishing and Forestry* in the five-county study area accounted for 817 jobs, thereby setting an upper limit on the scale of commercial fishing employment in the region. Data from the Potomac River Fisheries Commission (PRFC) indicate that, during the ten-year period from 2001 through 2010, 86 percent of finfish as well as 50 percent of crabs were obtained in the lower reaches of the river – from the mouth to Coltons Point, corresponding to the LDZ (Cosby, PRFC, pers. comm., March 1, 2011). Over the ten-year period, 16,189 bushels of oysters or 79 percent of the catch were obtained within the MDZ (see Table 3.2-12). The PRFC issues about 1,300 commercial finfish licenses annually, but many fishermen hold multiple licenses, so that an estimated 800 commercial fishermen fish the Potomac from its mouth to Moss Point, Maryland (Cosby, PRFC, pers. comm., October 7, 2008).

Efforts to survey fishermen for the EIS met with few responses. Those fishermen that did respond indicated no issues with NSWCDD's activities, presumably because most fishing activity is in the LDZ, which has relatively few RDT&E events compared to the MDZ, and because the fishermen are able to work around activities in the MDZ when needed.

Recreational Activities

Recreational marine activity is very popular on the Potomac River, as evidenced by the number of charter boat companies and marinas along the river. These are described at the end of Section 3.2.2.3, with various sources citing approximately 30 public and private marinas on each side of the river between Nanjemoy Creek (north of the Harry Nice Bridge) and the Chesapeake Bay (see also Section 3.1.2.3). Because recreational use of the river is heaviest on weekends and holidays, when events rarely take place, conflicts between RDT&E use of the range and recreational boating are minimized. Most of the vessels used in recreational boating in the vicinity of the MDZ have shallow drafts, so that, when access is restricted during testing, they are able to navigate around the MDZ by staying close to the Maryland shore if they are going up or down the river. As the range is contiguous with the Virginia shore around NSF Dahlgren, recreational vessels affected by RDT&E activities would be directed to the Maryland shore or out of the range. Recreational boaters wishing to cross the range when it is active or to proceed along the Virginia shoreline or in or out of Upper Machodoc Creek can contact the NSWCDD ROC, which will allow passage during gaps in the operations. Normally, the wait is no more than 30 minutes for recreational vessels and more typically 10 minutes. The popularity of recreational boating on the Potomac does not appear to be inhibited by NSWCDD's present activity level.

Real Estate Activity

Another segment of the local economy potentially affected by NSWCDD's activities at NSF Dahlgren and on the PRTR is the residential real estate market. Under the No Action Alternative, NSWCDD's testing activities on the PRTR would continue at existing levels. Future real estate development is likely to continue, some within proximity to NSF Dahlgren.

As noted in the discussion of demographics above, the five-county study area is forecast to increase its population by 175,810, or 69.6 percent, between 2000 and 2030 (Table 4.2-1). The great bulk – 84.8 percent – of this anticipated growth is projected for the two Maryland counties, with Charles County accounting for 47.6 percent and St. Mary's County 37.2 percent, and the three Virginia counties sharing the remaining 15.2 percent. If the study area's average number of persons per household of 2.73 (Table 3.2-4) is applied to this projected population (less the estimated 2010 population), there would be 45,164 new households in the study area by 2030. Most of the growth can be expected to occur at the periphery of the Washington, DC suburbs in Charles County, but some will be attracted to the waterfront of both the Maryland and Virginia shores of the Potomac.

Land use policies of the various counties and the municipality (Colonial Beach) adjacent to the PRTR will steer this anticipated residential growth to areas each community considers appropriate. In Maryland, communities' master plans must conform to the state's Eight Visions of Smart Growth (see Section 3.1.2.2). Among these visions are the following goals: concentrating development in suitable areas; protecting sensitive areas; directing growth to existing population centers; conserving resources; encouraging economic growth; and assuring appropriate public infrastructure is in place where growth is to occur. In Virginia, county and local comprehensive plans conform to the Code of Virginia, which states the purpose of such plans as "guiding and accomplishing a coordinated, adjusted and harmonious development of the territory which will, in accordance with present and future needs and resources, best promote the

public health, safety, morals, order, convenience, prosperity and general welfare of the inhabitants."

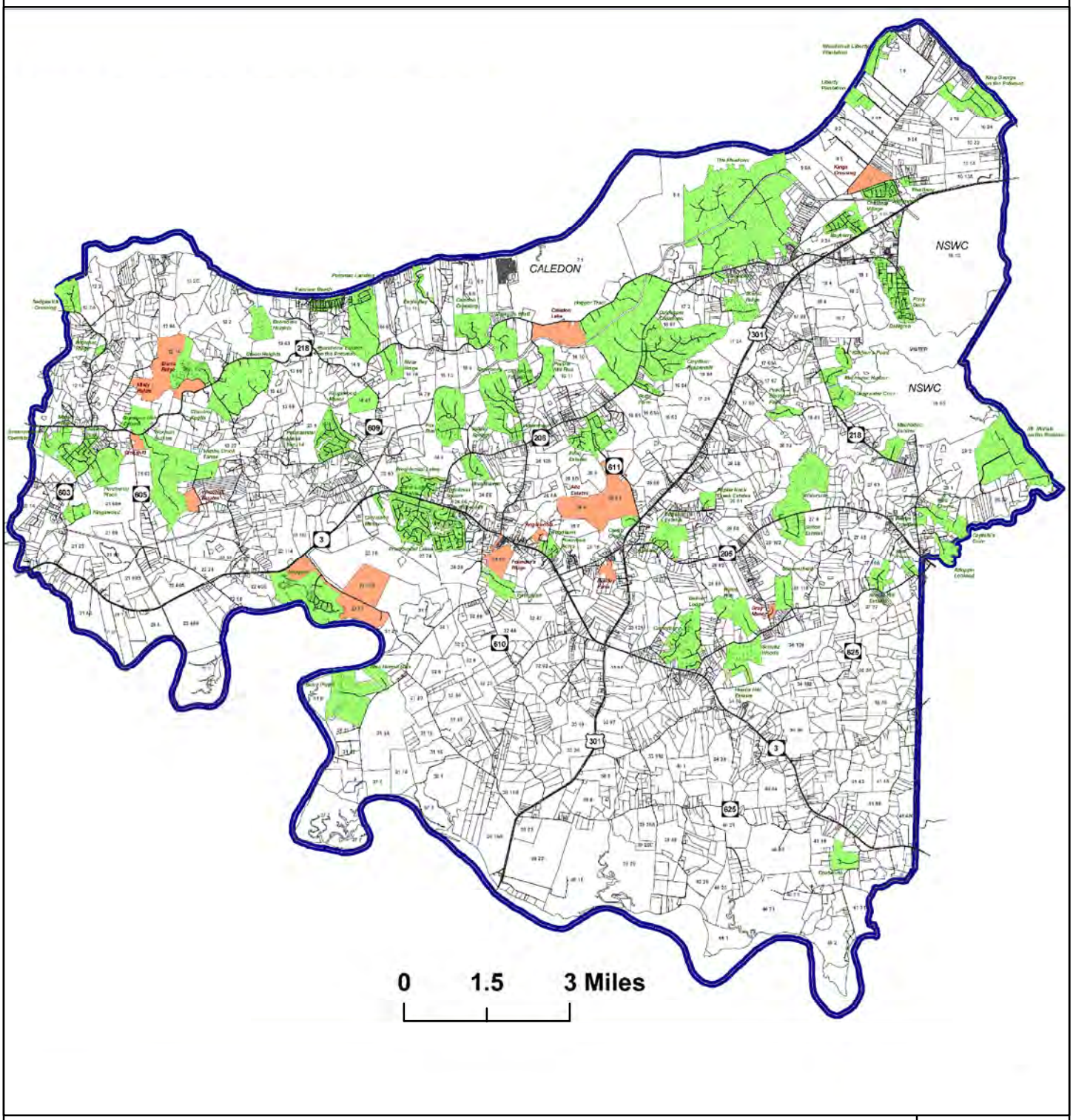
The comprehensive plans of all five study-area counties aim to direct most anticipated growth to specific areas (growth areas) already served by county services and to discourage sprawl. In order to assess the potential role that NSF Dahlgren has played in housing development and prices, it is most relevant to examine the counties in closest proximity to NSF Dahlgren and the active MDZ.

The 2000 Census revealed that of the workers of King George County, 32 percent lived and worked in the county, 40 percent were in-commuters, and 27 percent were out-commuters (with only 6 percent of these out-commuters working in Washington, DC) (Virginia Employment Commission, 2012). The Navy at NSF Dahlgren is the largest employer in the county and accounts for much of the in-commuting. Growth rates in the county have been substantial over recent decades, with a 29 percent increase in housing units (1,540 units) from 1990 to 2000, and a further 39 percent (2,657 units) from 2000 to 2010 (US Census Bureau, 2011, Census 1990, DP-1 General Population and Housing Characteristics 1990; Census 2000, QT-H4 Physical Housing Characteristics 2000; Census 2010, QT-H1 General Housing Characteristics 2010).

In King George County, the designated growth areas are referred to as "primary settlement areas" (King George County Planning Commission, 2006). The area near NSF Dahlgren is designated as one of these. The 2006 comprehensive plan anticipates the development of 3,800 new housing units by 2020 and considers their allocation under a "trend scenario" and a "compact scenario." The former assigns 50 percent of growth to the primary settlement areas and 50 percent to rural areas, while the compact scenario assigns 90 percent to the primary settlement areas. The compact scenario assumes 1,710 ac for higher-density development (at 0.5 units per ac) and 1,900 rural ac (at 5 ac per unit). The trend scenario would allocate 9,500 rural ac and 950 ac of higher-density areas to accommodate the anticipated growth. Adjusting to allow for efficient markets (a factor of three) and for non-residential land needs (10 percent, or 100 ac), the 2006 comprehensive plan foresees requiring 2,950 ac in the primary settlement areas under the trend scenario and 5,230 ac under the compact scenario – or, roughly 4.6 sq mi and 8.2 sq mi, respectively. Using an estimate for new housing units in 2030 and the same method for analyzing potential future land demand as used in the 2006 plan, the 2012 draft comprehensive plan (King George County, 2012) anticipates a need for 4.9 sq mi in the primary settlement areas under the trend scenario and 10.5 sq mi under the compact scenario. Both the 2006 current (adopted) and 2012 draft plans note that 10 sq mi are available for future development in the primary settlement planning areas, providing sufficient land for these demand estimates (King George County Planning Commission, 2006; King George County, 2012). These data indicate that anticipated housing growth in King George County can be accommodated in an efficient and smart-growth manner.

Recent residential development in the county has not been deterred by NSWCDD's activities, as evidenced by the high growth rates noted above. Moreover, the fact that the county has designated the area near NSF Dahlgren as a growth area implies that the local policymakers, who are familiar with the area, are not deterred by the Navy's testing activities. Figure 4.2-2 (King George County Subdivisions) shows existing subdivisions and those under review. Several subdivisions are on the water near NSF Dahlgren, notably Mt. Morieh on the Potomac and King George on the Potomac. The figure also shows that no major subdivisions are proposed on the waterfront of King George County. In part this may be because of a tightening of Virginia's

King George County Subdivisions



EXISTING LARGE SUBDIVISIONS

SUBDIVISIONS UNDER REVIEW

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: Department of Community Developement, King George County, Virginia. 09/10. www.king-george.va.us

Figure 4.2-2

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regulations under the Chesapeake Bay Preservation Act, with its goals of promoting clean waters in the state. Under these regulations, King George County has designated a 100-ft buffer from tidal wetlands as a *resource protection area,* where development is restricted to water-dependent uses or the redevelopment of already-developed areas. The entire remainder of the county is designated a *resource management area*.

The town of Colonial Beach, adjacent to King George County and in Westmoreland County, also has experienced substantial residential growth in recent years, including about 330 units at Monroe Point, 751 units on Virginia Route 205, and the proposed development of Potomac Crossing with 913 units, a golf course, and commercial space. However, in October, 2007, Potomac Crossing was put on hold (see Section 3.1.2.5) and has remained on hold (Colonial Beach Virginia Attractions, 2011). It appears, therefore, that although NSWCDD's activities have not deterred development in the past, the current economic downturn is deferring some planned growth.

In Charles County, the 2006 comprehensive plan provides for a "development district" located in the northern part of the county (Charles County, 2006). The part of the county along the Potomac River is largely designated as an "agricultural conservation" district. Exceptions are the area immediately around the Harry Nice Bridge (with Mirant's Morgantown Power Plant to the south and a business district to the north) and the "mixed use" district associated with the Swan Point development. The Villages at Swan Point project, sponsored by US Steel Corporation and Brookfield Homes Corporation, began as a high-end waterfront and golf resort community in 1986. An expansion is presently planned, providing for an additional 1,500 homes along with a hotel on the Weir Peninsula, a private beach, retail shops and restaurants along the Potomac shoreline, and a 150-slip marina on the Potomac River at Weir Creek (Degregorio, 2006; McConaty, 2007a, b). Although the project has been approved – after a lengthy review because it is in a critical waterfront area – initiation of construction of all components of the development has been delayed because of the state of the economy and the housing market. Construction is expected to start in 2012 (Lannin, pers. comm., July 27, 2010).

One possible foreseeable consequence of increased population encroachment with no economic affiliation to NSF Dahlgren is the potential for a growing negative reaction to the Navy's activities, and particularly to the noise associated with them. Increases in noise complaints can be expected, not from an increase in Navy activity, but rather from a changing population with little relationship to NSF Dahlgren. Although it would be a "self-created" hardship for new residents who choose to locate near NSWCDD's testing facilities, it is likely to create additional issues for the Navy's public relations in the future. Conceivably, dissatisfaction with NSF Dahlgren as a neighbor could nominally depress property values in the area and dampen the rate of future residential development.

However, to monitor and control noise from its outdoor RDT&E activities and, thereby, reduce noise complaints from surrounding communities, NSWCDD has developed and implemented a noise management process. The process is described in Section 3.5.3.5 and included in full in Appendix C. Implementation of the noise management process is expected to minimize noise impacts and noise complaints resulting from NSWCDD outdoor RDT&E activities and effectively preclude noise-related effects on property values and future residential development.

4.2.1.3 Environmental Justice and the Protection of Children

Assessments of environmental justice and protection of children are intertwined with other environmental topics. In particular, air emissions, noise emissions, health and safety issues, and water discharges from the Proposed Action may affect the quality of air, health and safety, and water resources in communities surrounding NSF Dahlgren and the PRTR. The effects of air emissions from RDT&E activities are addressed in Section 4.4, and the effects of noise are addressed in Section 4.5. The effects to public health and safety are addressed in Section 4.8 and the effects on water quality are addressed in Section 4.10.

Geographic Distribution

Baseline conditions for an environmental justice (EJ) review are presented in Section 3.2.4. Populations or communities of concern (COCs) are identified at the census tract level, with 22 of the 49 census tracts in the two Maryland counties identified as minority COCs. Of the 13 census tracts in the three Virginia counties, 3 are defined as minority COCs. Figure 3.2-2 shows the locations of the minority-defined COCs.

Three of the 22 minority COCs in the two Maryland counties are on the Potomac River, but distant from NSF Dahlgren and 25 river miles upriver from the upstream limit of the UDZ. The 3 minority COCs in the three Virginia counties – census tract 401, which is occupied by NSF Dahlgren, and census tracts 202 and 101 – are adjacent to the river and the PRTR.

Fifteen of the census tracts in Maryland and 5 of those in Virginia are defined as low-income COCs. Figure 3.2-3 shows the locations of the low-income COCs. Three of the 15 low-income COCs in Maryland are on the Potomac River, in Charles County. One of these COCs is distant from NSF Dahlgren and more than 25 river miles upriver from the UDZ. However, census tract 8504, in Charles County, is only approximately 4.9 miles from NSF Dahlgren and just 3.5 river miles upriver from the UDZ; and tract 8512, also in Charles County, is across the river from NSF Dahlgren, adjacent to the MDZ. Of the 5 low-income COCs in Virginia, one is about 5.9 miles from NSF Dahlgren and 9.2 river miles upriver from the UDZ, sufficiently distant to not be adversely affected by NSWCDD's RDT&E activities – see, for example, the peak noise level contours shown in Figures 3.5-5, 3.5-6, and 3.5-7. On the other hand, census tract 402 in King George County is immediately landward of the tract occupied by NSF Dahlgren; census tracts 104 and 103 in Westmoreland County are on the Potomac River and adjacent to the MDZ; and tract 202 in Northumberland County is on the river, adjacent to the lower LDZ.

As a result of the geographic distribution of COCs outlined above, the following minority and low-income census tracts on the Virginia and Maryland shores of the Potomac are of particular interest for the purposes of this evaluation, as they comprise the minority and low-income COCs at greatest risk of being adversely affected by the activities that comprise the Proposed Action:

Minority COCs

- 401 in King George County, Virginia
- 101 in Westmoreland County, Virginia
- 202 in Northumberland County, Virginia

Low-income COCs

- 8504 and 8512 in Charles County, Maryland
- 402 in King George County, Virginia
- 104 and 103 in Westmoreland County, Virginia
- 202 in Northumberland County, Virginia (also a minority COC)

With respect to Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, Section 3.2.5 describes the executive order and its requirements, and the use of 2010 Census data on children under 18 to identify any concentrations of minors. On average, such persons represented 25.7 percent of their respective tract populations. A meaningfully higher percentage of 10 points higher than this average – i.e., 35.7 percent – was set to identify any unusual concentrations of children.

Eleven of the census tracts in Maryland within the study area and two in Virginia were identified as having higher-than-average concentrations of children, as shown in Figure 3.2-4. None of these tracts in Maryland are adjacent to the Potomac River. Both tracts in Virginia are adjacent to the Potomac River and the PRTR—one adjacent to the MDZ and the other adjacent to the lower LDZ. As a result of this geographic distribution, the following census tracts on the Virginia shore of the Potomac are of particular interest for the purposes of this evaluation, as they have concentrations of children at greatest risk of being adversely affected by Proposed Action activities:

- 103 in Westmoreland County, Virginia
- 201 in Northumberland County, Virginia

Environmental Justice and Protection of Children Effects

Based on the analysis presented in this EIS on air quality, noise, public health and safety, and water resources associated with the No Action Alternative, the following conclusions are presented in regard to human health and environmental effects to minority populations, low-income communities, and concentrations of children:

- Air Quality – NSF Dahlgren's annual air emissions levels would not exceed the Title V major source threshold, and the facility would continue to operate under a state operating permit for stationary air emissions. With respect to simulant vapors emitted during chemical defense activities, based on the low toxicity of the simulants selected for testing, short exposure duration of simulants, restrictions on access to test areas, likely overestimate of simulant concentrations in modeling predictions, and the requirement that anyone potentially exposed to elevated concentrations would be equipped with personal protective equipment, adverse impacts from exposure to chemical simulants would be none to negligible. No Action Alternative RDT&E air emissions would not result in disproportionately high and adverse human health or environmental effects on minority or low-income populations, or pose disproportionate environmental health or safety risks to children.
- Noise – Based on the distribution and magnitude of noise impacts, noise from ordnance activities would affect some communities immediately adjacent to the PRTR MDZ, such as Potomac Beach, Colonial Beach, Swan Point, Cobb Island, and Coltons Point.

However, No Action Alternative RDT&E noise would not result in disproportionately high and adverse human health or environmental effects on minority or low-income populations, or pose disproportionate environmental health or safety risks to children – everyone living in these communities would be exposed equally.

- Health and Safety – RDT&E activities are conducted in accordance with Navy policies, carefully-conceived management controls, and operation-specific risk hazard assessments and standard operating procedures (SOPs) implemented to ensure safety to both participants and non-participants, including children. The No Action Alternative RDT&E activities would not result in disproportionately high and adverse human health or environmental effects on minority or low-income populations, or pose disproportionate environmental health or safety risks to children.
- Water Resources – No Action Alternative RDT&E activities would have little contact with surface water resources and minimal potential to affect them, and do not pose health or environmental risks.

Therefore, no disproportionately high and adverse human health or environmental effects on minority populations and low-income populations would occur. The RDT&E activities conducted by NSWCDD would not pose disproportionate environmental health or safety risks to children. As noted in the preceding discussion, the No Action Alternative would not alter existing conditions in the study area.

4.2.2 Alternative 1

Alternative 1 is described in Section 2.5. The use of large-caliber guns would remain at current levels, but small-arms firing would increase from 6,000 bullets to 25,500 bullets annually, and detonations would increase slightly, from 190 to 200 events. The number of EM energy events would increase by about 20 percent – from the current 490 to 590 annually. There would be substantial increases in tests using lasers (from 60 to 125 events) and chem/bio simulants (from 12 to 60 events). PRTR use would increase to 870 hours a year, or 16 percent more than the 750 hours under the No Action Alternative. Most range usage would be in the MDZ, as at present. Access to all or part of the UDZ and/or the LDZ would be restricted approximately two days a year for operations involving vessels and aircraft. Access to the upper LDZ to 40,000 yards from the firing line would be restricted up to ten days a year. In addition, some activities would take place outside the normal hours – Monday to Friday, 8 am to 5 pm – and would occur at dawn, dusk, and night, in order to test the performance of systems under all kinds of weather and light conditions.

4.2.2.1 Demographics

The projected future population in the study area, discussed in Section 4.2.1.1, would be unchanged as a result of the Navy's actions under Alternative 1. As no significant increase in NSWCDD outdoor RDT&E personnel is anticipated, there would be no infusion of additional households as a consequence of implementing the alternative. The Navy's activities on the PRTR have been shown not to have deterred past population growth in the study area, and the increases

in RDT&E activity levels under this alternative are unlikely to alter this pattern more than nominally. Alternative 1 would have no direct or indirect impact on demographics.

4.2.2.2 Economic Impacts

Economic factors, including marine-related economic activity and real estate, were examined for no action conditions in Section 4.2.1.2. The additional hours during which access to the PRTR would be restricted under Alternative 1 are not expected to materially alter the conditions for marine commercial freight movements, commercial fishing, or recreational boating on the Potomac River. Recreational boating and fishing would likely be minimally affected by any dawn, dusk, or night-time activities because they would be advertised well in advance (see also the discussion in Section 4.1.2.2). The commercial vessels using the main channel would continue to be subject to the minimal delays – typically 30 minutes, but possibly up to about an hour – they currently endure when the range is in use.

The increase in use of the upper LDZ for firing (up to ten days a year) and some or all of UDZ and LDZ for approximately two days a year, would, however, extend restrictions to areas that have been restricted for NSWCDD's activities infrequently in recent years. The restrictions would inconvenience river users not used to restrictions in these areas, causing them delays. These slight impacts would be minimized as described above by advertising restrictions well in advance and by the ROC's working with vessels to minimize delays.

Although the use of coal barges for the Mirant plant at Morgantown is expected to grow, the plant would require only four or five barges per week, which, as indicated in Section 4.2.1.2, would constitute an increase in vessel traffic of less than four percent. Actual coal deliveries vary and are very limited at this time – the majority of coal deliveries are by rail and, based on current market conditions, likely will remain so for the foreseeable future (Allen, pers. comm., June 3, 2010).

Real estate development in the area has been undaunted by the Navy's activities on the PRTR, as evidenced by the residential waterfront development that has already occurred close to NSF Dahlgren in King George County and in Colonial Beach, as well as by the proposed expansion of the luxury waterfront resort community of the Villages at Swan Point in Charles County. Ongoing efforts by the states and counties to steer future growth away from the sensitive waterfront areas to designated growth areas more appropriate for development and better served by infrastructure and amenities should ameliorate potential problems from residential "encroachment" close to the PRTR. However, the expansion of RDT&E activities outside the normal scheduling days and times of Monday to Friday, 8 am to 5 pm, along with the slight increase in detonations, may generate some quality-of-life concerns from residents. Residents are often concerned with noise from guns; however, Alternative 1 proposes no increase in large-caliber gun activities. Despite the more-than-threefold increase in the number of bullets fired in small arms events, such firings have a small noise impact area, almost entirely confined to the installation itself, and so are unlikely to contribute to quality-of-life concerns. The other activities with large annual increases – involving EM energy, lasers, and the use of chem/bio simulants – would generate little to no increase in noise impacts. Nearby residents would be unlikely to notice most of these tests.

Alternative 1 would have no direct and negligible, long-term, indirect, negative impacts on real estate development; and minor, short-term, direct and minor, long-term, indirect, negative impacts on marine commerce.

4.2.2.3 Environmental Justice and Protection of Children

Based on the analysis presented in this EIS on air quality, noise, public health and safety, and water resources associated with Alternative 1, the following conclusions are presented in regard to human health and environmental effects to minority populations, low-income communities, and concentrations of children:

- Air Quality – NSF Dahlgren's annual emissions levels would not exceed the Title V major source threshold, and the facility would continue to operate under a state operating permit for stationary air emissions. With respect to simulant vapors emitted during chem/bio testing, based on the low toxicity of the simulants selected for testing, short exposure duration of simulants, restrictions on access to test areas, likely overestimate of simulant concentrations in modeling predictions, and the requirement that anyone potentially exposed to elevated concentrations would be equipped with personal protective equipment, adverse impacts from exposure to chemical simulants would be none to negligible. Alternative 1 RDT&E air emissions would not result in disproportionately high and adverse human health or environmental effects on minority or low-income populations, or pose disproportionate environmental health or safety risks to children.
- Noise – Based on the distribution and magnitude of noise impacts, noise from ordnance activities would affect some communities immediately adjacent to the PRTR MDZ, such as Potomac Beach, Colonial Beach, Swan Point, Cobb Island, and Coltons Point. However, Alternative 1 RDT&E noise would not result in disproportionately high and adverse human health or environmental effects on minority or low-income populations, or pose disproportionate environmental health or safety risks to children – everyone living in these communities would be exposed equally.
- Health and Safety – RDT&E activities are conducted in accordance with Navy policies, carefully-conceived management controls, and operation-specific risk hazard assessments and SOPs implemented to ensure safety to both participants and non-participants, including children. Alternative 1 RDT&E activities would not result in disproportionately high and adverse human health or environmental effects on minority or low-income populations, or pose disproportionate environmental health or safety risks to children.
- Water Resources – Alternative 1 RDT&E activities would have little contact with surface water resources and minimal potential to affect them, and do not pose health or environmental risks.

Therefore, no disproportionately high and adverse human health or environmental effects on minority populations and low-income populations would occur. The RDT&E activities conducted by NSWCDD would not pose disproportionate environmental health or safety risks to children.

4.2.3 Alternative 2

Alternative 2 is described in Section 2.6. The use of large-caliber guns would remain at current levels; the number of detonation events would increase from the current 190 to 230 annually, or by about 21 percent; small-arms firing would increase from the current 6,000 to 30,000 bullets annually. The number of annual events involving EM energy would increase by about 40 percent, lasers by about 140 percent, and chem/bio simulants by more than 480 percent from current levels. PRTR usage would increase noticeably, to 1,000 hours a year, or 33 percent from the 750 hours under the No Action Alternative. Most range usage would be in the MDZ, as at present, but restrictions would be in place on the LDZ approximately two days every year for tests of integrated systems, involving multiple vessels and aircraft. Access to the upper LDZ to 40,000 yards from the firing line would be restricted for firing up to a maximum of ten days a year. In addition, some activities would take place outside the normal hours—Monday to Friday, 8 am to 5 pm—and would occur at night in order to test the performance of systems under all kinds of weather and light conditions.

4.2.3.1 Demographics

The projected future population in the study area, discussed in Section 4.2.1.1 would be unchanged as a result of the Navy's actions under Alternative 2. As no significant increase in NSWCDD's outdoor RDT&E personnel is anticipated under this alternative, there would be no infusion of additional households as a consequence of its implementation. The Navy's activities on the PRTR have been shown not to have deterred past population growth in the study area, and the increases in RDT&E activity levels under this alternative are unlikely to alter this pattern more than nominally. Alternative 2 would have no direct or indirect impact on demographics.

4.2.3.2 Economic Impacts

Economic factors, including marine-related economic activity and real estate, are described in Section 4.2.1.2. The difference in annual hours of river range usage can be expected to have some effect on marine commercial freight movements, commercial fishing, and recreational boating on the Potomac River. Average annual restriction of the range under existing and no action conditions would be 750 hours, or about 8.6 percent of the hours in a year. Under Alternative 2, this would increase to 1,000 hours, or about 11.4 percent. Except for approximately ten days a year when restrictions would apply to the upper LDZ, and two days a year when the restrictions would apply to the UDZ and the LDZ, the MDZ would be the part of the PRTR restricted. For many of these hours, however, the full MDZ is not restricted. For example, when directed energy or lasers are being emitted across Upper Machodoc Creek, much of the MDZ would not be restricted, and large vessels could use the shipping channel and commercial fishermen could cross the river. Nevertheless, this is a discernible increase and would add some inconvenience to commercial and recreational river users. The small amount of commercial freight shipping on the Potomac would experience on an annual basis an increase in the number of occasions that vessels are delayed from moving through the PRTR. However, given that typical delays are only about 30 minutes, these negative impacts would be minor and are not considered significant economic impacts to these users.

Recreational boating and fishing are also unlikely to be significantly affected by the increased hours of operation and would be relatively unaffected by testing at night or in adverse weather conditions that would drive small boats off the river. Testing of lasers at dusk and dawn would be announced in advance, minimizing impacts (see also Section 4.1.3.2 for potential impacts to recreational boating). Potential impacts to fishing and recreational boaters are unlikely to generate significant economic impacts to these users.

As noted in the case of the other alternatives, real estate development in the area has been undeterred by the Navy's activities on the PRTR, as evidenced by recent residential waterfront development that has already occurred close to NSF Dahlgren in King George County and in Colonial Beach as well as by the proposed expansion of the luxury waterfront resort community of the Villages at Swan Point in Charles County. Ongoing efforts by the states and counties to steer future growth away from the sensitive waterfront areas and into designated growth areas that are more appropriate for development and better served by infrastructure and amenities should ameliorate potential problems from residential "encroachment" close to the PRTR.

The additional hours of annual use of the PRTR are unlikely to alter recent trends. Quality-of-life comments from residents have noted noise from guns as being the principal concern, but Alternative 2 proposes an increase only in small-arms tests, which have limited noise impact areas. A 21-percent increase in detonations annually (40 more detonations) would add sporadic booms, but many of the detonations would be small and go unnoticed. The proposed increases in activities involving EM energy, lasers, and the use of bio/chem simulants would generate little to no noise, and nearby residents would be unlikely to notice most of these tests. Consequently, minimal effect on real estate markets is anticipated from implementing Alternative 2.

Alternative 2 would have no direct and negligible, long-term, indirect, negative impacts on real estate development; and minor, short-term, direct and minor, long-term, indirect, negative impacts on marine commerce.

4.2.3.3 Environmental Justice and Protection of Children

Based on the analysis presented in this EIS on air quality, noise, public health and safety, and water resources associated with Alternative 2, the following conclusions are presented in regard to human health and environmental effects to minority populations, low-income communities, and concentrations of children:

- Air Quality – NSF Dahlgren's annual emissions levels would not exceed the Title V major source threshold and the facility would continue to operate under a state operating permit for stationary air emissions. With respect to simulant vapors emitted during chem/bio testing, based on the low toxicity of the simulants selected for testing, short exposure duration of simulants, restrictions on access to test areas, likely overestimate of simulant concentrations in modeling predictions, and the requirement that anyone potentially exposed to elevated concentrations would be equipped with personal protective equipment, adverse impacts from exposure to chemical simulants would be none to negligible. Alternative 2 RDT&E air emissions would not result in disproportionately high and adverse human health or environmental effects on minority or low-income populations, or pose disproportionate environmental health or safety risks to children.

- Noise – Based on the distribution and magnitude of noise impacts, noise from ordnance activities would affect some communities immediately adjacent to the PRTR MDZ, such as Potomac Beach, Colonial Beach, Swan Point, Cobb Island, and Coltons Point. However, Alternative 2 RDT&E noise would not result in disproportionately high and adverse human health or environmental effects on minority or low-income populations, or pose disproportionate environmental health or safety risks to children – everyone living in these communities would be exposed equally.
- Health and Safety – RDT&E activities are conducted in accordance with Navy policies, carefully-conceived management controls, and operation-specific risk hazard assessments and SOPs implemented to ensure safety to both participants and non-participants, including children. Alternative 2 RDT&E activities would result in disproportionately high and adverse human health or environmental effects on minority or low-income populations, or pose disproportionate environmental health or safety risks to children.
- Water Resources – Alternative 2 RDT&E activities would have little contact with surface water resources and minimal potential to affect them, and do not pose health or environmental risks.

Therefore, no disproportionately high and adverse human health or environmental effects on minority populations and low-income populations would occur. The RDT&E activities conducted by NSWCDD would not pose disproportionate environmental health or safety risks to children.

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4.3 Utilities

4.3.1 No Action Alternative

Under the No Action Alternative, carrying out ordnance, EM energy, laser, and chemical defense activities would not increase demand for utilities above existing levels. Therefore, there would be no additional impact to the utility systems that support the installation and its tenants, including NSWCDD. NSWCDD's current power requirements are being adequately supplied by the power grid and NSF Dahlgren's auxiliary generators. Therefore, the No Action Alternative would not directly or indirectly impact utility systems.

4.3.2 Alternative 1

4.3.2.1 Electricity

Under Alternative 1, increased ordnance and chem/bio defense activities would not result in increased demand for electricity and would have no impact on the installation's electrical system.

The EM energy and HE laser events included under the alternative and the gradually-increasing power levels used during these events would generate more demand for electrical power. The planned new Dominion Virginia Power (DVP) 230 kV transmission line and substation, scheduled to begin construction in 2013 and to be completed in 2014 (DVP, 2011), would meet these power needs.

Given the planned completion and energizing of the new DVP 230 kV transmission line and substation in 2014, Alternative 1 would have no direct and negligible, long-term, indirect impacts on the Virginia power grid or the NSF Dahlgren electrical system.

4.3.2.2 Water and Wastewater

Under Alternative 1, there would be no significant increase in personnel and, therefore, no increase in the demand for potable water. Likewise, while there would be an increase in outdoor RDT&E activities, none of these activities would require additional water. Therefore, the installation's three deep-water wells would not be affected and would continue to provide the base with ample drinking and domestic water.

Because there would be no personnel or operational needs for additional water, there would be no increase in the production of wastewater. The Navy-owned municipal sewage treatment plant located at the southern end of Mainside would not be affected and would continue to meet current and future wastewater requirements.

4.3.2.3 Other Utilities

None of the other utilities listed in Section 3.3.3 would be affected by the implementation of Alternative 1.

4.3.3 Alternative 2

4.3.3.1 Electricity

Under Alternative 2, increased ordnance and chem/bio defense activities would not generate increased demand for electricity and, therefore, would have no impact on the installation's electrical system.

As under Alternative 1, the EM energy and HE laser events under Alternative 2 and the gradually-increasing power levels used would require more electricity. The amount of power required for the proposed activities would become clearer as RDT&E progresses. Because only the number of events, not the type, would change, Alternative 2 would not generate a greater maximum demand per event than Alternative 1. Although the total amount of electricity consumed in the future will depend on the RDT&E testing undertaken and therefore cannot be predicted accurately, it is expected that the amount consumed every year would be slightly greater. The planned new DVP 230 kV transmission line and substation, scheduled to begin construction in 2013 and to be completed in 2014 (DVP, 2011), would meet these power needs.

Given the planned completion and energizing of the new DVP 230 kV transmission line and substation in 2014, Alternative 2 would have no direct and negligible, long-term, indirect impacts on the Virginia power grid or the NSF Dahlgren electrical system.

4.3.3.2 Water and Wastewater

As described for Alternative 1 (Section 4.3.2.2), there would be no impacts on the installation's water or wastewater systems.

4.3.3.3 Other Utilities

None of the other utilities listed in Section 3.3.3 would be affected by the implementation of Alternative 2.

4.4 Air Quality

This section provides an assessment of the potential environmental impacts that would result from implementing the alternatives on stationary and mobile and other sources (chem/bio simulants). As described in Section 3.4.3, the potential effects of proposed greenhouse gas emissions change is discussed in the context of cumulative impacts in Chapter 5, as individual sources of greenhouse gas emissions are not large enough to have any noticeable effect on climate change.

4.4.1 No Action Alternative

4.4.1.1 Stationary and Mobile Sources

Under the No Action Alternative, air quality at NSF Dahlgren would remain the same as it is at present for stationary, mobile, and other sources. NSF Dahlgren's annual emissions levels do not currently exceed the Title V major source threshold of 100 tons per year for any individual criteria pollutant. NSF Dahlgren would continue to operate under a state operating permit that covers stationary emission sources on the installation. The No Action Alternative would have negligible long-term, direct and indirect, negative impacts on air quality.

4.4.1.2 Other Sources (Chemical Simulants)

NSWCDD is performing RDT&E activities on chem/bio detectors, decontaminants, and collective protection (COLPRO) systems under the DoD Chemical and Biological Defense Program (CBDP), as described in Section 2.1.4. These simulants, many of which are everyday compounds (see Section 3.8), are not hazardous air pollutants. Under the No Action Alternative chemical simulants of low toxicity would continue to be released as a vapor or mist over the MDZ. As noted in Section 3.4, these chemical simulants are not considered to be criteria pollutants under the Clean Air Act (CAA).

The detection systems used during activities using simulants are passive infrared spectrometers that detect vapors only. Clouds of simulant vapor need to be generated to test detection systems and thus achieve the desired test objectives. The ability to generate simulant clouds of vapor and very fine airborne liquid aerosol particles that will readily evaporate has already been demonstrated by previous tests (NSWCDD, 2003) using the same or similar simulant- delivery systems that would be continued to be used for simulant releases on the MDZ.

Assessments completed for chemical simulant testing performed by NSWCDD using some of the same chemical simulants showed no significant impacts and there were no observable environmental effects during or after testing (NSWCDL, 2004; Bossart, letter, February 9, 2006; NSWCDL, 31 July 2009). In addition, to monitoring performed during testing, chemical simulant modeling is performed prior to testing, as described below.

Chemical Simulant Dispersion Modeling

Air quality analyses for potential impacts from other sources (chemical simulants) are based on dispersion modeling of the chemical simulants that have been or are proposed to be released during RDT&E events.

Atmospheric dispersion of chemical simulants was modeled based on established testing methods and protocols used at NSWCDD. The analysis used the DoD-approved Vapor, Liquid, and Solid Tracking Model (VLSTRACK: Version 3.2.3) to calculate the air concentration and deposition levels resulting from the proposed testing. VLSTRACK is based on a Gaussian plume dispersion algorithm. Using this model, the simulant concentration at various points in time and distance from the release point can be predicted, along with the amount of each simulant that will be deposited on the water's surface within the MDZ. The modeling used a range of inputs for each parameter (see text box), including testing four release quantities, two release heights, three different atmospheric conditions (wind speeds), two temperatures, and two droplet sizes.

Release Quantities

A typical simulant test involves the release of approximately 10 gals of simulant, but the amount varies from a few ounces up to a maximum of 20 gals of simulant, with the larger quantities of 20 gals used primarily for whole-vessel tests that would occur infrequently. The amount of simulant used is the minimum amount needed to test the lowest level of simulant the sensor can detect. Quantities of 1.5, 5, 10, and 20 gals were used as modeling inputs.

Release Height and Method

One method of testing on the MDZ uses a pressurized spray tank or multiple tanks mounted on the release boat for dissemination of liquid simulants. The pressurized sprayer is mounted to the top of a ducting tube, at heights of about 6 ft or 40 ft. The blower and simulant spray tank are located on the deck of the simulant release boat. The simulant transfer line from the spray tank connects to an atomizing aerosol spray nozzle at the top of the duct and the nozzle releases the liquid simulants into the air as very fine aerosols or vapor. The blower discharge and spray nozzle also can be directed upward so that the fine aerosols are carried more than 40 ft above the water. Gases used for calibration, such as R-134 and R-152a, are disseminated directly from compressed gas cylinders. Chemical simulants are released over a maximum duration of a few minutes. Testing of 1.5 gals can be sprayed from a lower height of 6 ft.

Simulant Modeling Assumptions

Quantity: 1.5, 5, 10, and 20 gals.

Release height: 6 ft or 40 ft.

Atmospheric conditions: 1 mile per hour (mph) (0.5 meters per second [m/s]), 5 mph (2.25 m/s), and 10 mph (4.5 m/s)

Temperature: 65 and 85°F

Droplet size: 7 and 72 micron mass median diameter (MMD)

Simulant releases are conducted in such a manner as to ensure that no personnel or other individuals are exposed to concentrated simulant vapor or aerosol during or after release. During simulant releases, the simulant release boat generally heads into the wind. Upon completion of the simulant release, the release boat stays clear of the simulant release area until sufficient time has elapsed for the simulant to disperse. The existing standard operating procedure (SOP) calls for simulant releases to be spaced so that no area is exposed multiple times to the same simulant (NSWCDL, 15 July 2009).

Typically, for tests over water, less than 20 gals of a simulant would be released by boat at a height of approximately 40 ft. Simulant could also be released over land or water by a helicopter-mounted or UAV-mounted sprayer system at a height of about 300 ft to test chemical simulant decontamination and contamination avoidance equipment, similar to tests that have been performed at Naval Weapons Station Charleston, South Carolina (US Navy and US Army, 2001). In this scenario, a specially-designed sprayer tank mounted on a helicopter would spray

chemical simulants onto a vessel. Some simulant coming from the helicopter or UAV spraying over water might enter the river, and cleanup of the test platform (the vessel) would result in some simulant-containing effluent entering the environment. For tests done on the MDZ, the Maryland Department of the Environment (MDE) and the Virginia Department of Environmental Quality (VDEQ) are consulted by the NSWCDD Safety and Environmental Office prior to testing.

Droplet Size

Two types of nozzle configurations were simulated in the modeling conducted to provide estimates of simulant concentrations and deposition:

- A nozzle that generates a droplet mass median diameter (MMD) of 72 microns (to simulate misty conditions).
- For comparison purposes, a smaller nozzle that results in a droplet MMD of seven microns (to simulate maximum vapor concentrations).

Meteorological Conditions

The simulation included modeling at three wind speeds – 1 mph, 5 mph, and 10 mph – to represent neutral, stable, and unstable atmospheric stability categories. Two temperatures – 65° and 85°F – were also modeled to determine the effects of temperature on dispersion and deposition.

Receptor Locations

The model predicts short-term ground-level air concentration and surface deposition levels for every one-minute interval after the chemical simulants would be released and dispersed. Both air concentration and surface deposition levels were tracked down to specific thresholds in order to determine the size of the potential hazard area. The hazard area as defined for the VLSTRACK-modeled scenarios included the area with predicted levels that would exceed:

- 0.1 milligrams per cubic meter (mg/m^3) for ground-level air concentration
- 0.01 milligrams per square meter (mg/m^2) for surface deposition

Ambient Air Quality Impacts

The predicted maximum chemical simulant concentration levels at ground level and the distances to which these concentrations would spread are summarized in Table 4.4-1 for both small and large droplets. Forty-eight modeling scenarios were run for diethyl malonate (DEM) and methyl salicylate (MeS), and 36 modeling scenarios were run for the remainder of the chemical simulants (DMA, DMMP, GAA, and TEP). Each scenario modeled maximum concentrations and dispersal distances using a combination of possible release heights, quantity of simulant, droplet mass median diameter, wind speed, and air temperature. Table 4.4-1 presents the maximum modeled air concentrations from all modeling scenarios. A full listing of concentrations for all runs modeled is provided in Appendix J.

Based on the modeling, the highest concentrations occur close to the release point and well before any simulants reach landfall. No one is allowed close to the release vessel. The forward velocity of the release boat and the fact that the simulant is discharged into the air greatly limits the potential for exposure of the release vessel crew to the simulants. The crews operating the

vessels equipped with the infrared sensors to detect simulants remain well away from the vapor, and both the dispersing vessel and sensor crews are equipped with respirators and protective clothing as an extra safety measure, ensuring that there is no direct exposure of humans to the maximum concentrations of simulants.

Table 4.4-2 provides the maximum concentration for each simulant modeled after 10 minutes from the time of release from all 48 test runs for DEM and MeS and 36 test runs for DMA, DMMP, GAA, and TEP. Simulant concentrations decrease rapidly after release, with concentrations returning to undetectable levels within minutes.

An example of the quick return to background levels is shown in Figure 4.4-1, Decrease in Air Concentration over Time - DEM Test Run Example (Run 029, see Appendix J for summary).

Table 4.4-1
Modeled Maximum Air Concentrations

Chemical	Maximum Concentration (mg/m^3)	Distance from Release Point (ft)	Time from Release (minutes)	Conditions Resulting in Maximum Concentrations
Diethyl malonate (DEM)	20,200	≤33	0.5	1.5 gal, 7 MMD, 1 mph, 85°F (run 028)
Dimethyl adipate (DMA)	12,000	≤33	1.80	20 gal, 7 MMD, 1 mph, 85°F (run 028)
Dimethyl methylphosphonate (DMMP)	2,780	131	2.2	20 gal, 72 MMD, 1 mph, 65°F (run 103)
Glacial acetic acid (GAA)	4,940	197	11	20 gal, 72 MMD, 1 mph, 85°F (run 106)
Methyl salicylate (MeS)	19,300	≤33	0.47	20 gal, 7 MMD, 1 mph, 85°F (run 028)
Triethyl phosphate (TEP)	5,060	164	1.93	20 gal, 72 MMD, 1 mph, 65°F (run 103)

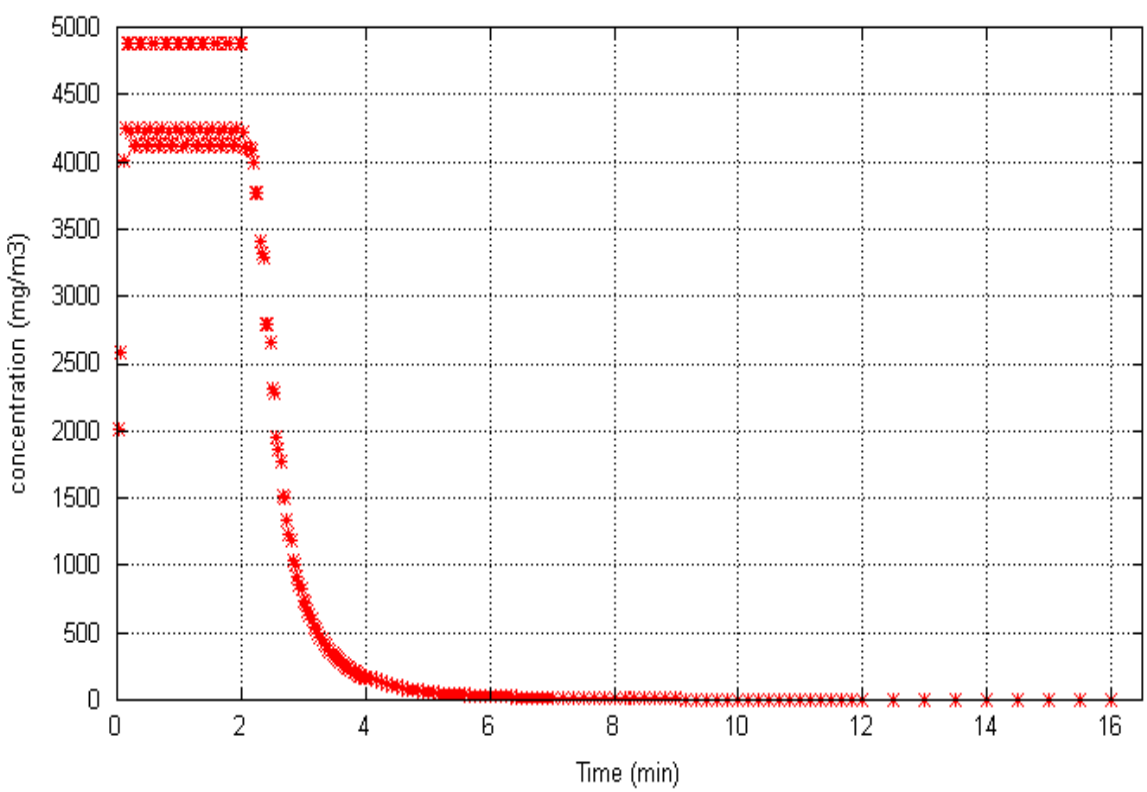
Notes: The maximum concentrations are based on the full range of parameters modeled.
mg/m^3 = milligrams per cubic meter; gal = gallons; MMD = mass median diameter; mph = miles per hour.
≤ 33 indicates that the simulant cloud is predicted to disperse within 33 feet (10 meters).
A full summary of all modeling runs is provided in Appendix J.

Table 4.4-2
Modeled Maximum Air Concentrations after 10 Minutes

Chemical	Maximum Concentration after 10 minutes (mg/m^3)	Distance from Release Point (ft)	Conditions Resulting in Maximum Concentrations
Diethyl malonate (DEM)	1,340	≤33	1.5 gal, 7 MMD, 10 mph, 85°F (run 030)
Dimethyl adipate (DMA)	851	919	20 gal, 7 MMD, 1 mph, 85°F (run 100)
Dimethyl methylphosphonate (DMMP)	801	919	20 gal, 7 MMD, 1 mph, 85°F (run 100)
Glacial acetic acid (GAA)	719	919	20 gal, 7 MMD, 1 mph, 85°F (run 100)
Methyl salicylate (MeS)	1,210	≤33	20 gal, 7 MMD, 10 mph, 85°F (run 030)
Triethyl phosphate (TEP)	726	919	20 gal, 7 MMD, 10 mph, 85°F (run 100)

Notes: The maximum concentrations are based on the full range of parameters modeled (i.e., quantity, droplet diameter, wind speed, and temperature).
mg/m^3 = milligrams per cubic meter; gal = gallons; MMD = mass median diameter; mph = miles per hour.
≤ 33 indicates that the simulant cloud is predicted to disperse within 33 ft (10 meters).
A full summary of all modeling runs is provided in Appendix J.

Figure 4.4-1
Decrease in Air Concentration over Time - DEM Test Run Example (Run 029)



Predicted maximum surface deposition levels are summarized in Table 4.4-3. The surface area with concentrations above 0.01 mg/m^2 using maximum deposition rates range from a fraction of an acre to 63.5 acres. Potential water-quality impacts on aquatic life from these chemical simulants deposited in the PRTR are further discussed in Sections 4.10 through 4.14. The chemicals that would be likely be used to calibrate the detectors – R-134a and R-152a – at normal temperatures are gases. Therefore, no deposition would occur for these chemicals.

Table 4.4-3
Predicted Maximum Surface Deposition Levels

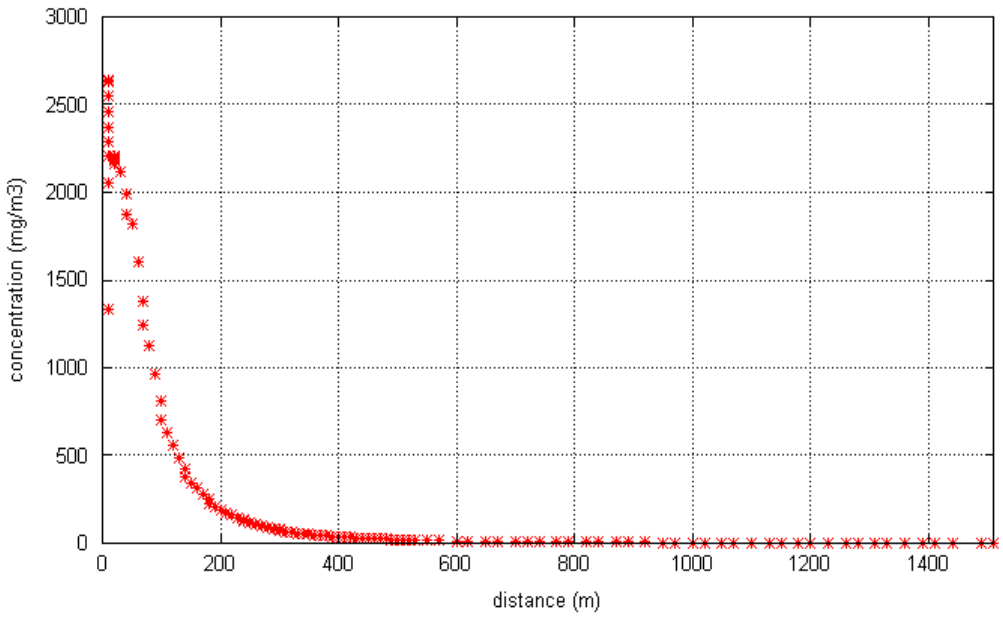
Chemical	Maximum Deposition Level (mg/m^2)	Total Mass Deposition (kilograms)	Surface Area with Concentrations above 0.01 mg/m^2 per km^2 (acres)
Diethyl malonate (DEM)	35,700	2.59	0.0043 (1.06)
Dimethyl adipate (DMA)	119,000	75.9	0.234 (57.8)
Dimethyl methylphosphonate (DMMP)	28.2	0.003	0.00068 (0.17)
Glacial acetic acid (GAA)	99,400	76.7	0.257 (63.5)
Methyl salicylate (MeS)	83,200	59.9	0.0371 (9.16)
Triethyl phosphate (TEP)	0.281	0.0004	0.00145 (0.36)

There is limited toxicity information available on most of the simulants, as these compounds are considered to have low toxicity and have not been the focus of extensive toxicological research. Most laboratory testing of chemical simulants is by exposure routes other than inhalation, such as ingestion – as these compounds are in a liquid state at room temperature – with the exception of the calibration gases. In addition, toxicity values are generally based on long-term exposure to compounds of low toxicity and concentrations of simulants would rapidly disperse so that exposure levels on shore would be at or near background levels within a short time period.

The individuals potentially exposed to higher concentrations of simulants would be limited to personnel associated with the dispersing vessel or structure and the sensor crews, all of whom would be equipped with respirators and protective clothing (NSWCDL, 15 July 2009). Full-face respirators are also worn by personnel while operating pressurized simulant lines or valves, in case of an incidental release (e.g., ruptured line). As shown in Figure 4.4-2, Decrease in Air Concentration over Distance – DEM Test Run Example (Run 027), concentrations of simulants decrease rapidly from the release point. Moreover, maximum concentrations are only present in one direction from the release point. Therefore, people without protective equipment would not be exposed to elevated simulant concentrations.

In addition, actual exposure concentrations of simulants are likely to be lower than predicted based on previous dispersion modeling and field tests conducted by NSWCDD on the PRTR (NSWCDD, 2003; Bossart, letter, February 9, 2006). The modeling results predicted both the airborne and water column concentrations that would result from simulant releases. Field tests indicated that the modeling results exceeded the concentrations that were measured during testing by more than an order of magnitude.

Figure 4.4-2
Decrease in Air Concentration over Distance – DEM Test Run Example (Run 027)



Based on the low toxicity of the simulants selected for testing, short exposure duration to simulants and limited exposure pathways (i.e., access to test area is restricted), likely overestimate of simulant concentrations in modeling predictions, spacing of tests, and the requirement that anyone potentially exposed to elevated concentrations would be equipped with personal protective equipment, adverse impacts from exposure to chemical simulants are considered to be none to negligible.

Summary

Based on the simulant modeling, previous testing, and low toxicity of chemical simulants, continued RDT&E activity involving chemical simulants under the No Action Alternative would result in negligible, long-term, direct and indirect, negative air quality impacts.

4.4.2 Alternative 1

4.4.2.1 Stationary and Mobile Sources

Alternative 1 does not include the construction of any new major stationary sources at NSF Dahlgren. However, the increase in activities from current No Action Alternative levels of 60 to 125 HE laser events per year, and of 490 to 590 EM energy events per year, coupled with an associated increase in power levels needed for testing, may increase the possibility in the future that an additional stationary source of power would be required. As described in Section 3.3, Dominion Virginia Power (DVP) has submitted an application to build a new 230 kV transmission source and substation at NSF Dahlgren. If this new source is built and operated the air permit would be updated. Expanded RDT&E activities under Alternative 1 would have negligible, long-term, direct and indirect, negative stationary source impacts on air quality.

With respect to the weapon operational activities, NSWCDD would:

- Continue to conduct the same number of large-gun firings annually on their operating ranges as under the No Action Alternative.
- Increase explosive detonations from 190 annual events under the No Action Alternative to 200 annual events in EEA Range Complex.
- Increase small-arms firing from 6,000 bullets fired annually under the No Action Alternative to 25,500 bullets fired annually.
- Continue to test rail gun with greater muzzle energy.

The increase of these weapon operational activities would likely increase air emissions over NSF Dahlgren. However, given the small magnitude of increase in firing rounds, slightly expanded weapon testing activities under Alternative 1 would have negligible impacts on air quality.

Clean Air Act General Conformity

As discussed in Section 3.4, NSF Dahlgren is located in an area currently designated as in attainment for all criteria pollutants, within which the general conformity rule does not apply to the Proposed Action. However, the activities in the MDZ within the boundary of Charles County, Maryland, an ozone nonattainment area, are subject to the general conformity rule.

The conformity analysis for the federal action should examine the impacts of the direct and indirect net emissions within the applicable nonattainment area as compared to the baseline condition. Both direct and indirect net emissions should be included in the determination if both of the following apply:

- The Navy can practicably control the emissions and has continuing program responsibility to maintain control.
- The emissions caused by the Proposed Action are reasonably foreseeable.

However, as summarized previously in this chapter, the net emissions resulting from operational activities under Alternative 1, such as increases in small arms firing and explosive detonation in EEA, would not affect those within the PRTR's MDZ nonattainment area as compared to the existing condition. Therefore, no net emissions would occur within the PRTR's MDZ nonattainment area and consequently the general conformity rule does not apply to Alternative 1.

4.4.2.2 Other Sources (Chemical/Biological Simulants)

Under Alternative 1 there would be up to 60 events annually of either chemical or biological simulants released for each event, but chemical and biological simulants would not be mixed. The areas in which the activities would take place would expand from part of the MDZ (depicted in Figure 1-11) to include all of the MDZ, the PRTR land ranges, the EEA, and the Mission Area. None of the chemical simulants used would be criteria pollutants.

Chemical Simulants

The existing SOP calls for simulant releases to be spaced so that no area is exposed multiple times to the same simulant (NSWCDL, 15 July 2009). Testing on the water would continue, as

described under the No Action Alternative. For land tests, a specially designed sprayer tank mounted on a helicopter or UAV would spray chemical simulants onto a land-based platform. Some simulant coming from the helicopter or UAV spraying over water might enter the river or land, and cleanup of the test platform (the vessel) would result in some simulant-containing effluent entering the environment.

For tests done on the MDZ, MDE and VDEQ would be consulted by the NSWCDD Environment and Safety Office prior to testing. If a helicopter-mounted sprayer or UAV were used over land, VDEQ and the Virginia Department of Game and Inland Fisheries (VDGIF) would be consulted prior to testing.

As described for the No Action Alternative, assessments completed for chemical simulant testing performed by NSWCDD showed no significant impacts and there were no observable environmental effects during or after testing (NSWCDL, 2004; Bossart, letter, February 9, 2006; NSWCDL, 31 July 2009). Modeling of chemical simulants that have been used in past indoor or outdoor RDT&E operations indicate that simulants would disperse rapidly and that high concentrations would only be found near the testing area for a short time period.

Future operations might use any of the previously tested simulants or other ones with similar or lesser toxicities. Prior to use, all simulants would be reviewed and approved by the NSWCDD Safety and Environmental Office in consultation with NSF Dahlgren personnel, as applicable, and would only be approved after considering toxicity data relative to the intended quantity and concentration of the simulant to be used.

Under Alternative 1, testing could also be conducted with the introduction of interferents, smokes, or obscurants (e.g., fog oil, PEG 200, poly alpha olephin, paints, fuels, and cleaners). The intended quantity, concentration, and toxicity of the interferent, smoke, or obscurant to be used along with the predicted dispersal would be carefully evaluated prior to use.

Based on the low toxicity of the simulants selected, short exposure duration to simulants and limited exposure pathways (i.e., access to test area is restricted), likely overestimate of simulant concentrations, spacing of tests, and the requirement that anyone potentially exposed to elevated concentrations be equipped with personal protective equipment, adverse impacts from exposure to chemical simulants are considered to be none to negligible.

Chemical simulants are not considered criteria pollutants under the CAA and no quantifiable nonattainment pollutant emissions would occur within the PRTR's Charles County ozone nonattainment area. Therefore, an emissions analysis in accordance with the general conformity rule is not required. As noted previously, the chemical simulants discussed in this report are not hazardous air pollutants.

Biological Simulants

Biological simulants that may be used for testing include bacteria, proteins, fungi, and bacteriophages. Only biosafety level (BSL)-1 simulants (see Section 3.8.4.2) would be used and NSWCDD will model biological simulant dispersion (similar to the chemical simulant dispersion modeling contained in Appendix J) before outdoor testing takes place. Modeling biological simulant dispersion requires information on the quantity, type, and dispersion method to be used for each simulant, which will not be known until outdoor tests are actually being planned. No tests using biological simulants currently take place outdoors.

Many of the BSL-1 organisms, such as the bacteria, are ubiquitous and often found in high concentrations in nature, including in water (CRI, 2004; USEPA, 1997). For example, *Bacillus subtilis* is a widely adapted bacterial species capable of growing within many environments including soil, plant roots and the gastrointestinal tracts of animals (Earl et al., 2008). Population levels of 10^6 to 10^7 per gram of soil have been estimated for this species (USEPA, 1997).

One of the organisms that could be used as a biological simulant, the bacterium *Pantoea agglomerans*, may be harmful to certain plants (for example, causing fire blight of pear and apple trees). There are no published reports of disease associated with these organisms in aquatic plants or animals, and the small concentrations of these bacteria deposited in the water are not expected to cause any significant increase in the resident bacteria populations nor would adverse effects be anticipated from a temporary increase in levels of these bacteria. Any testing of *Pantoea agglomerans* over land would be modeled prior to release to ensure that it is not dispersed in the direction of any pear or apple trees in the area. As described in Section 2.5.4.6, the PRTR's MDZ would be the most likely focus of the work because of DoD's – and particularly the Navy's – need to test biological sensors over water to observe how riverine/marine conditions affect them.

The amount of biological simulant used would be the minimum amount necessary to obtain the desired results. In contrast to chemical simulants, biosimulants are typically dry and powdery rather than liquid. Therefore, the simulants could be released by a blower to form a small dry cloud rather than a vapor cloud.

Respirators and personal protective equipment would be used by personnel on the release boat for biological, as well as chemical simulant testing. Individuals with compromised immune systems or respiratory conditions would not be able to serve as personnel on the release boat, as they would not qualify for respirator use. Therefore, no high risk individuals would be potentially exposed to biological simulants. As noted, only BSL-1 organisms would be used, so even in the event of exposure, the risk of adverse effects would be negligible.

Summary

Based on the simulant modeling, previous testing, and low toxicity of chemical and biological simulants, expanded RDT&E activity involving chemical and biological simulants under Alternative 1 would result in negligible, long-term, direct and indirect, negative air quality impacts.

4.4.3 Alternative 2

4.4.3.1 Stationary and Mobile Sources

Like Alternative 1, Alternative 2 does not include the construction of any new major stationary sources at NSF Dahlgren. Annual HE laser activities would increase from the Alternative 1 average of 125 annual events to 145 events, EM energy activities would increase from 590 to 680 annual events, and EEA Range Complex explosive detonations would increase from the Alternative 1 of 200 annual events to 230 events. This increase in testing may increase the possibility that other sources of power would be required. The 2010 installation power study conducted by NSF Dahlgren addressed future power needs and recommended needed

improvements. If new sources are implemented, the air permit would be updated. Expanded RDT&E activities under Alternative 2 would have negligible, long-term, direct and indirect, negative impacts on air quality.

Clean Air Act General Conformity

As compared to Alternative 1, Alternative 2 would only increase explosive detonation events from 200 to 230 at the EEA Complex. Therefore no net change in air emissions would occur under Alternative 2 within the PRTR's MDZ nonattainment area. Consequently the general conformity rule does not apply to Alternative 2.

4.4.3.2 Other Sources (Chemical/Biological Simulants)

The impacts from Alternative 2 would be similar to those for Alternative 1. None of the chemical simulants used would be criteria pollutants and are not hazardous air pollutants. The difference between chem/bio defense activities under the two alternatives would be an increase in the number of chemical and biological simulant events – from 60 per year under Alternative 1 to 70 per year under Alternative 2. In addition, whereas chemical simulants and biological simulants would be used separately under Alternative 1, they would be used separately or together under Alternative 2. The chemical and biological simulants used would be the same ones approved for use in the individual chemical and biological operational tests under Alternative 1. The same protective and safety measures taken for chemical-simulant testing and biological-simulant testing would be used for the combined chemical and biological sensor testing. There are no known synergistic effects between the chemical simulants and BSL-1 biological simulants that would be tested together. In addition, preliminary research indoors in laboratories is conducted at NSWCDD before tests are performed outdoors. Potential issues would be identified and addressed during indoor tests.

The concentrations of simulants used in any event would not change, and locations on the MDZ and on land would vary within the areas shown on Figure 1-11, so that no single area would be used for repeated testing until concentrations of chemical and biological simulants return to background levels. Concentrations of chemical and biological simulants that people would be exposed to without protective equipment would be at background levels and would not cause adverse effects to human health. Based on the previous testing, low toxicity of chemical and biological simulants, short exposure duration to simulants, limited exposure pathways (i.e., access to test area is restricted), likely overestimate of simulant concentrations, and spacing of tests, expanded RDT&E activities involving chemical and biological simulants under Alternative 2 would result in negligible, long-term, direct and indirect, negative air quality impacts.

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4.5 Noise

4.5.1 No Action Alternative

Under the No Action Alternative, NSWCDD would continue to conduct the same number of annual weapons-testing activities on its operating ranges as are conducted under existing conditions. Therefore, noise and vibration levels around Dahlgren would remain the same as under existing conditions, described in Section 3.5.

Existing noise conditions include continuous noise from aircraft/helicopter/UAV activities and impulse noise from ordnance activities. Continuous noise (as opposed to sporadic gun firing noise) from all flights is considered negligible due to the low number of flights. While UAVSs are flown more than helicopters or fixed-wing aircraft, the altitude at which they fly (normally 2,000 to 3,000 ft, but they can go up to 5,000 ft) and their associated noise levels (around 80 dBA at takeoff and landing for the smaller UAVs and about 100 dBA for the largest UAV flown by NSWCDD) make them fairly quiet and unobtrusive.

For large-gun firing and explosive detonations, modeling was used to develop installation-wide noise contours (Section 3.5.4). Peak blast noise levels in dBP from large-gun firing were predicted using the DoD's large-caliber weapon-noise model BNOISE2.

Additionally, noise measurements were taken in November 2009 at six historic structures located along the PRTR, as detailed in Appendix D. The measurements took place when NSWCDD was firing the largest gun routinely fired on the PRTR – the 5"/62 caliber gun – with live projectiles filled with relatively large amounts of explosives (approximately 9 lbs net explosive weight) compared to standard 5" live projectiles. This set of tests, therefore, produced the greatest possible noise and vibration levels using the 5" gun. NSWCDD's use of projectiles containing larger amounts of explosives than the projectiles tested is, and will continue to be, rare.

The noise measurements at historic structures confirmed that the model-predicted peak noise contours reasonably represent worst-case gun firing peak noise conditions around the PRTR. The monitored peak noise levels at each site along the PRTR were comparable to, though slightly lower than, the peak noise levels modeled for large-gun firing noise without the 8"/55 gun as shown in Figure 3.5-7, which shows targets areas in the MDZ. The contours shown in Figure 3.5-7 include 5"/54 caliber and 155 mm gun firing plus detonations and small gun firing.

Although NSWCDD is very unlikely to fire live projectiles from the 8"/55 caliber gun in the future, this caliber of gun was included in the development of the peak noise contours shown in Figure 3.5-5 as a surrogate for the 5"/62 gun, which is not included in the model, as well as for future versions of 5"guns/projectiles that may include more explosives than currently used. Because the 8"/55 gun has a much larger firing charge and carries projectiles with explosives weighing more than twice as much as the 5"/62 gun, this represents a worst case scenario because it overestimates expected noise levels.

Since the model predictions for peak sound levels without the 8"/55 gun were validated by field measurements during the historic structure noise measurement program, the modeled peak noise contours that include the 8"/55 gun and that were developed using the same methodology can be assumed to accurately reflect worst-case noise and vibration impacts. Furthermore, since the

measured noise levels were slightly lower than the predicted peak noise levels, the predicted peak noise levels can be considered conservative, particularly at on-land receiving sites.

The 2009 noise measurement program at six historic structures also included airborne and ground borne vibration monitoring. Based on the low vibration levels measured over the two-day firing and monitoring period, it is unlikely that the largest gun firing at NSWCDD would result in vibration impacts to structures near the PRTR significant enough to cause any structural damage (see Appendix D for detailed results).

In addition, as part of its outdoor noise management process (Appendix C), NSWCDD uses the Sound Intensity Prediction System (SIPS) to identify areas with potential to be exposed to peak-noise levels above 140 dBP based on weather conditions. Tests expected to generate such levels would be postponed until the weather changes to ensure that no peak-noise level would exceed 140 dBP when large-gun firing occurs. Implementation of SIPS and the other components of the noise management process (see Section 3.5.3.5 and Appendix C) are expected to minimize noise impacts resulting from NSWCDD outdoor RDT&E activities.

Therefore, minor, long-term, direct, negative weapons-testing noise impacts and negligible, long-term, direct, negative vibration impacts would occur under the No Action Alternative. No indirect noise or vibration impacts would occur.

4.5.2 Alternative 1

Under Alternative 1, NSWCDD would:

- Continue to conduct the same number of large-gun firings annually on its operational ranges as under the No Action Alternative.
- Increase the frequency of large-gun firing into a target area in the upper part of the LDZ within 40,000 yards of the firing line, from current occasional use up to ten days a year.
- Fire inert, shaped-metal projectiles from EM launchers over the PRTR land and water ranges. Because the projectiles are inert, noise would originate from the launch site but not from the target area.
- Increase explosive detonations from 190 events annually under the No Action Alternative to 200 events.
- Increase annual small-arms firings from 6,000 bullets under the No Action Alternative to 25,500 bullets.

Continuous noise from aircraft would increase because of an increase in the number of hours UAVs would be flown over the PRTR. However, the increase in hours would have negligible impact on overall noise levels because, as described under the No Action Alternative, the altitude at which UAVs fly (usually at 2,000 to 3,000 ft but they can go up to 5,000 ft) and their associated noise levels (around 80 dBA at takeoff and landing for the smaller UAVs and about 100 dBA for the largest UAV flown by NSWCDD) make them fairly quiet and unobtrusive.

Alternative 1 would only increase the frequency of small-arms firing and detonations on the installation. There would be no change in the number of large-gun firings. Therefore, event peak noise levels would not increase under Alternative 1. They would remain as described in Section

3.5 and shown in Figures 3.5-5. 3.5-6, and 3.5-7. Similarly, potential impacts from vibrations would remain unlikely, as described in Section 3.5.5 and Appendix D. The increase in the frequency of use of the long-range target area in the upper LDZ would lead to more days annually with firing noise experienced downrange, if live projectiles are used. However, the proposed increases would result in higher DNL noise. With respect to large-caliber guns, Figure 4.5-1 (Alternative 1 C-Weighted Day-Night Average Noise Contours with 8”/55 Gun Firing in the Middle Danger Zone) shows the predicted CDNL contours under Alternative 1. The contours would be marginally larger and the areas within Noise Zones II and III (CDNLs between 62 dBC and 70 dBC and equal or greater than 70 dBC, respectively) would be slightly greater than under existing and no action conditions as shown on Figure 3.5-3. However, the difference would be so small as to be negligible and contained within the EEA where the 10 additional detonations would take place.

Similarly, with respect to small-arms activities, comparison between Figure 3.5-8 and Figure 4.5-2 (Alternative 1/Alternative 2 Small Arms A-Weighted Day-Night Average Noise Contours) shows the increase in the amount of land within Noise Zones II and III (ADNLs between 65 dBA and 75 dBA and equal or greater 75 dBA, respectively) resulting from the higher number of bullets that would be fired under Alternatives 1 and 2. This slight increase would occur on the installation at the EEA and Mainside, and would be negligible. Under Alternative 1, the increase would be even less than shown because Figure 4.5-2 was developed using the higher number of bullets – 30,000 – that would be fired under Alternative 2.

For the reasons explained above, Alternative 1 would result in minor, long-term, direct, negative noise impacts. The impacts would be comparable to those predicted for the No Action Alternative, mostly because the noisiest activities would not increase (large-gun firings) or increase only negligibly (detonations). Further, Alternative 1 would result in negligible, long-term, direct, negative vibration impacts. No indirect noise or vibration impacts would occur.

4.5.3 Alternative 2

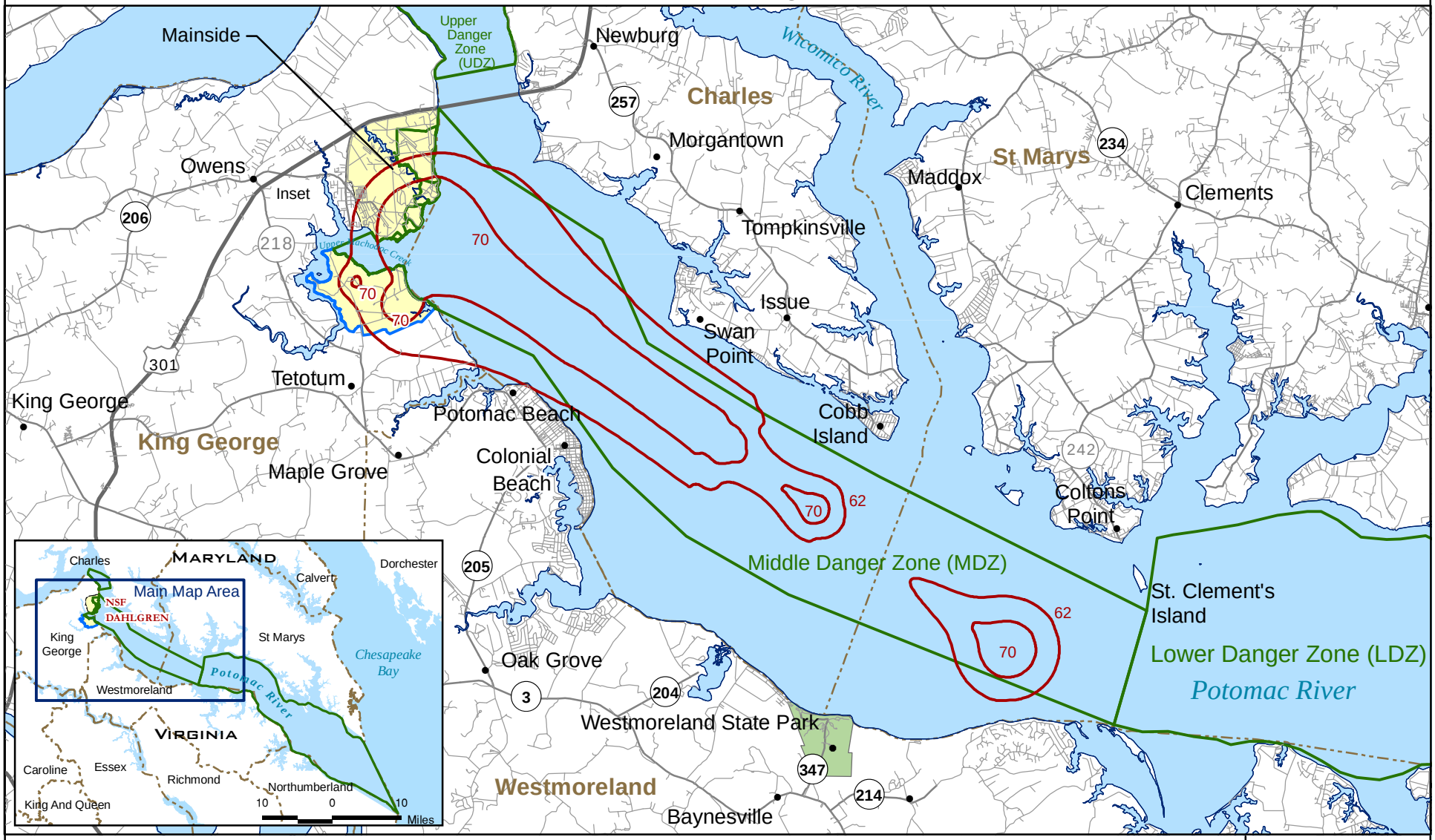
Under Alternative 2, NSWCDD would:

- Continue to conduct the same number of large-caliber gun firings annually on its operating ranges as under the No Action Alternative and Alternative 1.
- Increase the frequency of large-gun firing into a target area in the upper part of the LDZ within 40,000 yards of the firing line, from current occasional use up to ten days a year.
- Fire inert, shaped-metal projectiles from EM launchers over the PRTR land and water ranges. Because the projectiles are inert, noise would originate from the launch site but not from the target area.
- Increase the annual number of explosive detonations from 190 events under the No Action Alternative to 230 events (30 more events than under Alternative 1).
- Increase annual small-arms firings from 6,000 bullets under the No Action Alternative to 30,000 bullets (4,500 more bullets than under Alternative 1).
- Continuous noise from aircraft would increase above Alternative 1 levels because of an increase in the number of EM energy events on the PRTR, which would increase the

number of hours UAVs fly. However, as described under Alternative 1, the impact on noise levels would be negligible because of the altitude at which UAVs fly and the relatively small size of the craft used by NSWCDD.

- Event peak noise levels would remain the same as under existing conditions and as shown in Figures 3.5-5, 3.5-6, and 3.5-7. Similarly, potential impacts from vibrations would remain unlikely, as explained in Sections 3.5.5 and 4.5.1 and Appendix D.
- The proposed increases, however, would affect DNL contours. With respect to large-caliber guns, the predicted CDNL contours under Alternative 2 are shown in Figure 4.5-3 (Alternative 2 C-Weighted Day-Night Noise Average Contours with 8”/55 Gun Firing in the Middle Danger Zone). A comparison between Figure 3.5-3 and Figure 4.5-3 shows that, as under Alternative 1, the increase in the size of the contours under Alternative 2 would be so small as to be negligible and would be contained within the EEA, where the additional detonations would take place.
- The annual number of small-arms firings would rise to 30,000 under Alternative 2. However, as already noted in Section 4.5.2 and as can be seen by comparing Figures 3.5-8 and 4.5-2, the increase in the ADNL contours would be very small and fully contained within the vicinity of the firing ranges.
- Like Alternative 1, Alternative 2 would result in minor, long-term, direct, negative noise impacts; comparable to the impacts predicted for the No Action Alternative, because the noisiest activities would either not increase (large-gun firings) or increase only slightly (detonations). Alternative 2 also would result in negligible, long-term, direct, negative vibration impacts. No indirect noise or vibration impacts would occur.

Alternative 1 C-Weighted Day-Night Average Noise Contours with 8”/55 Gun Firing in the Middle Danger Zone



C-Weighted Day-Night Average Noise Contours

Potomac River Test Range (PRTR) Complex

Explosives Experimental Area (EEA) Range Complex

County Boundary

Naval Support Facility (NSF) Dahlgren

3 0 3 Miles

5 0 5 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Sources: BNOISE2 Model & NSWCDD SIPS Model

Figure 4.5-1

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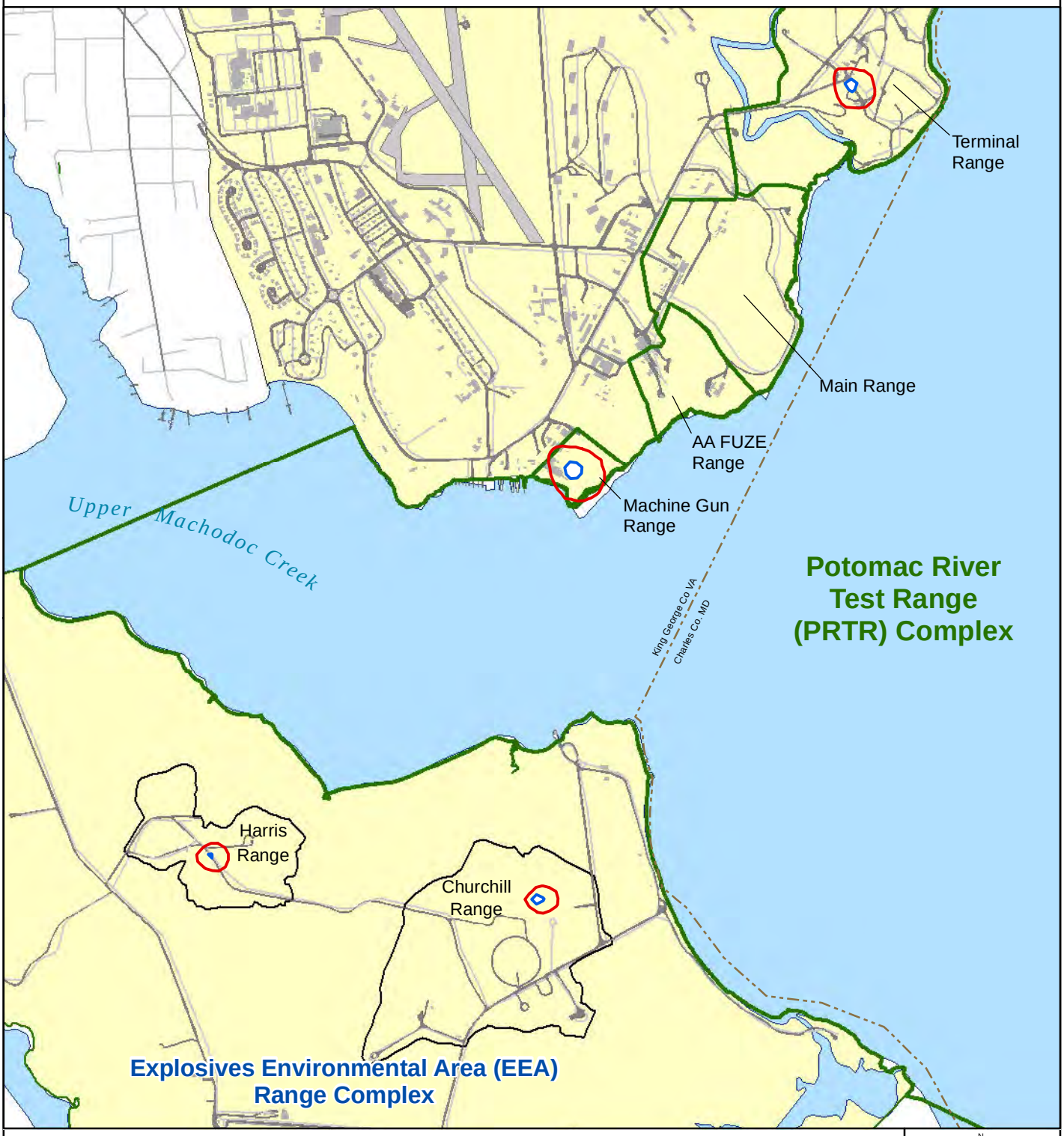
Alternative 1/Alternative 2 Small Arms A-Weighted Day-Night Average Noise Contours



65-dB Noise Contour

75-dB Noise Contour

Naval Support Facility (NSF) Dahlgren

1,500 0 1,500 Feet

500 0 500 Meters

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Sources: NSWCDD 2008-2011 and BNOISE2 Model

Figure 4.5-2

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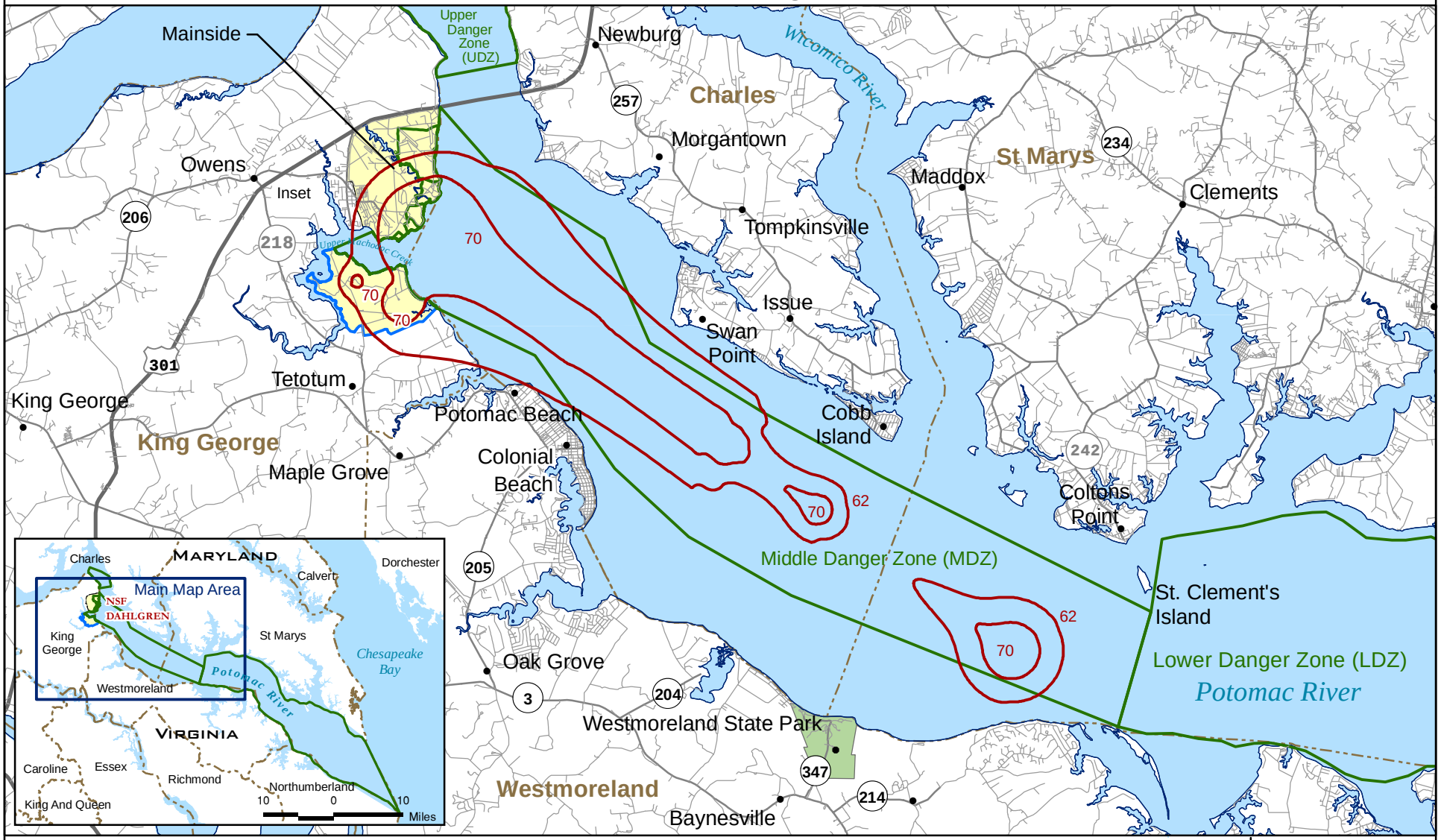
Alternative 2 C-Weighted Day-Night Noise Average Contours with 8”/55 Gun Firing in the Middle Danger Zone



Source: BNOISE2 Model & NSWCDD SIPS Model

Figure 4.5-3

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4.6 Cultural Resources

Section 106 of the National Historic Preservation Act (NHPA) provides that federally-funded agencies, such as NSWCDD, take into account the effects of their actions on any district, site, building, structure, or object included in, or eligible for inclusion in, the National Register. Implementing regulations for Section 106 established by the Advisory Council on Historic Preservation (ACHP) are contained in 36 CFR Part 800 – Protection of Historic Properties, as amended. These regulations provide specific criteria for identifying effects on historic properties. Effects on cultural resources listed in, or eligible for listing in, the National Register are evaluated with regard to the Criteria of Adverse Effect set forth in 36 CFR § 800.5(a)(1) (Table 4.6-1).

Table 4.6-1
Section 106 of NHPA – Criteria of Adverse Effect

Criteria of an Adverse Effect
"An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, setting, materials, workmanship, feeling, or association. Consideration shall be given to all qualifying characteristics of an historic property, including those that may have been identified subsequent to the original evaluation of the property's eligibility for the National Register. Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance or be cumulative" (36 CFR § 800.5(a)(1)).
Examples of Adverse Effects
Adverse effects on historic properties include, but are not limited to: 1. Physical destruction of or damage to all or part of the property; 2. Alteration of a property, including restoration, rehabilitation, repair, maintenance, stabilization, hazardous material remediation, and provision of handicapped access, that is not consistent with the *Secretary of the Interior's Standards for the Treatment of Historic Properties* (36 CFR Part 68) and applicable guidelines; 3. Removal of the property from its historic location; 4. Change of the character of the property's use or physical features within the property's setting that contribute to its historic significance; 5. Introduction of visual, atmospheric, or audible elements that diminish the integrity of the property's significant historic features; 6. Neglect of a property which causes its deterioration, except where such neglect and deterioration are recognized qualities of a property of religious and cultural significance to an Indian tribe or Native Hawaiian organization; 7. Transfer, lease, or sale of property out of Federal ownership or control without adequate and legally enforceable restrictions or conditions to ensure long-term preservation of the property's historic significance" (36 CFR § 800.5(a)(2)).

The Proposed Action is the expansion of NSWCDD's outdoor RDT&E activities at NSF Dahlgren within the PRTR and EEA Range complexes, the Mission Area at Mainside, and the SUA over the ranges. These activities require the use of ordnance, EM energy, HE lasers, and chemical and biological simulants as described in Chapter 2.

4.6.1 Archaeological Resources

The Archaeological Area of Potential Effect (APE) is typically concerned with *direct effects* and is defined by considering the areas of ground disturbance that would occur as a result of carrying out a proposed project action, such as building a new facility. In terms of the Proposed Action described in Chapter 2, the proposed activities associated with all three alternatives – the No Action Alternative, Alternative 1, and Alternative 2 – would have no direct impact on archaeological resources within or near NSF Dahlgren, because no groundbreaking activities are proposed.

However, *indirect effects* upon archaeological resources resulting from testing-related noise are of potential concern. The Archaeological APE encompasses the PRTR MDZ in the Potomac River; the EEA Complex at NSF Dahlgren; and a 300-ft-wide zone along the southern boundary of the EEA between Upper Machodoc Creek and the Potomac River shoreline where indirect impacts resulting from testing-related noise may occur.

Based on the files of the Virginia Department of Historic Resources (VDHR), the Maryland Historic Trust (MHT), and NSF Dahlgren, eight archaeological sites have been identified within the Archaeological APE. A review of the files of the Naval Historical Center (NHC) indicates that an additional three resources that may also be located within the Archaeological APE, for a total of 11 archaeological resources within or possibly within the Archaeological APE. Of these 11 resources, six are terrestrial sites identified on the EEA and include two prehistoric and four possible historic-period sites. The remaining five are maritime sites/resources identified within the Potomac River. The two maritime sites clearly identified within the Archaeological APE include an 18th-century anchor and a possible buried shipwreck; the three maritime resources whose exact locations are unknown but which may be located within the Archaeological APE consist of five US Navy shipwrecks from the Civil War Period.

VDHR and the MHT have not yet evaluated nine of the resources, and, therefore, their National Register eligibility status remains undetermined. VDHR evaluated the Black Marsh 1 and 2 sites, and concurred that they are eligible for listing in the National Register. Table 4.6-2 provides a list of the 11 archaeological resources identified within or potentially within the Archaeological APE, the condition of the resource, if known, and whether indirect impacts are anticipated.

The majority of the proposed project actions associated with the three alternatives, due either to the nature of their activities or the fact that no change in activities is proposed, would have no effect on previously identified or potential archaeological resources within the Archaeological APE. Because no increase in large-gun firing is proposed, only two of the proposed actions has the potential to indirectly impact previously identified or unknown resources: an increase in detonations on the Churchill and Harris Ranges within the EEA Complex (see Figure 3.6-4), and an increase in small arms firing.

Table 4.6-2
Archaeological Resources within or Potentially within the Archaeological APE

Resource Name	Resource Type	Indirect Impact to Resource			Condition of Resource	On File
		No Action	Alternative 1	Alternative 2		
44KG217 (Black Marsh 1)	Terrestrial	None	None	None	Recommended NRE[2]	VDHR and NSF Dahlgren
44KG218 (Black Marsh 2)	Terrestrial	None	None	None	Not recommended NRE[2]	VDHR and NSF Dahlgren
MWC17	Terrestrial	None	None	None	Unknown[3]	NSF Dahlgren
MWC18	Terrestrial	None	None	None	Unknown[3]	NSF Dahlgren
MWC19	Terrestrial	None	None	None	Unknown[3]	NSF Dahlgren
MWC34	Terrestrial	None	None	None	Unknown[3]	NSF Dahlgren
Colonial Beach South QF04 (Dahlgren Anchor Site)	Maritime	None	None	None	Anchor recovered from site by US Coast Guard in 1990[4]	MHT
STRATF QF05 [side-scan sonar anomaly]	Maritime	None	None	None	Unknown[4]	MHT
Christiana Keen[1]	Maritime	None	None	None	Burned and sunk[5]	NHC
Frances Elmor[1]	Maritime	None	None	None	Burned and sunk[5]	NHC
Three Boats[1]	Maritime	None	None	None	"Destroyed" and sunk[5]	NHC

[1] Resource located within or potentially within the Archaeological APE (MHT, 1997).
[2] Recommendations for National Register Eligibility (NRE) based on National Register criteria as determined in NSF Dahlgren and Engineering Field Activity Chesapeake (2006).
[3] GIS data from NSF Dahlgren, 2008.
[4] Site file forms at MHT.
[5] MHT, 1997.

4.6.1.1 No Action Alternative

Under this alternative, the annual level of outdoor RDT&E activities taking place in the PRTR and EEA Range complexes and the Mission Area would continue as currently executed. As this alternative does not propose an expansion of outdoor RDT&E activities, indirect impacts to previously identified or potential archaeological resources in the Archaeological APE are not anticipated. Therefore, in accordance with Section 106 of the NHPA, VDHR and MHT concurred that the No Action Alternative would have no adverse effect on archaeological resources within the APE (Appendix E, pages E-156 and E-148). In accordance with NEPA, the No Action Alternative would have no direct or indirect impact on archaeological resources.

4.6.1.2 Alternative 1

Alternative 1 proposes an increase in existing outdoor RDT&E activities in the PRTR and EEA Range complexes and the Mission Area, as described in Chapter 2. Impacts associated with proposed increased activities are discussed below.

The proposed increased HE laser, EM energy, and chem/bio defense activities and hours of PRTR use to support these activities under Alternative 1 are not expected to affect previously

identified or potential archaeological resources within the Archaeological APE based on the character of their actions, which would not affect resources underground.

An increase in the number of annual detonations from 190 events to 200 events is proposed at the Churchill and Harris ranges within the EEA Range Complex. The proposed detonations have the potential to directly or indirectly impact the ranges and the area immediately surrounding the ranges. A study conducted for military safety testing within the EEA noted that ground impacts from a buried detonation of up to 1,000 lbs net explosive weight (the largest detonation that takes place on the EEA) could cause ground motion that could impact structures less than 300 ft away (see Figure 3.5-4) (US Navy, Not Dated). As there are no previously identified sites within these locations on file with the VDHR or NSF Dahlgren, there would be no impacts to known resources from the proposed actions. The archaeological potential for unknown resources to be present within these two ranges is none-to-low, as a result of past subsurface disturbances. The Churchill and Harris ranges have been subjected to extensive subsurface disturbance as the result of aircraft bombing from 1944 to 1957 and detonations since World War II.

Under Alternative 1, the use of small arms would increase from 6,000 to 25,500 bullets fired outdoors annually. Some bullets will be fired indoors into backstops. Bullets fired outdoors will be fired from the Machine Gun Range either at a target on land that traps the projectiles or at a target in the water up to 4,000 yards out (typically ten percent of bullets). As the bullets on land would be fired into set targets, this action would not impact known or unknown archaeological resources. Similarly, the firing of rounds into the river would not impact known or unknown archaeological resources due to the small size of the rounds and the rapid deceleration of the rounds as they enter the water.

Finally, an increase in the number of annual hours of use of the PRTR is proposed – from 750 hours to 870 hours. For more than 90 years, activities within the PRTR Complex have included the firing of inert and live projectiles from the PRTR land ranges into the Potomac River. Inert projectiles consist of a steel case filled with material such as concrete, replicating the weight of live projectiles. Live ordnance utilized have included naval gun projectiles, small explosives (i.e., grenades), aircraft bombs, and small rockets, which are set to explode in the air above the water or upon impact with the water. However, it should be noted that due to the nature of testing, some projectiles remain unexploded. Remnants of the inert and live projectiles are propelled into the river bottom, where they remain, covered in silt.

Five unevaluated maritime resources have been identified within or possibly within the PRTR portion of the Archaeological APE. One of these resources – the anchor of the Colonial Beach South QF04-Dahlgren Anchor Site – has been removed to another location, while three others were either wholly or partially destroyed before they came to rest on the river bottom (shipwrecks of the Christiana Keen, Frances Elmor, and Three Boats). The remaining resource, known via a side-scan sonar anomaly identified in 2006, is situated along the river bottom at the northeastern end of the Archaeological APE. In addition, there is the potential for unknown resources to be located within the Archaeological APE. However, the prior nine decades of gun-testing in this area have likely heavily disturbed the river bottom. Therefore, while the previously described activities may cause indirect impacts to previously identified and unknown resources within the Archaeological APE, in accordance with Section 106, they are not expected to have an adverse effect on archaeological resources within it.

Therefore, the proposed activities are not expected to cause indirect impacts to previously identified and unknown resources within the Archaeological APE; in accordance with Section 106 of the NHPA, they are not expected to have an adverse effect on archaeological resources within it. VDHR and MHT have both concurred with the no adverse effect determination (Appendix E, pages E-156 and E-148). In accordance with NEPA, Alternative 1 would have no direct or indirect negative impact on archaeological resources within the APE.

4.6.1.3 Alternative 2

Alternative 2 would lead to increases in existing outdoor RDT&E activities at NSF Dahlgren, as described in Chapter 2. Table 4.6-2 summarizes the possibility for the Proposed Action to indirectly affect previously identified archaeological resources in or potentially within the Archaeological APE. Despite increases in small gun, detonation, chem/bio, laser, and EM energy activities, as described in the No Action Alternative and Alternative 1 discussions, there is little-to-no possibility for Alternative 2 to directly affect archaeological resources.

The possibility for Alternative 2 to indirectly affect previously identified and unknown archaeological sites within the Archaeological APE is the same as discussed for Alternative 1. Therefore, the proposed activities are not expected to cause indirect impacts to previously identified and unknown resources within the Archaeological APE; in accordance with Section 106 of the NHPA, they are not expected to have an adverse effect on archaeological resources within it. The VDHR and MHT have both concurred with the no adverse effect determination (Appendix E, pages E-156 and E-148). In accordance with NEPA, Alternative 2 would have no direct or indirect negative impacts on archaeological resources within the APE.

4.6.2 Historic Architectural Resources

Impacts on historic architectural resources outside and within NSF Dahlgren were examined with regard to the Criteria of Adverse Effect set forth in Table 4.6-1. Table 4.6-3 provides a list of 36 resources (20 National Register-listed resources and 16 National Register-eligible resources) within or immediately adjacent to the 120-dBP noise contour based on firing an 8” gun, which also functions as the Historic Architectural APE. These resources are featured in Figure 3.6-2. As the number of events associated with the 120-dBP noise contour (i.e., large-gun firing) is the same under the No Action Alternative, Alternative 1, and Alternative 2, the impacts of these alternatives are discussed together.

Table 4.6-4 provides a list of the four historic architectural resources both within and partially within the 134-dBP noise contour at NSF Dahlgren’s Mainside. These resources are featured in Figure 4.6-1, Detailed View of Historic Districts.

In accordance with Section 106 of the NHPA, VDHR and MHT concurred that the Proposed Action, under the No Action Alternative, Alternative 1, or Alternative 2, would have no adverse effect on historic architectural resources within the APE. In accordance with NEPA, the Proposed Action, under the No Action Alternative, Alternative 1, or Alternative 2, would have minor direct impacts and no indirect negative impacts on historic architectural resources within the APE. The following sections substantiate this finding.

4.6.2.1 Activities with No Impacts on Resources within the Historic Architectural APE

Five of the seven classes of RDT&E activities associated with the No Action Alternative, Alternative 1, and Alternative 2, are not anticipated to affect resources within the Historic Architectural APE. These activities and the reasons for no effect are:

- HE Laser Activities. Laser activities would take place on the range complexes and have no overlap with historic architectural resources.
- EM Energy Activities. EM energy activities would take place on the range complexes and have no overlap with historic architectural resources. Existing data for the EM launcher are not sufficient to develop a noise-prediction model, but the measurements to date do not show a close correlation between increasing power and noise (see Section 3.5.3.7).
- Chemical and Biological Defense Activities. Chemical and biological sensor tests employ low toxicity simulants rather than actual agents, in accordance with federal laws. Testing of simulants would not affect buildings.
- Small-Arms Activities. Firing of small arms (those of calibers 20 mm or less) occurs under controlled conditions on the PRTR and EEA ranges. Most bullets would be fired into gun butts on ranges. Approximately ten percent would be fired into the river. The frequency of outdoors small-arms testing would increase from 6,000 bullets annually under the No Action Alternative to 25,500 bullets annually under Alternative 1 and 30,000 bullets annually under Alternative 2. This action would generate additional noise in the vicinity of the installation, including the Proposed Main Battery Historic District at NSF Dahlgren Mainside, the site of the Main Range. However, the Historic Architectural APE is based upon peak-noise contours associated with large gun/projectile tests and detonations that may cause vibrations to buildings. Small-arms testing would not cause vibrations to buildings and, therefore, such testing would not impact buildings in the vicinity of the installation.
- PRTR Use. Increased use of the river would have no effect on buildings. The increased use would be to support non-ordnance activities, including HE lasers, EM energy, and chem/bio sensor tests.

Therefore, these five classes of activities would not directly or indirectly impact resources within the Historic Architectural APE and, as a result, will not be analyzed in this section.

Table 4.6-3
Historic Architectural Resources outside NSF Dahlgren

Map Number	Resource Name	Location	Status	Within APE	Adjacent to APE
1	Waverley	13535 Waverly Point Road, Newburg, Charles County, MD	National Register-listed, 1987	X	
2	Sarum	Budds Creek Road (Maryland State Route 234) Newport, Charles County, MD	National Register-listed, 1974		X
3	Christ Episcopal Church	Church: 25390 Maddox Road Chaptico, St. Mary's County, MD Parish Hall: 37497 Zach Fowler Road Chaptico, St. Mary's County, MD	National Register-listed, 1994		X
4	Deep Falls	Deep Falls Road Chaptico, St. Mary's County, MD	National Register-listed, 1975		X
5	Bachelor's Hope	Manor School Road Chaptico, St. Mary's County, MD	National Register-listed, 2007	X	
6	Ocean Hall	Bushwood Road Bushwood, St. Mary's County, MD	National Register-listed, 1973	X	
7	St. Clement's Island Historic District	St. Clement's Island St. Mary's County, MD	National Register-listed, 1972	X	
8	The River View	Burch Road St. Mary's County, MD	National Register-listed, 1976	X	
9	St. Francis Xavier Church and Newtown Manor Historic District	Newtown Neck Road (Maryland State Route 243) Leonardtown, St. Mary's County, MD	National Register-listed, 1972	X	
10	Bushfield	367 Club House Loop, Virginia State Route 708 Mount Holly, Westmoreland County, VA	National Register-listed, 2004	X	
11	Spring Grove	Virginia State Route 202, Mount Holly Westmoreland County, VA	National Register-listed, 1985	X	
12	Armstead T. Johnson High School	Virginia State Route 202, Montross Westmoreland County, VA	National Register-listed, 1998	X	
13	Stratford Hall	Great House Road, Stratford Westmoreland County, VA	National Historic Landmark; National Register-listed, 1966	X	
14	Westmoreland State Park Historic District	Westmoreland State Park Westmoreland County, VA	National Register-listed, 2005	X	
15	Ingleside	Virginia State Route 638 Oak Grove, Westmoreland County, VA	National Register-listed, 1977	X	

Table 4.6-3 (Cont'd)
Historic Architectural Resources outside NSF Dahlgren

Map Number	Resource Name	Location	Status	Within APE	Adjacent to APE
16	Blenheim	Virginia State Route 3 Oak Grove, Westmoreland County, VA	National Register-listed, 1976	X	
17	Roxbury	Virginia State Route 638 Oak Grove, Westmoreland County, VA	National Register-listed, 1977	X	
18	Wirtland	Virginia State Route 638 Oak Grove, Westmoreland County, VA	National Register-listed, 1977	X	
19	St. Peter's Episcopal Church	Virginia State Route 3 Oak Grove, Westmoreland County, VA	National Register-listed, 2004	X	
20	Bell House	821 Irving Avenue Colonial Beach, Westmoreland County, VA	National Register-listed, 1987	X	
21	Governor Harry W. Nice Memorial Bridge (Bridge 8039)	US Route 301 over the Potomac River Newburg, Charles County, MD	National Register-eligible, 2001	X	
22	Marshall's Rest (Clifton Potomac Property)	11985 Edgehill Road Newburg, Charles County, MD	National Register-eligible, 1997	X	
23	John H. Reeder Property (Jones Property)	11450 Edgehill Road Newburg Charles County, MD	National Register-eligible, 1997		X
24	Bridge 1808	Maddox Road (Maryland State Route 238) over Burroughs Run, vicinity of Maddox, St. Mary's County, MD	National Register-eligible, 2001	X	
25	Bridge CH-0016	Rock Point Road over Ditchley Prong, vicinity of the Village of Wayside, Charles County, MD	National Register-eligible, 2001	X	
26	Small Structure No. 18049XO	Maryland State Route 520 over Branch of Whites Neck Creek, Bushwood, St. Mary's County, MD	National Register-eligible, 1997	X	
27	Chaptico Historic District	Chaptico, St. Mary's County, MD	National Register-eligible, 2004	X	
28	Locust Grove	25434 Hurry Road, Chaptico, St. Mary's County, MD	National Register-eligible, 2004		X
29	Hague House	Virginia State Route 202 Hague, Westmoreland County, VA	National Register-eligible, 1996	X	
30	Washington & Lee Agricultural High School	16380 Kings Highway (Virginia State Route 3) Montross, Westmoreland County, VA	National Register Eligible, 2000	X	
31	Montross Town Hall (Bank of Montross) ***DEMOLISHED IN 2001***[1]	100 Hawthorne Street Montross, Westmoreland County, VA	National Register-eligible, 2000	X	

Table 4.6-3 (Cont'd)
Historic Architectural Resources outside NSF Dahlgren

Map Number	Resource Name	Location	Status	Within APE	Adjacent to APE
32	Panorama (Hummel Vineyards)	1005 Panorama Road Montross, Westmoreland County, VA	National Register-eligible, 2004; nominated to the NR in 2008; NR listing pending	X	
33	Endurance (Himes House)	29 Irving Avenue South Colonial Beach, Westmoreland County, VA	National Register-eligible, 2001; also located within potentially NR-eligible Colonial Beach Historic District.	X	
34	Bank of Westmoreland (Colonial Beach Town Hall)	18 Irving Avenue North Colonial Beach, Westmoreland County, VA	National Register-eligible, 2001; also located within potentially NR-eligible Colonial Beach Historic District.	X	
35	Colonial Beach Historic District	Colonial Beach, Westmoreland County, VA	National Register-eligible, 2001	X	
36	Greg House	1763 McKinney Boulevard, Potomac Beach, Westmoreland County, VA	National Register-eligible, 2008	X	

[1] Reamy, Brenda, Town of Montross, Virginia. October 14, 2009. Phone call with AECOM.

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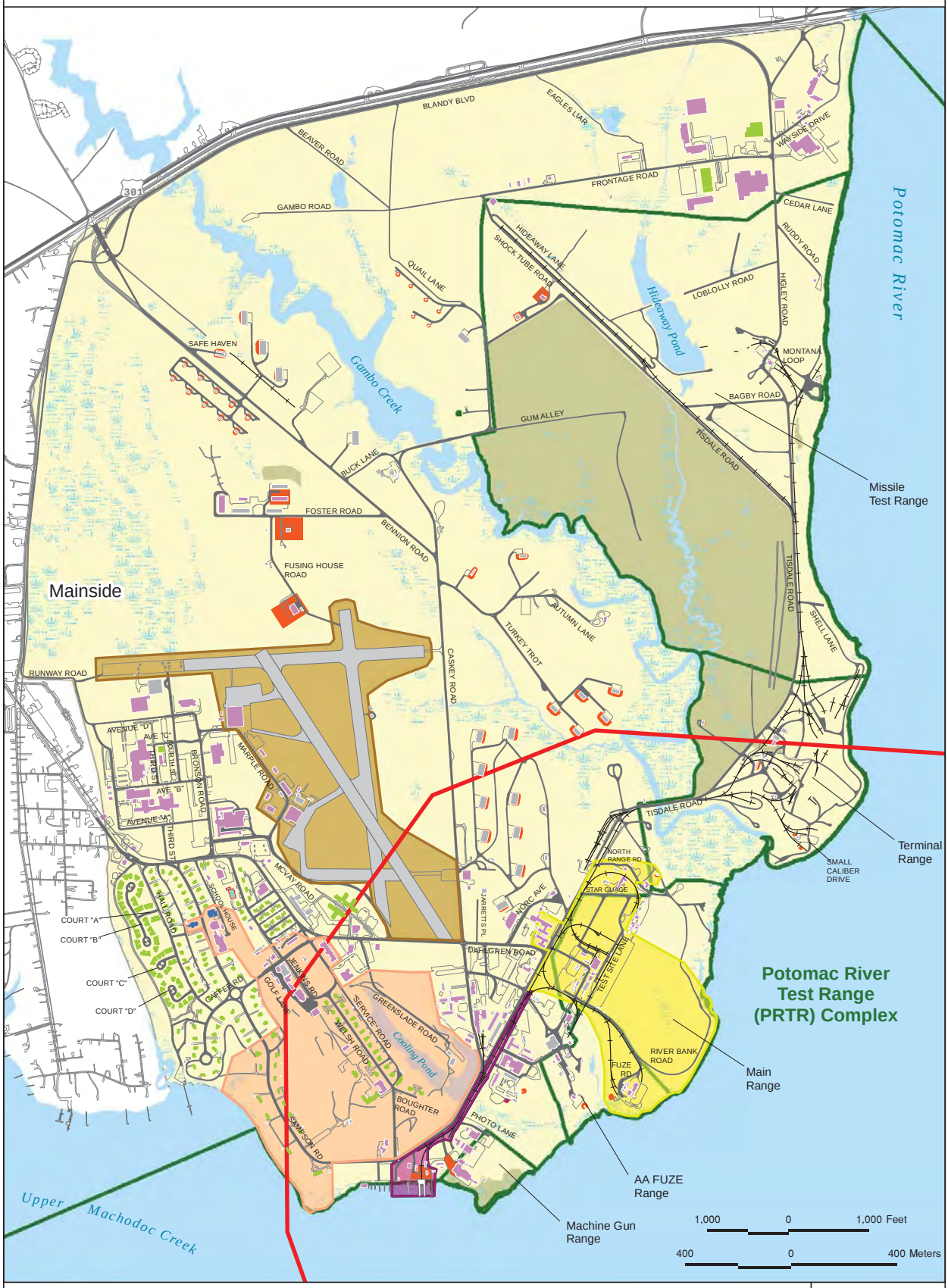
Detailed View of Historic Districts



Proposed Airfield Historic District (1994)
Proposed Main Battery Historic District (1994)
Proposed Residential Historic District (1994)
Proposed Wharf Area Historic District (1994)
Naval Support Facility (NSF) Dahlgren
Residential
Church
School
Office / Warehouse
Other Building
Ammunition Storage Area
Hazardous Materials Storage Area
Ordnance Explosive Waste Area
Potomac River Test Range (PRTR) Complex
Historic Architecture APE/134 dBP Peak Noise Contour

Source: NSWCDD, 2008-2011

Figure 4.6-1

NSWCDD EIS

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Table 4.6-4
Historic Architectural Resources within NSF Dahlgren-Mainside

Resource Name	Description	Status
Dahlgren Residential Historic District	Early 20th-century residential community at NSF Dahlgren; possesses historic significance as planned military community and architectural significance as good example of American domestic architecture from 1918 to 1945.	Determined National Register eligible, 2004.
Proposed Main Battery Historic District	Industrial buildings and structures which form the main battery at NSF Dahlgren. Resources date from the 1920s to the 1950s.	Recommended National Register eligible; determination pending.
Proposed Wharf Area Historic District	Industrial buildings and structures which form the wharf at NSF Dahlgren. Resources date from the 1920s to the 1970s.	Recommended National Register eligible; determination pending.
Proposed Airfield Historic District	Aviation-related buildings and structures at NSF Dahlgren airfield. Resources date from the 1920s to the 1970s.	Recommended National Register eligible; determination pending.

4.6.2.2 Activities with Potential to Impact Historic Architectural Resources

Impacts from two of the seven classes of RDT&E activities associated with the No Action Alternative, Alternative 1, and Alternative 2 may affect resources in the Historic Architectural APE. These two classes are:

- Large Gun/Projectile Activities
- Detonation Activities

As indicated in Section 3.6.2.2, the Historic Architectural APE is based upon peak-noise contours associated with multiple gun/projectile firings and detonations that would not occur simultaneously, but combined together form the worst-case scenario under the No Action Alternative, Alternative 1, and Alternative 2. The worst-case large gun/projectile firings are based on firing live projectiles from an 8”gun on the PRTR’s Main Range at a target 27,500 yds away on the surface of the PRTR’s MDZ. The worst case also includes ordnance detonations taking place on Churchill Range on the EEA Range Complex.

Four peak-noise contours are indicated in Figure 3.6-2: the 120-dBP noise contour, which circumscribes a wide area, and three 134-dBP noise contours around smaller, more-focused areas. The easternmost 134-dBP contour partially occurs on land and in target areas in the Potomac River, and is associated with gun/projectile activities. The central contour occurs in target areas in the Potomac River, and is associated with gun/projectile activities. The westernmost contour partially occurs on land and in target areas in the Potomac River, and is associated with both gun/projectile activities at Mainside and detonations on the EEA.

Impulse noises associated with large-gun firing and detonations, such as those that occur at NSF Dahlgren, have the potential to cause minor damage to structures when they reach levels of 134 dBP. Within the land-based portions of the easternmost and westernmost 134-dBP contours, such noises may result in vibrations which have the potential to cause window panes and plaster to crack in structurally-compromised buildings. Therefore, impacts to historic architectural resources within the land-based portions of the easternmost and westernmost 134-dBP contours

caused by worst-case scenario gun/projectile firings and detonations will be analyzed separately, according to activity type.

Impacts of the impulse noises associated with large-gun firing and detonations are unlikely to result in damage at levels of 120 dBP. However, such noises may result in vibrations which have the potential to rattle loose window panes and cause concern on the part of property owners. As described in Section 3.6.4 and Appendix D, NSWCDD selected six historic architectural resources within the 120-dBP contour of the Historic Architectural APE to conduct noise and vibration monitoring during the firing of live projectiles from the 5”/62 gun on the PRTR Complex’s AA Fuze Range in November 2009. The resources were selected in response to concerns raised by the National Register-listed Christ Episcopal Church in Chaptico, Maryland about the proposed expansion of NSWCDD’s outdoor RDT&E activities and the validity of noise models employed to develop the Historic Architectural APE.

The results of the noise and vibration monitoring at the six resources assisted in the analysis of impacts of worst-case scenario gun/projectile firings and detonations on historic architectural resources within the 120-dBP contour of the Historic Architectural APE. The analysis of impacts of gun/projectile activities and detonations on these resources will be combined because both actions would likely result in similar impacts.

4.6.2.3 Impacts to Historic Architectural Resources within the 134-dBP Peak-Noise Contours outside NSF Dahlgren

Gun/Projectile Activities

There are no previously identified and evaluated National Register-listed or National Register-eligible resources located within the land-based portions of the easternmost and westernmost 134-dBP noise contours associated with worst-case scenario gun/projectile firings outside NSF Dahlgren.

Detonation Activities

There are no previously identified and evaluated National Register-listed or National Register-eligible resources within the land-based portion of the westernmost 134-dBP noise contour associated with worst-case scenario detonations outside NSF Dahlgren.

4.6.2.4 Impacts to Historic Architectural Resources within the 134-dBP Peak-Noise Contour at NSF Dahlgren

Gun/Projectile Activities

Four historic districts within the 134-dBP peak-noise contour may be impacted by worst-case scenario gun/projectile firings conducted within the PRTR Complex ranges at Mainside, including firing an 8” gun with live projectiles from the Main Range. The districts are:

- National Register-eligible Dahlgren Residential Historic District
- Proposed National Register-eligible Main Battery Historic District
- Proposed National Register-eligible Wharf Area Historic District
- Proposed National Register-eligible Airfield Historic District

The districts are featured in Figure 4.6-1. The boundaries in the figure are based upon the 1994 survey described in Section 3.6. In 2004, VDHR determined one district National Register eligible, the Residential Historic District, and recommended a slightly different boundary. As noted previously, the 1994 boundary has been used for the purposes of this report as it was an installation evaluation. As indicated in Section 3.6, to date VDHR has not reviewed and concurred with the boundaries of the other three proposed districts.

As shown in Figure 4.6-1, the majority of the southern and central portion of the Dahlgren Residential Historic District is located within the 134-dBP contour, and the remainder of the district is located in proximity to the 134-dBP contour. Furthermore, the proposed Main Battery Historic District and proposed Wharf Area Historic District are fully located within the 134-dBP contour. Impulse noises associated with gun/projectile activities may result in vibrations that have the potential to cause window panes and plaster walls in weak buildings to crack.

The southern portion of the proposed Airfield Historic District is also located within the 134-dBP contour. This portion of the Airfield district is characterized by intersecting runways and taxiways which are rarely used, except by helicopters. However, buildings within the district are located roughly 1,000 ft north of the 134-dBP contour.

The worst-case scenario gun/projectile firings conducted within the PRTR Complex ranges, including the firing of an 8” gun with live projectiles from the Main Range, would indirectly affect the southern and central portions of the National Register-eligible Dahlgren Residential Historic District within the 134-dBP contour, and may also impact the remainder of the district because of its proximity to testing activity. The entire proposed Main Battery Historic District and the entire proposed Wharf Area Historic District would also be indirectly impacted. Buildings in the proposed Airfield Historic District located approximately 1,000 ft north of the 134-dBP contour and beyond may also be indirectly impacted because of their proximity to testing activity. According to Section 106 Criteria of Adverse Effect (Table 4.6-1), indirect effects to historic architectural resources may include noise and vibration. Noise and vibration may be caused by the ordnance activities conducted within the ranges of the PRTR Complex.

Although the four historic districts would be indirectly affected by the large-gun firing proposed under Alternative 2, the key event which drives the shape of the 134-dBP contour – the firing of an 8” gun with live projectiles from the Main Range – has not actually taken place in almost a decade. It was used only for worst case noise modeling purposes. If a gun requiring a firing charge similar to the 8” gun were to be fired in the future, weak buildings within the 134-dBP contour in the one National Register-eligible district and the three proposed districts may be subject to vibrations which could crack plaster and windows. Such actions would not diminish the integrity of the one eligible and three proposed districts provided that NSF Dahlgren personnel undertake repairs as required.

Furthermore, as indicated in Table 4.6-2, the level of gun/projectile activities under the No Action Alternative, Alternative 1, and Alternative 2 would remain constant for the foreseeable future. For this reason, it is unlikely that weak buildings within the one eligible district and three proposed districts would suffer further vibration damage beyond what they have in the past.

Therefore, in accordance with Section 106 and NEPA, worst-case scenario gun/projectile firings would have no adverse effect, with conditions, on either the National Register-eligible Dahlgren Residential Historic District or the three proposed historic districts at NSF Dahlgren, part or all of the areas of which fall within the 134-dBP contour. Such conditions would require NSF

Dahlgren personnel to undertake repairs to plaster walls and glass windows that may be cracked by vibrations associated with worst-case scenario gun/projectile firings. The VDHR and MHT have both concurred with the no adverse effect determination (Appendix E). The report *Noise and Vibration Measurements at Six Historic Structures* and cultural resources coordination and documentation are provided in Appendices D and E, respectively.

Detonation Activities

There are no previously identified and evaluated National Register-listed or National Register-eligible resources located within the land-based portion of the westernmost 134-dBP noise contour at NSF Dahlgren associated with the worst-case scenario of detonations at the Churchill Range in the EEA Complex.

4.6.2.5 Impacts to Historic Architectural Resources within the 120-dBP Peak-Noise Contour outside NSF Dahlgren

Thirty-six previously identified and evaluated historic architectural resources are located within or adjacent to the 120-dBP peak-noise contour outside NSF Dahlgren along the PRTR. Specifically, 18 National Register-listed resources are located within the 120-dBP contour outside NSF Dahlgren, and 2 National Register-listed resources are located immediately adjacent to the northern border of the 120-dBP contour. Furthermore, 14 National Register-eligible resources are located within the 120-dBP contour outside NSF Dahlgren, and two National Register-eligible resources are located immediately adjacent to the northern border of the 120-dBP contour. The 36 resources are depicted in Figure 3.6-2 and listed in Table 4.6-4.

As indicated in Section 4.6.2.2 and Appendix D, six historic architectural resources within the 120-dBP contour were selected for noise and vibration monitoring during the firing of the 5”/62 gun with live projectiles from the PRTR Complex AA Fuze Range in November 2009. Measured peak noise levels ranged from 89 to 129 dBP.

Vibration levels ranged from non-detectable to slightly above 0.5 in/sec. Vibration levels of 2.0 in/sec are regarded as the threshold at which minor structural damage may begin to occur. However, 0.5 in/sec has been conservatively identified as a potential level at which glass and plaster may crack in poorly maintained buildings and structures. Stratford Hall, Christ Episcopal Church, and St. Francis Xavier Church & Newtown Manor were not subject to clearly detectable vibration levels during gun/projectile firings. The Greg House and Waverley were subject to vibration levels well below 0.5 in/sec during gun/projectile firings. The Bell House was subject to vibration levels which were slightly above 0.5 in/sec. As indicated in Appendix D, the six resources did not suffer structural damage caused by vibration during gun/projectile firings.

According to Section 106 Criteria of Adverse Effect shown in Table 4.6-1, indirect effects may include noise and vibration. Although the six resources were not damaged during gun/projectile firings, live projectiles from the 5”/62-caliber gun resulted in indirect noise and vibration effects. Therefore, it is anticipated that the 36 resources would be indirectly affected by worst-case scenario gun/projectile firings and detonations in a similar manner to impacts caused by firing live projectiles from the 5”/62 gun.

Large gun/projectile activities would remain at current levels for the foreseeable future. Annual numbers of detonations would increase by about 5 percent under Alternative 1, and by about 21 percent under Alternative 2, as indicated in Table 4.6-2. It is unlikely that vibrations which may

result from the large-gun firing or the detonations would diminish the integrity of the 36 resources within and adjacent to the 120-dBP contour. Because of their age and their having remained intact through the period when 12”, 14”, and 16” guns were being fired (the 16” gun, for example, required a very large quantity of explosives to fire – the firing charge – and fired projectiles that contained 150 lbs of explosives vs. 9 lbs in the 5”/62 projectiles fired during noise measurements at historic structures), these resources have been subjected to such vibrations over time and would not likely suffer damage. Furthermore, the current NSWCDD Noise Management Process would ensure that noise and vibrations anticipated as a result of gun/projectile firing and detonations are kept to reasonable levels.

Therefore, in accordance with Section 106 of the NHPA and NEPA, worst-case scenario gun/projectile firings and detonations would have no adverse effect on the 36 resources within and adjacent to the 120-dBP contour. The VDHR and MHT have both concurred with the no adverse effect determination (Appendix E). The report *Noise and Vibration Measurements at Six Historic Structures* and cultural resources coordination and documentation are provided in Appendices D and E, respectively.

4.6.2.6 Impacts to Historic Architectural Resources within the 120-dBP Peak-Noise Contour at NSF Dahlgren

Four historic districts within the 120-dBP peak-noise contour may be impacted by worst-case scenario gun/projectile firings conducted at the PRTR Complex ranges and detonations conducted at the EEA Complex. The districts are as follows:

- National Register-eligible Dahlgren Residential Historic District
- Proposed National Register-eligible Main Battery Historic District
- Proposed National Register-eligible Wharf Area Historic District
- Proposed National Register-eligible Airfield Historic District

These districts are also located within the 134-dBP contour, and impacts were assessed in Section 4.6.2.4. The results of the impacts analysis indicate that the Proposed Action would result in no adverse effect to either the National Register-eligible Dahlgren Residential Historic District or the three proposed districts within the 134-dBP contour. Similarly, in accordance with Section 106 Criteria of Adverse Effect, worst-case scenario gun/projectile firings and detonations would result in no adverse effect to the National Register-eligible district or to the three proposed districts at NSF Dahlgren, all of which lie entirely within the 120-dBP contour. The VDHR and MHT have both concurred with the no adverse effect determination (Appendix E). The report *Noise and Vibration Measurements at Six Historic Structures* and cultural resources coordination and documentation are provided in Appendices D and E, respectively.

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4.7 Hazardous Materials and Hazardous Waste Management

4.7.1 No Action Alternative

Under the No Action Alternative, outdoor RDT&E activities at NSF Dahlgren would continue at the existing level into the foreseeable future. There would be no increase in the average annual number of such activities, as described in Table 2-1.

4.7.1.1 Ordnance

Under the No Action Alternative, the current firing of large-caliber guns and small arms, and detonations would continue. Large-caliber gun testing – averaging 4,700 projectiles per year in the most active years – is primarily conducted on NSWCDD's gun line on the Main Range and the Missile Test Range within the PRTR Complex (see Figures 1-4 and 1-5), but also on the AA Fuze Range and the Terminal Range. Outdoor small-arms activities usually employ machine guns firing inert bullets with small propellant charges, although some rounds are live. Approximately 10 percent of the small-arms rounds are fired into the river from the Main, Machine Gun, and Missile Test Ranges, but the vast majority of them are fired on land, principally on the Machine Gun, Terminal, Harris, and Churchill Ranges. Detonations take place at the EEA Range Complex's Harris and Churchill Ranges and range in size from less than 0.01 lbs up to 1,000 lbs net explosive weight (NEW).

As discussed in Section 3.7, NSF Dahlgren and NSWCDD have in place a number of programs, plans, and processes to safely use, transport, handle, store, and dispose of hazardous materials (HM) and hazardous waste (HW), inclusive of explosive hazardous waste (EHW). HW accumulation areas must have contingency plans designed to minimize hazards to human health and the environment. These planning documents include: a Hazardous Waste Contingency Plan, a Hazardous Waste Management Plan, a Military Munitions Implementation Plan, Accumulation Area Requirements, and Satellite Accumulation Point Requirements.

The USEPA Munitions Rule (MR) defines when used or unused munitions (ordnance) are considered EHW. Under the MR, military munitions are not considered EHW when used in training, used in RDT&E activities, during range clearance operations, repaired, or otherwise subjected to materials recovery. Under the MR definition of wastes, ordnance remaining on the land and water ranges at NSF Dahlgren is considered used for its intended purpose and is not subject to HW regulations. The operational ranges at NSF Dahlgren are managed under several military directives and programs that require range maintenance and clearance activities, as discussed in detail in Section 3.7. The NSWCDD Range Management Plan (RMP) and specific post-operation cleanup procedures documented in standard operating procedures (SOPs) prepared for each operation ensure that all range wastes, such as ordnance casings and residues, are managed as required by all applicable regulations and directives.

NSWCDD thermally treats (burns or detonates) EHW from on-site and off-site sources and non-transportable ordnance from on site. The amount of EHW generated, stored, and treated from on-site or off-site activities varies considerably from year to year. The NEW of EHW thermally treated (by open burning/open detonation [OB/OD]) at NSWCDD in 2007 was 8,597 lbs by OB and 10,277 lbs by OD.

To address the requirements of the Navy's Range Sustainability Environmental Program Assessment (RSEPA), a Range Condition Assessment (RCA) for land-based NSWCDD operational ranges at NSF Dahlgren was completed in September of 2010. The RCA found RDT&E activities at NSWCDD land-based ranges to generally be in compliance with all applicable environmental regulations and program requirements (NAVSEA, 2010).

In addition, as there is potential at the PRTR for interaction between the munitions fired into the Potomac River and human and ecological receptors, to support the environmental impact analysis in this EIS, range-specific screening-level risk assessments (RSSRAs) were performed. The results of the ecological and human health RSSRAs indicate that the effects of the cumulative and yearly input of munitions constituents (MCs) during RDT&E in the PRTR are orders of magnitude below concentrations that could cause adverse effects to human health or the environment. This analysis is further described in Sections 4.8, 4.11, 4.12, and 4.13, and Appendix F.

NSF Dahlgren and NSWCDD programs, plans, and processes ensure the safe use, transportation, handling, storage, and disposal of HM, HW, and EHW and the RCA findings indicate that NSWCDD's operational ranges are in compliance with all applicable HM and HW (inclusive of EHW) regulations. These regulations ensure that there are no adverse effects to human health or the environment from ordnance activities. However, even when all programs comply with all regulations, there is still the potential for small amounts of HM and HW to enter the environment. Therefore, there would be minor, long-term, direct and indirect, negative impacts on HM and HW management associated with the continuation of ordnance activities under the No Action Alternative.

4.7.1.2 EM Energy Activities

The EM energy devices included in the No Action Alternative include outdoor facilities for EM testing for the RDT&E of issues surrounding EM environmental effects: the Naval Ordnance Transient Electromagnetic Simulator (NOTES); the Maginot Open Air Test Site (MOATS); and two ground planes. Search and track sensor test site (STSTS) radars, the Navy Directed Energy Center (NDEC), and Counter Explosive Test Facility (CETFAC) for RDT&E of directed energy and HE lasers are also included in the No Action Alternative. NSWCDD conducts approximately 490 EM energy events a year; with more than three quarters of these events currently taking place at the ground planes.

As with ordnance activities, SOPs developed for each operation using EM energy identify and incorporate safe operating parameters with respect to personnel, ordnance, fuels, the environment, and electronic equipment near the test site. As described in Section 3.7, NSWCDD has a fully-developed HM management program in place, in accordance with Virginia Department of Environmental Quality (VDEQ) Resource Conservation and Recovery Act (RCRA) regulations and OPNAVINST 5100.23G procedures. Use of HM other than small amounts of lubricants and oils for high-voltage insulation would not be routine for EM energy RDT&E. However, should HM or HW be generated during outdoor EM energy activities, the material would be approved and tracked according to NSWCDD's HM management program. Any HW would be disposed of in accordance with applicable federal and state laws and regulations.

NSWCDD's programs, plans, and processes ensure the safe use, transportation, handling, storage, and disposal of HM, HW, and EHW, and the RCA findings indicate that NSWCDD's operational ranges are in compliance with all applicable HM and HW (inclusive of EHW) regulation. As the use and generation of HM and HW for EM energy operations would be minimal, there would be negligible, long-term, direct and indirect, negative impacts on HM, and HW management associated with outdoor EM energy activities under the No Action Alternative.

4.7.1.3 HE Laser Activities

The HE lasers primarily used at NSF Dahlgren include (NSWCDL, 2009):

- **Solid State** – Generally, the active medium of a solid-state laser consists of a glass or crystalline host material. Solid-state lasers are rugged, simple to maintain, and capable of generating high powers.
- **Carbon Dioxide (CO_2)** – Carbon dioxide lasers are the highest-powered continuous-wave lasers available. The most common gas composition in CO_2 lasers is a mixture of helium, nitrogen, and CO_2. Additional gases other than CO_2 are used to increase the efficiency of the laser.

Solid-state laser systems commonly use water as a coolant for the neodymium doped crystal yttrium aluminum garnet and thus produce no HW during the lasing process. Other solid-state laser systems may use deuterium as a coolant for the ytterbium-doped crystal yttrium aluminum garnet. Deuterium, also called heavy hydrogen, is an isotope of hydrogen with one proton and one neutron in the nucleus; natural hydrogen has one proton in the nucleus and no neutrons. In this case, deuterium may be considered as water, as it has many of the same properties as water, is a stable isotope, and does not have a regulated maximum contaminant level established by the USEPA.

CO_2 lasers do not require a coolant, but they do use several inert gases, such as helium and nitrogen, for increased operating efficiency, and CO_2 as the prominent lasing medium. None of these inert gases are hazardous, but nitrogen – although it comprises about 78 percent of our atmosphere – in its pure form is an asphyxiant and rapid release of nitrogen into an enclosed space can displace oxygen.

Laser coolants operate within a closed-loop system and are only replaced for routine system maintenance. During tests, the minimum amount of chemicals required would be used, in order to minimize the potential for an incidental release to the environment.

As part of NSWCDD's HW management program, all compressed gases would comply with Occupational Safety and Health Administration (OSHA) regulations contained in 29 CFR § 1910.101, *Compressed Gases (General Requirements)*. In the event that liquid oxygen or nitrogen facilities are required, they would also comply with those regulations. All operations are conducted in accordance with applicable federal and state regulations and policies, and under an NSWCDD-approved SOP.

The use of HM during HE laser activities is not routine. However, any HM utilized would be labeled, stored, contained, inspected, and disposed of according to the HM and HW management program. As with ordnance activities, SOPs developed for each operation using HE lasers identify and incorporate safe operating parameters with respect to personnel, ordnance, fuels, the environment, and electronic equipment near the test site. Therefore, there would be negligible,

long-term, direct and indirect, negative HM and HW management impacts associated with HE laser activities under the No Action Alternative.

4.7.1.4 Chemical Defense Activities

The quantities of simulants used in outdoor chem/bio defense activities represent a very small portion of the amount of materials requiring storage and handling at NSWCDD. The simulants utilized are non-hazardous, even in concentrated form, and are not subject to HM requirements. A maximum of 20 gals of chemical simulant is released over land or water per release. Prior to use, all simulants would be approved by the NSWCDD Safety and Environmental Office in consultation with the NSF Dahlgren Environmental Office and with the Maryland Department of the Environment (MDE) and the VDEQ. Simulants in a compressed-gas state would comply with OSHA regulations contained in 29 CFR § 1910.101.

All tests are conducted in accordance with applicable federal and state regulations and policies, and under an approved SOP. Under the No Action Alternative, only chemical simulants would be used. Chemical simulants are released and dispersed in small quantities as a vapor into the atmosphere, generating little to no HW. Based on the limited quantity and low toxicity of the simulants released into the environment, there would be negligible, long-term, direct and indirect, negative HM and HW management impacts from outdoor chemical defense activities under the No Action Alternative.

4.7.2 Alternative 1

4.7.2.1 Ordnance Activities

Under Alternative 1, the number of large-caliber projectiles at the PRTR would remain at the current levels, although the frequency of firing into the upper LDZ would increase to up to 10 days per year. Outdoor small-arms activities would increase from firing 6,000 bullets to 25,500 bullets. A nominal increase of detonations – from 190 to 200 annually – is anticipated.

NSWCDD has in place a number of programs and processes to ensure the safe use, transportation, handling, storage, and disposal of HM and HW, inclusive of EHW, generated at operational ranges. The RMP and specific post-operation cleanup procedures documented in SOPs ensure that all range wastes, such as ordnance casings and residues, are managed as required according to all applicable regulations and directives. The additional 19,500 bullets under Alternative 1 would be required to be tracked and spent bullets disposed of through the ordnance-handling and -disposal SOPs according to DoD directives. The RCA findings indicate that NSWCDD's operational ranges are in compliance with all applicable HM and HW (inclusive of EHW) regulations.

Under Alternative 1 there would be minor, long-term, direct and indirect, negative impacts on HM and HW management resulting from ordnance activities.

4.7.2.2 EM Energy Activities

Under Alternative 1, some outdoor EM activities would increase in power, and the number of annual events would increase from 490 to 590. Most EM energy events would continue to be conducted at the main outdoor facilities for EM testing – NOTES, MOATS, and the ground planes – the STSTS for radars as well as the NDEC and CETFAC facilities for RDT&E of directed energy and lasers, although some events could take place from mobile emitters anywhere on the ranges or the Mission Area. The majority of events would continue to take place at the two ground planes.

As with ordnance activities, SOPs developed for each operation using EM energy identify and incorporate safe operating parameters with respect to personnel, ordnance, fuels, the environment, and electronic equipment near the test site. Should HM or HW be generated during EM events, the material would be approved and tracked according to the NSF Dahlgren HM management program. Any HW would be disposed of in accordance with applicable federal and state laws and regulations.

As discussed under the No Action Alternative, the use of HM other than proposed lubricants and oils for high-voltage insulation would not be routine; NSWCDD programs, plans, and processes ensure the safe use, transportation, handling, storage, and disposal of HM, HW, and EHW; and the RCA findings indicate that NSWCDD's operational ranges are in compliance with all applicable HM and HW regulations. Therefore, there would be negligible, long-term, direct and indirect, negative impacts to HM and HW management associated with outdoor EM energy activities under Alternative 1.

4.7.2.3 HE Laser Activities

Under Alternative 1, the number of outdoor HE laser test events would increase from 60 to 125 per year and the maximum power from 100 kW to 500 kW. As discussed under the No Action Alternative, the HE lasers currently in use include solid state and CO_2 lasers (NSWCDL, 2009). As discussed in Section 4.7.1.3, coolants for the steady state lasers may include water or deuterium (heavy hydrogen). CO_2 lasers do not require a coolant, but they do use several inert gases, such as helium and nitrogen, for increased operating efficiency, and CO_2 as the prominent lasing medium, none of which are considered HM.

As part of NSWCDD's safety management program, all compressed gases would comply with storage and handling specifications under 29 CFR § 1910.101, and in the event that liquid oxygen or nitrogen facilities are required, they would comply with applicable standards. All laser activities would be conducted in accordance with applicable federal and state regulations and policies, and under an NSWCDD-approved SOP.

During laser activities, inclusive of HE lasers, the use of HM is not routine, and any HW utilized would be labeled, stored, contained, inspected, and disposed of. SOPs developed for use of HE lasers identify and incorporate safe operating parameters with respect to personnel, ordnance, fuels, the environment, and electronic equipment near the test site. Therefore, there would be negligible, long-term, direct and indirect, negative HM and HW management impacts associated with laser activities under Alternative 1.

4.7.2.4 Chemical and Biological Defense Activities

Under Alternative 1, outdoor testing using chemical and biological simulants would expand from the baseline 12 events annually to 60 events annually over land and water. The amount of simulants used in typical events would not increase from a maximum of 20 gals per test currently used. However, under Alternative 1, biological simulants could be used as well as chemical simulants.

The simulants that would be utilized for chem/bio tests are non-hazardous, even in concentrated form, and are not subject to HM requirements. Prior to use, all simulants would be approved by the NSWCDD Safety and Environmental Office, in consultation with the NSF Dahlgren Environmental Office and the MDE and VDEQ. All simulants in a compressed-gas state would comply with storage and handling specifications under 29 CFR §1910.101.

All activities would be conducted in accordance with applicable federal and state regulations and policies under an approved SOP. Chemical and biological simulants would be released and dispersed in small quantities into the atmosphere, generating no HW requiring disposal. Therefore, there would be negligible, long-term, direct and indirect, negative impacts from chem/bio sensor RDT&E on HM and HW management under Alternative 1.

4.7.3 Alternative 2

4.7.3.1 Ordnance Activities

Under Alternative 2, the number of large-caliber projectiles would remain at current levels and use would be the same as under Alternative 1. Outdoor small-arms activities would increase from firing 6,000 bullets to 30,000 bullets. An increase of detonations – from 190 to 230 annually – is anticipated.

NSWCDD has in place a number of programs and processes to ensure the safe use, transportation, handling, storage, and disposal of HM and HW generated at operational ranges. The RMP and specific post-operation cleanup procedures documented in SOPs ensure that all range wastes, such as ordnance casings and residues, are managed as required according to all applicable regulations and directives. The additional 24,000 bullets under Alternative 2 would be required to be tracked, and spent bullets disposed of, through the ordnance-handling and disposal SOPs according to DoD directives. The RCA findings indicate that NSWCDD's operational ranges are in compliance with all applicable HM and HW (inclusive of EHW) regulations.

There would be minor, long-term, direct and indirect, negative impacts on HM and HW management resulting from ordnance activities under Alternative 2.

4.7.3.2 EM Energy Activities

Under Alternative 2, the number of EM energy test events would increase from 490 per year under the No Action Alternative to 680 per year. It is anticipated that these events would be conducted at existing EM outdoor testing facilities on the Mission Area and operational ranges, with the majority of events continuing to take place at the ground plane test facilities. An increasing number of events would take place over the MDZ. Higher power levels would be used for some tests.

As discussed under previous alternatives, SOPs developed for each operation using EM energy identify and incorporate safe operating parameters with respect to personnel, ordnance, fuels, the environment, and electronic equipment near the test site. NSWCDD has an HM management program in place, in accordance with VDEQ RCRA regulations and OPNAVINST 5100.23G procedures. Should HM or HW be generated during EM energy RDT&E, the material or waste would be required to be approved and tracked according to the HM management program. Any HW generated as a result of activities would be managed in accordance with applicable regulations.

Based on a review of EM energy RDT&E testing materials, which indicate that the use of HM other than proposed lubricants and oils for high-voltage insulation would not be routine; NSWCDD programs, plans, and processes to ensure the safe use, transportation, handling, storage, and disposal of HM, HW, and EHW; and the RCA findings of NSWCDD's operational range compliance with all applicable HM and HW regulations, there would be negligible, long-term, direct and indirect, negative impacts to HM and HW management associated with outdoor EM energy activities under Alternative 2.

4.7.3.3 Laser Activities

Under Alternative 2, the number of HE laser events would increase from No Action Alternative levels of 60 to 145 annually. As discussed under the previous alternatives, the coolants used in the outdoor HE lasers are considered non-hazardous and are only replaced during routine system maintenance, and all compressed gases would comply with storage and handling specifications under 29 CFR § 1910.101. All laser activities would be conducted in accordance with applicable federal and state regulations and policies, and under an NSWCDD-approved SOP.

During laser activities, inclusive of HE lasers, the use of HM is not routine, and any HW utilized would be labeled, stored, contained, inspected, and disposed of. SOPs developed for use of HE lasers identify and incorporate safe operating parameters with respect to personnel, ordnance, fuels, the environment, and electronic equipment near the test site. Therefore, there would be negligible, long-term, direct and indirect, negative HM and HW management impacts associated with laser activities under Alternative 2.

4.7.3.4 Chemical and Biological Defense Activities

Under Alternative 2, outdoor activities using chemical and biological simulants would expand from the baseline 12 events annually to 70 events over land and water. The amount of simulants used for typical events would not be greater than the 20 gals per test currently used. Biological simulants could be used as well as chemical simulants and events could use both chemical and biological simulants simultaneously.

As discussed under previous alternatives, all simulants used in outdoor chem/bio sensor activities would be approved by the NSWCDD Safety and Environmental Office, in consultation with the NSF Dahlgren Environmental Office and appropriate Maryland and Virginia regulatory authorities, prior to use, and would only be approved after considering toxicity data relative to the intended quantity and concentration of the simulant to be used. The simulants approved for use are non-hazardous. All activities would be conducted in accordance with all applicable federal and state regulations and policies, under an approved SOP. Therefore, it is anticipated that there would be negligible, long-term, direct and indirect, negative HM and HW management impacts from chem/bio defense RDT&E activities under Alternative 2.

4.8 Health and Safety

4.8.1 No Action Alternative

Under the No Action Alternative, health and safety activities would remain the same as they are at present, continue to be an integral part of NSWCDD's mission, and continue to follow the Occupational Safety and Health Policy (NSWCDD, 2011). All outdoor activities associated with RDT&E activities would continue to comply with all applicable federal and state, Department of Defense- (DoD-), Navy-, and installation-level occupational and environmental safety requirements. The development and rigorous implementation of risk hazard assessments (RHAs), standard operating procedures (SOPs), or general operating procedures (GOPs) with associated operation procedures supplements (OPSs) described in Section 3.8 would continue for all activities described below, as would the safety measures specific to each type of operation, as detailed in Section 3.8.

Policies and SOPs/GOPs/OPSs include, but are not limited to, very specific operating parameters for range clearance and scheduling, safety controls, environmental preservation, materials-handling safety procedures, and control hazard briefings. Additionally, the dedicated technical facilities and equipment at NSF Dahlgren have features specifically designed to support safety requirements for the activities covered in this EIS.

4.8.1.1 Ordnance Activities

NSWCDD would continue to conduct weapon/explosives testing at various operating range locations, as at present, in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls, RHAs, and SOPs/GOPs/OPSs. Gun-firing control measures would be strictly adhered to (Section 3.8.2.1).

An average of 4,700 projectiles (greater than 20 mm to 8" caliber), 6,000 bullets (less than or equal to 20 mm caliber), and 190 detonations (less than 0.1 lbs to 1,000 lbs net explosive weight [NEW]) would be fired annually. The SOPs and GOPs/OPSs, range- and airspace-control measures, gun-firing control measures, unexploded ordnance (UXO) control measures, and procedures for UXO (Section 3.8.2.2) would remain in effect.

The safety zones (Section 3.8.1.1) associated with the PRTR, airfield and SUA, and explosive safety quantity distance (ESQD) arcs would remain in effect to minimize risks and ensure safety during activities.

Range Sustainability Program Assessment

The Navy's Munitions Response Program provides for compliance with the National Defense Authorization Act of 2000 requiring DoD to establish a program addressing military munitions as part of the Defense Environmental Restoration Program (US Navy, 2007). The purpose of the Munitions Response Program is to address munitions and explosives of concern and munitions constituents (MCs) used or released on sites from past activities.

The DoD Range Sustainability Environmental Program Assessment (RSEPA) process described in Section 3.7.6 specifically addresses the sustainability of land ranges, including a determination of whether the release or substantial threat of a release of MCs of potential concern (MCOPCs) from an operational range to an off-range area poses an unacceptable risk to human health or the

environment. DoD Directive 4715.11 (DoD, 2007), DoD Instruction 4715.14 (DoD, 2005), and the *US Navy Range Sustainability Environmental Program Assessment Policy Implementation Manual* (US Navy, 2006) define and provide guidance on this process. The RSEPA process provides a consistent and defensible approach for assessing and addressing the environmental condition of land-based operational ranges where munitions are or were used, excluding small-arms ranges, which are mainly assessed as part of an existing environmental compliance program (e.g., the Navy's best management practices [BMPs] for small-arms ranges).

The conditions on the seven land-based munitions ranges – Missile Test Range, Terminal Range, Main Range, AA Fuze Range, Machine Gun Range, Harris Range, and Churchill Range – at NSWCDD were assessed in the Range Condition Assessment (RCA) Report (NAVSEA, 2010). Areas where there is a potential for an off-range release of MCs are already under investigation and areas where releases have occurred have already been addressed in most cases through the Environmental Restoration Program (ERP) and Subpart X permitting requirements. Groundwater monitoring has detected explosives and perchlorate in wells located in a shallow aquifer. However, this aquifer is not used or suited for drinking water and consequently does not present a health risk. The RCA report concluded that there is no need to investigate any areas for potential off-range releases of MCs beyond investigations already planned and other programs and the procedures described in Section 3.7.6 to ensure the health and safety of NSF Dahlgren personnel and the general public.

PRTR Evaluation

An evaluation of whether MCs and military expended material constituents (MEMCs) entering the PRTR during RDT&E activities could result in an unacceptable risk to human health or the environment was conducted as part of this EIS. As there is potential for interaction of constituents released from munitions fired into the Potomac River to affect both human and ecological receptors, two separate range-specific screening-level risk assessments (RSSRAs) were performed, one for human health and one for ecological receptors.

The human health and ecological RSSRAs employed conservative (i.e., stringent/protective) assumptions to evaluate existing data on munitions in the PRTR and to determine whether additional analysis is necessary; protective measures are warranted; or whether the range poses acceptable risks, in which case no further analysis is needed. In order to perform the RSSRAs, the quantity of munitions entering the PRTR was estimated based on records extending back to the establishment of Dahlgren in 1918. Appendix F, Derivation of Concentrations of Munitions Constituents in Potomac River Test Range Sediment and Water, contains a summary of the quantification of munitions, focusing on large-caliber projectiles.

Once a list of the types and quantities of MCs used at Dahlgren was compiled, a subset of MCOPCs was selected for geochemical modeling to provide an estimate of their concentrations in sediments and water. MCOPCs were selected based on total mass (cumulative over the last 90 years), toxicity, and US Navy guidance (US Navy, 1999, 2001), as described in Appendix F.

The concentrations of the MCOPCs were estimated in the areas with the densest concentrations of large-caliber projectiles. The area between the Main Range Gun Firing Line (0 yds) and 25,000 yds in the MDZ accounts for a total of 341,706 rounds fired, or 99.4 percent of all large-caliber munitions recorded in log books as tested on the PRTR in the last 90 years (refer to Figure 3.7-1). This area was termed the "diffuse zone," as munitions are distributed over a relatively large area.

Within this area, the zone from 11,000 to 13,000 yds was termed the "dense zone," as it has the highest density of rounds in the PRTR. The dense zone has a surface area of approximately 2.29 sq NM and contains approximately 159,580 rounds, yielding a density of 69,686 rounds per sq NM. These two areas were used to derive upper bound estimates of MCOPCs in PRTR water and sediments using conservative modeling assumptions, as detailed in Appendix F. Dilution of MCOPCs in the water column and burial of sediments (the PRTR is a high deposition area; see Section 3.9) were not considered when modeling water or sediment concentrations. Estimates of concentrations of MCOPCs in fish based on uptake from the water column were calculated (see Section 4.11.1.1). The human health RSSRA is summarized below, while the ecological RSSRA is described in Sections 4.11.1.1, 4.12.1.1, and 4.13.1.

The human health RSSRA evaluated the following three exposure pathways in the absence of any institutional controls or other restrictions:

- Ingestion of fish from the PRTR.
- Incidental ingestion of and dermal contact with surface water during recreational uses (e.g., wading, boating, or swimming) in the PRTR.
- Incidental ingestion of and dermal contact with surface sediments during recreational uses (e.g., wading, boating, or swimming) in the PRTR.

To determine the potential for adverse effects, modeled concentrations of MCOPCs were compared to risk-based regional screening levels developed by the US Environmental Protection Agency (USEPA, 2012). These screening levels are based on default exposure parameters and factors that represent reasonable maximum exposure conditions for long-term/chronic exposures and methods outlined in USEPA's Risk Assessment Guidance for Superfund, Part B Manual (USEPA, 1991) and Soil Screening Guidance documents (USEPA, 1996; 2002).

The screening-level concentrations correspond to either a 1×10^{-6} (one in a million) excess cancer risk for carcinogens or a hazard quotient (HQ) of 1 for non-carcinogens (USEPA, 2012). The HQ is the ratio of the exposure concentration over the non-cancer reference dose. A value of 1.0 or higher indicates the potential for non-cancer effects from exposure to a compound. If the HQ is below 1 – i.e., all concentrations were below levels associated with adverse effects – concentrations are considered to be at acceptable levels and no further evaluation is required.

Modeled concentrations of constituents in fish in the dense and diffuse zones were compared to USEPA fish-ingestion regional screening levels. As shown in Table 4.8-1, there were no exceedances of USEPA fish-tissue screening-level concentrations. HQs of modeled concentrations are orders of magnitude below the target ratio of 1, indicating that concentrations of MCOPCs in fish from ordnance activities are hundreds of times to billions of times lower than concentrations that may result in adverse effects to people.

Table 4.8-1
Risk Characterization of Modeled Constituents in Fish Tissue

MCOPC	Concentration in Fish Tissue (mg/kg ww)		Fish-Tissue Screening Level (mg/kg)[1]	Hazard Quotient	
	Dense Zone	Diffuse Zone		Dense Zone	Diffuse Zone
Metals					
Cadmium	0.0000046	0.00000063	1.35	0.0000034	0.00000047
Chromium	0.00000016	0.000000037	2,030	7.9×10^{-11}	1.8×10^{-11}
Copper	0.0000042	0.0000011	54.1	7.8×10^{-8}	2.0×10^{-8}
Lead	5.2×10^{-13}	1.1×10^{-13}	NA	NA	NA
Manganese	0.00066	0.00022	189	0.0000035	0.0000012
Nickel	0.0000017	0.0000017	27	6.3×10^{-8}	6.3×10^{-8}
Zinc	0.000094	0.000015	406	0.00000023	3.7×10^{-8}
Explosives					
Ammonium Picrate	0.0000083	0.00000043	NA	NA	NA
HMX	4.9×10^{-9}	2.9×10^{-9}	67.6	7.3×10^{-11}	4.3×10^{-11}
RDX	0.0001	0.0000018	0.029	0.0035	0.000063
Tetryl	0.000013	0.00000036	5.41	0.0000024	6.7×10^{-8}
TNT	0.00025	0.000048	0.105	0.0024	0.00046

Notes: NA = not available, no criteria available.mg/kg ww = milligrams per kilogram (parts per million) wet weight; mg/kg = milligrams per kilogram; Scientific notation is used for very small numbers; for example 1.0×10^{-9} is one billionth (0.000000001).
Hazard quotients are the modeled concentration divided by the screening level concentration.
Hazard quotients above 1 indicate the potential for adverse effects.

Modeled concentrations of constituents in surface water were compared to USEPA tap water screening levels to screen whether ingestion of surface water posed a potential risk. In the event that ingestion of tap water posed a potential risk, site-specific parameters would have been modeled for incidental surface water ingestion as the next step. As shown in Table 4.8-2, there were no exceedances of residential tap water-ingestion screening-level concentrations for MCOPCs based on the modeled concentrations in the PRTR. HQs of modeled concentrations were far below the target ratio of 1, indicating that surface water concentrations are below tap water concentrations that could result in adverse effects. It should be noted that ingestion rates used for screening levels are based on water used as a drinking water source (2 liters per day), rather than incidental ingestion of water during recreational activities (0.05 liters per day).

Table 4.8-2
Risk Characterization of Modeled Constituents in Surface Water

MCOPC	Modeled River Water Concentration from Munitions (Daily) (µg/l)		USEPA Tap Water Screening Levels	Hazard Quotient	
	Dense Zone	Diffuse Zone		Dense Zone	Diffuse Zone
Metals					
Cadmium	0.000005	0.00000069	6.91	7.2×10^{-7}	1.0×10^{-7}
Chromium	0.0000085	0.0000019	1001	8.5×10^{-9}	1.9×10^{-9}
Copper	0.0000059	0.0000015	622	9.5×10^{-9}	2.4×10^{-9}
Lead	5.8×10^{-9}	1.2×10^{-9}	151	3.8×10^{-11}	7.9×10^{-12}
Manganese	0.00001	0.000034	322	3.1×10^{-8}	1.1×10^{-7}
Nickel	0.000022	0.000022	303	7.3×10^{-8}	7.3×10^{-8}
Zinc	0.000046	0.0000073	4,670	9.9×10^{-9}	1.6×10^{-9}
Explosives					
Ammonium Picrate	0.000052	0.0000027	No Criteria	NA	NA
HMX	4.5×10^{-9}	2.6×10^{-9}	781	5.8×10^{-12}	3.3×10^{-12}
RDX	0.000034	0.00000057	0.61	0.000056	9.4×10^{-7}
Tetryl	0.00000057	0.000000016	62.9	9.1×10^{-9}	2.5×10^{-10}
TNT	0.0000033	0.00000064	2.19	0.0000015	2.9×10^{-7}

Notes: NA = not available
µg/l = micrograms per liter (parts per billion);
Scientific notation is used for very small numbers; for example 1.0×10^{-9} is one billionth (0.000000001).
Hazard quotients are the modeled concentration divided by the screening level concentration.
Hazard quotients s above 1 indicate the potential for adverse effects.

Modeled concentrations of constituents in sediments were compared to USEPA residential soil screening levels, as site-specific parameters would have to be modeled for incidental sediment ingestion. As for surface water ingestion, this step would have been completed in the event that incidental ingestion of soil posed a potential risk. As seen in Table 4.8-3, there were no exceedances of residential soil screening concentrations. The ratios of modeled concentrations to screening levels are orders of magnitude below the target HQ of 1.

Based on the human health RSSRA, none of the MCOPCs exceed screening targets, even using extremely conservative exposure assumptions for water and sediment exposure that considerably overestimate potential exposure. Although one explosive (ammonium picrate) lacks health-based screening concentrations, it should not pose a significant risk to human health due to the lack of known significant toxicological effects associated with it. The analysis of fish consumption and recreational exposure scenarios indicates that there is no potential for increased risk from the ingestion of fish or incidental ingestion or contact with surface water or sediment, and that all potential risks posed by the range-related MCOPCs are within USEPA acceptable limits.

Based on health and safety procedures in place, the RCA report, and the risk screening, ordnance activities associated with the No Action Alternative would have negligible, long-term, direct and indirect, negative impacts on health and safety.

Table 4.8-3
Risk Characterization of Modeled Constituents in Sediments

MCOPC	Monthly Sediment Concentration from Munitions (mg/kg)		USEPA Residential Soil Screening Levels (mg/kg)	Hazard Quotient	
	Dense Zone	Diffuse Zone		Dense Zone	Diffuse Zone
Metals					
Cadmium	0.015	0.0021	70.22	0.00021	0.00003
Chromium	0.0056	0.0013	0.29	0.019	0.0045
Copper	6.5	1.7	3,130	0.002	0.00054
Lead	0.12	0.026	400	0.00030	0.00007
Manganese	2.3	0.80	1,830	0.00126	0.00044
Nickel	0.079	0.082	15,502	0.000005	0.000005
Zinc	1.1	0.19	23,000	0.000048	0.000008
Explosives					
Ammonium Picrate	0.00000054	0.000000041	No Criteria	NA	NA
HMX	6.1×10^{-9}	5.1×10^{-9}	3,800	1.6×10^{-12}	1.3×10^{-12}
RDX	0.000014	0.00000034	5.562	0.0000025	0.000000061
Tetryl	0.0006	0.000025	244	0.0000025	0.0000001
TNT	0.003	0.00081	19.42	0.00015	0.000042

Notes:
mg/kg = milligrams per kilogram; NA = not available, no criteria available.
Hazard quotients are the modeled sediment concentration divided by the screening level concentration.
Hazard quotients above 1 indicate the potential for adverse effects.
Scientific notation is used for very small numbers; for example 1.0×10^{-9} is one billionth (0.000000001).

4.8.1.2 EM Energy Activities

Under the No Action Alternative, NSWCDD would conduct up to 490 EM test events (three-quarters of which would be ground plane activities) at power levels ranging up to 500 MW at its present testing locations. Activities would continue to be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and RHAs and SOPs. RHAs and SOPs developed for each operation using EM energy would continue to identify and incorporate safe operating parameters with respect to personnel (HERP), ordnance (HERO), fuels (HERF), electronic equipment (EMI), and the environment near each test site, as described in Section 3.8.3.

Current EM activities at NSF Dahlgren have been addressed in the following four environmental assessments (EAs):

- The construction and operation of the Naval Ordnance Transient Electromagnetic Simulator (NOTES) facility (NSWCDD, 1992)
- The Electromagnetic Research and Engineering Facility [now called Navy Directed Energy Center (NDEC)] and Counter Explosive Test Facility (CETFAC) (NSF Dahlgren, 2006)
- The EM Launcher (Railgun) RDT&E Facility (MILCON P-306) (NSWCDL, 2009a).
- Maritime Laser RDT&E (NSWCDL, 2009c).

All four EAs resulted in findings of no significant impact (FONSIs). EM activities under the No Action Alternative would follow the specific SOPs previously developed for each type of operation. The magnetic and electrical fields generated during EM activities are discussed below.

Magnetic Fields

Magnetic fields generated during the operation of high-energy systems can present a potential EM hazard. A typical example of a strong magnetic field generated by RDT&E activities at NSF Dahlgren occurs when railguns, a type of EM launcher, are fired at the Electromagnetic Launch Facility (EMLF) (see Sections 1.5.1.2 and 1.5.2.5). The Railgun EA (NSWCDL, 2009a) evaluated magnetic fields projected to occur from the operation of a 64-megajoule (-MJ) railgun at the EMLF. The analysis in the EA determined that the magnetic field strength generated by the railgun would be intense close to the railgun launcher during firing. However, all site personnel would leave the EMLF during launcher firings and would conduct the testing from a control building located 80 ft behind the EMLF and with a thick wall facing the EMLF, thereby eliminating exposure to magnetic fields close to the EM launcher during RDT&E activities.

Magnetic fields predicted to result from the operation of a 64-MJ EM railgun are presented in Figure 4.8-1 (Magnetic Field Predictions) (Balchin, 2007). The magnetic field strengths predicted for on-site personnel and individuals at distances outside the testing area during the operation of the 64-MJ EM railgun were compared to exposure standards to determine whether operation of the railgun would pose a risk to people. The exposure standard selected for comparison was the lowest time-varying exposure guideline (i.e., most protective) listed by Institute of Electrical and Electronics Engineers (IEEE), International Commission on Non-Ionizing Radiation Protection (ICNIRP), or the American Conference of Governmental Industrial Hygienists (ACGIH). This guideline is the ICNIRP guideline for time-varying magnetic field exposure to pacemakers of 0.833 Gauss (G) (ICNIRP, 1998). For comparison, this magnetic field strength level is slightly more than five times the magnetic field strength experienced by an individual one foot away from an operating electric can opener.

As shown in Figure 4.8-1, the magnetic field strength measured in G would be intense close to the launcher during firing, decreasing by about four orders of magnitude within 30 ft. The exposure standard of 0.833 G selected for comparison is reached approximately 80 ft away from a 32-MJ EM railgun during firing (Figure 4.8-1). Distance is measured outwards from the mid-point of the EM railgun between the rear of the barrel, or breech, and the muzzle at the front end of the EM railgun. Since the EMLF would be vacated during launcher firings, and site personnel would be located in a control building – 80 ft behind the EMLF and with a thick wall facing the EMLF – the magnetic field strengths experienced by these site personnel would be well below the applicable exposure standards. In addition, any personnel having an active implantable medical device, such as pacemakers and implantable cardioverter defibrillators, must inform the Process Supervisor prior to the firing of the railgun.

Table 4.8-4 provides a comparison of the railgun magnetic field strength at a distance of 80 ft away from the firing launcher (0.833 G) to the established IEEE uncontrolled and controlled exposure limits at the mid-point frequencies of the frequency ranges covered.

Table 4.8-4
Comparison of Magnetic Field Strength 80 ft from EM Launcher (Railgun) to IEEE Exposure Limits

Frequency (Hz) [1]	IEEE Uncontrolled Environment Exposure Limit[2] (G)	Exposure Level at 80 ft[3] (G)	Magnitude Below IEEE Uncontrolled Exposure Limit	IEEE Controlled Environment Exposure Limit[2] (G)	Exposure Level at 80 ft[3] (G)	Magnitude Below IEEE Controlled Exposure Limit
0.076	1,180	0.833	1,416 times	3,530	0.833	4,237 times
10	18.1	0.833	21.7 times	54.3	0.833	65.1 times
370	9.04	0.833	10.8 times	27.1	0.833	32.5 times
1,120	0.613	0.833	-[4]	18.3	0.833	21.9 times

Notes: [1] The mid-point frequency of each IEEE C95.6 frequency range was selected for illustrative purposes. The four ranges are: <0.153; 0.153-20; 20-759; and 759-3000 Hertz (Hz).
[2] Exposure limits as cited in IEEE C95.6 *Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz*. Exposure limits are magnetic maximum permissible exposure (MPE) for head and torso.
[3] The exposure level at 80 ft from the EM launcher is also the ICNIRP guideline for time-varying magnetic field exposure to pacemakers.
[4] Exceeds the uncontrolled (general public) exposure limit at 80 feet by 1.3 times; however, the general public and site personnel will not have access to the launcher during firing activities. Therefore, no overexposures would occur.
Hz = Hertz.

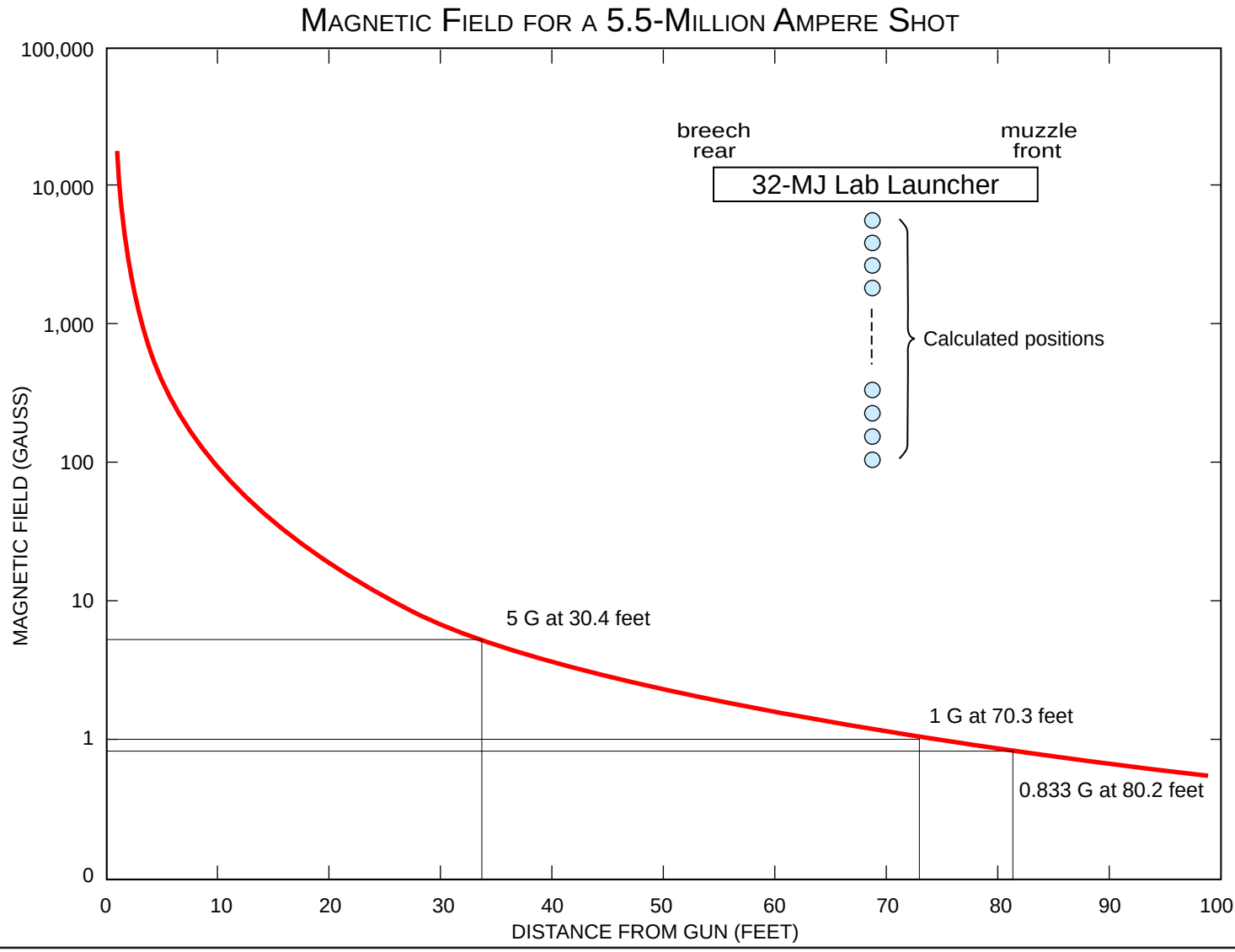
The predicted magnetic field levels represent the worst-case exposure potential. The 64-MJ railgun is being constructed with a series of steel plates along its length on both sides, which provide additional shielding from the radiated electric and magnetic fields. Protection would also be provided by the metal walls of the existing EMLF, which houses the 32-MJ railgun and the proposed launcher building addition, because metal substantially shields from and attenuates magnetic fields.

Electrical Fields

Using the railguns again as an example of a typical higher-power EM operation, RDT&E on EM energy applications would involve the generation and discharge of electrical energy at levels that could exceed 3 mega amps, the current associated with EM railgun muzzle energy levels of 64 MJ. The electrical fields that were observed during previous 32-MJ EM railgun firings (but below 32 MJ muzzle energy) were below the established IEEE exposure limits in IEEE C95.1 *Standard for Safety Levels with Respect to Radiofrequency Electromagnetic Fields, 3 kHz to 300 GHz*. Measurements showed that the highest electric field reading inside the EMLF was 17 kilovolt per meter (kV/m) as compared to the IEEE exposure limit of 100 kV/m (IEEE, 1999). Thus, the highest measurement within the EMLF during launcher testing was approximately 5.8 times lower than the exposure limit. The highest electrical field measured outside the EMLF during a test was 0.3 kV/m, which is less than one-fifteenth of the household guideline limit value of 5 kV/m (World Health Organization [WHO], 2008) and approximately 333 times lower than the 100 kV/m exposure limits applicable to electric fields associated with the EM launcher/railgun system testing.

Electric and magnetic field levels were also predicted for the closest locations where ordnance and persons may be present for activities involving EM energy, using the EMLF location as an example (Bean, 2006). The on-site facility in which ordnance is stored and handled that is closest to the EMLF facility is Building 1180. The electric and magnetic field levels reaching this building (located at a distance of 1,250 ft from the EM launcher facility) were modeled, even though no ordnance would be present at this building during EM launcher activities (Naval Ordnance Safety and Security Activity

Magnetic Field Predictions



G = Gauss
= B55MA vs Pos

NSWCDD EIS

Figure 4.8-1

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[NOSSA], letter, August 13, 2008). Also modeled were the nearest occupied building – Building 1426, at a distance of 435 ft – and the portion of US 301 closest to the EM launcher building, 1,600 ft away.

The results, presented in Table 4.8-5, show that both electric and magnetic field strengths are more than an order of magnitude below exposure limits for a muzzle energy of 64 MJ at all locations, thus providing room for an increase in muzzle energy in future testing. Additionally, the duration of the firing pulse is approximately 8 milliseconds (8/1000 of a second), which results in a very short exposure time.

Table 4.8-5
Electric and Magnetic Field Exposure Limits

Location	Concern	Electric Fields (volts/meter)		Magnetic Field Strength (G)	
		Limit	Predicted	Limit	Predicted
Control Van	HERP	614	0.60	2.3	0.32
	EMI	> 3.0		4.5	
Building 1426	HERP	614	2.77	2.3	0.068
Building 1180	HERO	50	0.97	74.5	0.008
US Route 301	EMI	> 3.0	0.40	4.5	0.005

Source: Bean, 2006.

Magnetic field and electric field exposures for personnel on-site and on-installation, as well as for the public off-installation, during firing of the 64-MJ railgun do not exceed established exposure limits. For powers greater than 64 MJ, electric and magnetic field strengths would be calculated and compared to safety limits. Testing would only occur after RHAs/SOPs/GOPs/OPs are established that would not put personnel or the general public at increased risks from EM exposure.

Using EMLF EM launcher/railgun activities at the EMLF as an example of high-energy EM activities under the No Action Alternative, indicates that activities at this facility and at other EM energy facilities on the installation would have negligible, long-term, direct and indirect, negative health and safety impacts.

4.8.1.3 Laser Activities

Under the No Action Alternative, NSWCDD would continue to conduct up to 60 test events (Class 3 and 4 lasers) at strengths of up to 100 kW at various present locations and continue its long history of safe testing. Activities would continue to be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and SOPs. A recent EA for Maritime Laser RDT&E at NSF Dahlgren (NSWCDL, 2009c) determined that no significant impacts are associated with current activities or expanded testing over the PRTR and those findings are considered to also be inclusive of the activities covered in this EIS.

Laser activities under the No Action Alternative would have negligible, long-term, direct and indirect, negative impacts on health and safety.

4.8.1.4 Chemical Defense Activities

Under the No Action Alternative, NSWCDD would continue to conduct chemical simulant sensor tests based on approval received for each series of events over land and water, and continue its long history of safe testing. No testing of biological simulants would be performed. Activities would continue to be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and SOPs.

A *Chemical and Biological Defense Program Programmatic Environmental Impact Statement* (US Army, 2004) covering nationwide chemical and biological military defense programs found impacts at NSWCDD to be negligible. All observed effects at the eight sites covered in the Programmatic EIS, including NSWCDD, were insignificant. The EIS concluded that potential risks to chemical and biological defense program laboratory workers, public health, and the environment are and will continue to be mitigated by adherence to the benchmark guidelines and regulations and by developing and following appropriate SOPs.

Chemical defense activities under the No Action Alternative would have negligible, long-term, direct and indirect, negative impacts on health and safety.

4.8.1.5 PRTR Use

Under the No Action Alternative, NSWCDD would continue to use the PRTR for up to 750 hours each year. Activities would continue to be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and SOPs.

PRTR activities under the No Action Alternative would have no indirect impacts and negligible, long-term, direct, negative impacts on health and safety.

4.8.2 Alternative 1

4.8.2.1 Ordnance Activities

Under Alternative 1, the number of large-caliber projectiles would remain at current levels, although the frequency of firing into the upper LDZ would increase to up to 10 days per year. Small-caliber gun use would increase from 6,000 bullets fired annually on average to 25,500 bullets. Detonations would increase from 190 to 200 detonations a year on average.

Bullets fired outdoors will be fired from the Machine Gun Range either at a target on land that traps the projectiles or about ten percent of them would be fired at a target in the water. Most bullets would be propelled or sink into the river bottom, where they would be covered in silt.

NSWCDD would continue to conduct weapon/explosive testing in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and SOPs, and gun-firing control measures would be strictly adhered to (Section 3.8.2.1).

NSWCDD would continue to comply with land and water range sustainability processes, and land ranges would be reassessed at a minimum of five-year intervals dating from the completion of the previous RCA as required by Navy policy (US Navy, 2006), regardless of the alternative implemented. The additional small-arms bullets fired and ten detonations per year under

Alternative 1 would result in a negligible increase in releases of MCs on-range or off-range and would not pose an unacceptable risk to human health or the environment.

The increased ordnance activities under Alternative 1 would result in negligible, long-term, direct and indirect, negative impacts.

4.8.2.2 EM Energy Activities

Under Alternative 1, there would be an increase in the number of EM activities from 490 to 590 events per year, power levels of EM energy activities would be increased, and RDT&E would be expanded. As under the No Action Alternative, the majority of these events would be ground plane activities, with the remaining activities occurring at MOATS, NOTES, NDEC, CEFTAC, STSTS, and on the PRTR. Directed-energy power levels would increase to allow for high-power microwave (HPM) and higher-power radio frequency (RF) emissions. EM energy may be directed at UAVs and USVs on the MDZ. EM energy emitted from a land range or a vessel on the PRTR may be reflected off a UAV or similar airborne platform over the horizon to a target on the land ranges or a platform located in the UDZ, MDZ, or LDZ. Some activities might take place in rain and fog, when activities are normally not conducted now, and at night. Activities would continue to be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and SOPs/GOPs/OPSs, with new operational procedures developed for any significant changes in activities.

Exposure to low-frequency EM fields normally results in negligible energy absorption and no measurable body temperature increase (ICNIRP, 1998). However, exposure to EM fields at frequencies above about 100 kilohertz (kHz) can lead to significant absorption of energy, resulting in an increase in body temperature. Prolonged exposure can result in increased body temperature, ultimately leading to failure of thermoregulatory mechanisms (ICNIRP, 1998). As discussed in Section 3.8.3, standards are available to determine maximum permissible exposure levels to frequencies up to 300 GHz (IEEE, 1999, 2002; ICNIRP, 1998), as well as Navy permissible exposure limits (PELs) (see Section 2216 of US Navy, 2011).

High-power microwave and higher-power (operating with high power levels) RF emissions (e.g., radar associated with navigation and surveillance systems) may be generated under Alternative 1. These are lower-frequency EM emissions with longer wavelengths (see Figure 1-2) than laser emissions.

Pulsed or modulated microwave frequencies can induce a microwave auditory effect in people, which consists of audible clicks in people with normal hearing (Frey, 1962). The phenomenon manifests itself as a clicking, buzzing, or hissing sound depending on the modulatory characteristics of the microwaves. Although the energy absorbed (less than 10 microjoules per gram) and the resulting increments of temperature (less than 10^{-6} °C) per pulse at the threshold of perception are small, most investigators of the phenomenon believe that it is caused by thermoelastic expansion. It is thought that this phenomenon takes place because we hear sound as the result of a miniscule wave of pressure that is set up within the head and then detected at the cochlea when the absorbed microwave pulse is converted to thermal energy (Chou et al., 1982). This phenomenon does not result in adverse effects, as described by Elder and Chou (2003):

> Human perception of pulses of RF radiation is a well-established phenomenon that is not an adverse effect. RF-induced sounds are similar to other common sounds such as a click, buzz, hiss, knock or chirp. Furthermore, the phenomenon

can be characterized as the perception of subtle sounds because, in general, a quiet environment is required for the sounds to be heard.

Increases in power and/or frequency of EM energy associated with RDT&E activities would be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and RHA/SOPs/GOPs/OPSs. Procedures would be developed so that NSF Dahlgren personnel and the general public would not be exposed to levels of EM energy that could result in adverse impacts. The Navy has specific guidance that requires adequate protection measures or operational restrictions for RDT&E activities (see Section 2220 of US Navy, 2011) and also in instances where multiple RF emitters exist close to one another (see Section 2217 of US Navy, 2011).

For each type of operation proposed in the future, NSWCDD's Safety and Environmental Office in consultation with the NSF Dahlgren Safety and Environmental Offices would consider the risks on a case-by-case basis. An RHA would be prepared to define the risks and the safety measures required to minimize risks. Using the RHA, the Range Safety Director would then make the final decision, and if he/she believes the operation can be done safely, the operation would proceed. If the Range Safety Director determines that the operation would be unsafe, it would not be conducted. For operations over the water, public access to the danger zones to be used and to the SUA would be controlled to ensure the safety of the public.

Based on the regulations, policies, and protocols that would be followed for all tests, increased EM energy activities under Alternative 1 would result in negligible, long-term, direct and indirect, negative health and safety impacts.

4.8.2.3 Laser Activities

Under Alternative 1 there would be an increase in the number of HE laser events from 60 to 125 per year, and the power, locations, and type of testing associated with these events would expand, as described in Section 2.5.3. HE lasers RDT&E activities could include: firing lasers from land ranges to floating targets on the MDZ; targeting UAVs by tracking and disabling/destroying mobile targets such as USVs on the water and mortar shells in the air; HE laser beams emitted from a land range or a vessel on the PRTR may be reflected off a UAV or similar airborne platform located over the horizon to a target on land ranges or on various types of platforms in the UDZ, MDZ, or LDZ; and if lighter-weight power sources are developed, lasers may be fired from UAVs at targets on the MDZ water surface. Some laser operations would take place beyond the normal 8 am to 5 pm, Monday-to-Friday PRTR range schedule because of the increasing need to test systems in all kinds of weather conditions and at dawn, dusk, and night.

Personnel Safety

As under the No Action Alternative, activities would be conducted in accordance with federal and state regulations, stringent DoD policies specifically developed for laser activities (see Sections 2204-2212 of US Navy, 2011), and carefully-conceived management controls and RHAs/SOPs/GOPs/OPSs. These procedures would minimize exposure to laser radiation that may present risks to the eyes and skin. Injuries can be associated with three mechanisms (WHO, 1982; University of California Berkeley, 2001):

- **Thermal** – Thermal injury mechanisms all require that sufficient radiant energy is absorbed in a tissue at a fast-enough rate to create a substantial increase above normal tissue temperature within a short period of time – typically less than a minute (WHO, 1982).
- **Photochemical** – A photochemical injury results from the impact of light particles (photons) on skin molecules; the molecule's chemical composition gets altered, resulting in minor or severe sunburn, and prolonged exposure may promote the formation of skin cancer.
- **Acoustical Transient (eye only)** – Acoustical transient effects are related to pulse duration and may occur in short-duration pulses (up to 1 millisecond or a thousandth of a second), depending on the specific wavelength of the laser. The acoustical transient effect is poorly understood, but it can cause retinal damage that cannot be accounted for by thermal injury alone (University of California at Berkeley, 2001).

Class 3 lasers – the less powerful of the two laser classes that are considered HE lasers – may cause injury to the eye through intrabeam viewing or through viewing a specular reflection for less than 250 milliseconds (see Section 1.5.3 for information on diffuse and specular reflections). Viewing a diffuse reflection from a Class 3 laser would not cause injury to the eye. Class 4 lasers pose the same hazards as Class 3 lasers, but due to their higher beam power – greater than 500 mW – they may also cause injury to the eye when viewing a diffuse reflection and may present a hazard to the skin.

Some of the proposed laser systems to be tested at NSWCDD are pulsed. The average power of a pulsed laser will usually be less than that of a continuous-wave laser, but the peak power in the pulse may be very large if the pulse duration is very short. Pulses lasting less than 1 microsecond focused on the retina can cause an acoustical transient effect, resulting in substantial damage and bleeding, in addition to thermal injury (University of California Berkeley, 2001). Laser safety standards applied by NSWCDD include ANSI Z136.1 (2007), which defines the maximum permissible exposure for direct, reflected, or scattered laser emissions that the eye can receive without expecting an eye injury (under specific exposure conditions).

For non-eye-safe activities, safety hazard zones are established around the laser corridor and the target/backstop based on calculations of the power being emitted by the laser. Safety hazard zones are demarcated to keep personnel a safe distance away during the brief time a laser operates. During these activities, much of the laser beam is absorbed by a specially-designed target within a backstop, but some energy would reflect off the backstop as diffuse reflections. The backstops are designed to have rough, irregular surfaces that cause most reflections to be diffuse rather than specular, as specular reflections bounce off a mirror-like surface and retain more of the beam's coherence and energy (see Figure 1-8b). Due to the surface roughness, diffuse reflectors scatter the reflected radiation in a wide distribution (see Figure 1-8a). Diffuse and specular reflections are also known as "backscatter." Even though the energy of diffuse reflections is scattered and weaker than that of specular reflections, an eye-safety hazard zone is calculated around the target/backstop, and personnel shelters are located beyond the area where diffuse or specular reflections pose a risk to personnel.

The eye-hazard area and associated backstop required is based on the beam diameter at the output of the laser, the divergence of the beam, and the distance traveled. For example, for a 100 kW HE laser operation examined in the Maritime Laser EA (NSWCDL, 2009c), the eye-hazard

area around the laser beam would be about 6 ft in diameter and the eye-hazard area would be at least 6 ft above mean water level, as shown in Figure 1-10. The hazard area would increase with the use of higher-powered lasers. The practicality of the required backstop size would be considered during test planning to ensure that the implementation of appropriate health and safety measures is feasible. In addition to the backstop, a laser safety buffer zone (or laser hazard cone) is established for each test, as discussed in Section 3.8.4 and shown in Figure 3.8-4.

Personnel near the target would be completely enclosed in a personnel shelter during eye-hazardous laser activities. Observers on land or on range control boats would be kept well away from the eye hazardous zone around the laser beams. By implementing strict health and safety procedures, NSWCDD scientists and engineers conducting HE laser testing would be located well beyond distances that could result in injury from either continuous-wave or pulsed lasers, and distance to the general public would be even farther away from testing (i.e., beyond areas of potential injury). In addition, the laser control measures that would be in place during testing as part of NSWCDD's Health and Safety Program (see Section 3.8), minimize the potential for exposure to lasers that could result in injury, and provide automatic and manual mechanisms to cease testing if required.

When a laser is directed on a distant target on the water, the beam would become more diffuse with distance and, therefore, larger targets would be used. Targets are likely to be a tunnel-like shape on a platform with extra layers of materials to absorb the energy. Backscatter out to the barge or the water can be reduced by increasing the length of the tunnel and/or the depth of absorbent material. Any laser energy that breaches the water surface would be absorbed, scattered, or reflected off of molecules in the water (Bai et al., 2007; De Giacomo et al., 2007; Li et al., 2007; Bai et al. 2008). As laser energy interacts with more molecules the energy dissipates and spreads out causing the amount and the intensity of the energy to decrease.

In addition to direct hazards to the eyes and skin associated with exposure to the laser beam, there are potential non-beam hazards – electrocution, fire, laser-generated air contaminants (LGACs), and collateral radiation – as a result of lasing activities.

As described in Section 3.8.4, LGACs may be generated when certain Class 4 laser beams interact with matter such as plastics, composites, metals, and tissues (ANSI, 2007). Areas will be cleared of debris prior to testing, and NSWCDD will ensure that appropriate industrial hygiene characterizations of exposure to LGACs take place in accordance with 29 CFR 1910.1000, Air Contaminants and OPNAVINST 5100.23G, the Navy Safety and Occupational Health Program Manual, so that no occupational over-exposures occur.

Potential collateral radiation or broad-band black-body radiation (i.e., ultraviolet or blue light) produced as a result of air breakdown at the laser/target interface does not present an immediate hazard to personnel, because no personnel will be within close proximity to the target impact area. Once lasing activities stop, all collateral radiation (if any) ceases, and no residual collateral radiation remains.

The non-beam control measures in place, along with strict adherence to the health and safety program, minimize the health and safety risks associated with non-beam effects of lasing activities at NSWCDD.

Increased laser activities would have negligible, long-term, direct and indirect, negative impacts on health and safety.

4.8.2.4 Chemical and Biological Defense Activities

Under Alternative 1, the number of simulant events would increase to up to 60 events per year, the use of outdoor biological simulants would be introduced (for use alone), and the area where testing could take place would be expanded, as described in Section 2.5.4. The simulants used and their degeneration products would be relatively harmless (low-toxicity) compounds, as discussed in Section 3.8.5. Activities would continue to be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and RHAs/SOPs/GOPs/OPSs. A nationwide Chemical and Biological Defense Program Programmatic Environmental Impact Statement that included NSWCDD's activities concluded that that the scale of military biological and chemical simulant activities could be increased without causing significant, unmitigable environmental and health impacts (US Army, 2004).

Prior to each release, surface meteorological conditions would be used to select the release point and confirm the anticipated cloud track. The procedure used would be similar to previous testing (NSWCDL, 2005), where the simulant release point was selected so that simulant clouds must travel 5,250 yds downwind before landfall (with concentrations essentially returning to background levels), except in situations when the air is calm or no wind direction is clearly established and a 3,830-yd standoff could be used. Additionally, during previous testing, simulant releases were spaced so that no land or water area was exposed multiple times to the same simulant (NSWCDL, 2009b). When quantities of more than 5 gals are to be used, crosswind releases could be specified by the Test Director in order to limit the dosage of simulant as the cloud passes over any area of land or water.

The modeling approaches used to determine potential impacts of concentrations of chemical simulants in the air and the deposition of chemical simulants on human health and the environment are discussed in Sections 4.4 and 4.11-4.13, respectively, and the results of modeling runs are provided in Appendix J. The results indicate that concentrations rapidly return to background levels within the test area, and potential impacts to human health and the environment would be negligible.

No modeling was performed for biological simulants, as NSWCDD would only use BSL-1 simulants. These organisms rarely cause reactions or diseases, and many are ubiquitous in the environment. Some of the *Bacillus* species proposed for testing may cause infections in people whose immune systems are already comprised if an individual is exposed to high numbers of bacteria. However, the SOP for simulant testing includes the provision that anyone with the potential for exposure to elevated concentrations within restricted test areas would be equipped with personal protective equipment, including respirators, in the event of an unexpected incident, such as a spill, or wind shift. Individuals with compromised immune systems or respiratory conditions would not be able to serve as personnel at the release site, as they would not qualify for respirator use. Therefore, no high risk individuals would be potentially exposed to biological simulants.

Under Alternative 1, biological defense activities and increased chemical defense activities would have negligible, long-term, direct and indirect, negative impacts on health and safety.

4.8.2.5 PRTR Use

Under Alternative 1, NSWCDD would use the PRTR for up to 870 hours each year, with the additional hours used to support increased testing of lasers, EM energy devices, and chem/bio simulants. Activities would continue to be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and SOPs.

Expanded activities under Alternative 1 could involve directing lasers at moving airborne targets, such as mortar shells and UAVs in flight over the waters of the MDZ. (UAVs would only be electronically tracked, not destroyed.) If an HE laser is proposed to be fired above the horizon, NSWCDD would coordinate with the FAA and affected DoD components, such as the North American Defense Command, and NAS Patuxent River, which coordinates the use of NSWCDD's SUA, to ensure that non-participating aircraft are not put at risk while RDT&E activities take place. Coordination would include giving details of the test, such as laser parameters, altitude of the targets, and time and location windows. Permission would only be given when it is certified that the testing would not interfere with aircraft or satellites that may be in the area at that time.

Access to public waters, such as Upper Machodoc Creek and the Potomac River, during testing would be restricted by NSWCDD's ROC and its range control boats, which clear the PRTR prior to testing and prevent unauthorized entry (e.g., by transiting boaters and recreational fishermen) during testing. Warning measures, continuous radar coverage, restricted access to the affected airspace, and visual clearances by range operation and test personnel would be implemented during all planned laser-system tests. Whenever possible, advance notice of scheduled activities and danger zone closures would be provided to the public.

PRTR activities under Alternative 1, would have negligible, long-term, direct, negative impacts and no indirect impacts on health and safety.

4.8.3 Alternative 2

4.8.3.1 Ordnance Activities

Under Alternative 2, the number of large-caliber projectiles would remain at current levels and use would be the same as under Alternative 1. Small-caliber gun use would increase from 6,000 bullets fired annually under the No Action Alternative to approximately 30,000 bullets, an increase over the 25,500 bullets of Alternative 1. Detonations would increase from the current 190 to 230 a year. Consistent with the No Action Alternative and Alternative 1,

Bullets fired outdoors will be fired from the Machine Gun Range either at a target on land that traps the projectiles or about ten percent of them would be fired at a target in the water. Most bullets entering the water would be propelled or sink into the river bottom, where they would be covered in silt.

NSWCDD would continue to conduct weapon/explosive testing in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls, RHAs, and SOPs, and gun-firing control measures would be strictly adhered to (Section 3.8.2.1). NSWCDD would continue to comply with land and water range sustainability processes. The

additional small-arms bullets fired and 40 additional detonations per year would not contribute significantly to releases of MCs in either on-range or off-range areas, based on the discussion provided in Section 4.8.2.1 for Alternative 1.

Large-gun firing and increased small-arms firing and detonations would have negligible, long-term, direct and indirect, negative impacts on health and safety under Alternative 2.

4.8.3.2 EM Energy Activities

Under Alternative 2, there would be an increase in the number of EM activities from 490 to 680 events per year, power levels used in EM energy activities would be increased, and RDT&E would be expanded, as described for Alternative 1. Some activities might take place in rain and fog, when activities are normally not conducted now, and at dawn, dusk, and night. Activities would continue to be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and RHAs/SOPs/GOPs/OPSs, with new operational procedures developed for any significant changes in activities, so that neither personnel nor the general public would be placed at increased risks from EM exposure, as described for Alternative 1.

Increased EM energy activities under Alternative 2 would result in negligible, long-term, direct and indirect, negative health and safety impacts.

4.8.3.3 Laser Activities

Under Alternative 2, there would be an increase in the number of HE laser activities from the current 60 events to 145 events per year, an increase in power levels and distances, and RDT&E would be expanded, as described for Alternative 1. Activities would be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and SOPs.

Increased laser activities under Alternative 2 would result in negligible, long-term, direct and indirect, negative impacts to health and safety and negligible, long-term, direct, negative impacts on aviation and maritime safety.

4.8.3.4 Chemical and Biological Defense Activities

Under Alternative 2, the number of simulant events would increase to up to 70 per year, and the area where testing could occur would be expanded, as under Alternative 1. Chemical and biological simulants would be tested together. The simulants used and their degeneration products would be relatively harmless (low-toxicity) compounds, as discussed in Section 3.8.5, and there are no known synergistic interactions between the low-toxicity chemical simulants and BSL-1 biological simulants. As for all simulant testing, there would be indoor trials in laboratories prior to simulants being tested outdoors. Activities would continue to be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and SOPs/GOPs/OPSs. A nationwide Chemical and Biological Defense Program Programmatic Environmental Impact Statement that included the NSWCDD program concluded that that the scale of military biological and chemical simulant activities could be increased without causing significant, unmitigable environmental and health impacts (US Army, 2004).

Based on these protocols, additional measures described under Alternative 1, and the air-concentration and deposition (Section 4.4) modeling performed, increased chem/bio defense activities under Alternative 2 would have negligible, long-term, direct and indirect, negative health and safety impacts.

4.8.3.5 PRTR Use

Under Alternative 2, NSWCDD would use the PRTR for up to 1,000 hours each year, with the additional hours used to support increased testing of lasers, EM energy devices, and chem/bio simulants. Expanded activities under Alternative 2 would be similar to those described under Alternative 1. Activities would continue to be conducted in accordance with federal and state regulations, stringent DoD policies, and carefully-conceived management controls and SOPs.

PRTR activities under Alternative 2, would have negligible, long-term, direct, negative impacts and no indirect impacts on health and safety.

4.9 Geology, Topography, Soils, and Sediment

This section discusses the physical impacts to the geology, topography, soils, and sediment of NSF Dahlgren, the PRTR, and areas near NSF Dahlgren that would result from outdoor RDT&E activities proposed under the No Action Alternative, Alternative 1, and Alternative 2. No new building or facility construction that would disturb surface topography and soils and subsurface geology is included in the Proposed Action. If such construction were necessary in the future, NEPA documentation would be prepared for each project, as required.

4.9.1 No Action Alternative

4.9.1.1 Ordnance Activities

Under the No Action Alternative, the current firing of large-caliber guns and small arms, and detonations would continue. Ordnance activities take place on water and land ranges, as described in Section 1.4.

The bullets used on land-based operational ranges are fired from the Machine Gun Range either at a target on land that traps the projectiles or at a target in the water up to 4,000 yards out, in which case they would clear the range up to 6,000 yards. The bullet fragments and residue at land-based operational-range butts or backstops are managed under NSWCDD Range Management Plan (RMP) and RDT&E test-specific SOPs that minimize impact to the surrounding topography. The NSWCDD RMP and RDT&E test-specific SOPs are described in Section 3.7.

Most detonations take place on the Harris and Churchill Ranges of the EEA Range Complex. In an average year, 95 percent of the items detonated for RDT&E activities contain less than 100 lbs net explosive weight (NEW). For example, the NEW of the detonations in 2007 ranged from less than 1 lb up to 623 lbs, with an average of 28 lbs per detonation. Large NEW detonations usually take place on the EEA for treatment of explosive wastes. In 2007, NSF Dahlgren treated 66 pieces of ordnance with a total NEW of 19,000 lbs. Detonations over 200 lbs NEW are buried under 8 ft or more of dirt to reduce noise and flying fragments.

Munitions detonations may displace or alter the soil structure immediately surrounding the detonations. Dust is likely, especially from larger detonations. The EEA ranges have been subjected to detonations since Pumpkin Neck was purchased as a range for aircraft bombing in 1944. Given the long testing period, areas used for testing have all been previously disturbed. Any localized soil displaced by detonations or fill placed over detonations of 200 lbs NEW or greater is regraded and the range is maintained according to the RMP.

As described in Section 3.5, ground-borne vibration data have been collected for a buried 1,000-lb detonation (the largest detonation that could take place) to determine the worst-case vibration condition around the Churchill Range. Based on the measurements of both lateral and vertical ground displacement, it was found that the worst-case ground-borne vibration resulting from a 1,000-lb buried detonation at the Churchill Range would be confined within the range (see Figure 3.5-10).

Although most of the bullets used are fired on land, approximately 10 percent are fired at a target in the water up to 4,000 yds out, in which case they would clear the range up to 6,000 yds. Most bullets fired in the river decelerate rapidly and are immediately buried intact in the soft bottom sediments. Burial isolates these munitions from movement and potential exposure pathways, thereby limiting contaminant release into surface water and surficial sediments.

The majority (74 percent) of projectiles fired on the PRTR are inert. Live projectiles fired on the PRTR are intended to detonate above the surface of the water. Thick deposits of soft or semi-liquid silts and clays are found beneath the primary target area in the PRTR. Inert projectiles and duds can be assumed to be buried in Potomac River sediment due to the force at which they are propelled into the river and hit the bottom (A. Swope, NSWCDL, pers. com., October 22, 2008). Past projectile-recovery efforts within the PRTR confirm that projectiles are propelled into the accumulated liquefied silt and clay substrate. Any ordnance not propelled into the sediment would be rapidly covered by sediment, with sediment-accumulation rates ranging up to 0.75 inches per year (in/yr). Metals and explosives in buried ordnance would leach slowly into the surrounding subsurface sediments, with no direct contact to surface water or sediments. Based on the current usage and sediment characteristics, the continued use of large-caliber guns and projectiles is expected to have minor physical impacts on the sediments of the Potomac River.

Airborne vibrations resulting from the pressure waves emanating from large-gun firing (described in Section 3.5.5) are unlikely to contribute to shoreline soil instability and erosion, discussed in Section 3.9.3.2. Naval District Washington's study of shoreline erosion at NSF Dahlgren (Naval District Washington, 2007) identified the following factors as responsible for shoreline erosion:

- Effects of hurricanes and nor'easters
- Long fetch (length of water surface across which winds are blowing) which allows wave energy to build when strong winds are present
- Regional soil stratigraphy which allows groundwater seepage into subsurface soils along shoreline cliffs and embankments, thus tending to undermine the layers above
- Boat traffic
- Multi-directional currents; and overland storm flow.

A 1985 United States Geological Survey (USGS) study of the Nomini Cliffs, adjacent to the MDZ, concluded that multiple seepage zones, discontinuous ironstone ledges, sheet joints, and tectonic joints were causing rapid erosion in this area.

Under the No Action Alternative, ordnance activities would have no indirect impacts and minor, long-term, direct, negative impacts to soils and sediments, and no direct or indirect impacts on geology or topography.

4.9.1.2 EM Energy Activities

Outdoor directed-energy RDT&E activities take place above the surface of the water or land and have minimal contact with geology, topography, soils, or sediment. Similarly, EM energy emitted by the E3 facilities – MOATS, NOTES, and the ground planes – is directed at equipment being tested within or on the facilities, not at the ground or water. Only incidental EM energy

would be likely to interact with the soil or sediment, and such energy would be quickly diminished by reflection, absorption, or scattering of the EM energy by surface soil or water.

Before an outdoor EM energy operation takes place, an RHA and SOP are approved and validated, as described in Section 3.8.1. Power levels, frequencies, and safety parameters must be approved in SOPs well before each event commences. These measures ensure that tests are conducted safely, with a minimum of environmental impact.

Under the No Action Alternative, EM energy activities would have negligible, short-term, direct impacts and no indirect impacts on geology, topography, soils, or sediments.

4.9.1.3 Laser Activities

Under the No Action Alternative, both the HE laser emitter and the target/backstop would be fixed. The laser would be pre-aimed at a fixed target slightly downgrade from the laser and would not be able to move in either elevation or azimuth, except for minute corrections to the aim point. For activities over water, the HE laser beam would begin and end well above mean water level. For activities over land, the HE laser beam is sufficiently high to clear the mowed vegetation on the ranges. Most backscatter from an HE laser beam's striking a target/backstop would be contained within the target/backstop, lined with dark, absorbent materials to minimize reflections, and the small amount of energy that could escape would not affect soils or sediments.

As for other operations, before a HE laser operation takes place, an RHA and SOP are developed, reviewed, and validated, as described in Section 3.8.1. Power levels, frequencies, and safety parameters must be approved in SOPs well before each event commences. These measures ensure that tests are conducted safely and with a minimum of environmental impact.

Outdoor HE laser activities under the No Action Alternative would have negligible, short-term, direct impacts and no indirect impacts on geology, topography, soils, or sediments.

4.9.1.4 Chemical Defense Activities

Under the No Action Alternative, NSWCDD would conduct up to 12 operations a year using chemical simulants to test chemical-detection sensors. All simulants used in outdoor sensor RDT&E activities would be approved prior to use by the NSWCDD Safety and Environmental Office, in consultation with the appropriate Maryland and Virginia regulatory authority, and would only be approved after considering toxicity data relative to the intended quantity and concentration of the simulant to be used. All activities would be conducted in accordance with all applicable federal and state regulations and policies, under an approved SOP.

Under the No Action Alternative, chemical defense activities would have negligible, short-term, direct impacts and no indirect impacts on geology, topography, soils, or sediments.

4.9.1.5 PRTR Use

NSWCDD uses several small range control boats to control traffic on the PRTR during outdoor RDT&E activities. The range control boats (and any boats used as part of the operations) create small wakes in the water that could contribute to wave propagation and ultimately to shoreline erosion. However, based on the current relatively limited number of PRTR usage hours requiring range control boats, the small number of boats deployed (typically three), and their relatively small size and speed, the impact from boat wakes has negligible impacts on shoreline erosion.

Range control boat and other boat usage by NSWCDD represents a very small percentage of the daily recreational and commercial boat usage of the waters of the PRTR. The commercial vessels that ply the PRTR include large ships and barges that carry petroleum, coal, sand and gravel to commercial and industrial sites in the region, which can create larger wakes and are more likely to contribute to shoreline erosion than the small craft used by NSWCDD.

PRTR use by NSWCDD under the No Action Alternative would have no direct impacts and negligible, long-term, indirect, negative impacts on geology, topography, soils, and sediments.

4.9.2 Alternative 1

4.9.2.1 Ordnance Activities

Under Alternative 1, the number of large-caliber projectiles would remain at the same level as under the No Action Alternative, although the frequency of firing into the upper LDZ would increase to up to 10 days per year. The impacts on NSF Dahlgren and the PRTR's geology, topography, soils, and sediments would be the same as for the No Action Alternative. Large-gun firing would have minor physical impacts on the sediments of the MDZ, and large-gun firing airborne vibrations would have no effect on shoreline erosion.

Under Alternative 1, small-arms use would increase considerably, with bullets fired increasing from 6,000 to 25,500 a year. Approximately ten percent of the bullets would be fired into the river, with the rest being fired indoors into a backstop or outdoors into a target on land that traps the projectiles. As noted under the No Action Alternative, bullets decelerate rapidly when they enter the river and are buried in the soft sediment, so the approximately 2,550 bullets fired into the river would have little or no impact on bottom sediments, with little displacement taking place as they enter the sediment. The bullets fired on land-based operational ranges are fired into targets and do not contact the ground.

Under Alternative 1, there would be a minor increase in detonations on the EEA, from 190 to 200 a year. Overall impacts on range soils would still be minor because the ranges have been so extensively disturbed for over 60 years.

Ordnance activities under Alternative 1 would have no indirect impacts and minor, long-term, direct, negative impacts on soils and sediments and no direct or indirect impacts on geology and topography.

4.9.2.2 EM Energy Activities

Under Alternative 1, the number of EM energy events would increase from 490 to 590 annually, the power of some of the events would increase, and activities using EM energy would increase. Only incidental EM energy would be likely to interact with the soil or sediment, and such energy would be quickly diminished by reflection, absorption, or scattering of the EM energy by surface soil or water.

EM energy activities under Alternative 1 would have negligible, short-term, direct impacts and no indirect impacts on geology, topography, soils, and sediments.

4.9.2.3 Laser Activities

Under Alternative 1, annual laser events would increase from 60 to 125, power levels for some events would increase, and activities using HE lasers would increase. HE lasers would continue to emit above the surface of the land and water with little interaction with the surface except for backscatter when a beam strikes a target. As described for the No Action Alternative, backscatter would have little effect on the ground or water surface. In the future, UAVs may carry HE lasers that may aim at targets on the MDZ, or laser beams may be bounced off a UAV from the LDZ to a target on the MDZ or one of the land ranges. However, it is anticipated that backscatter would be reflected, scattered, and/or absorbed by ground or water.

Under Alternative 1, HE laser activities would have negligible, short-term, direct impacts and no indirect impacts on geology, topography, soils, and sediments.

4.9.2.4 Chemical and Biological Defense Activities

Under Alternative 1, the number of annual events would increase from 12 to 60, and biological simulants would be tested as well as chemical simulants.

As described for the No Action Alternative, all simulants, inclusive of biological simulants, used in outdoor sensor RDT&E activities would be approved prior to use by the NSWCDD Safety and Environmental Office, in consultation with the appropriate Maryland and Virginia regulatory authority, and would only be approved after considering toxicity data relative to the intended quantity and concentration of the simulant to be used. All activities would be conducted in accordance with all applicable federal and state regulations and policies, under an approved SOP, and would not result in risks to the environment.

Under Alternative 1, biological defense activities and increased chemical defense activities would have negligible, short-term, direct impacts and no indirect impacts on the geology, topography, soils, or sediment.

4.9.2.5 PRTR Use

Under Alternative 1, NSWCDD would restrict public access to the PRTR danger zones for approximately 870 hours per year. Based on the relatively limited number of PRTR usage hours requiring range control boats and the small number of boats deployed (typically three), the impact from boat wakes is anticipated to have negligible impacts on shoreline sediment erosion. Range control boat and other boat usage by NSWCDD represents a very small percentage of the daily recreational and commercial boat usage of the waters of the PRTR.

PRTR use by NSWCDD under Alternative 1 would have no direct impacts and negligible, long-term, indirect, negative impacts on geology, topography, soils, and sediments.

4.9.3 Alternative 2

4.9.3.1 Ordnance Activities

Under Alternative 2, the number of large-caliber projectiles would remain the same and use would be the same as under Alternative 1. Bullets fired annually from small arms would increase from 6,000 under the No Action Alternative and 25,500 under Alternative 1 to 30,000 under Alternative 2. Approximately ten percent of the bullets would be fired into the river and the remainder into targets on land that trap the projectiles. Even with the increase in the number of bullets fired, the impacts on river sediments and range land surfaces would be negligible.

Detonations would increase from 190 to 230 events annually. The munitions safety tests would be conducted within existing ranges with very disturbed soils, and activities would take place in accordance with the NSWCDD RMP and SOPs, which stipulate how the surface would be regraded after detonations.

Under Alternative 2, ordnance activities would have no indirect impacts and minor, long-term, direct, negative impacts on sediments and soils and no direct or indirect impacts on geology or topography.

4.9.3.2 EM Energy Activities

Under Alternative 2, the number of EM events would increase from 490 to 680 per year and activities would be expanded. As described under the No Action Alternative and Alternative 1, activities using EM energy would either take place at the existing indoor facilities where energy is directed at equipment being tested, or take place above the surface of the land or water on operational ranges. Only incidental EM energy would be likely to interact with the soil or sediment, and such energy would be quickly diminished by reflection, absorption, or scattering of the EM energy by surface soil or water.

EM energy activities under Alternative 2 would have negligible, short-term, direct impacts and no indirect impacts on geology, topography, soils, or sediments.

4.9.3.3 Laser Activities

Under Alternative 2, the number of HE laser events would increase from 60 to 145 events per year, and activities would be expanded, as described in Section 2.6. HE laser activities would take place in existing facilities or above the surface of the water or soil on operational ranges; they would not affect soil or sediment.

As described for the No Action Alternative and Alternative 1, laser target backscatter would have little effect on the ground or water surface. In the future, UAVs may carry HE lasers that may aim at targets on the MDZ, or laser beams may be bounced off a UAV from one part of the PRTR or land range to another. However, it is anticipated that brief energy bursts that bypass a target would be reflected, scattered, and/or absorbed by ground or water.

Under Alternative 2, HE laser activities would have negligible, short-term, direct impacts and no indirect impacts on geology, topography, soils, or sediments.

4.9.3.4 Chemical and Biological Defense Activities

Under Alternative 2, the number of events using chem/bio simulants would increase from the current baseline of 12 events annually using chemical simulants to 70 events annually using both chemical and biological simulants. As discussed under the No Action Alternative and Alternative 1, all simulants used in outdoor sensor RDT&E activities would be approved prior to use by the NSWCDD Safety and Environmental Office, in consultation with the appropriate Maryland and Virginia regulatory authority, and would only be approved after considering toxicity data relative to the intended quantity and concentration of the simulant to be used. All activities would be conducted in accordance with all applicable federal and state regulations and policies, under an approved SOP. Activities using chem/bio simulants would not be harmful to land or water.

Under Alternative 2, biological defense activities and increased chemical defense activities would have negligible, short-term, direct impacts and no indirect impacts on the geology, topography, soils, or sediment.

4.9.3.5 PRTR Use

Under Alternative 2, NSWCDD would restrict public access to the PRTR danger zones, usually the MDZ, for approximately 1,000 hours per year. Based on the relatively limited number of PRTR usage hours requiring range control boats and the small number of boats deployed (typically three), the impact from boat wakes is anticipated to have negligible impacts on shoreline sediment erosion. Range control boat and other boat usage by NSWCDD represent a very small percentage of the daily recreational and commercial boat usage of the waters of the PRTR.

PRTR use by NSWCDD under Alternative 2 would have no direct impacts and negligible, long-term, indirect, negative impacts on geology, topography, soils, and sediments.

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4.10 Water Resources

4.10.1 Surface Water

4.10.1.1 No Action Alternative

Implementing the No Action Alternative would not increase the average annual number of outdoor RDT&E activities above existing levels. The activities associated with the No Action Alternative are described in Section 2.4.

Ordnance Activities

Existing NSWCDD ordnance procedures comply with the Navy's *Operational Range Clearance Policy for Navy Ranges* (DoD Instruction 3200.16), which includes requirements for activities such as the removal, treatment, disposal, and recycling of unexploded ordnance (UXO), range scrap, and debris (see Section 3.7.5). Pursuant to the Navy policy, NSWCDD removes fired military munitions and range scrap and debris that are exposed on the ground surface or partially buried.

Residues from the land-based firing of munitions and detonation of explosives that remain on land after operational range surface clearance could enter surface waters indirectly via surface water or soil runoff and shallow groundwater discharge. Drainage from land ranges at NSF Dahlgren – Main, AA Fuze, Missile Test, Machine Gun, Terminal, Churchill, and Harris Ranges – flows into Hideaway Pond, Gambo Creek, Black Marsh Creek, Upper Machodoc Creek, and the Potomac River, as well as to small, unnamed tributaries to Gambo Creek, Upper Machodoc Creek, and the river via surface runoff and groundwater discharge. Although some residues likely would migrate into surface waters, they are expected to occur at concentrations below standard detection levels.

As discussed in Section 3.7.6, a Range Condition Assessment (RCA) was completed for NSWCDD land-based operational ranges in September of 2010 as part of the Range Sustainability Environmental Program Assessment (RSEPA) process. The RCA concluded that the Navy is already investigating, and in most cases has already addressed, areas where there is a potential for an off-range release of MCs from land-based operational areas through the ERP and Subpart X permitting requirements. Further, the RCA concluded that there is no need to investigate any areas for potential off-range releases beyond planned investigations (NAVSEA, 2010). Munitions constituents (MCs) detected in groundwater and soil at the open burn/open detonation (OB/OD) units are monitored and managed in accordance with VDEQ guidance and the RCRA Subpart X Permit and no additional actions are recommended.

On the PRTR, most targets are virtual and generate no debris. Environmental impacts of fragmenting targets – such as floating radar reflectors, fixed platforms in the river, UAVs, aerostats, vessels, towed sleds, and causeway sections – are minimized by removing hazardous materials such as batteries, oil, gasoline, and antifreeze to the extent possible prior to destroying or damaging them. After the target is impacted and the test completed, all remaining debris and any waste is cleaned up.

NSWCDD works to ensure range sustainability while protecting human health and the environment. As there is potential at the PRTR for interaction between the munitions fired into the Potomac River and human and ecological receptors, range-specific screening-level risk assessments (RSSRAs) were performed for this EIS, as described in Sections 4.8, 4.11, 4.12, and 4.13, based on sediment and water concentrations predicted for the areas of heaviest use (see Appendix F). A subset of MCs was selected as munitions constituents of potential concern (MCOPCs) based on their total mass (cumulative over the last 90 years), toxicity of constituents, and Navy guidance, as described in Appendix F.

The ecological and human health RSSRAs employed conservative (i.e., stringent/protective) assumptions to evaluate existing data and determine whether additional analysis is necessary, protective measures are warranted, or the range poses acceptable risks so no further analysis is needed.

The RSSRAs evaluated MCOPCs by comparing modeled concentrations in water, sediment, and fish tissues to risk-based screening concentrations. The results of the ecological and human health RSSRAs indicate that input of MCOPCs from munitions testing in the PRTR are orders of magnitude – hundreds to billions of times – below concentrations that could cause adverse effects to human health or the environment. Therefore, no further analyses are required at this time and continued use of the PRTR for ordnance activities is expected to have negligible impacts on surface water.

Under the No Action Alternative, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on surface waters.

EM Energy Activities

NSWCDD conducts approximately 490 EM energy events a year at three main outdoor facilities for EM testing: NOTES, MOATS, and two ground planes, all of which are located in the Mission Area or land ranges away from the PRTR and other surface waters. Three-quarters of current EM events take place on the ground planes. Testing in the future at these facilities as well as the EMLF would have no potential impacts on surface water.

NSWCDD currently and would continue to transmit directed energy – microwave and RF, as well as laser – across the waters of the PRTR, between the NDEC on the Machine Gun Range and the CETFAC on the EEA, and from radars in the STSTS on Main Range into the MDZ. Beams of directed energy are transmitted above the water between the NDEC and the CETFAC, and do not strike or penetrate the water surface; however, portions of the directed energy beams from radars could strike the water surface. In the event that directed energy does strike the water surface, waves of EM energy do not move easily through water because the energy is reflected at the air-water boundary or is quickly absorbed by the water molecules, with negligible effects on surface water.

Further, some backscatter – diffuse and specular reflections – from a directed energy beam's striking a target could hit the water surface near the target. Backscatter that hits the water has much less energy than the EM beam itself, and would be rapidly diminished further through reflection, absorption, and scattering. When EM energy interacts with water molecules or molecules within a body of water (organic or inorganic), energy is transferred to those molecules. As the transfer of energy is inefficient, there is a loss of some energy as heat to the

water. The amount of heat transferred when backscatter hits the water is negligible and would not impact the surface water.

NSWCDD occasionally conducts RDT&E in the PRTR using modified passive sonobuoys, which constitute the only EM sensor testing conducted below water. Passive sonobuoys do not generate underwater sounds or noise of their own; they only detect sound. The sounds detected by the sonobuoys are amplified, and are converted into and transmitted by EM waves in the air to a receiver, where the sounds can be analyzed. The sonobuoys used in the Potomac are recovered for reuse at the conclusion of the RDT&E events. The use of sonobuoys in the PRTR does not affect surface water.

Overall, EM energy activities under the No Action Alternative would have negligible, short-term, direct, negative impacts and no indirect impacts on surface waters.

Laser Activities

Under the No Action Alternative, NSWCDD would continue to conduct approximately 60 outdoor HE laser events a year. All testing using HE lasers over water would occur in the established laser operating corridors from Terminal Range to CETFAC across the PRTR, from NDEC to CETFAC across the PRTR, or from NDEC to the EEA Dock Area, across the entrance to Upper Machodoc Creek. All testing would occur over land or above the surface of the water.

For activities over water, the HE laser beam would begin about 12 ft above mean water level and terminate at 9 ft above mean water level. Some backscatter – diffuse and specular reflections – from an HE laser beam's striking a target/backstop could hit the water surface near the target. The target/backstops are located within a tunnel-like container or structure, such as CETFAC, and are lined with dark, absorbent materials to minimize reflections, but some energy would escape. Backscatter that hits the water has much less energy than the laser beam itself, and would be rapidly diminished further through reflection, absorption, and scattering, with essentially no effects on surface waters near the target.

There would be negligible, short-term, direct, negative impacts and no indirect impacts to surface waters from laser activities under the No Action Alternative.

Chemical Defense Activities

NSWCDD currently conducts up to 12 outdoor chemical simulant events a year. Outdoor chemical-detector testing may take place on any of the land ranges or the Mission Area, but most testing is conducted on the MDZ. Tests consist of up to a maximum of 20 gals of simulant per release.

Testing of chemical simulants results in the release of small quantities of simulants into the air with even smaller quantities of simulants being deposited on the surface of the water. Once simulants settle upon and sink into the water, they are rapidly diluted in the water column. Water-quality analysis conducted following simulant testing performed by NSWCDD in 2003, 2005, and 2009 showed no significant impacts.

Atmospheric dispersion of chemical simulants was modeled to calculate the concentration and deposition levels resulting from testing. The modeling methodology used is described in Section 4.4 and Table 4.4-3 summarizes the resulting predicted maximum deposition levels. At normal temperatures, 1,1,1,2-tetrafluoroethane (R-134), 1,1-difluoroethane (R-152a), and SF_6 (a

greenhouse gas which is being phased out) used for calibration of sensors are gases and, therefore, no deposition would occur for these chemicals. The surface area with concentrations predicted to be above 0.01 milligrams per square meter (mg/m^2) using maximum deposition rates range from a fraction of an acre to 63.5 acres. There is limited toxicity information available on most of the simulants, as these compounds are considered to be of low toxicity; potential effects on aquatic life are discussed in Section 4.11.1.4. The small amounts of chemical simulants deposited coupled with their low toxicity would not affect surface waters.

Under the No Action Alternative, chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts on surface waters.

PRTR Use

Under the No Action Alternative, NSWCDD currently restricts public access to the PRTR danger zones, usually the MDZ, for testing approximately 750 hours a year.

Existing levels of military small boat traffic have temporary effects to water quality through the direct release into the water of small quantities of oil and gas, contact of antifouling paint (containing chemicals and metals) used on vessels with water, and by vessel wakes that may contribute to shoreline erosion and indirectly to resulting water turbidity. Military boat activities as well as commercial and recreational boat activities on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts to these surface water resources. The overall vessel traffic on the PRTR decreases during testing because the movement of commercial and recreational vessels is restricted. Vessels present in the PRTR are limited to range control boats (approximately three) stationed along the perimeter of the range and barges or vessels associated with testing.

The military boats create small wakes that could contribute to shoreline erosion and, ultimately, increased nearshore turbidity. However, based on the relatively limited number of hours NSWCDD restricts public access to the PRTR, requiring range control boats, and the small number of boats deployed, wakes from NSWCDD boats would have negligible effects on shoreline erosion and turbidity. NSWCDD boat use represents a very small percentage of the daily recreational and commercial boat traffic on the waters of the PRTR. The commercial vessels that traverse the PRTR include large ships and barges that can create larger wakes and are more likely to contribute to shoreline erosion than the small craft used by NSWCDD.

Under the No Action Alternative, PRTR use by NSWCDD would have negligible, long-term, direct and indirect, negative impacts on surface waters.

4.10.1.2 Alternative 1

Ordnance Activities

Under Alternative 1, the number of large-caliber projectiles would remain at current levels, although the frequency of firing into the upper LDZ would increase above current use levels to a maximum of 10 days per year. Small-caliber gun use would increase from 6,000 bullets fired annually under the No Action Alternative to 25,500 bullets annually. Approximately 10 percent of the bullets would be fired into the river. Future firing of small arms would take place mainly on the Machine Gun Range, but also on the Terminal Range, Churchill Range, and Harris Range. Fragmentation arena tests on the Churchill Range are expected to increase in the future, leading

to an increase in annual detonations from the current 190 to 200 detonations under Alternative 1, as described in Section 2.5.1.

Pursuant to the Navy's *Operational Range Clearance Policy for Navy Ranges*, NSWCDD removes fired military munitions and range scrap and debris that are lying exposed on the ground surface or partially buried. Residues from the land-based firing of munitions and detonation of explosives that remain on land after operational range surface clearance could enter surface waters indirectly via surface water or soil runoff and shallow groundwater discharge. Although some residues likely would eventually migrate into surface waters, they are expected to occur at concentrations that are virtually undetectable.

For the land ranges on Mainside and the EEA Complex, the RCA found the operational ranges to be in compliance with relevant regulatory requirements, and no additional protective measures related to potential off-range release of MCs were recommended. Continued removal of fired military munitions and range scrap and debris from land ranges is expected to ensure that the substantial increase in small-arms firing and the small increase in detonations under Alternative 1 would not substantially increase potential indirect impacts to surface waters.

As described in Section 4.10.1.1 and detailed in Sections 4.8.1.1, 4.11.1.1, 4.12.1.1, and 4.13.1.1, the results of the human health and ecological RSSRAs indicate that input of MCOPCs from munitions testing in the PRTR are orders of magnitude below concentrations that could cause adverse effects to human health or the environment. Therefore, continued use of the PRTR for ordnance activities is expected to have negligible impact on surface water quality. As the use of large-caliber guns and projectiles would remain at current levels, impacts to surface waters would not increase.

Under Alternative 1, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on surface waters.

EM Energy Activities

Under Alternative 1, the number of EM test events would increase from 490 to 590 per year, power would increase, and RDT&E activities would increase, as described in Section 2.5.2. The number of events at the STSTS, NDEC, CETFAC, and on the PRTR would increase and directed-energy power levels would increase. Directed-energy technology could be used anywhere on the ranges or the Mission Area. Boats and even UAVs could be used as platforms for directed-energy emitters. Beams of directed energy might be directed at targets on the land ranges, the PRTR, or at UAVs, or reflected off of UAVs or other types of aircraft to targets on the land ranges or the PRTR.

NSWCDD would transmit directed energy across the land ranges or across the waters of the PRTR. Beams of directed energy would be transmitted above the water between the NDEC and the CETFAC, and would not strike or penetrate the water surface; however, portions of the directed energy beams from radars could strike the water surface. Were directed energy beams to strike the water surface, the rough surface of the water would cause EM energy to scatter in all directions at the air/water boundary (see Figure 1.8a) and energy entering the water would quickly be absorbed by the water molecules, with negligible effects on surface water. Any backscatter from a directed energy beam's striking a target would be also reflected, absorbed, and scattered, with negligible effects on surface water near the target. The use of sonobuoys in the PRTR, likewise, is expected to have no effects on surface water.

EM energy activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on surface waters.

Laser Activities

Under Alternative 1, the number of HE laser test events would increase from 60 to 125 per year, power levels would increase, and RDT&E activities would increase as described in Section 2.5.3.

Some future laser use might include firing lasers from UAVs at targets on the water. Laser use also might involve directing lasers at a mirror-like surface on an airborne platform to reflect the laser beam to a target over the horizon on a land range or a platform on the UDZ, MDZ, or LDZ. Testing of lasers would occur above the surface of the water, and the laser would not be focused on the water surface. Initially, laser emissions would be at eye-safe power levels, with a gradual increase in power as RDT&E progresses Because of the accuracy of lasers, interaction with the water surface would only be incidental or result from backscatter from an HE laser beam's striking a target/backstop. The rough surface of the water would cause the laser beam to scatter in all directions at the air/water boundary (see Figure 1.8a) and energy entering the water would quickly be absorbed by the water molecules, with negligible effects on surface water.

For each laser operation proposed in the future, NSWCDD's Safety and Environmental Office would consider the risks on a case-by-case basis through preparation of a risk hazards assessment (RHA) to ensure that the operation is safe. If the RHA process indicated that the operation could not be performed safely, the activities would not be conducted. For activities over the water, public access to the PRTR and to NSWCDD's SUA would be restricted during activities, to ensure the safety of the public.

There would be negligible, short-term, direct, negative impacts and no indirect impacts on surface waters from laser activities under Alternative 1.

Chemical and Biological Defense Activities

Under Alternative 1, chemical and biological defense activities would expand from the baseline 12 events annually using only chemical simulants to 60 events annually using both chemical and biological simulants, as described in Section 2.5.4.

For tests of chemical simulants, the impacts from Alternative 1 would be similar to those for the No Action Alternative, although there would be a substantially higher number of events. During releases, some simulant coming from the sprayer system may enter the river, and cleanup of the test platform (the vessel) would result in some simulant-containing effluents' entering the river. The increased testing of chemical simulants would result in a larger number of events involving the dispersal of small quantities of simulants. For each event, the point concentrations of simulants that potentially could settle on the water surface – or settle on land and be carried by runoff into adjacent water – and be dispersed into surface waters would not increase. Simulants entering the PRTR and other surface waters would be rapidly diluted to well-below-detection levels.

No modeling was performed for biological simulants, as NSWCDD would only use BSL-1 simulants (see Section 3.8.4.2 for a description of BSL-1 substances). BSL-1 bacteria, fungi, viruses, and proteins rarely cause reactions or diseases, and many are ubiquitous in the

environment. Therefore, no adverse effects are anticipated from a temporary increase in these organisms.

Under Alternative 1, chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts on surface waters.

PRTR Use

Under Alternative 1, NSWCDD would restrict public access to the PRTR danger zones, usually the MDZ, for testing approximately 870 hours a year, compared to 750 hours under the No Action Alternative, as described in Section 2.5.5.

Although military small boat traffic would have temporary effects to water quality – nominally contributing directly to water pollution and indirectly to turbidity – military, commercial, and recreational boat activities on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts to these surface water resources. The overall vessel traffic on the PRTR would decrease during testing because of closure of part of the PRTR to commercial and recreational vessels. Vessels present would be limited to range control boats (approximately three) and barges or vessels associated with testing. Although the military boats create small wakes that could contribute to shoreline erosion and, ultimately, increased near shore turbidity, NSWCDD boat use represents a very small percentage of the daily recreational and commercial boat traffic on the waters of the PRTR.

PRTR use by NSWCDD under Alternative 1 would have negligible, long-term, direct and indirect, negative impacts on surface waters.

4.10.1.3 Alternative 2

Ordnance Activities

Under Alternative 2, the number of large-caliber projectiles would remain at current levels and use would be the same as under Alternative 1. Small-caliber gun use would increase from 6,000 bullets fired annually under the No Action Alternative to 30,000 bullets fired annually and detonations would increase from 190 to 230 detonations, as summarized in Section 2.6.

As noted for the No Action Alternative, the RCA found the operational ranges to be in compliance with relevant regulatory requirements, and no additional protective measures related to potential off-range release of MCs were recommended. Continued removal of fired military munitions and range scrap and debris from land ranges is expected to ensure that the increases in small-arms firing and detonations under Alternative 2 would not substantially increase potential indirect impacts to surface waters. The results of the ecological and human health RSSRAs indicate that continued use of the PRTR for ordnance activities is expected to have negligible impact on surface water quality. As the use of large-caliber guns and projectiles would remain at current levels, impacts to surface waters would not increase.

Under Alternative 2, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on surface waters.

EM Energy Activities

Under Alternative 2, the number of EM energy events would increase from 490 to 680 per year, power levels would increase, and EM energy RDT&E activities would increase, as summarized in Section 2.6.

As under the No Action Alternative and Alternative 1, were beams to strike the water surface, EM energy would be reflected at the air/water boundary or quickly absorbed by the water molecules, with negligible effects on surface water. Any backscatter would be reflected, absorbed, and scattered, with no effects on surface water near the target.

EM energy activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on surface waters.

Laser Activities

Under Alternative 2, the number of HE laser events would increase from the current 60 to 145 annually, and power levels and HE laser RDT&E activities would increase, as summarized in Section 2.6.

As described for the No Action Alternative and Alternative 1, were beams to strike the water surface, energy would be reflected at the air/water boundary or quickly absorbed by the water molecules, with negligible effects on surface water. Any backscatter would be reflected, absorbed, and scattered, with no effects on surface water near the target.

For each laser operation proposed in the future, NSWCDD's Safety and Environmental Office would consider the risks on a case-by-case basis through preparation of an RHA to ensure that the operation is safe. If the RHA process indicated that the operation could not be performed safely, the activities would not be conducted. For activities over the water, public access to the PRTR and to NSWCDD's SUA would be restricted during activities to ensure the safety of the public.

There would be negligible, short-term, direct, negative impacts and no indirect impacts on surface waters from laser activities under Alternative 2.

Chemical and Biological Defense Activities

Under Alternative 2, chemical and biological defense activities would expand from the baseline 12 events annually using only chemical simulants to 70 events using both chemical and biological simulants, as summarized in Section 2.6.

The impacts from Alternative 2 would be similar to those for Alternative 1; the only difference would be a slightly higher number (10) of simulant tests and chemical and biological simulants may be tested together. For each chemical simulant event, the point concentrations of simulants that potentially could settle on the water surface or on land and be dispersed into surface waters would not increase. Simulants entering the PRTR and other surface waters would be rapidly diluted to well-below-detection levels.

For tests employing biological simulants, NSWCDD would only use BSL-1 simulants, which rarely cause reactions or diseases, and many of which are ubiquitous in the environment. Therefore, no adverse effects are anticipated from a negligible temporary increase in bacteria, fungi, viruses, or proteins levels.

The impacts of testing biological and chemical simulants together are expected to be similar to using either type of simulant alone because simulants entering the PRTR and other surface waters would be rapidly diluted to well-below-detection levels and biological simulants are already ubiquitous in the environment.

Under Alternative 2, chemical and biological defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts on surface waters.

PRTR Use

Under Alternative 2, NSWCDD would restrict public use of the PRTR danger zones, usually the MDZ, for testing approximately 1,000 hours a year, compared to 750 hours under the No Action Alternative, as summarized in Section 2.6.

As under the No Action Alternative and Alternative 1, future levels of military small boat traffic would have temporary effects on water quality – nominally contributing directly to water pollution and indirectly to turbidity. However, NSWCDD boat use represents a very small percentage of the daily recreational and commercial boat traffic on the waters of the PRTR.

PRTR use by NSWCDD under Alternative 2 is would have negligible, long-term, direct and indirect, negative impacts on surface waters.

4.10.2 Wetlands and Floodplains

4.10.2.1 No Action Alternative

Ordnance Activities

Residues from the land-based firing of munitions and detonation of explosives that remain on land after operational range surface clearance could enter wetlands and floodplains via surface water or soil runoff and shallow groundwater discharge. Although some residues may migrate into these resource areas, they are expected to occur at concentrations below most standard detection levels. As described for surface waters, the RCA found the operational ranges to be in compliance with relevant regulatory requirements, and no additional protective measures related to potential off-range release of MCs were recommended. Continued removal of fired military munitions and range scrap and debris from land ranges is expected to ensure that the impacts to wetlands and floodplains of small-arms firing and detonations under the No Action Alternative would be negligible.

Residues from large-caliber gun testing in the PRTR also could enter wetlands and floodplains associated with the Potomac River, Upper Machodoc Creek, Gambo Creek, and Black Marsh Creek, as well as other tidal water bodies along the lower river. As described in Section 4.10.1.1 and detailed in Sections 4.8.1.1 and 4.11.1.1, the results of the ecological and human health RSSRAs indicate that input of MCOPCs from munitions testing in the PRTR are orders of magnitude below concentrations that could cause adverse effects to human health or the environment. Therefore, continued use of the PRTR for ordnance activities is expected to have negligible impact on surface water. By extension, as the use of large-caliber guns and projectiles would remain at current levels, impacts to wetlands and floodplains would be negligible.

Ordnance activities under the No Action Alternative would have no direct impacts and negligible, long-term, indirect, negative impacts on wetlands and floodplains.

EM Energy Activities

NSWCDD currently uses the STSTS, NOTES, MOATS, and two ground planes for the RDT&E of issues surrounding EM energy environmental effects. These outdoor facilities for EM energy testing are located on land in the Mission Area or land ranges away from wetlands and not in the floodplain. EM energy testing at these facilities has no potential impacts on wetlands and floodplains.

NSWCDD would transmit EM energy – microwave, RF, and laser – between the NDEC and the CETFAC, across the waters of the PRTR, and across the associated floodplains and estuarine intertidal emergent wetlands. Beams of EM energy would be transmitted above the wetlands and floodplains, and would not strike or penetrate the ground or water surface. However, some backscatter from a directed energy beam's striking a target could hit wetlands and floodplains near the target, and portions of the directed energy beams from radars could strike wetlands and floodplains.

Under the No Action Alternative, EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on wetlands and floodplains.

Laser Activities

Testing using HE lasers would occur in the established laser corridors from Terminal Range to CETFAC across the PRTR, from NDEC to CETFAC across the PRTR, or from NDEC to the EEA Dock Area, across the entrance to Upper Machodoc Creek (Figure 1-9). All testing would occur over land or above the surface of the water. Some backscatter from an HE laser beam's striking a target/backstop could hit wetlands and floodplains near the target.

There would be negligible, short-term, direct, negative impacts and no indirect impacts to wetlands and floodplains from laser activities under the No Action Alternative.

Chemical Defense Activities

Simulant releases would be spaced so that no land or water area would be exposed multiple times to the same simulant. When quantities of more than 5 gals are to be used, crosswind releases could be specified by the Test Director to limit the dosage of simulant as the cloud passes over any land or water biological system.

Testing of chemical simulants results in the release of small quantities of simulants into the air with even smaller quantities deposited on the land and on the surface of the water. Concentrations of chemical simulants that would reach land would be very low – well below concentrations that have been shown to cause adverse effects – as would the concentrations that could be deposited on terrestrial vegetation or to which wetland communities would be exposed. Assessments completed for similar past simulant activities performed by NSWCDD using some of the same simulants showed no significant impacts and there were no observable environmental effects during or after events (NSWCDD, 2003; NSWCDL, 2004; Bossart, letter, February 9, 2006).

Chemical defense activities under the No Action Alternative would have negligible, short-term, direct, negative impacts and no indirect impacts on wetlands and floodplains along the river and at NSF Dahlgren.

PRTR Use

The banks along the Potomac River and Upper Machodoc Creek shorelines of NSF Dahlgren have experienced undercutting and sloughing (NSWCDL, 1999). As described in Section 4.9, most causes of erosion are natural (NSWCDL, 1999; Naval District Washington [NDW], 2007).

Field measurements made at monitoring sites at Swan Point, Maryland, and Mason Neck, Virginia, during a USGS five-year inter-disciplinary study of the tidal Potomac River and estuary indicated that short-term (10- to 18-month) recession and volume-erosion rates along a shoreline less than 3,280 ft long may vary greatly (USGS, 1985). Local factors, such as the capacity of the beach to buffer wave impact, presence or absence of obstructions that modify patterns of sediment transport, and trees at the top of the bank, may be primarily responsible for these variations. The maximum average volume-erosion rates for an individual reach in this study were measured along the Nomini Cliffs in Westmoreland County (adjacent to the MDZ) and resulted from multiple seepage zones, discontinuous ironstone ledges, sheet joints, and tectonic joints (USGS, 1985).

Military as well as commercial and recreational boat activities on the waters of the Potomac River and Upper Machodoc Creek potentially contribute to the shoreline erosion. NSWCDD range control boats, as well as other range vessels, create small wakes in the water that could contribute to wave propagation and ultimately shoreline erosion. In general, wetland and floodplain areas help control erosion (MDE, 2006). The shallow bottoms near the shore reduce wave action. Range control boat and other boat usage by NSWCDD represent a very small percentage of the daily recreational and commercial boat usage of the waters of the PRTR. Based on the relatively limited number of PRTR usage hours requiring range control boats and the small number of boats deployed (typically three), boat wakes are anticipated to have negligible impacts on wetlands and floodplains.

Existing levels of military small boat traffic may have temporary effects to water quality, if fuel, oil, and/or other related contaminants leak from vessels and enter wetlands and floodplains associated with the Potomac River, Upper Machodoc Creek, Gambo Creek, and Black Marsh Creek, as well as other tidal water bodies along the lower river. However, boats are regularly maintained by NSWCDD to minimize inadvertent releases and activities on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts to the wetland and floodplain resources.

Under the No Action Alternative, PRTR use would have no direct impacts and negligible, long-term, indirect, negative impacts on wetlands and floodplains.

4.10.2.2 Alternative 1

Ordnance Activities

Although some residues from the land-based firing of munitions and detonation of explosives could enter wetlands and floodplains, they are expected to occur at concentrations that are virtually undetectable. For both the land ranges on Mainside and for the EEA Range, the RCA

found the operational ranges to be in compliance with relevant regulatory requirements, and no additional protective measures related to potential off-range release of MCs were recommended. Continued removal of fired military munitions and range scrap and debris from land ranges is expected to ensure that the substantial increase in small-arms firing and the small increase in detonations under Alternative 1 would not substantially increase potential indirect impacts to wetlands and floodplains.

Residues from large-caliber gun testing in the PRTR also could enter wetlands and floodplains associated with the Potomac River, Upper Machodoc Creek, Gambo Creek, and Black Marsh Creek, as well as other tidal water bodies along the lower river. As described in Section 4.10.1.1 and detailed in Sections 4.8.1.1 and 4.11.1.1, the results of the human health and ecological RSSRAs indicate that input of MCOPCs from munitions testing in the PRTR are orders of magnitude below concentrations that could cause adverse effects to human health or the environment. Therefore, continued use of the PRTR for ordnance activities is expected to have negligible impact on surface water. By extension, as the use of large-caliber guns and projectiles would remain at current levels, impacts to wetlands and floodplains would be negligible.

Ordnance activities under Alternative 1 would have no direct impacts and negligible, long-term, indirect, negative impacts on wetlands and floodplains.

EM Energy Activities

The outdoor facilities for EM energy testing – STSTS, NOTES, MOATS, and two ground planes – are located on land in the Mission Area or land ranges away from wetlands and not in the floodplain. EM energy testing at these facilities under Alternative 1 would have no potential impacts on wetlands and floodplains.

NSWCDD would transmit directed energy across the land ranges or across the waters of the PRTR, and across the associated floodplains and estuarine intertidal emergent wetlands. Beams of directed energy would be transmitted above the wetlands and floodplains, and would not strike or penetrate the ground or water surface. However, some backscatter from a directed energy beam's striking a target could hit wetlands and floodplains near the target, and portions of the directed energy beams from radars could strike wetlands and floodplains.

Under Alternative 1, EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on wetlands and floodplains.

Laser Activities

Under Alternative 1, HE laser RDT&E activities on the PRTR would expand, as described in Section 2.5.3. However, controls implemented under the detailed RHA/SOP process for the use of HE lasers outdoors would ensure that interaction with wetland or floodplain resources is minimal, as a clear line of sight is required for testing and therefore lasers would have minimal contact with vegetation. Some backscatter from an HE laser beam's striking a target/backstop could hit wetlands and floodplains near the target.

There would be negligible, short-term, direct, negative impacts and no indirect impacts to wetlands and floodplains from laser activities under Alternative 1.

Chemical and Biological Defense Activities

Under Alternative 1, the same quantities of chemical simulants would be used as under the No Action Alternative, as described in Section 2.5.4.Concentrations of chemical simulants that would reach land would be very low – well below concentrations that have been shown to cause adverse effects – as would the concentrations that could be deposited on terrestrial vegetation or to which wetland communities would be exposed. No modeling was performed for biological simulants, as NSWCDD would only use BSL-1 simulants. These bacteria, fungi, viruses, and proteins rarely cause reactions or diseases, and many are ubiquitous in the environment. Therefore, no adverse effects are anticipated from a temporary increase in these organisms.

Chem/bio defense activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on wetlands and floodplains.

PRTR Use

Based on the relatively limited number of PRTR usage hours requiring range control boats and the small number of boats deployed (typically three), boat wakes would have negligible impacts on wetlands. Boat activities on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts to the wetland and floodplain resources.

PRTR use under Alternative 1 would have no direct impacts and negligible, long-term, indirect, negative impacts on wetlands and floodplains.

4.10.2.3 Alternative 2

Ordnance Activities

For both the land ranges on Mainside and for the EEA Complex, the RCA found the operational ranges to be in compliance with relevant regulatory requirements, and no additional protective measures related to potential off-range release of MCs were recommended. Continued removal of fired military munitions and range scrap and debris from land ranges is expected to ensure that the substantial increases in small-arms firing and detonations under Alternative 2 would not substantially increase potential indirect impacts to wetlands and floodplains.

As described in Sections 4.8.1.1 and 4.10.1.1 and detailed in Section 4.11.1.1, the results of the human health and ecological RSSRAs indicate that input of MCOPCs from munitions testing in the PRTR are orders of magnitude below concentrations that could cause adverse effects to human health or the environment. Therefore, continued use of the PRTR for ordnance activities is expected to have negligible impact on surface water. By extension, as the use of large-caliber guns and projectiles would remain at current levels, impacts to wetlands and floodplains would be negligible.

Ordnance activities under Alternative 2 would have no direct impacts and negligible, long-term, indirect, negative impacts on wetlands and floodplains.

EM Energy Activities

As described previously, the outdoor facilities for EM energy testing are located on land in the Mission Area or land ranges away from wetlands and not in the floodplain. EM energy testing at these facilities under Alternative 2 would have no potential effects on wetlands and floodplains.

NSWCDD would transmit directed energy across the land ranges or across the waters of the PRTR, and across the associated floodplains and estuarine intertidal emergent wetlands. Beams of directed energy would be transmitted above the wetlands and floodplains, and would not strike or penetrate the ground or water surface. However, some backscatter from a directed energy beam's striking a target could hit wetlands and floodplains near the target, and portions of the directed energy beams from radars could strike wetlands and floodplains.

Under Alternative 2, EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on wetlands and floodplains.

Laser Activities

Under Alternative 2, the increase in HE laser RDT&E activities would be similar to those described for Alternative 1, with a slightly higher frequency, as summarized in Section 2.6. Controls implemented under the detailed RHA/SOP process for the use of HE lasers outdoors would ensure that interaction with wetland or floodplain resources is minimal, as a clear line of sight is required for testing. Some backscatter from an HE laser beam's striking a target/backstop could hit wetlands and floodplains near the target.

There would be negligible, short-term, direct, negative impacts and no indirect impacts to wetlands or floodplains from laser activities under Alternative 2.

Chemical and Biological Defense Activities

Concentrations of chemical simulants that would reach land would be very low – well below concentrations that have been shown to cause adverse effects – as would the concentrations that could be deposited on terrestrial vegetation or to which wetland communities would be exposed. No adverse effects are anticipated from a temporary increase in BSL-1 organisms. There would be no interaction between chemical and biological simulants that would adversely affect water resources.

Chem/bio defense activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on wetlands and floodplains along the PRTR or on NSF Dahlgren.

PRTR Use

Based on the relatively limited number of PRTR usage hours requiring range control boats and the small number of boats deployed (typically three), boat wakes would have negligible impacts on wetlands. Boat activities on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts to the wetland and floodplain resources.

PRTR use under Alternative 2 would have no direct impacts and negligible, long-term, indirect, negative impacts on wetlands and floodplains.

4.10.3 Groundwater

4.10.3.1 No Action Alternative

Ordnance Activities

The recharge zones for the aquifer systems supplying NSF Dahlgren and surrounding areas – the Aquia aquifer and the Potomac aquifer – are approximately 25 miles west of the installation (Brown and Root Environmental, 1996, as cited in Agency for Toxic Substances and Disease Registry [ATSDR], 2006; NSWCDD, 2003). Therefore, there would be little opportunity for residues from land-based firing of munitions and detonation of explosives to contaminate these groundwater resources that supply industrial, municipal, or domestic users.

Some individual households and businesses may withdraw water from the unconfined Columbia aquifer, which is recharged directly by precipitation across most of NSF Dahlgren and elsewhere within King George County. However, the amounts of range residues deposited on the land would be negligible, and exposure concentrations would be below toxicity thresholds. Continued removal of fired military munitions and range scrap and debris from land ranges is expected to further ensure that range residues would have minimal potential impacts on groundwater.

Under the No Action Alternative, ordnance activities would have no direct impacts and negligible, long-term, indirect, negative impacts on groundwater.

EM Energy Activities, Laser Activities, and PRTR Use

Under the No Action Alternative, EM energy activities, HE laser activities, and PRTR use have no contact with groundwater and therefore they would have no direct or indirect impacts on groundwater.

Chemical Defense Activities

Testing of chemical simulants results in the release of small quantities of simulants into the air with even smaller quantities being deposited on the land and on the surface of the water. Chemicals deposited on land or on the surface water would degrade or be diluted to non-detectable levels well before reaching the groundwater.

Chemical defense activities under the No Action Alternative would have no direct or indirect impacts on groundwater.

4.10.3.2 Alternative 1

Ordnance Activities

Some individual households and businesses may withdraw water from the unconfined Columbia aquifer. However, the amounts of range residues that would be deposited on the land would be negligible and exposure concentrations would be well below toxicity thresholds. Continued removal of fired military munitions and range scrap and debris from land ranges is expected to further ensure that range residues would have minimal potential impacts on groundwater under Alternative 1.

Under Alternative 1, ordnance activities would have no direct impacts and negligible, long-term, indirect, negative impacts on groundwater.

EM Energy Activities, Laser Activities, and PRTR Use

Under Alternative 1, EM energy activities, HE laser activities, and PRTR use have no contact with groundwater and therefore they would have no direct or indirect impacts on groundwater.

Chemical and Biological Defense Activities

Testing of chemical and biological simulants results in the release of small quantities of simulants into the air with even smaller quantities of simulants being deposited on the land and on the surface of the water. Chemicals deposited on land or on the surface water would degrade or be diluted to non-detectable levels well before reaching the groundwater and biological organisms would be diluted to non-detectable levels or die before reaching the groundwater.

Under Alternative 1, chem/bio defense activities would have no direct or indirect impacts on groundwater.

4.10.3.3 Alternative 2

Ordnance Activities

Some individual households and businesses may withdraw water from the unconfined Columbia aquifer. However, the amounts of range residues that would be deposited on the land would be negligible, and exposure concentrations would be well below toxicity thresholds. Continued removal of fired military munitions and range scrap and debris from land ranges is expected to further ensure that range residues would have minimal potential impacts on groundwater under Alternative 2.

Under Alternative 2, ordnance activities would have no direct impacts and negligible, long-term, indirect, negative impacts on groundwater.

EM Energy Activities, Laser Activities, and PRTR Use

Under Alternative 2, EM energy activities, HE laser activities, and PRTR use have no contact with groundwater and therefore they would have no direct or indirect impacts on groundwater.

Chemical and Biological Defense Activities

Testing of chemical and biological simulants results in small quantities of simulants being released into the air with even smaller quantities of simulants being deposited on the land and on the surface of the water. Chemicals deposited on land or on the surface water would degrade or be diluted to non-detectable levels well before reaching the groundwater and biological organisms would be diluted to non-detectable levels or die before reaching the groundwater.

Under Alternative 2, chem/bio defense activities would have no direct or indirect impacts on groundwater.

4.11 Potomac River Aquatic Biological Resources

4.11.1 No Action Alternative

4.11.1.1 Ordnance Activities

As described in Section 3.7.7, almost all recorded large-caliber projectiles fired at NSF Dahlgren since 1918 have been fired into the MDZ, with a limited number of projectiles entering the upper end of the LDZ (up to 40,000 yds from the firing line). Nearly half (46.4 percent) of large-gun projectiles tested at NSF Dahlgren have been targeted to a 2.3-sq NM area – referred to as the dense zone – approximately 11,000 to 13,000 yds from the Main Range gun line (see Figure 3.7-1). Under the No Action Alternative, as well as under Alternatives 1 and 2, the majority of the 4,700 large-gun projectiles fired in particularly active years would continue to be fired into the same heavily-used area.

In recent years – i.e., for the period from 1995 through 2009 – approximately 74 percent of the large-gun projectiles fired into the Potomac River have been inert. Inert projectiles enter the water and are propelled by their forward momentum into the sediment. Duds, which comprise about 3 percent of live projectiles, have the same impacts as inert projectiles, as they also enter the sediments and are buried without exploding. Under this alternative, as well as under Alternatives 1 and 2, inert projectiles would continue to be the dominant type of ordnance.

Approximately 26 percent of large-caliber projectiles fired in recent years have been live projectiles, which detonate primarily above the water surface. Most of the live ordnance tested currently is and will continue to be fuzed to explode well above the water surface. More than 98 percent of the live projectiles that detonate are estimated to do so on or above the water, resulting in less than 2 percent – i.e., approximately 24 of the projectiles fired annually during particularly active firing years – detonating under water, at depths of 6 ft or less. After detonation of live projectiles above the water, small fragments or particles would be deposited on the surface of the water, which would then disperse over a wide area upon entering the water column. Limited amounts of material would be deposited in any single area, and constant water movement in the river would redistribute smaller particles after they settle on the bottom.

Approximately 6,000 bullets would be fired each year. Much of the outdoors small-arms firing is directed into gun butts, reducing the number of bullets entering the river. Approximately 90 percent of small-arms firings are and would continue to be over land and those bullets would not enter the river. The remaining 10 percent (600) of the firings would be from land into the river, with the bullets entering the river mainly within 1,000 yds of the shoreline. Under current small-arms activities, as described in Section 1.5.1.3, most bullets fired are inert, but some are explosive.

Approximately 190 detonations would take place each year. Most detonations would take place inland on the EEA's Harris and Churchill Ranges, and much less frequently on the EOD training range on the Missile Test Range, all at considerable distances from the waters of the Potomac River. Occasionally, devices would be detonated on vessels in the river. A portion of the debris and residues from detonations on vessels could enter the river, but the quantities of these materials would be small, as such detonations would be infrequent.

As discussed in Section 3.7.5, NSWCDD removes fired military munitions, as well as range scrap and debris that are exposed on the ground surface or partially buried. Residues from the land-based firing of munitions and detonation of explosives that remain on land after operational range surface clearance could enter surface waters indirectly via surface water or soil runoff, and shallow groundwater discharge. Although some residues would eventually migrate into surface waters, they are expected to occur at extremely low concentrations. The RCA recommends that no actions are required related to potential off-range release of MCs, as discussed in Section 3.7.6.

Impacts related to large-caliber projectiles and bullets may be direct or indirect. Direct impacts could result from inert projectiles or bullets striking organisms directly, or from the detonation of explosive projectiles or bullets above, at, or below the water surface. There would be a small possibility that some individual organisms – notably fish and birds – may be directly impacted if they are in the target area and, in particular, at the point of physical impact at the time of ordnance delivery. However, the size of the projectiles, coupled with the often patchy distribution of fish and birds and the low probability that a fish or bird would occur at the immediate location of impact, minimizes the potential for a direct strike.

As noted above, more than 98 percent of the live projectiles that detonate are estimated to do so on or above the water. The potential effects from above-water detonations would not be of any consequence to aquatic organisms, as the air-water interface would reflect most of the energy from the shockwave outward and upward. Underwater detonations would have more expansive zones of influence and greater potential for injuring fish than would on- or above-water detonations.

Munitions exploding underwater, comprising less than 2 percent of live projectiles that detonate (about 24 in a particularly active firing year), create a shock wave that has the potential to impact aquatic organisms, particularly those with gaseous pockets or cavities. The shock wave creates an expansion of gas and the irregular movement of tissues. The shock wave created by an underwater explosion can rupture swim bladders and blood vessels, tear tissues, and rupture and hemorrhage the spleen, kidney, liver, gonads, and sinus venosus (Wright, 1982; Wright and Hopky, 1998; Lewis, 1996; Govoni et al., 2003). Generally, the closer the detonation is to the water surface, the smaller the horizontal range or extent of the impact zone and the lower the potential impact. This is because the resultant bubble of expanding gases would break the water surface, allowing a significant portion of the energy to escape into the less dense air, in turn reducing the peak pressure. Conversely, the shallower the detonation, the greater the depth at which the maximum horizontal range of the impact zone is attained (Naval Surface Weapons Center [NSWC], 1984).

In addition to direct physical impacts, large-gun projectiles could have indirect impacts on aquatic organisms and communities. Indirect impacts may include increasing turbidity and sedimentation close to the area of impact, or the release of MCs that can alter water and/or sediment quality.

When projectiles impact the river bottom, they disturb bottom sediments, re-suspending sediment into the water column. A disturbance to bottom sediments in aquatic ecosystems can degrade water quality by stirring up sediments that introduce excess organic matter and nutrients into the water column and change the reduction or redox potential (short for reduction-oxidation reaction, which describes all chemical reactions in which atoms have their oxidation number

[oxidation state] changed) (Heinsohn et al., 1977; Burton and Scott, 1992; Kelaher et al., 2003; Bilotta and Brazier, 2008). A change to the redox potential can transform and release toxins, making the habitat unfit for many species to survive (Heinsohn et al., 1977).

Increases in the level of suspended solids in the water column would be concentrated near areas where projectiles enter the sediment. A shell impacting the river sediment is anticipated to create a small crater at the entry point, releasing sediment into the water column. No estimates of the increase in suspended material could be made, but it is anticipated that the sediments disturbed at the impact site would quickly settle out of the water column. Increases in levels of suspended sediments would be localized, short-term events that would not affect current levels of suspended solids found in the water column.

Water and Sediment Quality Modeling

The munitions fired into the PRTR over the last 90 years have introduced organic compounds (explosives) and inorganic compounds (metals) into the river. A fate and transport model was used to provide a quantitative estimate of the potential loading of explosive and metal munitions constituents of potential concern (MCOPCs) to river water and sediment. The potential effects of munitions firing into the PRTR on biological resources based on water and sediment modeling are summarized below and further information on the modeling procedures and assumptions is contained in Appendix F of this EIS.

Concentrations of metal and explosive MCOPCs in water and sediments in the two areas of the PRTR with the highest concentrations of munitions were modeled to focus on the areas with the greatest potential to impact aquatic life. The area between the Main Range gun line and 25,000 yds in the MDZ accounts for 99.4 percent of all munitions tested on the PRTR and is referred to as the diffuse zone (see Figure 3.7-1). Within this area, the dense zone – the zone from 11,000 to 13,000 yds – has the highest density of projectiles. A subset of constituents contained in munitions that were most likely to contribute to an ecological or human health risk was selected for modeling. The annual concentrations of organic explosives and metals constituents were estimated assuming 90 years of environmental exposure for corrosion. The predicted concentrations of metals in the dense and diffuse zones of the MDZ are shown in Table 4.11-1.

Table 4.11-1
Summary of Modeled Concentrations of Metals in Water and Sediment in the PRTR

Metal	Adsorbed in Sediment Due to Munitions (Monthly)		In River Water Column Due to Munitions (Daily)	
	Dense Zone	Diffuse Zone	Dense Zone	Diffuse Zone
	(µg /kg)	*(µg /kg)*	*(µg /l)*	*(µg /l)*
Cadmium	14.5	2.09	0.00000504	0.000000694
Chromium	5.61	1.29	0.00000845	0.00000194
Copper	6,500	1,710	0.00000591	0.00000150
Lead	11.9	26,2	0.00000000577	0.00000000119
Manganese	2,320	797	0.00104	0.000342
Nickel	78.7	81.5	0.0000221	0.0000220
Zinc	1,140	192	0.0000458	0.00000729

Notes: *µg* /kg = micrograms per kilogram (parts per billion); *µg* /l = milligrams per liter (parts per billion).
A concentration of 0.001 mg/kg is equal to 1 part per 1,000,000,000 (part per billion).

Water and sediment criteria and guidelines for protection of aquatic life were selected for comparison with modeled concentrations of metals using the following guidance:

- **USEPA Current National Recommended Water Quality Criteria** (USEPA, 2009) – USEPA's national recommended water quality criteria for the protection of aquatic life and human health in surface water include about 150 pollutants. These criteria are published pursuant to Section 304(a) of the Clean Water Act (CWA) and provide guidance for states and tribes to use in adopting water quality criteria. These aquatic life criteria are intended to be protective of the vast majority of the aquatic communities in the United States. The criteria maximum concentration (acute) is an estimate of the highest concentration of a material in surface water to which an aquatic community (two or more populations of different species occupying the same area) can be exposed briefly without resulting in an unacceptable effect, while the criteria continuous concentration (chronic) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.
- **NOAA Screening Quick Reference Tables (SQuiRTs)** (NOAA, 2008) – These tables compiled by NOAA provide a range of screening concentrations for constituents found in sediments. For freshwater sediments the following values are provided:
  - **Threshold effects level**– Calculated as the geometric mean of the 15th percentile concentration of the toxics effects dataset and the 50th percentile (median) of the no-effect dataset. Threshold effects level represents the concentration at which toxic effects are expected to occur only rarely.
  - **Probable effects level** – Calculated as the geometric mean of the median concentration of impacted samples and the 85th percentile of the non-impacted samples. Probable effects level represents the concentration at which toxic effects are frequently expected.
  - **Upper effects threshold**– The concentration at which biological indicators of adverse effects (e.g., sediment bioassay or reduced benthic infauna) are seen. At concentrations above the upper effects threshold, adverse biological effects are expected.

Marine sediment values also were used for comparison, as most of the PRTR is mesohaline with salinities typically ranging from 5 to 18 ppt. For marine sediments the following values were used:

- **Effects range-low (ER-L)** – The concentration that represents the lowest 10th percentile of the concentrations at which toxic effects were observed. At concentrations below the ER-L, toxic effects are rarely expected (Long and Morgan, 1990).
- **Effects range-median (ER-M)** – The concentration that represents the 50th percentile (median) at which toxic effects were observed. At concentrations above the ER-M, toxic effects are likely to occur (Long and Morgan, 1990).
- **Apparent effects threshold (AET)** – The concentration at which biological indicators of adverse effects (e.g., sediment bioassay or reduced benthic infauna) is seen, essentially equivalent to the concentration in the highest non-toxic sample. At concentrations above the AET, adverse biological effects are always expected.

Tables 4.11-2 and 4.11-3 present the water and sediment criteria and guidelines selected for comparison of MC concentrations.

Table 4.11-2
USEPA Water Quality Criteria for Metals

Metal	Freshwater		Saltwater	
	Acute Ambient Water Quality Criteria (µg/l)	Chronic Ambient Water Quality Criteria (µg/l)	Acute Ambient Water Quality Criteria (µg/l)	Chronic Ambient Water Quality Criteria (µg/l)
Cadmium	2.0	0.25	40	8.8
Chromium III	570	74	NA	NA
Chromium VI	16	11	1,100	50
Copper	13	9.0	4.8	3.1
Lead	65	2.5	210	8.1
Manganese*	NA	NA	NA	NA
Nickel	470	52	74	8.2
Zinc	120	120	90	81

Note: µg/l = micrograms per liter (parts per billion).
* Manganese is a non-priority pollutant.
Source: USEPA, 2009.

Table 4.11-3
NOAA Sediment Quality Guidelines for Metals

Metal	Freshwater Sediment			Marine Sediment				
	Threshold Effects Level	Probable Effects Level	Upper Effects Threshold	Threshold Effects Level	Effects Range-Low	Probable Effects Level	Effects Range-Median	Apparent Effects Threshold
	µg/kg dw							
Cadmium	596	3,530	3,000	676	1,200	4,210	9600	3000
Chromium	37,300	90,000	95,000	52,300	81,000	160,400	370,000	62,000
Copper	35,700	197,000	86,000	18,700	34,000	108,200	270,000	390,000
Lead	35,000	91,300	127,000	30,240	46,700	112,180	218,000	400,000
Manganese	630,000	NA	NA	1,100,000	NA	NA	NA	260,000
Nickel	18,000	35,900	43,000	15,900	20,900	42,800	51,600	110,000
Zinc	123,100	315,000	520,000	124,000	150,000	271,000	41,000	41,000

Notes: µg/kg dw = micrograms per kilogram dry weight (parts per billion).
NA = not available.
Source: NOAA, 2008.

MCs from explosives are not listed on USEPA's Contract Laboratory Program Toxic Compound List (USEPA, 2011) and are generally not included in government criteria or guidelines. Talmage et al. (1999, as cited in US Navy, 2002) calculated freshwater and sediment screening levels based on available data using the standard USEPA methodology for generation of water quality. These freshwater and sediment concentrations are presented in Table 4.11-4. No sediment data were available for ammonium picrate or Tetryl.

Table 4.11-4
Freshwater and Sediment Criteria for Explosives

Constituent	Acute Water Quality Criteria-Freshwater [1] (μ g/l)	Chronic Water Quality Criteria-Freshwater [1] (μg /l)	Sediment [1] (mg/kg)
Ammonium picrate	220,000 FW [2] 66,000 SW [2]	No Data	No Data
HMX	3,800	330	470
RDX	1,440	190	1,300
Tetryl	1,200 [3]	No Data	No Data
TNT	570	90	9,200

Notes: μg/l = micrograms per liter (parts per billion); μ g/kg = micrograms per kilogram (parts per billion).
FW = freshwater; SW = saltwater.
Sources:
[1] Talmage et al., 1999; as cited in US Navy, 2002.
[2] NOAA, 2008; FW based on lethal concentration 50 (LC50) (lethal dose resulting in 50 percent mortality) for 96-hr exposure of bluegill sunfish; SW based on LC50 for 96-hr exposure of the inland silverside *Menidia beryllina*.
[3] NAVFAC, 2000; Saltwater toxicity to red fish larvae based on no observed effect.

These modeled concentrations of munitions-related metals and explosives were then compared to water and sediment quality criteria and guidelines to determine if they were above guidelines for the protection of aquatic life. Tables 4.11-5 and 4.11-6 summarize the ratios of modeled concentrations of metals to water and sediment criteria, respectively. Ratios of less than one indicate that concentrations are below levels that could cause adverse effects to aquatic organisms. The ratios of all comparisons of predicted water concentrations and sediment concentrations were well below one, indicating that there are no exceedances associated with metals from munitions usage in water or sediment. Most concentrations are many orders of magnitude below criteria (more than a million times below effects levels).

Concentrations of explosives in water and sediment were also modeled, as summarized in Tables 4.11-7 and 4.11-8, respectively. Ratios of modeled concentrations to water and sediment criteria were also orders of magnitude below one, as shown in these tables, indicating that there would be no adverse effects to aquatic organisms associated with metals or explosives released from munitions.

Vegetation

The primary aquatic vegetation potentially impacted by the Proposed Action is submerged aquatic vegetation (SAV), which is discussed in this section. Emergent intertidal wetlands are discussed separately, in Section 4.10.

SAV is generally found in shallower waters along the edges of the Potomac River (see Figures 3.11-1 and 3.11-2, and Figure 4.11-1, SAV in Relation to the PRTR), as it is restricted to the photic zone where light is available for growth. SAV in the Potomac River in the region of the MDZ and upper LDZ (mesohaline region) requires at least 3.3 ft of light penetration (Buchanan, 2008). The MDZ and LDZ do not include extensive nearshore areas where sufficient light is available for SAV growth.

Table 4.11-5
Summary of Modeled Metal Concentrations in Water Compared to USEPA Water Quality Criteria in the PRTR

Metal	Freshwater		Saltwater	
	Acute Ambient Water Quality Criteria	Chronic Ambient Water Quality Criteria	Acute Ambient Water Quality Criteria	Chronic Ambient Water Quality Criteria
Dense Zone				
Cadmium	0.00000252	0.0000202	0.000000126	0.000000573
Chromium III	0.0000000148	0.000000114	NA	NA
Chromium VI	0.000000528	0.000000768	0.00000000768	0.000000169
Copper	0.000000455	0.000000657	0.00000123	0.00000191
Lead	0.0000000000888	0.00000000231	0.0000000000275	0.000000000712
Manganese	NA	NA	NA	NA
Nickel	0.0000000470	0.000000425	0.000000299	0.00000270
Zinc	0.000000382	0.000000382	0.000000509	0.000000565
Diffuse Zone				
Cadmium	0.000000347	0.00000278	0.0000000174	0.0000000789
Chromium III	0.00000000340	0.0000000262	NA	NA
Chromium VI	0.000000121	0.000000176	0.00000000176	0.0000000388
Copper	0.000000115	0.000000167	0.000000313	0.000000484
Lead	0.0000000000183	0.000000000476	0.00000000000567	0.000000000147
Manganese	NA	NA	NA	NA
Nickel	0.0000000468	0.000000423	0.000000297	0.00000268
Zinc	0.0000000608	0.0000000608	0.0000000810	0.0000000900

Notes: NA = criteria not available.
Values below 1 indicate that concentrations are below water quality criteria. All values shown here are orders of magnitude below 1 (each order of magnitude is equal to ten times).

Table 4.11-6
Summary of Modeled Metal Concentrations in Sediment Compared to NOAA Sediment Quality Criteria in the PRTR

Metal	Freshwater				Saltwater				
	Lowest ARCS	Threshold Effects Level	Probable Effects Level	Upper Effects Threshold	Threshold Effects Level	Effects Range-Low	Probable Effects Level	Effects Range-Median	Apparent Effects Threshold
Dense Zone									
Cadmium	0.025	0.024	0.0041	0.0048	0.021	0.012	0.0034	0.0015	0.0048
Chromium	0.00015	0.00015	0.000062	0.000059	0.00011	0.000069	0.000035	0.000015	0.000090
Copper	0.23	0.18	0.033	0.076	0.35	0.19	0.06	0.024	0.017
Lead	0.0032	0.0034	0.0013	0.00094	0.0039	0.0025	0.0011	0.00055	0.0003
Manganese	0.0058	0.0037	NA	NA	0.0021	NA	NA	NA	0.0089
Nickel	0.004	0.0044	0.0022	0.0018	0.0049	0.0038	0.0018	0.0015	0.00072
Zinc	0.012	0.0093	0.0036	0.0022	0.0092	0.0076	0.0042	0.028	0.028
Diffuse Zone									
Cadmium	0.0036	0.0035	0.00059	0.0007	0.0031	0.0017	0.0005	0.00022	0.0007
Chromium	0.000036	0.000035	0.000014	0.000014	0.000025	0.000016	0.0000080	0.0000035	0.000021
Copper	0.061	0.048	0.0087	0.02	0.091	0.05	0.016	0.0063	0.0044
Lead	0.00071	0.00075	0.00029	0.0021	0.00087	0.00056	0.00023	0.00012	0.000066
Manganese	0.002	0.0013	NA	NA	0.00072	NA	NA	NA	0.0031
Nickel	0.0042	0.0045	0.0023	0.0019	0.0051	0.0039	0.0019	0.0016	0.00074
Zinc	0.002	0.0016	0.00061	0.00037	0.0015	0.0013	0.00071	0.0047	0.0047

Notes: ARCS = Assessment and Remediation of Contaminated Sediments Program.

NA = criteria not available.

Values below 1 indicate that concentrations are below sediment guidelines. All values shown here are orders of magnitude below 1 (each order of magnitude is equal to ten times).

Source: NOAA, 2008.

Table 4.11-7
Summary of Modeled Explosive Concentrations in Water Compared to Water Quality Values in the PRTR

Explosive	Modeled Water Concentration (mg/l)		Ratios of Water Concentration: Acute Water Values		Ratios of Water Concentration: Chronic Water Values	
	Dense Zone	***Diffuse Zone***	***Dense Zone***	***Diffuse Zone***	***Dense Zone***	***Diffuse Zone***
Ammonium Picrate	0.0000517	0.00000269	0.00000024 FW 0.00000078 SW	0.000000012 FW 0.000000041 SW	No Data	No Data
HMX	4.46×10^{-9}	2.60×10^{-9}	1.2×10^{-9}	6.8×10^{-10}	0.000000014	7.9×10^{-9}
RDX	0.0000337	0.0000000573	0.000023	0.00000040	0.00018	0.0000030
Tetryl	0.000000574	0.0000000164	0.00000048	0.000000014	No Data	No Data
TNT	0.00000334	0.000000635	0.0000059	0.0000011	0.000037	0.0000071

Notes: mg/l = milligrams per liter.

FW = freshwater; SW = saltwater.

Scientific notation is used for very small numbers; for example 1.0×10^{-9} is one billionth (0.000000001).

Values below 1 indicate that concentrations are below water quality values. All values shown here are orders of magnitude below 1 (each order of magnitude is equal to ten times).

Table 4.11-8
Summary of Modeled Explosive Concentrations in Sediment Compared to Sediment Quality Criteria in the PRTR

Explosive	Modeled Dry Sediment Concentration (mg/kg)		Ratios of Sediment Concentration: Sediment Values	
	Dense Zone	***Diffuse Zone***	***Dense Zone***	***Diffuse Zone***
Ammonium Picrate	0.000000541	0.0000000406	No Data	No Data
HMX	0.00000000611	0.00000000510	0.000000013	0.000000011
RDX	0.0000138	0.000000337	0.000011	0.00000026
Tetryl	0.000603	0.0000250	No Data	No Data
TNT	0.00298	0.000814	0.00032	0.000089

Notes: mg/kg = milligrams per kilogram.

Values below 1 indicate that concentrations are below sediment quality values. All values shown here are orders of magnitude below 1 (each order of magnitude is equal to ten times).

There is little SAV present in the MDZ and upper LDZ, as shown in Figure 4.11-1, and few plants are found in deeper waters of the PRTR where most large-caliber gun projectiles currently are and would continue to be fired. Therefore, there would be limited potential for direct hits of vegetation, disturbance of vegetation adjacent to direct hits, or settlement of shell fragments onto plants in the PRTR.

A limited number of inert or dud projectiles that enter the river where SAV is present may damage plants at and in the immediate vicinity of the point of entry. After detonation of live projectiles, small fragments or particles may be deposited on SAV. Fragments and particles are anticipated to be dispersed over a wide area, with limited amounts of material deposited in any single area. Constant water movement on the surface of submerged plant leaves would remove smaller particles.

The limited number of plants damaged by projectiles would not affect the SAV community. Areas where projectiles enter the sediment are likely to be recolonized by neighboring plants. Relatively low numbers of small-arms bullets would enter the MDZ and there is little SAV in the area where bullets would enter the water (see Figure 4.11-1).

Detonations on the land ranges, all at considerable distances from the waters of the Potomac River, and the occasional detonation of devices on vessels in the river would have no direct impact on SAV communities.

As discussed above, comparison of the modeled concentrations of munitions-related metals and explosives to water and sediment quality criteria and guidelines indicated that concentrations are below levels that could cause adverse effects to aquatic organisms. Most concentrations of metals and all concentrations of explosives were many orders of magnitude below criteria, indicating that there would be no adverse effects to SAV associated with metals or explosives released from munitions. Based on the comparison of metals and explosive concentrations associated with ordnance use in the PRTR to aquatic toxicity values and the minimal increase in suspended solids in the water column, the indirect impacts of ordnance activities on SAV would be negligible.

As discussed previously, NSWCDD removes fired military munitions, and range scrap and debris that are exposed on the ground surface or partially buried. Residues from the land-based firing of munitions and detonation of explosives that remain on land after operational range surface clearance could enter surface waters indirectly via surface water or soil runoff, and shallow groundwater discharge. Although some residues would migrate into surface waters, they are expected to occur at extremely low concentrations. Some debris from occasional detonations on vessels in the river also may enter the river, but only at low concentrations.

Under the No Action Alternative, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on SAV communities.

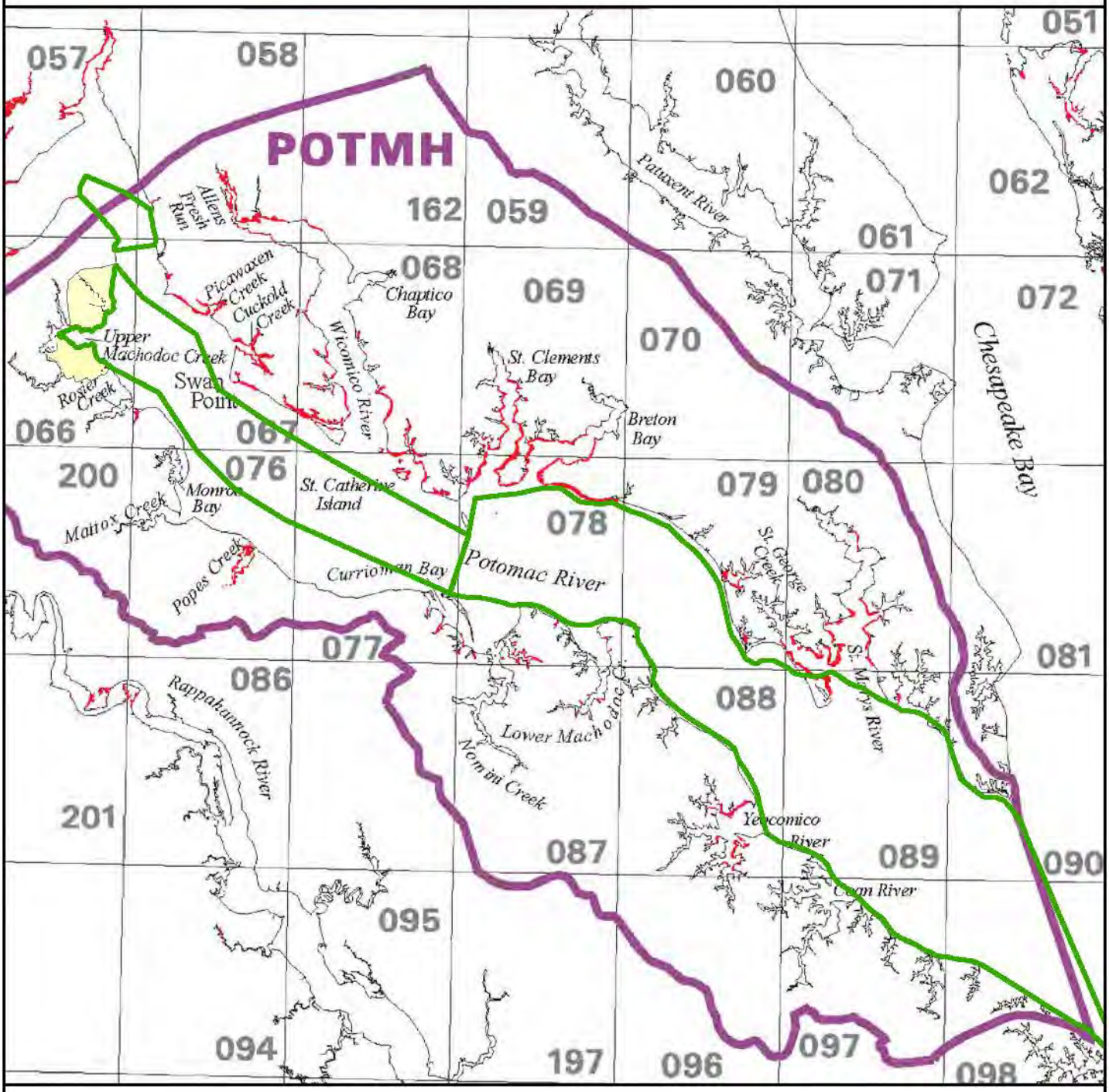
Plankton

Shock waves created by the small number of munitions that explode at or under the surface of the water have the potential to rupture gaseous pockets in plankton. Both phytoplankton and zooplankton possess pockets of gas and tissues that may be impacted from a shock wave induced from an explosion. However, most projectiles fired are inert and less than 2 percent (24 in a particularly active year) of the live projectiles fired are estimated to detonate below water. For these reasons, direct impacts to plankton communities would be negligible.

Large-caliber projectiles may indirectly impact plankton and plankton communities. Potential short-term impacts to plankton would primarily result from increased turbidity and could include the scouring of external respiratory and photosynthetic structures, and decreased biomass (Bilotta and Brazier, 2008; Testa et al., 2008). Increased turbidity can also clog the gut of an organism, causing the organism to stop feeding and starve (Alabaster and Lloyd, 1982). However, due to the ubiquity and abundance of plankton, any indirect impacts to plankton from ordnance activities would be limited to individuals and would not impact the planktonic community of the PRTR.

Impacts of small-arms activities on plankton would be limited to areas within the MDZ, close to shore. As most bullets fired are inert, there would be little interaction with plankton. Detonations

Submerged Aquatic Vegetation in Relation to the PRTR



2005 SAV

Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR)

0 2 4 6
Miles

0 2 4 6 8 10
Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: Orth et al. (2006) Scale is approximate.

Figure 4.11-1

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that take place inland on the EEA and occasionally on the Missile Test Range as well as on vessels in the river would not impact plankton communities.

Negligible, long-term, direct and indirect, negative impacts to phytoplankton and zooplankton communities from ordnance activities would occur under the No Action Alternative.

Aquatic Invertebrates

Few aquatic invertebrates would be directly impacted from explosions, as only a small number would occur annually over a large area and any impacts related to turbidity would be negligible. Most explosions would occur above the surface of the water and most organisms are considered to be adapted to living in a turbid environment due to the high annual sediment-accumulation rates in the Potomac River, which range up to 0.75 in per year.

Concentrations of MCOPCs from leaching of ordnance are predicted to be well below freshwater, saltwater, and sediment criteria and guidelines – generally by many orders of magnitude – based on the modeling results presented above. The concentrations used for comparisons were in the densest areas of target firing and represent the highest concentrations of MCOPCs in the PRTR. Based on these comparisons, negligible impacts to aquatic invertebrates are anticipated.

Most small-arms bullets fired during testing are inert and only a portion may enter the river; therefore, there would be little interaction with invertebrates. Most detonations take place inland a considerable distance from the waters of the Potomac River and would not impact aquatic invertebrate communities.

NSWCDD removes fired military munitions and range scrap and debris that are exposed on the ground surface or partially buried. Residues from the land-based firing of munitions and detonation of explosives that remain on land after operational range surface clearance could enter surface waters indirectly via surface water or soil runoff, and shallow groundwater discharge. Residues would be reduced to virtually undetectable concentrations prior to reaching surface waters.

Ordnance activities under the No Action Alternative would have negligible, long-term, direct and indirect, negative impacts on aquatic invertebrate communities.

Fish

Fish Species and Stocks

There are approximately 90 species of fish known to occur in the PRTR portion of the Potomac River, as listed in Table 3.11-4. These species are found in a range of habitats and salinities. Some species are year-round residents, while others migrate between the Chesapeake Bay and its tributaries seasonally. Because NSWCDD requires their RDT&E activities to be flexible for optimal weather and other environmental conditions, there is no seasonal component to specific activities. Thus, it is not possible to assess the impacts with respect to the seasonal occurrence of some species of fish. However, the potential effects are differentiated by location within the PRTR, with varying effects between the UDZ, MDZ, and LDZ indicated, as applicable. As the salinity increases downriver (see Subchapters 3.10 and 3.11), the species composition also changes.

Based on PRFC commercial fishing harvest data from 2001 to 2010 (see Table 3.11-11), the majority (89 percent) of landings were in Area 1 (Figure 3.11-6), the lower portion of the river that includes the LDZ. As mentioned in Chapter 3, this highly productive area supports sought-after commercial fish species. The large harvests in Area 1 suggest that these species are more abundant in the LDZ, where NSWCDD activities are limited; however, catch per unit effort data would be necessary to confirm this.

As discussed in Chapter 3, some fish stocks or populations in the Potomac River are more abundant than others, and a few species have been overfished historically and/or are being overfished currently. This section examines the impacts of the RDT&E activities on all species of fish occurring in the PRTR, although it should be noted that species with locally declining population trends and species with a depleted population status may be affected differently than species with a healthy or rebuilding population status (see Table 3.11-12). Individual fish that are part of abundant populations in the Potomac River are more likely to be affected simply because there are more of these fish. However, because these species have healthy, abundant populations, there would be minimal to no long-term population-level effects; thus, these species are discussed in the general analysis. This is in contrast to species with declining population trends (e.g., winter flounder). Individuals of these species are less likely to be affected, but long-term population-level effects would be more pronounced. Nevertheless, fish mortality as the result of recreational and commercial fishing currently being carried out on the river is many orders of magnitude greater than the numbers of fish that would be injured or killed as a result of the proposed RDT&E activities.

Impacts to the shortnose sturgeon, a federal- and state-listed endangered species, and Atlantic sturgeon, a federal proposed species, are discussed in Section 4.14.

Impacts to Fish

Under the No Action Alternative, large-gun projectiles and bullets fired from small arms would continue to enter the PRTR, potentially impacting fish. Direct hits of fish may occur when projectiles are fired in the MDZ. Direct hits would affect fish throughout the water column, but would have more of an impact on shallow-water and pelagic species than on demersal species (see Section 3.11.4.1 for species). In addition, juveniles would be less at risk of being hit than adults, because projectiles are primarily fired into the middle of the Potomac River, and juveniles generally are found in shallow, nearshore areas outside target areas.

As approximately 24 large-caliber projectiles are estimated to detonate underwater annually during particularly active years and because of the large size of the dense zone – approximately 2.3 sq NM – the probability of an underwater explosion's affecting an individual fish would be minimal. Because the shock wave generated by a detonation below the surface of the water spreads spherically outward (NSWC, 1978), the energy of the shock wave attenuates exponentially away from the point of detonation. However, individual fish close to the detonation may be adversely affected.

The potential damage to the fish would depend on the size of the fish, physiology of the species, depth at impact, weight of the explosive charge, depth of the explosion, river bathymetry, and distance between the fish and the explosion. Young fish are more sensitive than adults to direct impacts, as are fish with swim bladders. Direct effects from underwater explosions could include death, damage to swimbladders and blood vessels, tearing of tissues, and rupturing and

hemorrhaging of the spleen, kidney, liver, gonads, and sinus venous (Wright, 1982; Wright and Hopky, 1998; Lewis, 1996; Govoni et al., 2003).

The potential impact of an underwater explosion on a group or school of fish would be proportional to the density of the group. For species with very low populations in the PRTR, the probability of an underwater explosion's affecting the group would be negligible. Conversely, for species with high populations in the PRTR, the probability of an underwater explosion's affecting the group would be higher.

Naval Surface Warfare Center (NSWC, 1991) provides an equation that allows estimation of the potential effect of an underwater explosion on fish with swimbladders using a damage prediction method. The equation predicts the range of vulnerability within which there would be a 90 percent probability of survival for swimbladder fish of given weights, exposed to explosions of given net explosive weights and given detonation depths. The equation parameters are independent of environmental conditions, such as depth of the fish relative to the detonation and the depth to the bottom. Table 4.11-9 provides estimated 90 percent survivability ranges derived from NSWC (1991) for 1-lb, 10-lb, and 100-lb net explosive weight (NEW) charges at a detonation depth of 1 ft and 6 ft, for 1-ounce, 1-lb, and 30-lb fish.

The 90 percent survivability range, or 10 percent mortality range, is the distance beyond which 90 percent of the fish present would be expected to survive and defines the extent of the kill zone, although many fish will survive at positions closer to the charge (NSWC, 1984, 1991). The 90 percent survivability range for a 1-ounce fish would extend for a radius of approximately 385 ft around the location of a 10-lb NEW detonation at a depth of 6 ft, encompassing an area of approximately 465,660 sq ft or about 0.01 sq NM.

Table 4.11-9
Estimated 90 Percent Survivability Ranges (in ft)
for Fish with Swim Bladders

Detonation Depth and NEW	Weight of Fish		
	1 ounce	1 lb	30 lb
1-ft detonation depth			
1-lb NEW	136.2	95.0	61.1
10-lb NEW	259.6	181.0	116.3
25-lb NEW	335.5	234.0	150.4
6-ft detonation depth			
1-lb NEW	202.0	140.9	90.6
10-lb NEW	385.0	268.5	172.5
25-lb NEW	497.6	347.0	223.0
Source: Based on NSWC, 1991, Table 2.			

As discussed in Section 3.10.1.2, based on data provided by the Maryland Department of the Environment (Luckett, pers. comm., February 9, 2010), 65 fish kills involving 12 or more fish occurred from 1984 through 2009 in the tidal Potomac River in Charles and Saint Mary's Counties, Maryland – i.e., from upstream of the UDZ to the mouth of the river. Most of the fish kills probably were caused by low dissolved oxygen (DO) levels or by low DO in combination with other stresses, water quality conditions other than low DO levels, or commercial and

recreational discards. Although the causes of the remaining 16 fish kills are not known, underwater explosions have not been implicated as the probable causes.

Exposure to metal and explosive constituents may occur directly via contact with water and/or sediment, or indirectly via consumption of contaminated prey or food. As discussed above, the potential effects of exposure to metals and explosive MCOPCs that enter the water column and sediments were analyzed. The modeled metal and explosive concentrations in water and sediment were well below levels that could cause adverse effects to fish and, in fact, most concentrations were many orders of magnitude below freshwater and saltwater quality criteria and the sediment quality guidelines. Therefore, based on these comparisons, there would be no adverse effects to fish from metals or explosives released from munitions under the No Action Alternative.

The potential impacts on fish also were evaluated by comparing predicted fish-tissue concentrations (body burdens) to the lowest tissue-residue concentration levels with adverse effects, shown in Table 4.11-10. If a ratio is greater than 1, the concentration of the constituent that a fish is exposed to is above the level at which no adverse effects are expected. Conversely, if a ratio is less than 1, the concentration of the constituent that a fish is exposed to is below the adverse effect level and no adverse effects are expected from exposure. As shown in Table 4.11-11, ratios are all well below 1 – indicating that there are no risks to fish from metal constituents associated with munitions.

Table 4.11-10
Fish Tissue Residue-Based Toxicity Screening Values for Metals

Metal	Screening Concentration (mg/kg)	Level of Confidence	Source
Cadmium	0.9	Very low	Stickleback adult lowest observed effect concentration for mortality (Pascoe and Mattey, 1977).
Chromium	NA	NA	Insufficient fish ecotoxicity data.
Copper	0.4	Very low to moderate	Reduced oxygen consumption in carp (Jezierska and Sarnowski, 2002).
Lead	0.6	Very low	Mortality NOEC in immature brook trout (Holcombe et al., 1976 as cited in Jarvinen and Ankley, 1999).
Manganese	NA	NA	Insufficient fish ecotoxicity data.
Nickel	0.8	Very Low	Rainbow trout survival NOEC, muscle tissue (Calamari et al., 1982).
Zinc	12	Very low to moderate	Atlantic salmon juvenile growth NOEC – whole tissue.

Notes: mg/kg = milligrams per kilogram (parts per million).
NA = criteria not available; NOEC = no observed effect concentration.

A comparison of explosive concentrations in fish tissue was not performed because there are insufficient studies available associating toxicological effects with fish tissue concentrations. However, predicted concentrations of explosives in fish tissue are extremely low (below parts per trillion) and much lower than the modeled concentrations of explosives in water and sediment (see Appendix F). Therefore, inferred results indicate that explosives in the PRTR do not pose a risk to fish.

Table 4.11-11
Modeled Fish Tissue Concentrations Compared to Metal Toxicity Screening Values in the PRTR

Metal	Concentration of Metals in Fish Tissues (mg/kg ww)		Ratio to Toxicity Screening Tissue Concentrations	
	Dense Zone	Diffuse Zone	Dense Zone	Diffuse Zone
Cadmium	0.0000046	0.00000063	0.0000051	0.00000070
Chromium	0.00000016	0.000000037	NA	NA
Copper	0.0000042	0.0000011	0.000010	0.0000027
Lead	0.00000000000052	0.00000000000011	0.00000000000087	0.00000000000018
Manganese	0.00066	0.00022	NA	NA
Nickel	0.0000017	0.0000017	0.0000022	0.0000021
Zinc	0.000094	0.000015	0.0000079	0.0000013

Notes: mg/kg ww = milligrams per kilogram (parts per million) wet weight.

NA= not available (no toxicity data).

Ratios below 1 indicate that concentrations are below fish tissue screening concentrations values. All values shown here are orders of magnitude below 1 (each order of magnitude is equal to ten times).

As noted previously, low numbers of small-arms bullets would enter the PRTR, most of which would be inert. Bullets entering the PRTR would do so mainly within 1,000 yds of the shoreline. Negligible impacts would result from small-arms firing.

Detonations on the land ranges, all at considerable distances from the waters of the Potomac River, and as noted for invertebrates, residues would be reduced to virtually undetectable concentrations prior to reaching surface waters. The occasional detonation of devices on vessels in the river would have no direct impacts and negligible indirect impacts on fish communities.

Ordnance activities under the No Action Alternative would have negligible, long-term, direct and indirect, negative impacts on fish communities.

Essential Fish Habitat Assessment

As stated in Section 3.11.4.4, essential fish habitat (EFH) has been identified in the Potomac River for one or more life stages of cobia, king mackerel, Spanish mackerel, red drum, windowpane flounder, summer flounder, and bluefish. The composition of EFH in the PRTR is as follows:

- UDZ – juvenile and adult summer flounder and bluefish
- MDZ – juvenile and adult summer flounder and bluefish
- LDZ – juvenile and adult cobia, king and Spanish mackerel, red drum, windowpane and summer flounder, and bluefish

For each of the alternatives evaluated below, impacts refer to effects on EFH in general for the life stages of species identified in each danger zone (see Section 3.11.4.4). EFH is defined as "…those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Depending on the operation, there is the potential for NSWCDD RDT&E activities to affect only water, only substrate, or both. This is specified in the analysis below.

In addition to EFH designations, habitat areas of particular concern (HAPCs) are designated to provide additional focus for conservation efforts; they represent a subset of designated EFH that are especially important ecologically to a species/life stage or are vulnerable to degradation (50

CFR §§ 600.805-600.815). For detailed effects on SAV, which is identified as HAPC for summer flounder and red drum, refer to the SAV discussions elsewhere throughout Section 4.11. As impacts on SAV would be absent or negligible, impacts on HAPC likewise would be absent or negligible.

Impacts to Essential Fish Habitat

Under the No Action Alternative, bullets would be fired into the MDZ, and large-caliber projectiles would be fired into the MDZ and infrequently into the upper end of the LDZ. NSWCDD does not fire projectiles into the UDZ or the lower LDZ. Therefore, there would be no impacts to EFH in the UDZ or lower LDZ from large-caliber gunfire. Due to the low numbers of small-arms bullets that would enter the PRTR and because most bullets would be inert, negligible impacts would result from small-arms firing.

The only two species with EFH in the MDZ and upper LDZ are juvenile and adult bluefish and summer flounder. Both are seasonal inhabitants, and EFH may be affected during the seasonal occurrence of the species in the Potomac River. Adult bluefish start to enter the Potomac River shortly after they enter the Chesapeake Bay, in March or April. Juveniles enter the Chesapeake Bay in late summer. All stages of bluefish have left the estuary by mid-November. Summer flounder undertake definitive seasonal inshore-offshore movements; they usually enter the Potomac River in April and leave by November, but may arrive in March and leave in December.

EFH for juvenile and adult summer flounder consists of demersal waters, muddy substrate, and sand. EFH for bluefish includes pelagic waters. As discussed in previous sections, impacts from live and inert ordnance would be limited to the initial explosion or transit through the water column. There would be minimal potential for contact with adults and less potential for contact with juveniles, as projectiles are fired into the middle of the river, whereas juveniles generally occur in shallow, nearshore waters. The majority of targets are virtual rather than physical objects, and virtual targets generate no debris. Hazardous materials are removed from physical targets, to the extent possible, prior to destroying or damaging them, with the remaining debris and any waste cleaned up following each event. Therefore, the only impacts from ordnance would be the potential for direct and indirect impacts on prey species and on substrate utilized by prey species.

The potential impacts of metal and explosive constituents on aquatic receptors, including plants, invertebrates, and fish, were analyzed. The predicted concentrations of MCOPCs in the water column and sediments were compared to federal and state criteria and guidelines for the abovementioned organisms and all modeled metals and explosives concentrations were well below the applicable freshwater and saltwater and sediment criteria and guidelines, generally by many orders of magnitude. Therefore, MCOPCs would not adversely affect EFH under the No Action Alternative.

Ordnance also may affect the prey species of bluefish and summer flounder through direct hits and underwater explosions. Wyanski (1990) found that in the lower Chesapeake Bay mysids were the dominant prey of smaller juvenile summer flounder. Lascara (1981 as cited in National Marine Fisheries Service, 1999a) reported that larger juveniles and adults in the same area fed on juvenile spot (*Leiostomus xanthurus*), pipefish (*Syngnathus fuscus*), the mysid *Neomysis americana*, and shrimps (*Palaemonetes vulgaris, Crangon septemspinosa*). In the Chesapeake Bay, oyster bar and reef habitats provide an important source of benthic prey for bluefish,

particularly during time periods when preferred small pelagic fish prey are less abundant (Harding and Mann, 2001). Oyster bars in the Potomac River (see Figure 3.11-5) likely also are a source of benthic prey for bluefish. Bluefish and summer flounder feed on anadromous fish, including shad, alewife, blueback herring, and white/yellow perch in the Potomac River (Nichols, pers. comm., March 9, 2009). Given the low probability for direct hits, the low percentage of live projectiles detonating underwater (2 percent), and the variety of prey species targeted by summer flounder and bluefish, any impacts to prey species would be negligible and would not noticeably affect the ability of summer flounder and bluefish to feed.

Ordnance activities under the No Action Alternative may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. Consistent with Navy policy (US Navy, 2011), the Navy consulted with NMFS in accordance with the Magnuson-Stevens Fishery Conservation and Management Act (MSA). In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, under the No Action Alternative, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on EFH.

4.11.1.2 EM Energy Activities

As described previously, the three main outdoor facilities for E3 and HERO RDT&E are located on land in the Mission Area or land ranges, away from the PRTR, and their use would not affect aquatic organisms or aquatic habitats. Radars are tested at the STSTS on Main Range and would continue to operate over the PRTR. The EM energy from these radars does strike the water surface.

In 2009, NSWCDD constructed and began operating the NDEC and the CETFAC to transmit directed energy (microwaves, RF, and lasers) outdoors across the waters of the Potomac River within the PRTR, near the mouth of Upper Machodoc Creek (see Figure 1-7). For directed energy activities over the water, beams of directed energy are transmitted above the water and are not targeted at the water surface. Activities are tightly controlled and the likelihood of directed energy beams straying from the target and hitting the surface of the water is small.

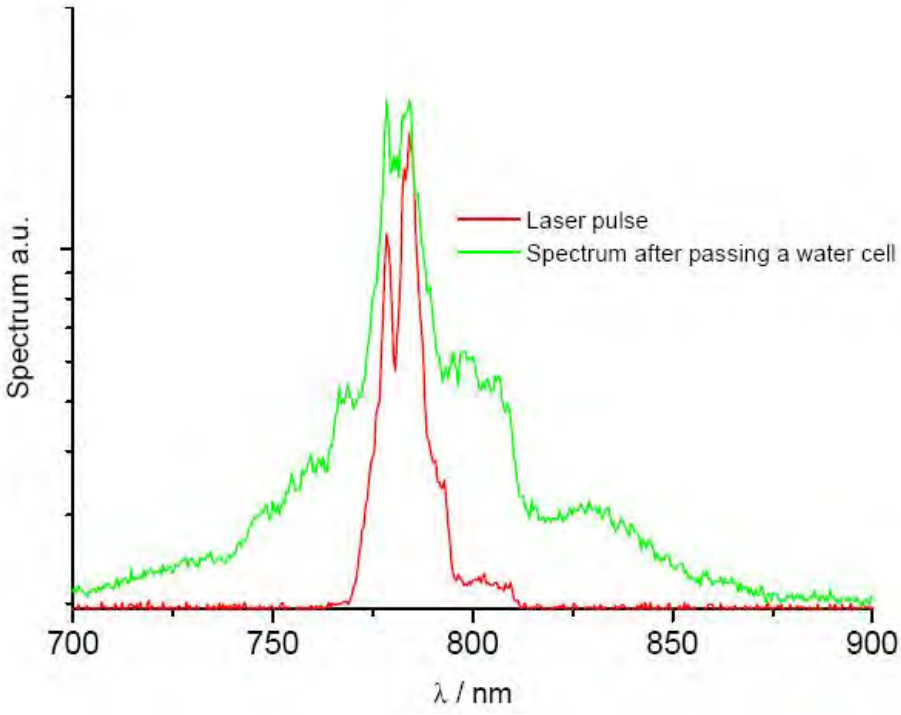
EM energy strikes on the water surface would be incidental. When EM energy interacts with water molecules or molecules within a body of water (organic or inorganic), energy is transferred to those molecules. As the transfer of energy is inefficient, there is a loss of some energy as heat to the water.

The potential harmful effects of EM energy on aquatic organisms would be highly localized and would be limited to the upper-most water layers. EM energy that breaches the water surface would be absorbed, scattered, or reflected off of organic and inorganic molecules (Boulnois, 1986; Dolgaev et al., 2003; Lubatschowski and Heisterkamp, 2004; Bai et al., 2007; De Giacomo et al., 2007; Li et al., 2007; Bai et al. 2008). As the EM energy interacts with more molecules the energy dissipates and spreads out causing the amount and the intensity of the energy to decrease. Water is a strong absorbing medium, and as EM energy travels through a body of water it is subjected to propagation (spreading or broadening) and attenuation (lessening of power), as shown in Figure 4.11-2, Spectrum of a Laser Propagating after Passing through 15 mm of Water.

Propagation and attenuation of EM energy in water are caused primarily by its interaction with the hydrogen bonds of water molecules and are also perpetuated by interactions with suspended particles, which include suspended sediments, dissolved inorganic materials, dissolved organic materials, and plankton (Wetzel, 2001; Babin and Stramski, 2002; Dolgaev et al. 2003).

The only EM sensor activity that would be conducted below water is the occasional deployment of modified passive sonobuoys in the PRTR. Passive sonobuoys detect EM signals but do not emit them. The use of passive sonobuoys would not generate additional sounds or other EM energy on the PRTR. The sonobuoys used in the Potomac River would be recovered for reuse at the conclusion of the events.

Figure 4.11-2
Spectrum of a Laser Propagating after Passing through 15 mm of Water



Note: Spectrum is in atomic units and wavelength (λ) is in nanometers (nm).
Source: Lubatschowski and Heisterkamp, 2004; simplified from Figure 2.

Vegetation, Plankton, and Aquatic Invertebrates

Under the No Action Alternative, the continued use of NOTES, MOATS, and two ground planes on land would not impact aquatic plants or animals. There would be negligible impacts to SAV, plankton, and aquatic invertebrates from radar or directed EM energy striking the surface of the water, due to limited direct and indirect thermal effects.

Although the initial deployment of the modified passive sonobuoys could temporarily scare fish away from the immediate area, the fish would return shortly after deployment. As passive sonobuoys would not generate additional sounds or other EM energy on the PRTR, their use

would not affect SAV, plankton, or aquatic invertebrates in the long term. As noted, the sonobuoys would be recovered for reuse at the conclusion of the events.

Under the No Action Alternative, EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on SAV, plankton, aquatic invertebrates, and their respective communities.

Fish

Fish swimming at or near the surface and at or near the location of impact could be exposed to EM energy. Deeper in the water column and more distant from the impact location, it is unlikely that the remaining low level of EM energy would have any impacts on fish. However, even if fish were swimming at or near the surface, the probability of being in the direct path of incidental EM energy is extremely low.

Nevertheless, some fish species are sensitive to electromagnetic fields (EMFs) in seawater (Kalmijn, 1982), and a disruption to the natural EMF utilized by a navigating fish has the potential to create a non-thermal effect (Adey, 1993; ICNIRP, 1998). Several marine fish, such as elasmobranchs (sharks, rays, and skates) and anadromous (migrating from salt water to spawn in fresh water) fish are well known to utilize natural EMFs for navigation, migratory behavior, finding prey, and sensing potential mates (Gill et al., 2005). A few such species exist in the Potomac River, including, but not limited to, the cow nose ray, sea lamprey, and American eel.

However, only in rare instances would there be the potential for incidental energy to hit the surface of the water and remain powerful enough to affect fish below. Further, there is a lack of conclusive, consistent evidence suggesting that exposure to EMFs has a positive or negative effect on elasmobrachs or other marine species (Gill et al., 2005; Gill et al., 2009). Therefore, any non-thermal effects on fish, and effects on navigation and orientation of EMF-sensitive species would be negligible and limited to fish at or near the surface water.

Under the No Action Alternative, EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on fish communities.

Essential Fish Habitat Assessment

EM energy would have the potential to affect EFH waters only, because the energy likely would not reach substrate on the river bottom, due to propagation and attenuation. In the event that incidental EM energy were to hit the surface of the water, the only effect would be a brief and minor increase in temperature of the immediately surrounding waters as energy is transferred, which would have no impact on waters designated as EFH.

There is a low probability that incidental EM energy could breach the water surface and reach prey species. However, the probability that prey for EFH species would be in the direct path of incidental EM energy is minimal, and the prey would have to be swimming near the surface to be exposed to a high level of EM energy. Further, only certain species are sensitive to EMFs. Therefore, activities under the No Action Alternative would have negligible effects on prey species of fish with EFH in the Potomac River.

The only impact from deployment of modified passive sonobuoys in the PRTR would be the occasional introduction of manmade objects into the water column, which would not adversely affect EFH.

EM energy activities under the No Action Alternative may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, under the No Action Alternative, EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on EFH.

4.11.1.3 Laser Activities

Three of NSWCDD's five current laser corridors cross the waters of Upper Machodoc Creek and the Potomac River through the PRTR. Research in aquatic areas currently is and will continue to be conducted above the surface of the water.

For No Action Alternative activities, both the HE laser emitter and the target/backstop would be fixed and the laser would emit almost horizontally. The laser would be pre-aimed and would not be able to move, except for minute corrections to the aim point. Under the current maximum power (100 kW), for over-water activities, the laser beam would begin at least 12 ft above mean water level and terminate at least 9 ft above mean water level. The eye-hazard area around the laser beam would be about 6 ft in diameter and at least 6 ft above mean water level (see Figure 1-10). Neither the laser beam nor the eye-hazard zone would come in contact with the water.

As with EM energy, laser activities are tightly controlled and the likelihood of a laser beam's hitting the surface of the water is extremely small. Should EM energy from laser tests strike the water surface it would be incidental and the potential adverse effects on aquatic organisms would be highly localized and limited to the uppermost water layers. Waves of EM energy that strike the surface of the water may be reflected at the air-water boundary. Energy that breaches the water surface would be propagated and attenuated, rapidly decreasing in amount and intensity as it travels through the water.

Vegetation, Plankton, and Aquatic Invertebrates

Laser interaction with the water surface, and possibly with SAV, plankton, or aquatic invertebrates, would only be incidental. Were a laser to strike the surface of the water, the energy could be reflected at the air-water boundary or would be propagated and attenuated if it breached the water surface, rapidly decreasing in magnitude and intensity.

Laser activities under the No Action Alternative would have negligible, short-term, direct, negative impacts and no indirect impacts on SAV, plankton, aquatic invertebrates, and the respective biological communities.

Fish

In the rare event that a laser beam does hit the water surface, the beam would be moving at the speed of light and, to be impacted, a fish would have to be at the water surface, at the point of impact, exactly when the laser beam strikes. The surface area of the MDZ is vast (approximately 38.5 sq NM) in comparison to the size of a fish and the small cross-section of a laser beam and the likelihood of a laser beam's striking a fish would be extremely low.

Effects of laser radiation on fish are largely unstudied and must be inferred from available evidence of biological interactions with other sources of EM energy. Should a laser beam strike a fish close to the surface of the water, the fish potentially could suffer from thermal or heating effects on body tissues. In the future, as more powerful lasers are used, the severity of the potential thermal effects would be greater.

The severity of the thermal effects depends on multiple variables, including, but not limited to, the ability of the tissues to conduct heat, EM energy frequency, duration of exposure, and distance from source. The severity of potential effects would be greater were a laser to strike a fish at the surface of the water. However, if a fish were struck by a laser beam below the water surface, the severity of the potential effects would decrease rapidly due to the attenuation and propagation of the laser beam as it travels through water. Although adverse effects may occur if a laser beam comes into contact with a fish located at or near the surface, the probability of this occurring is extremely low.

Under the No Action Alternative, laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on fish communities.

Essential Fish Habitat Assessment

Laser interaction with the water surface, and possibly with EFH waters or substrate, or prey for EFH species, would only be incidental. Were a laser to strike the surface of the water, the energy could be reflected at the air-water boundary or would be propagated and attenuated if it breached the water surface, rapidly decreasing in magnitude and intensity. In the extremely rare event that a laser beam does interact with the water surface, there is the potential for prey species swimming at or near the surface to be adversely affected. However, the loss of the few prey fish that may be affected would not impact the ability of EFH species to find sufficient prey to meet their energy requirements.

Laser activities under the No Action Alternative may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on EFH.

4.11.1.4 Chemical Defense Activities

Outdoor chemical defense activities using simulants would occur under the No Action Alternative, as described in Section 1.5.4. Chemical simulant tests result in small quantities of simulants being released in the air and even smaller quantities of simulants being deposited on the surface of the water. Simulants deposited on the water surface would undergo immediate dilution. Assessments completed for similar past simulant activities performed by NSWCDD using some of the same simulants showed no significant impacts and there were no observable environmental effects during or after events (NSWCDL, 2004; Bossart, letter, February 9, 2006; NSWCDL, 31 July 2009).

Chemical Simulant Modeling

NSWCDD modeled the atmospheric dispersion of chemical simulants released during chemical defense activities, based on established test methods and protocols. The methodology used for modeling is described in Section 4.4, and the model inputs and results are provided in Appendix J.

The predicted maximum surface-deposition levels for a range of simulants that could potentially be used are summarized in Table 4.4-3, based on the maximum amount of simulant tested and conditions that would result in the highest deposition rate. Simulant vapor tests are designed to minimize deposition on land and water areas. The maximum deposition that would occur in any one area, total mass of simulant deposited, and the surface area that would receive a concentration of more than 0.01 milligrams per square meter (mg/m^2) are presented.

Aquatic Toxicity of Chemical Simulants

A comparison of aquatic toxicity values of chemical simulants to estimated concentrations of simulants on surface water was performed to determine potential impacts of simulants on aquatic organisms. Table 4.11-12 lists aquatic toxicity values for chemical simulants modeled.

Table 4.11-12
Simulant Aquatic Toxicity Endpoints

	Toxicity Endpoint (mg/l)[1]	Reference, Notes
Diethyl malonate	*Pimephales promelas* (fathead minnow) LC50 96-hr = **163** mg/l	Netzeva et al., 2005
Dimethyl adipate	*Daphnia magna* EC50 (immobilization), 48-hr, **72** mg/l Green alga *Selenastrum capricornutum,* EC50 (Growth rate inhibition), 72-hr > 100 mg/l	Dow Chemical Company, 2008
Dimethyl methylphosphonate	Fish LC50 96-hr = 21,503 mg/l *Daphnia* EC50 16-d = **330** mg/l Green algae EC50 96-hr = 10,4967 mg/l	Nyden et al., 2000
Glacial acetic acid	Shrimp LC50 48-hr = 100 - 300 mg/l *Pimephales promelas* (fathead minnow) LC50 96-hr = 88 mg/l/ Bluegill/Sunfish: LC50 96-hr = 75 mg/l Goldfish: LC50 24-hr = 423 mg/l *Daphnia*: EC50 96-hr = **32**-47 mg/l	Fisher Scientific Company, 2008
Methyl salicylate	*Brachydanio reri* (zebrafish) LC0 96-hr = **42** mg/l *Daphnia* EC50 24-hr = 50 mg/l	The Good Scents Company, 2011
Triethyl phosphate	*Leuciscus idus* (ide [fish]) LC50 48-hr = 2,140 mg/l *Daphnia magna* EC50 48-hr = 350 mg/l *Scenedesmus subspicatus* (alga) EC50 72-hr = 900 mg/l *Daphnia magna* EC50 21-d = 729 mg/l NOEC 21-d = **31.6** mg/l	United Nations Environmental Program, 1998

Notes: mg/l = milligrams per liter.
LC50= lethal concentration 50; LC0 = lethal concentration 0; EC50 = effect concentration 50; NOEC = no observed effect concentration.
[1] Exposure time varied from 24 hours to 21 days.
Bolded numbers indicate the lowest effect concentration selected for toxicity comparisons.

The lowest aquatic toxicity available, inclusive of algae (considered to be representative of SAV), invertebrates, and fish, was selected for comparison with surface water concentrations for each simulant. Effect levels presented are generally the lowest lethal concentration 50 (LC50) threshold (i.e., the dose that kills 50 percent of the test organisms within a designated period) or

the lowest effect concentration (EC50) threshold (i.e., the dose that has an adverse effect on 50 percent of the test organisms within a designated period) identified for representative organisms.

To estimate the chemical simulant exposure concentrations for aquatic organisms, the total amount of simulant deposited (in kilograms [kg]) for each test was divided by the area where it would be deposited at a concentration of greater than 0.01 mg/m^2. For example, as shown in Table 4.4-3, the total deposition of diethyl malonate (DEM) would be 2.59 kg (2.59×10^6 mg) over an area of 0.0043 square kilometers (km^2) (4,300 square meters). A 1-m mixing depth in the surface water was assumed so that the deposition rate (square meters converted to cubic meters) was divided by 1,000 (1 cubic meters = 1,000 liters) to determine the exposure concentration. Assuming a one-meter (3.3-ft) mixing depth, the exposure concentration of DEM would be:

$$2.59 \times 10^6 \text{ mg} \div (4.3 \times 10^3 \div 1{,}000) = 0.60 \text{ milligrams per liter (mg/l)}$$

Maximum predicted exposure concentrations for all modeled simulants are provided in Table 4.11-13, along with a comparison to the lowest toxicity values found. As shown in this table, all exposure concentrations are below the lowest aquatic toxicity value found, indicating that chemical simulant activities would have no adverse effects on aquatic life. In addition, the shortest exposure time used to derive the aquatic toxicity values is 24 hours. This is far longer than the time period during which the maximum concentration of simulants would be present, as simulants would be rapidly diluted upon entering the Potomac River, resulting in much lower exposure concentrations than presented here.

Table 4.11-13
Maximum Predicted Simulant Exposure Concentrations

Chemical	Total Mass Deposition (kg)	Surface Area with conc. > 0.01 mg/m^2 (km^2)	Exposure Concentration (mg/l)	Lowest Aquatic Toxicity Value (mg/l)
Diethyl malonate	2.59	0.00430	0.602	163
Dimethyl adipate	75.9	0.234	0.325	72
Dimethyl methylphosphonate	0.00300	0.000679	0.00442	330
Glacial acetic acid	76.7	0.257	0.298	32
Methyl salicylate	59.9	0.0371	1.61	42
Triethyl phosphate	0.000400	0.00145	0.0002765	31.6

NSWCDD conducted dispersion modeling and field tests of chemical simulants released on the PRTR to determine the potential human and ecological health risks associated with the release of chemical simulants as a vapor on the MDZ (NSWCDD, 2003). The modeling results predicted both the airborne and water-column concentrations that would result from the vapor releases. Comparison of the modeling results to known human health and ecological toxicity values indicates that the modeled concentrations of chemical simulants released into the air were at least one or two orders of magnitude (10 to 100 times) lower than those values. Monitoring performed during the tests in 2005 (Bossart, letter, February 9, 2006) also supports the conclusions that risks to aquatic organisms from simulant activities are negligible. The Maryland Department of the Environment determined that the modeling results supported the conclusion that the potential for aquatic toxicity was negligible during simulant tests in 2003 (Carlson, Ken, Maryland Department of the Environment, July 7, 2003).

Vegetation, Plankton, Aquatic Invertebrates, and Fish

As discussed above, the quantities of chemical simulants released into the environment and the resulting concentrations of simulants in the river would be well below levels that could cause adverse effects to aquatic organisms. Chemical simulants entering the Potomac River were found to dilute rapidly to well below detection levels, and the use of chemical simulants has not resulted in any observable environmental effects. Considering the low toxicity of the chemical simulants selected for use, the low concentrations of simulants deposited on the water surface, and the large volumes of water available to dilute the simulants, SAV, plankton, aquatic invertebrates, and fish would be exposed to very low concentrations of chemical simulants.

Under the No Action Alternative, chemical defense activities would have negligible, short-term, indirect, negative impacts and no direct impacts on SAV, plankton, aquatic invertebrates, fish, and the respective biological communities.

Essential Fish Habitat Assessment

The quantities of chemical simulants released into the environment and the resulting concentrations of simulants in the river would be well below levels that could cause adverse effects to aquatic organisms, including the prey of EFH species. Chemical simulants entering the Potomac River were found to dilute rapidly to well below detection levels, and the use of chemical simulants has not resulted in any observable environmental effects.

Chemical defense activities under the No Action Alternative may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, under the No Action Alternative, chemical defense activities would have negligible, short-term, indirect, negative impacts and no direct impacts on EFH.

4.11.1.5 PRTR Use

Under the No Action Alternative, PRTR use for RDT&E activities would remain at present levels. Most NSWCDD vessel activities take place on the MDZ. NSWCDD would restrict public access to part or all of the MDZ and occasionally to the upper LDZ approximately 750 hours per year.

The overall vessel traffic on the PRTR would decrease during activities requiring that public access be restricted, because the portion of the PRTR being used would be restricted to range control boats (approximately three) stationed along the perimeter of the range and barges or vessels associated with RDT&E activities. Even when the range is restricted, small watercraft can move up and down the river along the Maryland shoreline, just outside the PRTR boundary. Deep-draft vessels that need to stay in the main channel, which runs through the range, may be advised to slow before reaching the range or could be delayed up to an hour near the range, though in practice the delays are usually less than 30 minutes. During breaks in the activities, range operations center (ROC) personnel work with smaller watercraft to allow them to cross the

range from one side of the river to the other or through the entrance to Upper Machodoc Creek, and with deep-draft vessels so that they can proceed up and down the river channel.

Existing levels of military small-boat traffic have temporary effects to water quality. Range boat activities, as well as commercial and recreational boat activities, on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts to these surface water resources.

Vegetation

Vessel traffic, including range boats, as well as recreational and commercial vessels, potentially could incidentally strike SAV at or just below the surface, depending on the draft of the vessel. Vessel wakes and propeller wash also could scour bottom sediments in or near SAV beds, potentially resulting in the uprooting of individual SAV plants or the settlement of sediments on SAV.

SAV is generally found in shallower waters along the edges of the Potomac River and there is little SAV present in the MDZ (as shown in Figure 4.11-1), the most actively used portion of the PRTR. Most NSWCDD vessel activities currently are and will continue to occur in the vicinity of the mouth of Upper Machodoc Creek and in the deeper portions of the PRTR, especially the MDZ. Therefore, there would be limited potential for direct impacts to vegetation, or disturbance of sediments in or adjacent to SAV beds.

Under the No Action Alternative, PRTR use would have negligible, short-term, direct, negative impacts and no indirect impacts on SAV communities.

Plankton

NSWCDD boat activities, as well as commercial and recreational boat activities, on the waters of the PRTR and Upper Machodoc Creek routinely occur without long-term adverse impacts to plankton communities. PRTR use would have no direct impacts and negligible, short-term, indirect, negative impacts on plankton communities of the Potomac River due to temporary effects on water quality.

Aquatic Invertebrates

NSWCDD boat activities, as well as commercial and recreational boat activities, on the waters of the PRTR and Upper Machodoc Creek routinely occur without long-term adverse impacts to aquatic invertebrate communities. PRTR use would have no direct impacts and negligible, short-term, indirect, negative impacts on aquatic invertebrate communities of the Potomac River due to temporary effects on water quality.

Fish

Research is limited on the effects of vessel strikes on fish that occur in the PRTR. Vessel traffic, including range boats, as well as recreational and commercial vessels, potentially could incidentally strike fish swimming at or just below the surface, depending on the draft and speed of the vessel. However, the overall vessel traffic on the PRTR would decrease during activities requiring that public access be restricted. The majority of fish generally would swim out of the way of an approaching vessel; thus, impacts to fish would be negligible under the No Action

Alternative. NSWCDD boat activities, as well as commercial and recreational boat activities, on the waters of the PRTR and Upper Machodoc Creek routinely occur without long-term adverse impacts to fish communities.

PRTR use would have negligible, short-term, direct and indirect, negative impacts on fish communities.

Essential Fish Habitat Assessment

Military small boat traffic would have temporary effects on water quality – nominally contributing directly to water pollution and indirectly to turbidity – and, therefore, would adversely affect EFH and the prey of EFH species. Military as well as commercial and recreational boat activities on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts to these surface water resources. The overall vessel traffic on the PRTR would decrease during testing because of closure of the PRTR to commercial and recreational vessels; vessels present would be limited to range control boats (approximately three) and barges or vessels associated with testing. Although the military boats create small wakes that could contribute to shoreline erosion and, ultimately, increased nearshore turbidity, the wakes of NSWCDD boats would have negligible effects on shoreline erosion and turbidity. NSWCDD boat use represents a very small percentage of the daily recreational and commercial boat traffic on the waters of the PRTR.

PRTR use under the No Action Alternative may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, under the No Action Alternative, continued PRTR use by NSWCDD would have negligible, short-term, direct and indirect, negative impacts on EFH.

4.11.2 Alternative 1

4.11.2.1 Ordnance Activities

The number of large-caliber projectiles would remain at current levels, although the frequency of firing into the upper LDZ would increase to up to 10 days per year. Small-caliber gun use would increase from an average of 6,000 bullets fired a year under the No Action Alternative to 25,500 bullets fired a year. Approximately 2,550 bullets would be fired from land into the river. Detonations would increase from 190 events to 200 events under Alternative 1, as described in Section 2.5.1.

Vegetation

Approximately 2,550 bullets a year would enter the river within about 1,000 ft of shore, where there is no SAV present (Figure 4.11-1). Even if ordnance lands in or near SAV, the impacts would be negligible for the reasons described in Section 4.11.1.1 for the No Action Alternative.

Most detonations would take place on the land ranges of the EEA Complex and only occasionally would devices be detonated on vessels in the river. NSWCDD removes fired military munitions, as well as any remaining scrap and debris exposed on the ground or partially buried. Residues from the land-based firing of munitions and detonation of explosives that remain on land after operational range surface clearance could enter surface waters indirectly via surface water or soil runoff and shallow groundwater discharge. Although small concentrations of residues could migrate into surface waters, they would be expected to occur at concentrations that are virtually undetectable. Therefore, detonations would have negligible impacts on SAV communities.

Ordnance activities under Alternative 1 would have negligible, long-term, direct and indirect, negative impacts on SAV communities.

Plankton

The firing of large-gun projectiles would have negligible impacts on plankton communities. The area proposed to be utilized by small-arms activities is small, and most small-arms bullets fired during testing are inert. Therefore, an increase in small-arms activities would not negatively impact plankton communities in the Potomac River. Most detonations would take place on the land ranges of the EEA Complex and would negligibly impact plankton communities.

Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on plankton communities.

Aquatic Invertebrates

Continued large-caliber gun firing at existing levels would have negligible impacts on aquatic invertebrate communities. Small-arms firing would take place near shore with most of the empty cartridges entering the Potomac River in the MDZ. Most small-arms bullets would be inert and only approximately 2,550 bullets potentially would enter the river; therefore, impacts from small-arms bullets on the Potomac River aquatic invertebrate community would be negligible.

As discussed for SAV, aquatic invertebrates would not be directly exposed to detonations. Any residues that migrate into surface waters are expected to occur at concentrations that are virtually undetectable. Under this alternative, impacts from detonations to aquatic invertebrate communities would be negligible.

Ordnance activities under Alternative 1 would have negligible, long-term, direct and indirect, negative impacts on aquatic invertebrate communities.

Fish

Under Alternative 1, impacts to fish from the firing of large-gun projectiles would be the same as the impacts resulting from the No Action Alternative, described above. Although a greater number of small-caliber bullets would enter the PRTR, the probability of a direct hit would be low and impacts to fish would be negligible. Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on fish communities.

Essential Fish Habitat Assessment

Due to the low numbers of small-arms bullets that would enter the PRTR and because most bullets would be inert, negligible impacts would result from small-arms firing. Under Alternative 1, impacts to EFH and the prey of EFH species from the firing of large-gun projectiles would be identical to the impacts resulting from the No Action Alternative, described above. As most detonations would occur on land, impacts to EFH and the prey of EFH species would be negligible.

Ordnance activities under Alternative 1 may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on EFH.

4.11.2.2 EM Energy Activities

Under Alternative 1, the number of EM energy events would increase from 490 to 590 per year, the power of the EM energy events would increase, and activities would increase as described in Section 2.5.2.

Vegetation, Plankton, Aquatic Invertebrates, and Fish

Despite expanded activities and an increase in annual events under Alternative 1, there would be negligible impacts to SAV, plankton, aquatic invertebrates, and fish from radar's or directed EM energy's striking the surface of the water. The increase in EM energy activities might slightly increase the probability of EM energy incidentally interacting with surface waters. However, EM energy that hits the surface of the water may be reflected off the surface of the water. Any incidental EM energy that breaches the water surface would likely be absorbed immediately and would rapidly dissipate.

EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on SAV, plankton, and aquatic invertebrate communities.

In the rare event that EM energy does interact with the water surface, the likelihood of its striking a fish would be extremely low. Laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on fish communities.

Essential Fish Habitat Assessment

The potential for EM energy to incidentally interact with surface waters is negligible, and there would be no impacts on EFH waters or substrate under Alternative 1. In the extremely rare event that EM energy does interact with the water surface, there is the potential for prey species swimming at or near the surface to be adversely affected. However, the loss of the few prey fish that may be affected would not impact the ability of EFH species to find sufficient prey to meet their energy requirements.

EM energy activities under Alternative 1 may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on EFH.

4.11.2.3 Laser Activities

Under Alternative 1, the number of HE laser events would increase from the current 60 annually to 125 annually, power would increase, and activities would be expanded as described in Section 2.5.3.

Vegetation, Plankton, and Aquatic Invertebrates

Laser activities would be tightly controlled and the likelihood of lasers straying from the target and hitting the water surface would be very small. Interaction with the water surface, and possibly vegetation, plankton, aquatic invertebrates, or fish, would be incidental. Were a laser to strike the surface of the water, the EM energy might be reflected at the air-water boundary or, if it breaches the water surface, the energy would be propagated and attenuated, rapidly decreasing in amount and intensity as it travels through the water.

Laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on SAV, plankton, and aquatic invertebrate communities.

Fish

In the rare event that a laser beam does interact with the water surface, the likelihood of a laser beam's striking a fish would be extremely low. The severity of potential effects would be greater were a laser to strike a fish at the surface of the water. However, if a fish were struck by a laser beam below the water surface, the severity of the potential effects would decrease. Although adverse effects may occur if a laser beam comes into contact with a fish located at or near the surface, the probability of this occurring is extremely low.

Laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on fish communities.

Essential Fish Habitat Assessment

Under Alternative 1, if laser activities were conducted in the LDZ (where there is EFH for seven species), lasers would not be directed at targets on the LDZ but rather to the other ranges. Laser activities would be conducted predominantly in the MDZ, where EFH is limited to two species. The potential for a laser to incidentally interact with surface waters is negligible, and there would be no impacts on EFH waters or substrate under Alternative 1. In the extremely rare event that a laser beam does interact with the water surface, there is the potential for prey species swimming at or near the surface to be adversely affected. However, the loss of the few prey fish that may be affected would not impact the ability of EFH species to find sufficient prey to meet their energy requirements.

Laser activities under Alternative 1 may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on EFH.

4.11.2.4 Chemical and Biological Defense Activities

Under Alternative 1, activities using chem/bio simulants outdoors would increase from the current baseline of 12 events annually using chemical simulants to 60 events annually using chemical and biological simulants separately, as described in Section 2.5.4. The areas in which the activities would take place would expand to include all the land ranges, the Mission Area, and the MDZ.

As discussed for the No Action Alternative, all modeled chemical simulant exposure concentrations are below the lowest aquatic toxicity value found, indicating that chemical simulant activities would have no adverse effects on aquatic life. In addition, chemical simulants entering the Potomac River would dilute rapidly to well below detection levels, and past use of chemical simulants has not resulted in any observable environmental effects.

No modeling was performed for biological simulants, as NSWCDD would use only BSL-1 simulants. Many of these simulants are ubiquitous and are often found in high concentrations in nature, including in water (CRI, 2004; USEPA, 1997). The increase in these organisms from simulant testing is miniscule in relation to levels naturally present in the environment. There are no published reports of disease associated with the proposed biological simulants in aquatic plants or animals, nor are they considered to be disease-causing agents. The small concentrations of these simulants deposited on the water would not cause any significant increases in their localized populations, and no adverse effects are anticipated.

Vegetation, Plankton, Aquatic Invertebrates, and Fish

The increase in the number of events under Alternative 1 would not affect chemical-simulant exposure concentrations. Based on the aquatic toxicity evaluation, the quantities of chemical simulants released into the environment and the resulting concentrations of simulants in the river would be well below levels that could cause adverse effects. All modeled exposure concentrations are below the lowest aquatic toxicity value found. Considering the low toxicity of the chemical simulants selected for use and the large volumes of water available to dilute the simulants, SAV, plankton, aquatic invertebrates, and fish would be exposed to very low concentrations of chemical simulants.

No adverse effects are anticipated from a temporary increase in levels of BSL-1 biological simulants.

Chem/bio defense activities under Alternative 1 would have no direct impacts and negligible, short-term, indirect, negative impacts on SAV, plankton, aquatic invertebrates, fish, and the respective biological communities.

Essential Fish Habitat Assessment

The increase in the number of events under Alternative 1 would not affect chemical-simulant exposure concentrations. Based on the aquatic toxicity evaluation, the quantities of chemical simulants released into the environment and the resulting concentrations of simulants in the river would be well below levels that could cause adverse effects to aquatic organisms, including the prey of EFH species. All modeled exposure concentrations are below the lowest aquatic toxicity value found.

No adverse effects are anticipated from a temporary increase in levels of BSL-1 biological simulants.

Chem/bio defense activities under Alternative 1 may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, chem/bio defense activities would have no direct impacts and negligible, short-term, indirect, negative impacts on EFH.

4.11.2.5 PRTR Use

Under Alternative 1, NSWCDD would restrict public access to some part of the PRTR danger zones – usually some or all of the MDZ – for approximately 870 hours per year, as described in Section 2.5.5.

Vegetation

SAV is generally found in shallower waters along the edges of the Potomac River, and there is little SAV present in the MDZ. However, most NSWCDD vessel activities take place in deeper waters, mainly in the MDZ. Under Alternative 1, there would be limited potential for direct impacts to vegetation, or disturbance of sediments in or adjacent to SAV beds. PRTR use would have negligible, short-term, direct, negative impacts no indirect impacts on SAV communities.

Plankton and Aquatic Invertebrates

Although future levels of NSWCDD small-boat traffic would have temporary effects on plankton and aquatic invertebrates, military, commercial, and recreational boat activities on the waters of the PRTR and Upper Machodoc Creek routinely occur without long-term adverse impacts. PRTR use would have no direct impacts and negligible, short-term, indirect, negative impacts on plankton and aquatic invertebrate communities.

Fish

Vessel traffic, including range boats, as well as recreational and commercial vessels, potentially could incidentally strike fish swimming at or just below the surface, depending on the draft and speed of the vessel. The majority of fish generally would swim out of the way of an approaching vessel; thus, impacts to fish would be negligible under Alternative 1, despite increased levels of range-vessel activities. NSWCDD boat activities, as well as commercial and recreational boat

activities, on the waters of the PRTR and Upper Machodoc Creek routinely occur without long-term adverse impacts to fish communities.

PRTR use would have negligible, short-term, direct and indirect, negative impacts on fish communities.

Essential Fish Habitat Assessment

Military small boat traffic would have temporary effects on water quality – nominally contributing directly to water pollution and indirectly to turbidity – and, therefore, would adversely affect EFH and the prey of EFH species. However, military as well as commercial and recreational boat activities on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts to these surface water resources. Although the military boats create small wakes that could contribute to shoreline erosion and, ultimately, increased nearshore turbidity, the wakes of NSWCDD boats would have negligible effects on shoreline erosion and turbidity. NSWCDD boat use represents a very small percentage of the daily recreational and commercial boat traffic on the waters of the PRTR.

PRTR use under Alternative 1 may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, under Alternative 1, PRTR use would have negligible, short-term, direct and indirect, negative impacts on EFH.

4.11.3 Alternative 2

4.11.3.1 Ordnance Activities

The number of large-caliber projectiles would remain at current levels, and use would be the same as under Alternative 1. The use of small arms would increase. The number of bullets expended annually would increase from 6,000 to 30,000, of which approximately 3,000 bullets would be fired from land into the river. Detonations would increase from 190 events to 230 events, as described in Section 2.6.

Vegetation

Small-arms firings at increased levels would have negligible impacts on SAV communities, as discussed for Alternative 1. As most detonations would take place on the land ranges of the EEA Complex, detonations would not affect SAV communities. Under Alternative 2, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on SAV communities.

Plankton

The firing of large-gun projectiles would have negligible impacts on plankton communities in the Potomac River. The in-river area that would be used for small-arms activities is small in comparison to the Potomac River, and most small-arms bullets fired during testing are inert. Therefore, an increase in small-arms activities would produce negligible impacts to plankton in the Potomac River. Most detonations would take place on the EEA Complex's land ranges and would have negligible impact on plankton.

Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on plankton communities.

Aquatic Invertebrates

Impacts to aquatic invertebrate communities from large-caliber guns and projectiles would have negligible impacts. The increase in small-arms firing would take place in the MDZ, within 1,000 yds of the shoreline. Only 10 percent of small-arms bullets would potentially enter the river, most small-arms bullets fired during testing would be inert, and the area occupied by small-arms bullets entering the river would be small in comparison to the entire Potomac. Therefore, negligible impacts to aquatic invertebrate communities would result from an increase in small-arms activities. Most detonations would take place on the EEA Complex's land ranges and would have negligible impact on aquatic invertebrates.

Ordnance activities under Alternative 2 would have negligible, long-term, direct and indirect, negative impacts on aquatic invertebrate communities.

Fish

Under Alternative 2, impacts to fish from the firing of large-gun projectiles would be the same as the impacts resulting from the No Action Alternative, described in Section 4.11.1.1. Although a greater number of small-caliber bullets would be fired into the PRTR, the probability of a direct hit is low, and impacts to fish would be negligible. Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on fish communities.

Essential Fish Habitat Assessment

Under Alternative 2, impacts to EFH and the prey of EFH species from the firing of large-gun projectiles would be similar to the impacts resulting from the No Action Alternative, described in Section 4.11.1.1. Due to the low numbers of small-arms bullets that would enter the PRTR and because most bullets would be inert, negligible impacts would result from small-arms firing. As most detonations would occur on land, impacts to EFH and the prey of EFH species would be negligible.

Ordnance activities under Alternative 2 may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. Consistent with Navy policy (US Navy, 2011), the Navy initiated consultation

with NMFS in accordance with the MSA. In accordance with NEPA, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on EFH.

4.11.3.2 EM Energy Activities

Under Alternative 2, the number of EM events would increase from 490 to 680 per year and activities would expand, as described in Section 2.6.

Vegetation, Plankton, Aquatic Invertebrates, and Fish

Despite expanded activities and an increase in annual events under Alternative 2, there would be negligible impacts to SAV, plankton, aquatic invertebrates, and fish from radar's or directed EM energy's striking the surface of the water. The increase in EM energy activities might slightly increase the probability of EM energy's incidentally interacting with surface waters. However, EM energy that hits the surface of the water might be reflected off the surface of the water. Any incidental EM energy that breaches the water surface would be absorbed immediately and would rapidly dissipate.

EM energy activities under Alternative 2 would have no indirect impacts and negligible, short-term, direct, negative impacts on SAV, plankton, aquatic invertebrate, and fish communities.

Essential Fish Habitat Assessment

Despite expanded activities and an increase in annual events under Alternative 2, the potential for EM energy to incidentally interact with surface waters is negligible, and there would be no impacts on EFH waters or substrate. In the extremely rare event that EM energy does interact with the water surface, there is the potential for prey species swimming at or near the surface to be adversely affected. However, the loss of the few prey fish that may be affected would not impact the ability of EFH species to find sufficient prey to meet their energy requirements.

EM energy activities under Alternative 2 may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, EM energy activities would have no indirect impacts and negligible, short-term, direct, negative impacts on EFH.

4.11.3.3 Laser Activities

Under Alternative 2, the number of HE laser events would increase from 60 to 145 events per year, and activities would expand, as described in Section 2.6.

Vegetation, Plankton, Aquatic Invertebrates, and Fish

The likelihood of lasers straying from the target and hitting the water surface would be very small. Interaction with the water surface, and possibly vegetation, plankton, aquatic invertebrates, or fish, would be incidental. Were a laser to strike the surface of the water, the EM energy might be reflected at the air-water boundary or, if it breaches the water surface, the

energy would be propagated and attenuated, rapidly decreasing in amount and intensity as it travels through the water. Therefore, any impacts to SAV, plankton, aquatic invertebrates, or fish would be incidental and negligible, and HE laser activities would not result in any long-term impact to the respective aquatic communities of the Potomac River.

Laser activities under Alternative 2 would have no indirect impacts and negligible, short-term, direct, negative impacts on SAV, plankton, aquatic invertebrate, and fish communities.

Essential Fish Habitat Assessment

Under Alternative 2, if laser activities were conducted in the LDZ (where there is EFH for seven species), lasers would not be directed at targets on the LDZ but rather to the other ranges. Laser activities would be conducted predominantly in the MDZ, where EFH is limited to two species. The potential for a laser to incidentally interact with surface waters is negligible, and there would be no impacts on EFH waters or substrate under Alternative 1. In the extremely rare event that a laser beam does interact with the water surface, there is the potential for prey species swimming at or near the surface to be adversely affected. However, the loss of the few prey fish that may be affected would not impact the ability of EFH species to find sufficient prey to meet their energy requirements.

Laser activities under Alternative 2 may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, laser activities would have no indirect impacts and negligible, short-term, direct, negative impacts on EFH.

4.11.3.4 Chemical and Biological Defense Activities

Under Alternative 2, the number of events using chem/bio simulants would increase from the current baseline of 12 events annually using chemical simulants to 70 events annually potentially using chemical and biological simulants together, as described in Section 2.6. The chemical and biological simulants used would be the same ones approved for use in the individual chemical and biological operational tests under Alternative 1.

Vegetation, Plankton, Aquatic Invertebrates, and Fish

The increase in the number of events under Alternative 2 would not affect chemical simulant exposure concentrations. As described in Section 4.11.1.4, the quantities of chemical simulants released into the environment and the resulting concentrations of simulants in the river would be well below levels that could cause adverse effects. Considering the low toxicity of the chemical simulants selected for use and the large volumes of water available to dilute the simulants, SAV, plankton, aquatic invertebrates, and fish would be exposed to very low concentrations of chemical simulants. No adverse effects would be anticipated from a temporary increase in levels of BSL-1 biological simulants.

Chem/bio defense activities under Alternative 2 would have no direct impacts and negligible, short-term, indirect, negative impacts on SAV, plankton, aquatic invertebrates, fish, and their respective biological communities.

Essential Fish Habitat Assessment

The increase in the number of events under Alternative 2 would not affect chemical simulant exposure concentrations. The quantities of chemical simulants released into the environment and the resulting concentrations of simulants in the river would be well below levels that could cause adverse effects to aquatic organisms, including the prey of EFH species. All modeled exposure concentrations are below the lowest aquatic toxicity value found.

No adverse effects are anticipated from a temporary increase in levels of BSL-1 biological simulants.

Chem/bio defense activities under Alternative 2 may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, chem/bio defense activities would have no direct impacts and negligible, short-term, indirect, negative impacts on EFH.

4.11.3.5 PRTR Use

Under Alternative 2, NSWCDD would restrict public access to the PRTR danger zones, usually the MDZ, for approximately 1,000 hours per year, as described in Section 2.6.

Vegetation

SAV is generally found in shallower waters along the edges of the Potomac River, and there is little SAV present in the MDZ. However, most NSWCDD vessel activities take place in deeper waters, mainly in the MDZ. There would be limited potential for direct impacts to vegetation, or disturbance of sediments in or adjacent to SAV beds. Under Alternative 2, PRTR use would have negligible, short-term, direct, negative impacts and no indirect impacts on SAV communities.

Plankton and Aquatic Invertebrates

Although future levels of NSWCDD small-boat traffic would have temporary effects on plankton and aquatic invertebrates, military, as well as commercial and recreational, boat activities on the waters of the PRTR and Upper Machodoc Creek routinely occur without long-term adverse impacts. PRTR use under Alternative 2 would have no direct impacts and negligible, short-term, indirect, negative impacts on plankton and aquatic invertebrate communities.

Fish

Vessel traffic, including range boats, as well as recreational and commercial vessels, potentially could incidentally strike fish swimming at or just below the surface, depending on the draft and speed of the vessel. The majority of fish generally would swim out of the way of an approaching vessel; thus, impacts to fish would be negligible under Alternative 2, despite increased levels of range-vessel activities. NSWCDD boat activities, as well as commercial and recreational boat activities, on the waters of the PRTR and Upper Machodoc Creek routinely occur without long-term adverse impacts to fish communities.

PRTR use would have negligible, short-term, direct and indirect, negative impacts on fish communities.

Essential Fish Habitat Assessment

Military small boat traffic would have temporary effects on water quality – nominally contributing directly to water pollution and indirectly to turbidity – and, therefore, would adversely affect EFH and the prey of EFH species. However, military as well as commercial and recreational boat activities on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts to these surface water resources. Although the military boats create small wakes that could contribute to shoreline erosion and, ultimately, increased nearshore turbidity, the wakes of NSWCDD boats would have negligible effects on shoreline erosion and turbidity. NSWCDD boat use represents a very small percentage of the daily recreational and commercial boat traffic on the waters of the PRTR.

PRTR use under Alternative 2 may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant. The Navy consulted with NMFS in accordance with the MSA. In a letter dated June 7, 2013 (Appendix G, page G-105), NMFS concurred with the Navy's determination that the proposed expansion of RDT&E activities at NSF Dahlgren would not substantially adversely affect EFH or HAPC and had no EFH conservation recommendations. In accordance with NEPA, under Alternative 2, PRTR use would have negligible, short-term, direct and indirect, negative impacts on EFH.

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4.12 Potomac River Birds

4.12.1 No Action Alternative

4.12.1.1 Ordnance Activities

As described previously, almost all recorded large-caliber projectiles fired at NSF Dahlgren since 1918 have been fired into the MDZ, with a limited number of projectiles entering the upper end of the LDZ (up to 40,000 yds from the firing line). Within the MDZ, the primary target area is the dense zone (see Figure 3.7-1). The majority of large-caliber projectiles fired is inert. Most of the live ordnance tested currently is and will continue to be equipped with fuzes that would explode well above the water surface.

Of the approximately 6,000 bullets that would be fired each year, about 10 percent would be from land into the river, with the bullets entering the river mainly within 1,000 yds of the shoreline. Approximately 190 detonations would take place each year. Most detonations would take place inland; occasionally, devices would be detonated on vessels in the river.

Small-caliber bullets are not considered here, as they have a limited range on the Potomac River. Birds are not targeted during ordnance activities and the number of birds in the vicinity of the gunnery range during firing is low due to the noise associated with firing. Most detonations take place on the land ranges of the EEA Complex, with rare detonations on the Missile Test Range and on vessels in the river, which would not result in negative impacts to birds on the river.

Ordnance activities have the potential to affect birds, particularly waterfowl that rest on the water's surface and spend much of their time on or near the river. Many waterfowl make extensive use of the bays and creeks off the main stem of the Potomac River. As described in Section 3.12, the Potomac River is an important resource for birds: it forms parts of a corridor that is used by migratory birds traveling between summer breeding grounds and winter feeding grounds, waterfowl concentration areas are found along the river, it is used as a nesting and migration area for the bald eagle, and it hosts large great blue heron breeding colonies (see Figures 3.12-1 and 3.12-2). Bald eagle and heron nests are located on land in the vicinity of the Potomac River shoreline or tributaries, with no physical presence in the PRTR, as shown in Figure 4.12-1 (Bald Eagle and Great Blue Heron Areas in Relation to the PRTR).

Fired bullets and projectiles have the potential to directly affect birds by injuring them or killing them. However, the often patchy distribution of birds and the low probability that birds would occur at the exact target location at the time a projectile would detonate diminishes the likelihood of direct impacts. Even during late autumn to spring, when ducks, geese, swans, and other waterfowl flock on the river, they are more likely to be found in the bays and creeks than the main stem of the river, with the exception of diving ducks. Although individuals could be hit by projectiles, the total number of birds affected would be too small to cause population-level impacts.

NSWCDD's range operations center (ROC) restricts the range before events begin and deploys range control boats to clear the range of watercraft and waterfowl on the water surface. If waterfowl are resting on the water surface in the target or operations area, they are scared away. However, there is no way to ensure that birds do not enter the airspace during tests or to keep the river surface clear of birds during tests.

While the Migratory Bird Treaty Act prohibits the taking, killing, or possessing of migratory birds unless permitted by regulation, an exemption to the rule that allows for incidental "takes" (wounding or killing) of migratory birds by DoD during military readiness activities was finalized in February 2007 (72 FR 8931). As directed by Section 315 of the 2003 National Defense Authorization Act, this rule authorizes such takes that result from military readiness activities, with limitations. Ordnance activities discussed in this report are considered military readiness activities. There are no reasonably foreseeable takes of migratory birds under the No Action Alternative. Therefore, consultation under the MBTA is not required.

Indirect impacts from ordnance fired into the PRTR, in particular water and sediment quality impacts, are detailed in Appendix F, Derivation of Concentrations of Munitions Constituents in PRTR Sediment and Water. A screening-level ecological risk assessment was performed to determine if concentrations of metals and explosives in water and sediments from ordnance fired into the PRTR are present at concentrations that could cause adverse effects on avian and mammalian wildlife. One representative receptor modeled was the great blue heron. The great blue heron would have higher exposure to MCOPCs in the PRTR than birds feeding on plants, invertebrates, or seeds because it feeds on fish which are exposed to MCOPCs in sediments and water.

To assess potential risks to wildlife, the modeled exposure rate of each constituent was divided by the no-observed-adverse-effect-level (NOAEL[1]) toxicity value to derive a value known as the hazard quotient (HQ). If an HQ is greater than 1 (i.e., the exposure dose is greater than the NOAEL), the concentration of the constituent that a receptor is exposed to is above the level at which no adverse effects are expected. Conversely, if an HQ is less than 1, the concentration of the constituent that a receptor is exposed to is below the level at which no adverse effects are expected and therefore no adverse effects are expected from exposure.

HQs were calculated for the dense zone and the diffuse zone. If HQs for both zones are all well below the target of 1 – indicating that there are no risks to ecological receptors from MCOPCs – then it can be concluded that the areas outside these zones, with lower munitions-related constituent concentrations, are also below levels of concern. As shown in Table 4.12-1, the HQs of all modeled constituents for the great blue heron are orders of magnitude below 1 – hundreds of thousands of times below 1 – indicating that none of the constituents entering into the Potomac River by munitions activities are released at concentrations high enough to cause adverse effects in the great blue heron, which was selected to represent Potomac River birds.

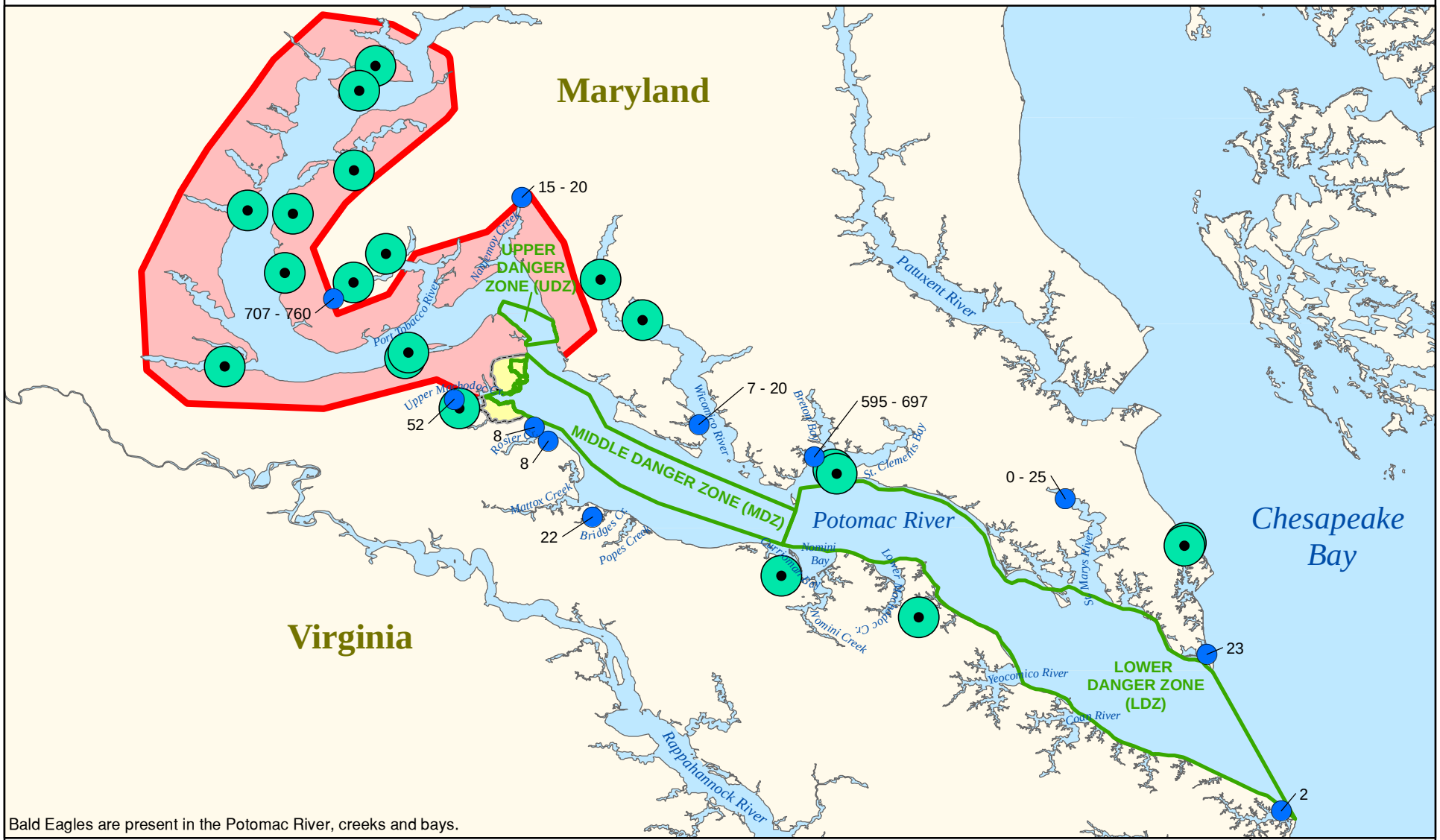
Based on these analyses, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on Potomac River birds.

4.12.1.2 EM Energy Activities

Under the No Action Alternative, the three main outdoor facilities used for E3 and HERO activities – NOTES, MOATS, and two ground planes – are located on land, away from the PRTR. Radars are tested at the STSTS on Main Range and would continue to operate over the PRTR.

[1] The NOAEL is the highest exposure level at which there are no biologically significant increases in the frequency or severity of adverse effect between the exposed population and its appropriate control. Some effects may be produced at this level, but they are not considered adverse or precursors of adverse effects.

Bald Eagle and Great Blue Heron Areas in Relation to the PRTR



Bald Eagles are present in the Potomac River, creeks and bays.

22 Number of Heron Nests / Pairs

Heron Nests / Pairs

Bald Eagle Communal Roosts

Bald Eagle Concentration Areas

Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR) Complex

7 0 7 Miles

11 0 11 Kilometers

N

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source for Heron Data: National Ocean Service Environmental Sensitivity Index Maps VA-(116,115,111 & 95) , 2005; MD-(54, 52, 44, 43, 29 & 21), 2007.
Source for Bald Eagle Data: Center for Conservatin Biology, 2008.

Figure 4.12-1

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Table 4.12-1
Screening Hazard Quotients for the Great Blue Heron

Constituent	Fish Concentration [1] (mg/kg dw)	Sediment Concentration (mg/kg dw)	Water Concentration (mg/l)	Estimated Environmental Dose (mg/kg-day)	NOAEL (mg/kg-day)	Hazard Quotient
Dense Zone						
Metals						
Cadmium	0.0000011	0.015	5.0×10^{-9}	0.0000064	1.45	0.0000044
Chromium	0.000000040	0.0056	8.5×10^{-9}	0.0000025	1.0	0.0000025
Copper	0.0000010	6.5	5.9×10^{-9}	0.0000029	47	0.000061
Lead	1.3×10^{-13}	0.12	5.8×10^{-12}	0.00005.2	1.13	0.000046
Manganese	0.00016	2.3	0.0000010	0.0010	977	0.0000011
Nickel	0.00000043	0.079	0.000000022	0.000035	77.4	0.00000045
Zinc	0.000024	1.1	0.000000046	0.00050	14.5	0.000035
Explosives						
Ammonium picrate	0.0000021	0.00000054	0.000052	0.0000030	NA	NA
HMX	1.2×10^{-9}	6.1×10^{-9}	4.5×10^{-9}	3.1×10^{-10}	50	6.1×10^{-12}
RDX	0.000026	0.000014	0.000034	0.0000031	8.0	0.00000038
Tetryl	0.0000032	0.00060	0.00000057	0.00000045	13	0.000000034
TNT	0.000063	0.0030	0.0000033	0.0000043	0.5	0.0000085
Diffuse Zone						
Metals						
Cadmium	0.00000016	0.0021	6.9×10^{-10}	0.00000095	1.45	0.00000065
Chromium	9.2×10^{-9}	0.0013	1.9×10^{-9}	0.00000058	1	0.00000058
Copper	0.00000027	1.7	1.5×10^{-9}	0.00077	47	0.000016
Lead	2.7×10^{-14}	0.026	1.2×10^{-12}	0.000012	1.13	0.000010
Manganese	0.000054	0.80	0.00000034	0.00036	977	0.00000037
Nickel	0.00000043	0.082	0.000000022	0.000037	77.4	0.00000047
Zinc	0.0000038	0.19	7.3×10^{-9}	0.000087	14.5	0.0000060
Explosives						
Ammonium picrate	0.00000011	0.000000041	0.0000027	0.00000016	NA	NA
HMX	7.2×10^{-10}	5.1×10^{-9}	2.6×10^{-9}	1.8×10^{-10}	50	3.6×10^{-12}
RDX	0.00000044	0.00000034	0.00000057	0.000000052	8.0	6.5×10^{-9}
Tetryl	0.000000091	0.000025	0.000000016	0.000000016	13	1.3×10^{-9}
TNT	0.000012	0.00081	0.00000064	0.00000094	0.5	0.0000019

Notes: mg/kg = milligrams per kilogram (parts per million); dw = dry weight; mg/l = milligrams per liter (parts per million).
NA = No criteria available.
[1] Fish were assumed to be 75 percent water for conversion from wet to dry weight.
Scientific notation is used for very small numbers; for example 1.0×10^{-9} is one billionth (0.000000001).
Hazard quotients above 1 indicate the potential for adverse effects.
All hazard quotients shown here are orders of magnitude below 1 (each order of magnitude is equal to ten times).

NSWCDD operates NDEC and CETFAC to transmit directed energy (microwaves, RF, and lasers) outdoors across the waters of the Potomac River within the PRTR, near the mouth of Upper Machodoc Creek (see Figure 1-7). For directed-energy activities over the water, beams of directed energy are transmitted above the water and are not directed at the water surface. Activities are tightly controlled and the likelihood of directed energy's straying from the target and unintentionally hitting the surface of the water is small.

Most current EM energy activities occur away from the PRTR, reducing the likelihood of Potomac River birds' coming in contact with EM energy. However, during operation of the EM energy sources, birds entering safety zones around EM energy emitters could be exposed to high electric or magnetic field levels. However, impacts to birds during operation of EM energy emitters would be negligible for two reasons. First, range areas used for EM energy activities are checked for the presence of birds before testing begins; and if they are present, they are either scared away or tests are paused until they leave. Second, even if birds are present in the area, the high electric or magnetic field levels experienced within test areas quickly dissipate and return to background levels outside the test areas. For example, background levels are reached within 80 ft of firing EM launchers at the EMLF (NSWCDL, 2009a). The magnetic field levels outside of the EM launcher's 80-ft buffer zone would be below the most stringent guidelines for humans (i.e., people with pacemakers), which are also considered protective of birds and other wildlife.

Birds flying above EM energy test facilities are unlikely to be exposed to high electric or magnetic fields, as exposure levels rapidly dissipate with distance. For example, for current EM launcher activities, magnetic field exposure levels dissipate to 5 Gauss (G) – well below exposure limits for the general population – within 30 ft from the launcher (NSWCDL, 2009a). In addition, the duration of the EM energy emission is usually brief – varying from less than a second to several minutes. The short duration of each test also means that the likelihood of affecting any animal using magnetic fields for orientation is extremely small.

The EM energy facilities are located outside the buffer zones of bald eagle nests (Figure 3.12-3) and do not offer any specialized habitats for bald eagles, either for nesting or foraging. Therefore, the likelihood of a bald eagle's entering the buffer areas around existing EM energy facilities during operation is extremely small.

EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on Potomac River birds.

4.12.1.3 Laser Activities

Three of NSWCDD's five HE laser corridors cross the waters of Upper Machodoc Creek and the Potomac River through the PRTR (Figure 1-9). Under the No Action Alternative activities, both the laser emitter and the target/backstop would be fixed, and the laser would emit almost horizontally. The laser would be pre-aimed and would not be able to move, except for minute corrections to the aim point. Under the current maximum power (100 kW), for over-water activities, the laser beam would begin at least 12 ft above mean water level and terminate at least 9 ft above mean water level. The eye-hazard area around the laser beam would be about 6 ft in diameter and at least 6 ft above mean water level (see Figure 1-10).

HE laser activities require a high level of preparation and safety precautions prior to firing. NSWCDD has written safety programs and procedures for the protection of scientists and the

public and to minimize potential impacts to wildlife. The impact to birds from HE laser activities would be negligible to minor because of the safety procedures implemented prior to and during events. Lasers would emit beams well above the water and ground surface, and the outdoor activities would be of short duration and intermittent. Before an event begins, NSWCDD personnel would clear the test areas of people and visible wildlife, and the event would be stopped if people or wildlife approach the laser corridor during the event.

Under the No Action Alternative, for over-water activities the laser beam would begin at least 12 ft above mean water level and terminate at least 9 ft above mean water level. Therefore, the lasers would not impact birds on the ground, in shallow water, or flying at very low levels.

The probability of adversely affecting a bird that may fly into or along the laser beam during an event would be very low due to the short duration of the laser emissions and the small area that would be used for testing. Comparison of the volume of a laser eye-hazard area to the size of a square mile of the MDZ illustrates the low probability of a bird's flying into the laser beam during an event and being adversely impacted. The eye-hazard area of a 100-kW laser transmission – the most powerful transmission under the No Action Alternative – would have a calculated diameter of 6 ft and, transmitted over a distance of one mile, a volume of approximately 149,300 cubic feet. By comparison, a one-mile-square area on the MDZ extending from the water surface to a height of 100 ft would have a volume of 2.788 billion cubic feet. A 100-ft height was used in the calculation based on the finding that 60 percent of bird strikes to civil aircraft between 1990 and 2007 occurred at 100 ft above ground level or lower (Federal Aviation Administration and Animal and Plant Health Inspection Service, 2008). This statistic suggests both an abundance of birds at this height and a potential inability of the birds to avoid hazards within this stratum. Based on the preceding assumptions, the volume of the laser eye-hazard area would be approximately 0.005 percent of the volume of the test area. The odds of a bird's flying into the beam during emission would be very low, particularly as most birds spend the majority of their time in activities other than flying – e.g., resting or feeding.

During each laser test, a visual observer trained by the NSF Dahlgren's natural resources manager would watch for eagles, ospreys, waterfowl, other birds, and wildlife that may wander into the laser corridor. The observer would radio the Computer Control Center (C3) van to immediately halt the test if any wildlife is observed. In addition, there would be cameras trained on the laser corridor, with video feed monitored by test personnel in the C3 van. In the event that wildlife moves into the laser corridor, the person doing video surveillance could press a button to immediately stop the test. Small animals close to the ground that may not be seen (e.g., mice, shrews, or rabbits) would be 2 to 3 ft below the 6-ft-diameter eye-hazard zone for the maximum power 100 kW laser and would not have contact with the laser beam (NSWCDL, 2009b). The laser corridor is defined to be wide enough to allow sufficient response time to shut down the laser system. The range would also be visually surveyed for dead animals prior to the commencement of any tests and any dead animals would be removed to limit the chances of scavenger wildlife's entering the test corridor.

Similar procedures would be carried out for the over-water laser corridors. Range control boats would traverse the laser path over the water, and shore personnel would survey the path over land, to look for and remove any dead animals prior to performing any tests to avoid scavengers' entering the test area. Other controls include a video surveillance system and visual observers to watch the corridor to detect wildlife or unauthorized personal watercraft that may enter the area.

Water or shore birds nearby would not be exposed to hazardous backscatter from the target or target shelter because the target shelter would be placed 100 ft from the Potomac River shoreline. Range clearance activities would be brief and similar to normal vessel and range activities. Risks to birds would be no greater than that posed by routine gun activities on the PRTR and would occur at a lower frequency. The use of lasers does not provide a long-term, consistent source of light. Therefore, it is unlikely to attract or disorient birds, as may occur with a fixed light source. In addition, pulsed light does not attract large numbers of insects, which could attract feeding bats and birds.

In the event of a strike, injury to animal tissue from laser exposure is likely to be thermal. Because of the eye's capacity to focus incident light, it is the organ that is most sensitive to laser exposure. Risk of ocular injury is greatest when laser light is focused on the sensory retina (Bennett, 1983). The eye of a bird differs from the human eye, as it is more capable of filtering damaging radiation. It contains a structure called the pecten, which is a pigmented, highly vascularized body near the attachment of the optic nerve that supplies the inner layers of the retina with oxygen (Brach, 1977). Birds' eyes are also coated with a film or oils, depending on species, to protect them from the UV rays of the sun, which some species use to orient themselves (Lustick, 1972).

The highest bird densities are likely to be seen during periods of migration in the spring and fall. However, the probability of striking migratory birds would be very low. Most fly at high altitudes when migrating, and many birds migrate at night to minimize predation, avoid overheating, and allow feeding during the day (Lincoln, 1979). While some laser activities would take place at night, most would take place from dawn to dusk. Nocturnal migrants include the majority of land birds and some waterfowl and shorebirds. Some migrating birds might stop to feed or rest on the waters of Upper Machodoc Creek or the Potomac River near the laser corridors, but the test procedures described above would minimize the likelihood of their being struck by a laser. These safety measures would minimize the risk of a bird's or bat's randomly flying across the laser beam, thereby minimizing potential impacts. Because of the efforts that would be made to clear the area where tests are occurring, and to keep it free of large wildlife, as well as the very brief periods the laser would actually be operating, the likelihood of the beam's hitting an animal would be negligible.

It is possible, although unlikely, that a migratory bird could be struck by the laser and injured. As described previously, the USFWS finalized regulations on February 28, 2007 broadly authorizing incidental takings of migratory birds during military readiness activities (72 FR 8931). The laser activities are considered military readiness activities.

Clearing the corridor prior to the onset of tests may temporarily disturb waterfowl and other water birds, possibly during feeding, resting, and mating periods. The disruption is brief, similar to the disruptions caused by normal vessel and range activities. Test sequences are brief and represent a small fraction of ongoing range and non-range activities. The ongoing presence of waterfowl and other wildlife using the range and near-shore areas indicates that laser and other RDT&E activities under the No Action Alternative have had negligible impact on Potomac River waterfowl.

Laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on Potomac River birds.

4.12.1.4 Chemical Defense Activities

Outdoor chemical defense activities using simulants would occur under the No Action Alternative; activities using biological simulants would not occur. Chemical simulants would be released as a vapor or mist – from a boat or from shore – over the test area in the MDZ (see Figure 1-11) in a variety of weather conditions. Simulant tests are designed to minimize deposition on water and land areas.

NSWCDD conducted dispersion modeling and field tests of chemical simulants released on the PRTR to determine the potential human and ecological health risks associated with the release of chemical simulants as a vapor on the MDZ, as described in Sections 4.4.1.2 and 4.11.1.4. The modeling results predicted both the airborne and water-column concentrations that would result from the vapor releases.

As discussed previously, concentrations of chemical simulants released into the air are well below levels that could cause adverse effects in people (see Section 4.4.1.2) and below concentrations that would result in adverse effects on aquatic life (see Section 4.11.1.4). As the threshold values concentrations for people are based on animal studies, these values are also considered to be protective of birds and other wildlife. Chemical simulants are selected based on their low toxicity and similarity of physicochemical properties to chemical weapons. There is no evidence that, or reason to believe that, birds are more sensitive to these chemicals. Some of the simulants used (e.g., MeS) occur naturally in plants where birds and other wildlife may be exposed to them. Previous modeling and field tests using chemical simulants used at NWSCDL have shown exposure concentrations to be well below levels that could cause adverse impacts.

Chemical defense activities would have negligible, short-term, indirect, negative impacts and no direct impacts on Potomac River birds.

4.12.1.5 PRTR Use

Under the No Action Alternative, PRTR use for RDT&E activities would remain at present levels. Most NSWCDD vessel activities would occur in the deeper portions of the PRTR, especially the MDZ. NSWCDD would restrict public access to part of the PRTR – usually some or all of the MDZ – approximately 750 hours per year.

Existing levels of military small-boat traffic may temporarily disturb birds in the immediate vicinity of boat activities. Range boat activities, as well as commercial and recreational boat activities, on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts.

PRTR use by NSWCDD would have negligible, short-term, direct and indirect, negative impacts on Potomac River birds.

4.12.2 Alternative 1

4.12.2.1 Ordnance Activities

Under Alternative 1, the number of large-caliber projectiles would remain at current levels, although the frequency of firing into the upper LDZ would increase to up to 10 days per year. Small-caliber gun use would increase from an average of 6,000 bullets fired a year under the No Action Alternative to 25,500 bullets fired a year. Approximately 2,550 bullets (10 percent) would be fired from land into the river. Detonations would increase from 190 events to 200 events under this alternative, as described in Section 2.5.1.

Although individual birds may be directly impacted by live ordnance, the often patchy distribution of birds and the low probability that birds would occur at the location of ordnance delivery provide little potential for direct impacts. The total number of birds affected would be too small to cause population-level impacts. There are no reasonably foreseeable takes of migratory birds under Alternative 1. Therefore, consultation under the MBTA is not required.

The increase in small-arms testing is unlikely to impact Potomac River birds as it commonly takes place on the Machine Gun, Main, and AA Fuze Ranges, all of which are developed areas that are regularly maintained and do not provide suitable habitat for birds. With respect to potential indirect effects, the results of the screening-level ecological risk assessment indicated that none of the constituents released into the Potomac River by munitions activities are found at concentrations high enough to cause adverse effects in birds. Most detonations would occur over land and would not result in negative impacts to birds on the river.

Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on Potomac River birds.

4.12.2.2 EM Energy Activities

Under Alternative 1, the number of EM energy events would increase from 490 to 590 per year, the power of the EM energy events would increase, and activities would increase, as described in Section 2.5.2.

As detailed in Section 4.8, EM energy activities would follow strict safety protocols so that they pose minimal risk to humans and wildlife. Safety measures in place for birds and other wildlife would follow those described under the No Action Alternative.

Based on these protocols, EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on Potomac River birds.

4.12.2.3 Laser Activities

Under Alternative 1, the number of HE laser events would increase from the current 60 annually to 125 annually. Power levels and activities would also increase, and lasers would be used in more areas, as described in Section 2.5.3.

The safety measures described under the No Action Alternative would also be implemented under Alternative 1. These measures would minimize the risk of a bird’s randomly flying across the laser beam at the precise time that the laser is being fired, minimizing potential impacts.

Safety procedures would be modified as needed to address risks associated with increased activities. For example, current target/backstops that intercept the laser beam and absorb its energy would be enlarged to capture the laser beam, which becomes more diffuse and increases its diameter as it gets farther from the laser emitter.

Given that safety procedures would be adapted to specific event requirements, laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on Potomac River birds.

4.12.2.4 Chemical and Biological Defense Activities

Under Alternative 1, activities using chem/bio simulants outdoors would increase from the current baseline of 12 events annually using chemical simulants to 60 events annually using both chemical and biological simulants, as described in Section 2.5.4. The maximum quantity of simulant (20 gals) per release would not increase and the amount of simulant used would be the minimum amount needed to test the lowest level of simulant the sensor can detect. Other chemical simulants with low toxicity, as well as BSL-1 biological simulants, would be added to the tests. The areas in which the activities would take place would expand to include all the land ranges, the Mission Area, and the MDZ.

As described for the No Action Alternative, the use of chemical simulants would have negligible impacts on Potomac River birds. Based upon previous activities and the modeling presented in Sections 4.4.1.2 and 4.11.1.4, simulant concentrations that Potomac River birds would be exposed to are predicted to be well below levels that would cause toxicity.

The biological simulants that may be used include spore-forming bacteria such as *Bacillus atrophaeus, B. subtilis, and B. thuringiensis;* non-spore forming bacteria such as *Pantoea agglomerans* and *Deinococcus radiodurans;* ovalbumin; bacteriophage MS2; and the fungus *Aspergillus niger.* No modeling was performed for biological simulants, as NSWCDD would use only BSL-1 simulants, defined by the Centers for Disease Control and Prevention as well-characterized strains of viable microorganisms with minimal potential hazard to the environment. Many of these biological simulants, such as the bacteria, are ubiquitous and often found in high concentrations in nature, including in water (CRI, 2004). There are no published reports of disease associated with these biological simulants in aquatic plants or animals, nor are they considered to be disease-causing agents. The small concentrations of these simulants deposited on the water would not cause any significant population increase in the environment, and no adverse effects are anticipated from temporary increases of them.

Chem/bio defense activities would have negligible, short-term, indirect, negative impacts and no direct impacts on Potomac River birds.

4.12.2.5 PRTR Use

NSWCDD would restrict public access to some part of the PRTR danger zones, usually some or all of the MDZ, for approximately 870 hours per year, as described in Section 2.5.5.

PRTR use at increased levels would have negligible impacts on Potomac River birds, as there would be only minor increases in range boat traffic (16 percent) or other activities that could disturb them. Range boat activities, as well as commercial and recreational boat activities, on the waters of the

PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts.

PRTR use would have negligible, short-term, direct and indirect, negative impacts on Potomac River birds.

4.12.3 Alternative 2

4.12.3.1 Ordnance Activities

The number of large-caliber projectiles would remain at current levels and use would be the same as under Alternative 1. The use of small arms would increase, with the number of bullets expended annually increasing from 6,000 to 30,000; approximately 3,000 bullets would be fired from land into the river. Detonations would increase from 190 events to 230, as described in Section 2.6.

Although individual birds may be directly impacted by gun firing, the often patchy distribution of birds, the low probability that birds would occur at the target area provide little potential for direct impacts. The increase in small-arms testing is unlikely to impact Potomac River birds as it commonly takes place on the Machine Gun, Main, and AA Fuze Ranges, all of which are developed areas that are regularly maintained and do not provide suitable habitat for birds. The total number of birds affected would be too small to cause population-level impacts. There are no reasonably foreseeable takes of migratory birds under Alternative 2. Therefore, consultation under the MBTA is not required.

With respect to potential indirect effects, the results of the screening-level ecological risk assessment indicated that none of the constituents released into the Potomac River by munitions activities are found at concentrations high enough to cause adverse effects in birds. Most detonations would occur on land and, therefore, the increase in detonations would not affect birds on the river.

Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on Potomac River birds.

4.12.3.2 EM Energy Activities

Under Alternative 2, the number of EM events would increase from 490 to 680 per year and activities would expand, as described in Section 2.6. Safety measures in place for birds and other wildlife would follow those described under the No Action Alternative.

EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on Potomac River birds.

4.12.3.3 Laser Activities

Under Alternative 2, the number of laser events would increase from 60 to 145 events per year, and activities would expand, as described in Section 2.6.

The safety measures described under the No Action Alternative would minimize the risk of a bird's randomly flying across the laser beam at the precise time that the laser is being fired, minimizing

potential impacts. Safety procedures would be modified to address risks associated with increased activities, as described under Alternative 1.

Laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on Potomac River birds.

4.12.3.4 Chemical and Biological Defense Activities

The number of events using chem/bio simulants would increase from the current baseline of 12 events annually using chemical simulants to 70 events annually using both chemical and biological simulants, as described in Section 2.6. The chemical and biological simulants used would be the same ones approved for use in the individual chemical and biological operational tests under Alternative 1.

The use of chem/bio simulants would have negligible impacts on Potomac River birds. Based upon previous events and the modeling presented in Sections 4.4.1.2 and 4.11.1.4, simulant concentrations that Potomac River birds would be exposed to are predicted to be are well below levels that would cause toxicity to them. The use of BSL-1 biological simulants would have no effects on birds, as these organisms pose minimal potential hazard to the environment, and some of these organisms are already naturally present in the area. There is no research on synergistic effects between low toxicity chemical and BSL-1 biological simulants most likely because given the low level of risk from both elements, no synergistic effects are expected.

Chem/bio defense activities would have negligible, short-term, indirect, negative impacts but no direct impacts on Potomac River birds.

4.12.3.5 PRTR Use

NSWCDD would restrict public access to some part of the PRTR danger zones, usually some or all of the MDZ, for approximately 1,000 hours per year, as described in Section 2.6.

PRTR use at increased levels would have negligible impact on Potomac River birds, as there would be only minor increases in range boat traffic, operational craft, or other activities that could disturb them. Range-boat activities, as well as commercial and recreational boat activities, on the waters of the PRTR, Upper Machodoc Creek, and other waterways in the vicinity of NSF Dahlgren routinely occur without long-term adverse impacts.

PRTR use would have negligible, short-term, direct and indirect, negative impacts on Potomac River birds.

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4.13 NSF Dahlgren's Biological Resources

4.13.1 No Action Alternative

4.13.1.1 Ordnance Activities

Almost all recorded large-caliber projectiles fired at NSF Dahlgren since 1918 have been fired into the MDZ, with a limited number of projectiles entering the upper end of the LDZ (up to 40,000 yds from the firing line). Under this alternative, and under Alternatives 1 and 2, inert projectiles would continue to be the dominant type of ordnance.

Approximately 6,000 bullets would be fired each year. Much of the outdoors small-arms firing is directed into gun butts and approximately 90 percent of small-arms firings are and would continue to be over land, with the remaining 10 percent from land into the river.

Approximately 190 detonations would take place each year. Most detonations would take place inland on the EEA's Harris and Churchill Ranges, and infrequently on the EOD training range on the Missile Test Range or on vessels on the PRTR. NSWCDD removes fired military munitions, as well as range scrap and debris from the land-based firing of munitions and detonation of explosives that are exposed on the ground surface or partially buried.

NSF Dahlgren's Ponds, Streams, and Creeks

As discussed in Section 3.10, aquatic resources other than the Potomac River associated with NSF Dahlgren include Upper Machodoc Creek, Gambo Creek, Black Marsh Creek, Beaver Pond, Lespedeza Pond, Hideaway Pond, and Cooling Pond. Fish living in aquatic environments outside of the Potomac River generally would have minimal contact – lower than would fish living in the river – with ordnance (the exception is Hideaway Pond, which has elevated levels of contaminants from long-past uses). As described in Section 4.11, RDT&E activities under the No Action alternative would have negligible, long-term, direct and indirect, negative impacts on fish in the Potomac River. The impacts of RDT&E activities would be even lower in aquatic environments outside the river, as there would be fewer interactions with fish. Therefore, potential impacts to fish are not discussed further in this section.

Wildlife living near aquatic resources are not near the Churchill and Harris ranges in the EEA where ordnance activities occur and, therefore, would not be directly exposed to ordnance. Concentrations of MCs entering inland waters from surface water or groundwater transport would be minimal, as operational range clearance (ORC) and best management practices (BMPs) are followed to reduce potential risks to human health and/or the environment if munitions are exposed via erosion from past range activities (NSWCDL, 2003; NAVSEA, 2010).

None of the inland waters are part of the PRTR with the exception of the entrance to Upper Machodoc Creek. Ordnance activities do not occur in this area with the possible exception of some small-arms firing from the Machine Gun Range entering the area at the confluence of Upper Machodoc Creek and the Potomac River.

Ordnance activities under the No Action Alternative would have negligible, long-term, direct and indirect, negative impacts on biological resources associated with NSF Dahlgren's ponds, streams, and creeks.

NSF Dahlgren's Vegetation

To minimize fire hazards, areas where guns are fired and where explosives are detonated are maintained with short or no surrounding vegetation. Larger guns are typically mounted well above the ground, which is covered with concrete, or in the case of the 155 mm howitzer and the 8" gun, guns are placed on concrete slabs.

Projectiles fired from the large guns to targets on land are typically caught in projectile catch facilities. The projectiles have no contact with vegetation, but fragments of the projectile may land on plants nearby. Similarly, small arms fired on land are typically fired into gun butts. Fragments or particles of bullets or projectiles may land on plants. Smaller fragments and particles are unlikely to damage plants, but larger fragments may damage individual plants.

Open detonations (over 200 lbs net explosive weight [NEW]) on the EEA ranges are buried under 8 ft or more of dirt to reduce noise and flying fragments and have no contact with vegetation. Detonations of less than 200 lbs NEW detonate on the EEA ranges above ground and could affect nearby vegetation, although the vegetation on the Harris and Churchill Ranges detonation areas is sparse and short. Various types of tests on the EEA result in detonations that create fragments, such as arena tests where fragmentation patterns are studied.

Overall, the potential impacts on terrestrial vegetation from use of ordnance include direct hits of vegetation, fires, disturbance of vegetation adjacent to direct hits, settlement of shell fragments onto plants, and changes in soil quality from the release of constituents in shell components and explosives. Direct hits of vegetation or adjacent to vegetation may cause damage to individual plants, but as vegetation on the parts of the ranges used for ordnance detonations is mowed intermittently, the species that survive are mowed grasses, short shrubs resistant to repeated mowing, or fast growing colonizing species, which are adapted to their environment.

Ordnance activities under the No Action Alternative would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

Wildlife may potentially be exposed to large-caliber gun firing, small-arms tests, and detonations. Ranges are cleared before events begin but there is no way to ensure that birds and mammals do not enter the areas during tests. Noise and human activity associated with activities may startle wildlife and cause them to temporarily leave the area, and likely would act as a deterrent to their return before an event's end. Birds or mammals could be injured or killed if they pass in front of guns or near detonations. However, direct hits of wildlife are unlikely, as wildlife would normally vacate test areas temporarily when firing begins because of the noise associated with firing and then return after events conclude.

The availability of vegetation for grazing wildlife, including grasses, shrubs, and other plants would not be affected by ordnance RDT&E activities. It is also likely that the wildlife species that flourish on and near the ranges are adapted to range operations, and may actually benefit from them, such as hawks, owls, and foxes, which may find the mowed vegetation on the ranges (much of which is not mowed to lawn heights, but rather is mowed intermittently to retard tree growth) to be good hunting grounds for mice and rabbits. Ospreys have been known to build their nests near the Main Range gun line, an open landscape which may offer protection from nest predators as well as good visibility. Also, in general, the need to maintain buffer zones

around the most-heavily used parts of the ranges has resulted in the protection of large forested areas and wetlands, which offer excellent wildlife habitat.

Semi-aquatic mammals, such as the river otter, muskrat, and mink, may spend much of their time on or near the Potomac River in search of prey. It is unlikely that individual mink, river otter, or muskrat would be in the PRTR target area, as they forage near the shoreline (USEPA, 1993) and generally would not be out far enough in the river to be within the target range. In addition, mink are nocturnal and would not usually be active during firing times.

Indirect impacts from ordnance fired into the PRTR, in particular water and sediment quality impacts, are detailed in Appendix F, Derivation of Concentrations of Munitions Constituents in PRTR Sediment and Water. As described in Section 4.12.1.1, a screening-level ecological risk assessment was performed to determine if concentrations of MCOPCs (metals and explosives) in water and sediments from ordnance fired into the PRTR are present at concentrations that could cause adverse effects on wildlife. The river otter was selected as a representative receptor for semi-aquatic mammals. The river otter is considered to be at the upper end of the exposure range, as it feeds almost exclusively on fish and aquatic invertebrates that would be exposed to MCOPCs in the PRTR. The results of the screening assessment for the river otter are presented in Table 4.13-1.

HQs were calculated for both the dense zone and the diffuse zone. If HQs for these zones are all well below the target of 1 – indicating that there are no risks to ecological receptors from MCOPCs – then it can be concluded that the areas outside these zones, with lower munitions-related constituent concentrations, are also below levels of concern. As shown in Table 4.13-1, the HQs for all constituents are orders of magnitude below 1 – more than thousands of times lower – indicating that the MCOPCs released into the Potomac River by munitions testing are well below levels that may cause adverse effects in mammals.

Ordnance activities under the No Action Alternative would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren’s wildlife.

Special Interest Areas (SIAs)

Five SIAs (Figure 3.13-1) have been established at NSF Dahlgren. Of the five, two are wetland areas on Mainside that possess unique ecological characteristics and high-quality rare species habitat; the remaining three are areas on the EEA that provide nesting habitat for bald eagles.

All of the SIAs are located away from firing ranges and detonation areas. There is no spatial overlap between ordnance activities and SIAs. Ordnance activities under the No Action Alternative would have no direct or indirect impacts on biological resources associated with SIAs.

Table 4.13-1
Screening Hazard Quotients for the River Otter

Constituent	Fish Concentration[1] (mg/kg dw)	Sediment Concentration (mg/kg dw)	Water Concentration (mg/l)	Estimated Environmental Dose (mg/kg -day)	NOAEL (mg/kg-day)	Hazard Quotient
Dense Zone						
Metals						
Cadmium	0.0000011	0.015	5.0×10^{-9}	0.0000075	1.0	0.0000075
Chromium	0.000000040	0.0056	8.5×10^{-9}	0.0000029	3.28	0.00000087
Copper	0.0000010	6.5	5.9×10^{-9}	0.0033	11.7	0.00027
Lead	1.3×10^{-13}	0.12	5.8×10^{-12}	0.000061	8.0	0.0000076
Manganese	0.00016	2.3	0.0000010	0.0012	88	0.000014
Nickel	0.00000043	0.079	0.000000022	0.000040	40	0.0000010
Zinc	0.000024	1.1	0.000000046	0.00058	160	0.00000036
Explosives						
Ammonium picrate	0.0000021	0.00000054	0.000052	0.0000055	NA	NA
HMX	1.2×10^{-9}	6.1×10^{-9}	4.5×10^{-9}	5.3×10^{-10}	50	1.1×10^{-11}
RDX	0.000026	0.000014	0.000034	0.0000049	8.0	0.00000061
Tetryl	0.0000032	0.00060	0.00000057	0.00000053	13	0.000000041
TNT	0.000063	0.0030	0.0000033	0.0000051	0.5	0.000010
Diffuse Zone						
Metals						
Cadmium	0.00000016	0.0021	6.9×10^{-10}	0.0000011	1	0.0000011
Chromium	9.2×10^{-9}	0.0013	1.9×10^{-9}	0.00000066	3.28	0.00000020
Copper	0.00000027	1.7	1.5×10^{-9}	0.00087	11.7	0.000075
Lead	2.7×10^{-14}	0.026	1.2×10^{-12}	0.000013	8	0.0000017
Manganese	0.000054	0.80	0.00000034	0.00041	88	0.0000047
Nickel	0.00000043	0.082	0.000000022	0.000042	40	0.0000010
Zinc	0.0000038	0.19	7.3×10^{-9}	0.000098	160	0.00000061
Explosives						
Ammonium picrate	0.00000011	0.000000041	0.0000027	0.00000029	NA	NA
HMX	7.2×10^{-10}	5.1×10^{-9}	2.6×10^{-9}	3.1×10^{-10}	50	6.2×10^{-12}
RDX	0.00000044	0.00000034	0.00000057	0.000000083	8.0	0.000000010
Tetryl	0.000000091	0.000025	0.000000016	0.000000019	13	1.5×10^{-9}
TNT	0.000012	0.00081	0.00000064	0.0000011	0.5	0.0000022

Notes: mg/kg = milligrams per kilogram (parts per million); dw = dry weight; mg/l = milligrams per liter (parts per million).
NA = No criteria available.
[1] Fish were assumed to be 75 percent water for conversion from wet to dry weight.
Scientific notation is used for very small numbers; for example 1.0×10^{-9} is one billionth (0.000000001).
Hazard quotients above 1 indicate the potential for adverse effects.
All hazard quotients shown here are orders of magnitude below 1 (each order of magnitude is equal to ten times), with a minimum of thousands of times below the target value.

Hunting and Fishing

Hunting and fishing at NSF Dahlgren are limited based on time of day, day of week, and time of year, with the limitations based on activities related to the military mission. Hunting takes place in designated areas on NSF Dahlgren's Mainside and EEA (see Figure 3.13-3). Weekday hunting using firearms is prohibited with the exception of: 1) during muzzleloader season at Pumpkin Neck after work hours; 2) federal holidays; 3) site-observed shutdown between Christmas and New Years; and 4) waterfowl hunting from blinds 11 through 15 along the Pumpkin Neck shoreline (NSA South Potomac, 2009a, 2009b). Weekday bow hunting of deer is permitted all day in hunting compartments west of Gambo Creek and after 1500 hours in hunting

compartments east of Gambo Creek (see Figure 3.13-3). Hunting of turkey, small game, and migratory birds is only permitted on Saturday and federal holidays (NSA South Potomac, 2009a, 2009b).

All designated hunting areas are and would continue to be restricted and monitored during RDT&E activities to eliminate any potential impacts. Fishing activities on Mainside and within the Potomac River and Upper Machodoc Creek are restricted based on military mission activities. NSWCDD may restrict fishing on part or all of the MDZ, or infrequently the upper LDZ, when actively using that part of the range.

Current ordnance activities do not physically overlap with hunting and fishing activities; however, restrictions imposed during ordnance activities indirectly affect hunting and fishing. Therefore, ordnance activities under the No Action Alternative would have no direct impacts and negligible, long-term, indirect, negative impacts on hunting and fishing.

4.13.1.2 EM Energy Activities

Under the No Action Alternative, NSWCDD currently uses and would continue to use three main outdoor facilities for E3 and HERO activities: NOTES, MOATS, and two ground planes. MOATS and the two ground planes are in highly-developed areas with little or no natural habitat surrounding them, whereas NOTES is surrounded by forest in an area with little human activity. Radars are tested at the STSTS on Main Range in a developed area. NSWCDD operates NDEC and CETFAC to transmit directed energy (microwaves, RF, and lasers) outdoors, across the waters of the Potomac River. The EM Launcher Facility, beyond a cleared buffer area, is surrounded by forest.

As discussed in the Chapter 2, EM energy devices evaluated in this EIS operate in the frequency range of 300 kHz to more than 300 GHz and at powers up to 500 MW (average power). Exposure to the upper end of these frequencies can result in thermal or heating effects on body tissues. However, the higher frequencies are only present close to EM energy generators when they are operating. The distance from EM energy generators for exposure to reach levels where thermal effects could occur is carefully controlled during events.

NSF Dahlgren's Ponds, Streams, and Creeks

EM energy generators are not located near the ponds, streams, and creeks on NSF Dahlgren. Therefore, there would be minimal potential for wildlife on or near these surface waters to be exposed to dangerous levels of EM energy. EM energy that breaches the water surface would be propagated and attenuated, rapidly decreasing in amount and intensity as it travels through the water.

Under the No Action Alternative, EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on biological resources associated with NSF Dahlgren's ponds, streams, or creeks.

NSF Dahlgren's Vegetation

MOATS and the two ground planes are in highly-developed areas with little or no natural habitat, and minimal vegetation, surrounding them, whereas NOTES is surrounded by forest.

Vegetation growing at the edges of these facilities would not receive high enough doses of EM energy to be impacted because the energy is directed inwards.

Corridors where EM energy activities take place are areas that are already maintained or over open water. No high quality habitat would be cleared for corridors and therefore the effect on vegetation would be negligible. Under the No Action Alternative, EM energy activities would have negligible, short-term, direct, negative impacts and no indirect impacts on vegetation.

NSF Dahlgren's Wildlife

MOATS and the two ground planes are in highly-developed areas and do not provide high-quality habitat that would attract wildlife, whereas NOTES is surrounded by forest in an area with little human activity. Outdoor EM energy activities at NSF Dahlgren require the use of HERP safety zones to protect personnel and these zones would also exclude wildlife, thereby protecting them from high levels of EM energy

As EM energy dissipates exponentially with distance from the energy source, wildlife outside the test area would encounter very low doses of EM energy. Although there are no controls to exclude wildlife from the safety zones during activities, the probability of wildlife's entering test areas at the time of firing would be very low, due to the poor quality habitat (i.e., maintained or concrete areas), the occurrence of tests primarily during times of low wildlife activity, and the presence of test personnel. As discussed above, impacts on vegetation such as grasses, shrubs and other plants used by grazing wildlife would be negligible and therefore there would be no indirect impacts on wildlife from EM energy. EM energy activities under the No Action Alternative would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

MOATS and the two ground planes are located far enough away from SIAs that the power of EM energy would be reduced to background levels by the time the energy reaches the SIAs. Therefore, EM energy activities under the No Action Alternative would have no direct or indirect impacts on biological resources associated with SIAs or the SIAs themselves.

Hunting and Fishing

Minimal wildlife is expected near the EM energy facilities, as vegetation is cleared providing little to no habitat for wildlife species. There is an 8-ft fence surrounding the EM Launcher Facility that prevents large wildlife, such as deer, from coming within 80 ft of the launcher (NSWCDL, 2009). Test areas are cleared prior to the onset of EM energy tests and interruptions are brief. Any interruptions to hunting and fishing are considered to be negligible.

EM energy activities under the No Action Alternative would have negligible, short-term, direct, negative impacts and no indirect impacts on hunting and fishing at NSF Dahlgren.

4.13.1.3 Laser Activities

Two of NSWCDD's five current laser corridors are on the PRTR's developed land ranges. For No Action Alternative activities, both the HE laser emitter and the target/backstop would be fixed and the laser would emit almost horizontally. The laser would be pre-aimed and would not

be able to move, except for minute corrections to the aim point. Under the current maximum power the laser beam would be a minimum of 6 ft above ground level. As with EM energy, laser activities are tightly controlled and the likelihood of a laser beam's straying from the target/backstop and hitting the ground is extremely small.

NSF Dahlgren's Ponds, Streams, and Creeks

As discussed in Section 4.11.2, there is a very low probability that Potomac River birds would be near HE laser beams during RDT&E activities. Birds living in or near inland waters on NSF Dahlgren are also unlikely to be exposed to lasers. Current activities have negligible impact on wildlife living in or near inland waters due to the low number of birds and mammals present during activities; the use of spotters to report whether wildlife is present when lasers are being used; health and safety protocols; and the small volumes occupied by laser beams over short emission times.

Under the No Action Alternative, laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on biological resources associated with NSF Dahlgren's ponds, streams, and creeks.

NSF Dahlgren's Vegetation

Current activities using lasers provide little opportunity for lasers to contact croplands, forest resources, or other vegetation between the laser site and the target area during operations, as laser activities require a clear line of sight. Tree foliage is removed and ground vegetation is cut where necessary to achieve a clear line of sight. The effect of increased vegetation maintenance, if required, in laser corridors is considered negligible.

Exposure of plant material to HE lasers may result in direct damage to the plant, as evidenced by wilting. Selective application of lasers can also inactivate the synthesis of essential amino acids within plants. This finding has led to the filing and granting of a patent for use of lasers in control of water weeds and other invasive plants (US Patent Office, 1972). However, field tests showed that although laser irradiation initially caused a substantial decrease in growth rates with an increase in irradiation level, this effect decreased over time until there was no substantial difference between treated and control plots (Long and Smith, 1975). Rates of photosynthesis were not significantly affected by laser irradiation (Long and Smith, 1975), although more information is needed on threshold responses (both beneficial and deleterious) of plant tissues to laser light (Bennett, 1983).

Under the No Action Alternative, laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on biological resources associated with NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

Laser activities require a high level of preparation and safety precautions prior to firing. As described previously, NSWCDD has written safety programs and procedures for the protection of scientists and the public and to minimize potential impacts to wildlife. Personnel used as spotters make sure the test area is clear of large wildlife – predominantly white-tailed deer and visible birds – before initiating each test sequence, and the video surveillance system provides an observer the opportunity to stop the test in the event of wildlife entering the test area. In addition,

trained visual observers with radios or cameras watch for eagles, other birds, and wildlife that may wander into the laser corridor. The corridor is defined to be wide enough to allow sufficient response time to shut down the laser system. The range is also visually surveyed for dead animals prior to performing any tests and any dead animals are removed to limit the chances of scavenger wildlife entering the test range. These safety measures minimize the risk of wildlife entering the area during tests.

Clearing the range prior to the onset of tests may temporarily disturb wildlife. Test sequences are brief and represent a small fraction of ongoing range and non-range activities. The ongoing presence of birds and wildlife using the range suggests that laser activities have little effect on terrestrial wildlife under current usage. As discussed above, impacts on vegetation such as grasses, shrubs and other plants used by grazing wildlife would be negligible and therefore there would be no indirect impacts on wildlife from laser RDT&E activities.

Under the No Action Alternative, laser activities would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

All outdoor laser activities are located well away from SIAs. Therefore, under the No Action Alternative there would be no direct or indirect impacts to SIAs from laser activities.

Hunting and Fishing

Minimal wildlife is expected near areas of HE laser operations, as laser corridors are characterized by low vegetation – mowed for range operations – and paved areas (NSWCDL, 2009). HE laser activities require a high level of preparation and safety precautions prior to firing. NSWCDD has written safety programs and procedures for the protection of personnel, the public, and to minimize potential impacts to wildlife. Personnel used as spotters make sure that the test area is clear of large wildlife – predominantly white-tailed deer and visible birds – before initiating each test sequence. Any interruptions to hunting and fishing would be brief and are considered to be negligible.

Laser activities under the No Action Alternative would have negligible, short-term, direct, negative impacts and no indirect impacts on hunting and fishing at NSF Dahlgren.

4.13.1.4 Chemical Defense Activities

Outdoor chemical defense activities using simulants would occur under the No Action Alternative; activities using biological simulants would not occur. Chemical simulants would be released over the test area in the MDZ in a variety of weather conditions. When quantities of more than 5 gals are to be used, crosswind releases could be specified by the Test Director to limit the dosage of simulant as the cloud passes over any land or water biological system.

NSF Dahlgren's Ponds, Streams, and Creeks

Chemical simulant tests result in small quantities of simulants being released in the air and even smaller quantities of simulants being deposited on the surface of the land. Assessments completed for similar past simulant activities performed by NSWCDD using some of the same

simulants showed no significant impacts and there were no observable environmental effects during or after events (NSWCDD, 2003; NSWCDL, 2004; Bossart, letter, February 9, 2006).

NSWCDD conducted dispersion modeling and field tests of chemical simulants released on the PRTR to determine the potential human and ecological health risks associated with the release of chemical simulants as a vapor on the MDZ, as described in Sections 4.4.1.2 and 4.11.1.4. The modeling results predicted both the airborne and water-column concentrations that would result from the vapor releases and the results are provided in Appendix J.

As discussed previously, concentrations of chemical simulants released into the air are well below levels that could cause adverse effects in people (see Section 4.4.1.2) and below concentrations that would result in adverse effects on aquatic life (see Section 4.11.1.4). The concentrations of chemical simulants reaching NSF Dahlgren's ponds, streams, and creeks likely would be much lower and below detection levels.

Under the No Action Alternative, chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts on biological resources associated with NSF Dahlgren's ponds, streams, or creeks.

NSF Dahlgren's Vegetation

Simulant vapor tests are designed to minimize deposition on land and water areas. Simulants released into the air would rapidly disperse in the environment. Concentrations of chemical simulants that may be deposited on terrestrial vegetation would be very low – at or near background levels and well below concentrations that have been shown to cause adverse effects. Under the No Action Alternative, chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

Concentrations of chemical simulants to which terrestrial wildlife would be exposed would be very low – at or near background levels and well below concentrations that have been shown to cause adverse effects. Vegetation such as grasses, shrubs and other plants used by grazing wildlife would not be affected by chemical or biological simulants. Under the No Action Alternative, chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

Chemical simulants are not tested in the SIAs and any simulants that reach SIAs would be at concentrations equivalent to background levels. Chemical defense activities under the No Action Alternative would have no direct or indirect impacts on biological resources associated with SIAs.

Hunting and Fishing

Chemical defense activities would take place during specific times throughout the year, rather than every day of the year, and would likely occur at times where hunting and fishing is not taking place. As NSWCDD normally conducts outdoor RDT&E activities Monday through Friday between 8 am and 5 pm during daylight hours, chemical defense activities would not

conflict with prime hunting and fishing, which tend to occur early in the morning or late in the evening. Therefore, any interruptions to hunting and fishing activities would be negligible.

Under the No Action Alternative, chemical defense activities would have negligible, short-term, direct, negative impacts and no indirect impacts on hunting and fishing.

4.13.2 Alternative 1

4.13.2.1 Ordnance Activities

The number of large-caliber projectiles would remain at current levels, although the frequency of firing into the upper LDZ would increase to up to 10 days per year. Small-caliber gun use would increase from an average of 6,000 bullets fired a year under the No Action Alternative to 25,500 bullets fired a year. Detonations would increase from 190 events to 200 events under this alternative, as described in Section 2.5.1.

NSF Dahlgren's Ponds, Streams, and Creeks

Ordnance activities would not occur in the ponds, streams, or creeks on NSF Dahlgren, with the possible exception of some small-arms firing from the Machine Gun Range entering the area at the confluence of Upper Machodoc Creek and the Potomac River. As discussed previously, small arms fired on land are typically fired into gun butts with approximately 10 percent of rounds entering the Potomac River within approximately 1,000 yds of shore. The majority of bullets entering the river would be immediately buried, isolating bullets from movement and exposure pathways, resulting in negligible impacts to water bodies. Ordnance activities under Alternative 1 would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's ponds, streams, and creeks.

NSF Dahlgren's Vegetation

Ordnance activities at NSF Dahlgren would minimally affect terrestrial plants under Alternative 1. Although individual plants may be damaged by bullets, plants found in maintained areas are generally rapidly growing species that would be replaced in a short time. Ordnance activities under Alternative 1 would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

As described for the No Action Alternative, ranges would be cleared before events begin, but there is no way to ensure that birds and mammals do not enter the areas during tests. Noise and human activity associated with activities may startle wildlife and cause them to temporarily leave the area, and likely would act as a deterrent to their return before an event's end. Direct hits of wildlife are unlikely, as wildlife would normally vacate test areas temporarily when firing begins because of the noise associated with firing, and then return after events conclude. Modeling of MCOPCs in munitions indicates that there are no risks to ecological receptors.

Ordnance activities are unlikely to affect terrestrial wildlife, as wildlife would likely avoid the ranges during activities. Ordnance activities under Alternative 1 would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

Increased small-arms firing and detonations would not affect SIAs or associated biological resources, as all of the SIAs are located away from firing ranges and detonation areas. Therefore, ordnance activities under the Alternative 1 would have no direct or indirect impacts on biological resources associated with SIAs or the SIAs themselves.

Hunting and Fishing

Under current conditions, large-caliber guns cause negligible interruptions to hunting and fishing activities. The large increase in small-arms activities would take place mainly on the Machine Gun Range, but also on the Terminal Range, Churchill Range, and Harris Range. Hunting and fishing are not allowed on or near the ranges while events are taking place and there is very limited designated hunting with restricted hours near areas where small-arms activities would occur (see Figure 3.13-3). Detonation activities occur on the EEA, but hunting and fishing do not take place where detonation activities occur.

Ordnance activities under Alternative 1 would have negligible, long-term, indirect, negative impacts and no direct impacts on hunting and fishing.

4.13.2.2 EM Energy Activities

Under Alternative 1, the number of EM energy events would increase from 490 to 590 per year, the power of the EM energy events would increase, and NSWCDD would expand its outdoor RDT&E activities, as detailed in Section 2.5.2.

NSF Dahlgren's Ponds, Streams, and Creeks

EM generators, likely including any additional areas used for EM energy activities in the future, would not be located close to the ponds, streams, and creeks on NSF Dahlgren. EM energy activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's ponds, streams, and creeks.

NSF Dahlgren's Vegetation

Most facilities used for EM energy activities are surrounded by pavement and low, maintained vegetation. The vegetation growing at the edges of the EM energy facilities would not receive high doses of EM energy, as the high electric or magnetic field levels experienced within test areas quickly dissipate and return to background levels outside the test areas. Corridors where EM energy activities would take place are areas that are already maintained or over open water. No high quality habitat would be cleared for corridors and therefore the effect on vegetation would be negligible.

EM energy activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

Areas where outdoor EM energy activities occur at NSF Dahlgren generally do not provide high-quality habitat that would attract wildlife, and the HERP safety zones around the facilities are cleared of any large wildlife prior to events. Wildlife outside the test area would encounter very low doses of EM energy as the high electric or magnetic field levels experienced within test areas quickly dissipate and return to background levels. The probability of wildlife's entering test areas at the time of firing would be very low. Although clearing the ranges could disturb wildlife, disturbance would be temporary, and likely would not affect foraging or nesting activities. As discussed above, impacts on vegetation such as grasses, shrubs and other plants used by grazing wildlife would be negligible and therefore there would be no indirect impacts on wildlife from EM energy.

EM energy activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

Before reaching the SIAs, the power of EM energy would be reduced to background levels. Therefore, EM energy activities under Alternative 1 would have no direct or indirect impacts on biological resources associated with SIAs or the SIAs themselves.

Hunting and Fishing

During EM activities, HERP, HERO, HERF, and EMI safety zones and restrictions would be in effect. More EM energy activities may temporarily interrupt hunting and fishing activities. However, most hunting and fishing are not focused in the areas where EM activities would take place and would occur outside of prime hunting and fishing hours. EM energy activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on hunting and fishing.

4.13.2.3 Laser Activities

Under Alternative 1, the number of HE laser events would increase from the current 60 annually to 125 annually. Laser power levels would increase, and activities would be expanded as described in Section 2.5.3.

NSF Dahlgren's Ponds, Streams, and Creeks

The increase in laser activities is unlikely to affect NSF Dahlgren's inland waters due to the low number of laser events performed near them and the implementation of health and safety protocols during events. Laser activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on biological resources associated with NSF Dahlgren's ponds, streams, and creeks.

NSF Dahlgren's Vegetation

Under Alternative 1, HE laser activities would be continue to be conducted on corridors where the vegetation is mowed, as activities require a clear line of sight. Therefore, laser beams would

have little, if any contact with vegetation and increased maintenance is considered to have negligible impacts on vegetation.

Laser activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

Because the corridors used for laser activities are mowed to ensure a clear line of sight, the corridors are not prime wildlife habitat but may adjoin natural areas. NSWCDD personnel would ensure that the test area is clear of wildlife before initiating each test sequence. These safety measures, described under the No Action Alternative, would minimize the risk of wildlife's entering the test area, minimizing potential impacts. As discussed previously, impacts on vegetation such as grasses, shrubs and other plants used by grazing wildlife would be negligible and therefore there would be no indirect impacts on wildlife from laser RDT&E activities.

Laser activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

Under Alternative 1, all outdoor laser activities would continue to be located well away from SIAs. Therefore, laser activities under Alternative 1 would have no direct or indirect impacts on biological resources associated with SIAs or the SIAs themselves.

Hunting and Fishing

During laser activities, eye safety zones and restrictions would be in effect, and laser corridors would be monitored closely before and during all events. The increase in laser activities may cause slight interruptions to hunting and fishing activities but, considering that tests are unlikely to occur at the times during which hunting and fishing is permitted these potential interruptions are considered negligible.

Laser activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on hunting and fishing.

4.13.2.4 Chemical and Biological Defense Activities

Under Alternative 1, activities using chem/bio simulants outdoors would increase from the current baseline of 12 events annually using chemical simulants to 60 events annually using both chemical and biological simulants, but not mixed, as described in Section 2.5.4. Maximum concentrations of chemical simulants that biological receptors could be exposed to are presented in Appendix J. The areas in which the activities would take place would expand to include the PRTR land ranges, the Mission Area, and the MDZ.

NSF Dahlgren's Ponds, Streams, and Creeks

As described for the No Action Alternative, NSWCDD modeled the atmospheric dispersion of chemical simulants released during chemical defense activities, based on established test methods and protocols. Based upon the proposed activities and the modeling presented in Sections 4.4 and 4.8.1, simulant concentrations that aquatic life would be exposed to are

predicted to be well below levels that would cause toxicity, even if simulants are released close to inland waters. The increase in the number of events under Alternative 1 would not affect chemical simulant exposure concentrations.

The biological simulants that may be used under Alternative 1 include spore-forming bacteria such as *Bacillus atrophaeus, B. subtilis, and B. thuringiensis;* non-spore forming bacteria such as *Pantoea agglomerans* and *Deinococcus radiodurans;* ovalbumin; bacteriophage MS2; and the fungus *Aspergillus niger.* No modeling was performed for biological simulants, as NSWCDD would use only BSL-1 simulants. Many of these simulants, such as the bacteria, are ubiquitous and often found in high concentrations in nature, including in water (CRI, 2004; USEPA, 1997). There are no published reports of disease associated with these biological simulants in aquatic plants or animals, nor are they considered to be disease-causing agents. The small concentrations of these simulants deposited on the water would not cause any significant increase in the environment.

Chem/bio defense activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's ponds, streams, and creeks.

NSF Dahlgren's Vegetation

Simulant vapor tests are designed to minimize deposition on land and water areas. Simulants released into the air as vapors would rapidly disperse in the environment. Concentrations of chemical simulants deposited on land and on terrestrial vegetation would be very low – at or near background levels and well below concentrations that have been shown to cause adverse effects. Although there are no terrestrial plant toxicity benchmarks for the simulants that would be used, concentrations that plants would be exposed to would be below levels that would cause adverse effects based on available toxicity tests. In addition, processes such as volatilization and precipitation would reduce concentrations of simulants further. No adverse effects on vegetation would be anticipated from testing of BSL-1 biological simulants.

Chem/bio defense activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

As noted for vegetation, concentrations of chemical simulants deposited on land and on terrestrial vegetation, and to which terrestrial wildlife would be exposed, also would be very low – well below concentrations that have been shown to cause adverse effects. Air concentrations would also be below levels causing adverse effects. No adverse effects on wildlife are anticipated from testing of BSL-1 biological simulants.

Chem/bio defense activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

Chem/bio simulants would not be tested in the SIAs and any simulants that reach SIAs would be at concentrations equivalent to background levels. Chem/bio defense activities under Alternative 1 would have no direct or indirect impacts on biological resources associated with SIAs.

Hunting and Fishing

Under Alternative 1, the increase in annual events may cause slight interruptions to hunting and fishing activities on Mainside and the EEA and to fishing activities on the PRTR. Although chem/bio defense activities may interrupt hunting and fishing activities; however most testing will take place at times when hunting and fishing is not permitted, limiting the potential overlap. Any interruptions would be brief and concentrations of chem/bio simulants would return to background levels prior to the resumption of hunting and fishing.

Chem/bio defense activities under Alternative 1 would have negligible, short-term, direct, negative impacts and no indirect impacts on hunting and fishing.

4.13.3 Alternative 2

4.13.3.1 Ordnance Activities

The number of large-caliber projectiles would remain at current levels and use would be the same as under Alternative 1. The use of small arms would increase, with the number of bullets expended annually increasing from 6,000 to 30,000. Detonations would increase from 190 events to 230 events, as described in Section 2.6.

NSF Dahlgren's Ponds, Streams, and Creeks

Under Alternative 2, ordnance activities would not occur in the ponds, streams, or creeks on NSF Dahlgren, with the possible exception of some small-arms firing from the Machine Gun Range entering the area at the confluence of Upper Machodoc Creek and the Potomac River. As described for Alternative 1, only a small percentage of the bullets fired would enter the river and most of those would be immediately buried, isolating bullets from movement and exposure pathways, resulting in negligible impacts to water bodies. Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's ponds, streams, and creeks.

NSF Dahlgren's Vegetation

Ordnance activities at NSF Dahlgren would minimally impact terrestrial plants. Although individual plants may be damaged by bullets, plants found in maintained areas are generally rapidly growing species that would be replaced in a short time. Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

As described for the No Action Alternative and Alternative 1, ranges would be cleared before events begin, but there is no way to ensure that birds and mammals do not enter the areas during tests. Noise and human activity associated with activities may startle wildlife and cause them to temporarily leave the area, and likely would act as a deterrent to their return before an event's end. Direct hits of wildlife are unlikely, as wildlife would normally vacate test areas temporarily when firing begins and then return after events conclude. Modeling of MCOPCs in munitions indicates that there are no risks to ecological receptors.

Ordnance activities would have negligible, long-term, direct and indirect, negative impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

Increased small-arms firing and detonations under Alternative 2 would have no impacts on SIAs, as all of the SIAs are located away from firing ranges and detonation areas. Therefore, ordnance activities would have no direct or indirect impacts on biological resources associated with SIAs or the SIAs themselves.

Hunting and Fishing

Under this alternative the use of large-caliber guns would remain at current levels, which have negligible impacts to hunting and fishing. The interruption to hunting and fishing from an increase in small-arms firing would result in negligible impact. Detonations would increase, but as hunting and fishing do not take place on the EEA in the areas where detonations occur, no impacts to hunting and fishing would result. Ordnance activities under Alternative 2 would have negligible, long-term, indirect, negative impacts and no direct impacts on hunting and fishing.

4.13.3.2 EM Energy Activities

Under Alternative 2, the number of EM events would increase from 490 to 680 per year, the power of the EM energy devices would increase, and NSWCDD would expand its outdoor RDT&E activities, as detailed in Section 2.5.2.

NSF Dahlgren's Ponds, Streams, and Creeks

EM generators, likely including any additional areas used for EM energy activities in the future, would be located distant from the ponds, streams, and creeks on NSF Dahlgren. EM energy activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's ponds, streams, and creeks.

NSF Dahlgren's Vegetation

The vegetation growing at the edges of the EM energy facilities would not receive high enough doses of EM energy to be impacted. The vegetation growing at the edges of the EM energy facilities would not receive high doses of EM energy, as the high electric or magnetic field levels experienced within test areas quickly dissipate and return to background levels outside the test areas. Corridors where EM energy activities would take place are areas that are already maintained or over open water. No high quality habitat would be cleared for corridors and therefore the effect on vegetation would be negligible.

EM energy activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

Areas where outdoor EM energy activities occur at NSF Dahlgren do not provide high-quality habitat that would attract wildlife, and the HERP safety zones around the facilities are cleared of large wildlife prior to events. Wildlife outside the test area would encounter very low doses of

EM energy, and the probability of wildlife's entering test areas at the time of firing would be very low. Although clearing the ranges could disturb wildlife, disturbance would be temporary, and likely would not affect foraging or nesting activities. As discussed above, impacts on vegetation such as grasses, shrubs and other plants used by grazing wildlife would be negligible and therefore there would be no indirect impacts on wildlife from EM energy.

EM energy activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

Before reaching the SIAs, the power of EM energy would be reduced to background levels. Therefore, EM energy activities under Alternative 2 would have no direct or indirect impacts on biological resources associated with SIAs.

Hunting and Fishing

During EM activities, HERP, HERO, HERF, and EMI safety zones and restrictions would be in effect. However, most hunting and fishing are not focused in the areas where increased EM activities would take place and would occur outside of prime hunting and fishing hours. EM energy activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on hunting and fishing.

4.13.3.3 Laser Activities

Under Alternative 2, the number of HE laser events would increase from 60 to 145 events per year, and power levels would increase, and activities would be expanded as described in Section 2.6.

NSF Dahlgren's Ponds, Streams, and Creeks

The increase in laser activities is unlikely to affect NSF Dahlgren's inland waters due to the low number of laser events performed near them and the implementation of health and safety protocols during events. Laser activities under Alternative 2 would have would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's ponds, streams, and creeks.

NSF Dahlgren's Vegetation

Under Alternative 1, HE laser activities would be continue to be conducted on corridors where the vegetation is mowed, as activities require a clear line of sight. Therefore, laser beams would have little, if any contact with vegetation and increased maintenance is considered to have negligible impacts on vegetation.

Laser activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

Because the corridors used for laser activities are mowed to ensure a clear line of sight, the corridors are not prime wildlife habitat but may adjoin natural areas. NSWCDD personnel used

as spotters would ensure that the test area is clear of wildlife – predominantly white-tailed deer and visible birds – before initiating each test sequence. These safety measures, described under the No Action Alternative, would minimize the risk of wildlife's entering the test area, minimizing potential impacts. As discussed previously, impacts on vegetation such as grasses, shrubs and other plants used by grazing wildlife would be negligible and therefore there would be no indirect impacts on wildlife from laser RDT&E activities.

Laser activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

Under Alternative 2, all outdoor laser activities would continue to be located well away from SIAs. Therefore, laser activities under Alternative 2 would have no direct or indirect impacts on biological resources associated with SIAs or the SIAs themselves.

Hunting and Fishing

During HE laser activities, eye safety zones and restrictions would be in effect, and laser corridors would be monitored closely before and during all events. The increase in laser activities may cause slight interruptions to hunting and fishing activities but, considering that tests are unlikely to occur at the times during which hunting and fishing is permitted these potential interruptions are considered negligible.

Laser activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on hunting and fishing.

4.13.3.4 Chemical and Biological Defense Activities

Under Alternative 2, the number of events using chem/bio simulants would increase from the current baseline of 12 events annually using chemical simulants to 70 events annually using both chemical and biological simulants, which may be mixed together, as described in Section 2.6. Maximum concentrations of chemical simulants that biological receptors could be exposed to are presented in Appendix J. The areas in which the activities would take place would expand to include the PRTR land ranges and the Mission Area.

NSF Dahlgren's Ponds, Streams, and Creeks

As described for the No Action Alternative and Alternative 1, NSWCDD modeled the atmospheric dispersion of chemical simulants released during chemical defense activities, based on established test methods and protocols. Based upon the proposed activities, simulant concentrations that aquatic life would be exposed to are predicted to be well below levels that would cause toxicity, even if simulants are released close to inland waters. The increase in the number of events under Alternative 2 would not affect chemical simulant exposure concentrations.

There are no published reports of disease associated with these biological simulants in aquatic plants or animals, nor are they considered to be disease-causing agents. The small concentrations of these simulants deposited on the water would not cause any significant increase in the

environment. There are no records of synergistic reactions between the low-toxicity chemical simulants and BSL-1 simulants that would be used.

Chem/bio defense activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's ponds, streams, and creeks.

NSF Dahlgren's Vegetation

Simulant vapor tests are designed to minimize deposition on land and water areas. Simulants released into the air as vapors would rapidly disperse in the environment. Concentrations of chemical simulants deposited on land and on terrestrial vegetation would be very low – at or near background levels and well below concentrations that have been shown to cause adverse effects. Although there are no terrestrial plant toxicity benchmarks for the simulants that would be used, concentrations that plants would be exposed to would be below levels that would cause adverse effects based on available toxicity tests. In addition, processes such as volatilization and precipitation would reduce concentrations of simulants further. No adverse effects would be anticipated from testing of BSL-1 biological simulants. There are no records of synergistic reactions between the low-toxicity chemical simulants and BSL-1 simulants that would be used; and given the low level of risk from both elements, no synergistic effects are expected.

Chem/bio defense activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's vegetation.

NSF Dahlgren's Wildlife

As noted for vegetation, concentrations of chemical simulants deposited on land and on terrestrial vegetation, and to which terrestrial wildlife would be exposed, also would be very low – well below concentrations that have been shown to cause adverse effects. Air concentrations would also be below levels causing adverse effects. No adverse effects on wildlife are anticipated from the testing of BSL-1 biological simulants.

Chem/bio defense activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on NSF Dahlgren's wildlife.

Special Interest Areas (SIAs)

Chem/bio simulants would not be tested in the SIAs and any simulants that reach SIAs would be at concentrations equivalent to background levels. Chem/bio defense activities under Alternative 2 would have no direct or indirect impacts on biological resources associated with SIAs or the SIAs themselves.

Hunting and Fishing

Under Alternative 2, the increase in annual events may cause more interruptions to hunting and fishing activities on Mainside and the EEA and to fishing activities on the PRTR. However most testing will take place at times when hunting and fishing is not permitted, limiting the potential overlap. Any interruptions would be brief and concentrations of chem/bio simulants would return to background levels prior to the resumption of hunting and fishing.

Chem/bio defense activities under Alternative 2 would have negligible, short-term, direct, negative impacts and no indirect impacts on hunting and fishing.

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4.14 Protected Species

NSWCDD coordinated with appropriate federal and state natural resource agencies, including the United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), Virginia Department of Conservation and Recreation (VDCR), Virginia Department of Game and Inland Fisheries (VDGIF), and Maryland Department of Natural Resources (MDNR), regarding regulatory compliance with federal and state laws. Coordination with these agencies is documented, as relevant, in this section for protected species and in other applicable sections of Chapters 3 and 4; in Appendix A, which contains the comments received on the NSWCDD DEIS for Outdoor RDT&E Activities; and in Appendix G, which presents the correspondence with these agencies.

4.14.1 No Action Alternative

4.14.1.1 Ordnance Activities

Almost all recorded large-caliber projectiles fired at NSF Dahlgren since 1918 have been fired into the MDZ, with a limited number of projectiles entering the LDZ, particularly the area up to 40,000 yds from the firing line. Under this alternative, as well as under Alternatives 1 and 2, most of the 4,700 large-gun projectiles fired in particularly active years would continue to be fired into the same heavily-used area in the MDZ.

Approximately 6,000 bullets would be fired each year. Much of the outdoors small-arms firing is directed into gun butts, reducing the number of bullets entering the river. Approximately 90 percent of small-arms firings are and would continue to be over land, and the bullets would not enter the river. The remaining 10 percent (600 rounds) of the firings would be from land into the river, with the bullets entering the river.

Approximately 190 detonations would take place each year. Most detonations would take place inland on the EEA's Harris and Churchill Ranges, and infrequently on the EOD training range on the Missile Test Range, all well-removed from the waters of the Potomac River. Occasionally, devices would be detonated on vessels in the river. A portion of the debris and residues from detonations on vessels could enter the river, but the quantities of these materials would be small, as such detonations would be infrequent.

Fish

As described in Section 3.14.2, two federally-listed endangered fish species, the shortnose sturgeon and the Atlantic sturgeon, are found in the PRTR portion of the Potomac River. In compliance with Section 7 of the Endangered Species Act (ESA), a Biological Assessment (BA) was prepared to evaluate the potential effect of the Proposed Action on the shortnose, Atlantic sturgeon, and sea turtles and sent to NMFS (NSWCDD, 2011). NMFS concurred with the determination in the BA on January 11, 2012 (Morris, January 11, 2012). The BA is included as Appendix H of this EIS. The potential impacts on both sturgeon species are discussed below because they share many characteristics.

There is the potential for direct and indirect impacts on sturgeon from RDT&E ordnance activities. Direct effects are considered to be any adverse effects arising from Proposed Action

activities that could result in immediate impacts on individuals or changes to their habitat. These effects include physical injury or death, disruption of migration or reproduction, disruption of egg development, and direct alteration of existing habitat. Indirect effects are defined as any effects that are caused by or could result from the Proposed Action later in time, but which are still reasonably certain to occur. These effects include water/sediment quality impairment and indirect alteration of habitat.

Both shortnose and Atlantic sturgeon are anadromous (migrate to fresher water to spawn but live in more saline water) and demersal (spend most of their time on or near the bottom of the river). Therefore, they usually are found in the river below the water depth where detonations occur, as described below. As discussed in Section 1.5.1, projectiles fired into the MDZ and upper LDZ by NSWCDD can be live or inert. The fuzes tested in both inert and live projectiles are programmed to detonate above the water surface, where detonations can be observed and recorded by researchers. The potential effects from above-water detonations are not expected to affect the shortnose or Atlantic sturgeon, as the air-water interface would reflect most of the energy from the shock wave outward and upward (see Section 4.11.1.1).

A small percentage of projectile fuzes NSWCDD tests fail to detonate in the air and instead detonate when the projectile hits the water surface or below the surface. NSWCDD estimates that less than two percent of live rounds detonate underwater, and those that do generally detonate near the surface of the water (NSWCDL, 2008). A shock wave can be created when fluid (air or water) is rapidly displaced by a projectile. Impacts from live projectiles that detonate underwater may include direct strike of an animal or the effects of pressure pulses generated by the detonation (e.g., organ damage) if an animal is nearby.

In addition to the potential for direct effects from the detonation of live projectiles, there is a remote possibility of directly hitting a breaching sturgeon as it breaks the water surface by the entry of a projectile (either live or inert) into the water, or shooting a foraging/migrating sturgeon as an inert or live dud projectile embeds in the river bottom.

Detonations close to the water surface would have low potential to impact sturgeon that, as bottom feeders, spend most of their time on or near the river bottom (NMFS, 1998; ASSRT, 2007). Because the shock wave generated by a detonation below the surface of the water spreads spherically outward (NSWC, 1978), the energy of the shock wave attenuates exponentially away from the point of detonation and would be substantially reduced near the bottom, the preferred habitat of sturgeon.

Currently, in particularly active years approximately 4,700 large-caliber projectiles are fired into the PRTR. Under the Proposed Action, this number would not change. As described in Section 1.5.1, only 26 percent of projectiles fired are live and of those less than 2 percent detonate under water, resulting in the detonation of about 24 projectiles under water each year (4,700 x 0.26 x 0.02 = 24.4). As described previously, the area between the Main Range gun line and 25,000 yds in the MDZ accounts for 99.4 percent of all munitions tested on the PRTR; this area is referred to as the diffuse zone, and covers an area of 31 sq NM.

The projectiles are fired at gunnery targets – mainly virtual targets (effectively, the river itself), as well as floating targets – on the Potomac River, mostly in the MDZ but infrequently in the upper LDZ. By design, gunfire may destroy or damage some physical targets, such as floating radar reflectors, fixed platforms in the river, UAVs, vessels, towed sleds, and causeway sections. The environmental impacts of fragmenting these targets are minimized by removing hazardous

materials such as batteries, oil, gasoline, and antifreeze to the extent possible prior to destroying or damaging them. After the target is impacted and the test completed, all remaining debris and any waste is cleaned up. Therefore, any impacts from target debris are considered insignificant.

Between 1996 and 2010, 15 shortnose sturgeon and 226 Atlantic sturgeon were documented in the Potomac River as a result of the Atlantic Sturgeon and Shortnose Sturgeon Reward Program (refer to Figures 3.14-2 and 3.14-3). A maximum of two shortnose sturgeon have been captured in any single year, while a maximum of 36 Atlantic sturgeon (including five recaptures) have been caught in any one year. Forty-four of these captures have been within the diffuse zone (43 Atlantic sturgeon and 1 shortnose sturgeon) and nine of these captures (8 Atlantic sturgeon, 1 shortnose sturgeon) have been within the zone receiving the highest density of projectiles, the dense zone.

Given the small number of live projectiles detonating underwater annually (24), the small area that would be affected by a projectile's detonating close to the surface of the water, the large area over which almost all munitions are fired (31 sq NM), the intermittent nature of the testing, and the small number of sturgeon in the Potomac River, the probability of a sturgeon's being hit by a projectile or by an associated shockwave is extremely low.

Indirect effects of ordnance on sturgeons could include increases in the suspended sediments near the area where projectiles enter the sediment, impairment of water and/or sediment quality, disruption of migration or spawning, and habitat disturbance, as discussed below.

Under all alternatives, the number of large-caliber projectiles fired annually in the PRTR would be similar to the levels of the last 15 years. Indirect effects on the shortnose and Atlantic sturgeon from testing are potential increases in suspended sediments in the water column, water and/or sediment quality impairment from munitions constituents, habitat disturbance (i.e., burial of prey by sediment resuspension), and disruption of sturgeon.

When an inert or dud projectile penetrates river sediment, a small crater is created at the entry point, releasing sediment into the water column. Sediment in the main channel of the PRTR is predominantly gray to black clay or silty clay based on samples taken there (Knebel et al., 1981; also see Figure 3.9-9). Increases in the level of suspended solids would be concentrated near the area where projectiles enter the sediment. No documented estimates of the increase in suspended material could be found, but it is anticipated that the sediments disturbed at the impact site would quickly settle out of the water column and not affect populations of invertebrates that sturgeon feed upon. Increases in levels of suspended sediments caused by projectiles entering the sediment would be localized, and these short-term individual events would not affect the current levels of suspended sediments found in the water column.

As described previously, munitions fired into the PRTR over the last 90 years have introduced explosives and metals into the river. A fate and transport model was used (Appendix F) to estimate the potential loading of explosives and metals into the river water and sediment using conservative assumptions. The predicted concentrations of metals in the dense and diffuse areas of the MDZ (Table 4.11-1) were compared to water quality (Tables 4.11-2 and 4.11-4) and sediment quality (Tables 4.11-3 and 4.11-4) criteria. Modeled concentrations of metals and explosives contributed by munitions activities in the PRTR range from about 5 to more than a billion times below target water and sediment quality criteria values (Tables 4.11-5 to 4.11-8) for both metals and explosives, indicating that compounds from munitions activities have no adverse impacts on aquatic life, including shortnose and Atlantic sturgeon.

Sediment criteria and guidelines are generally based on benthic community metrics and toxicity studies performed on invertebrates and fish. As an additional comparison, metal body burdens (tissue concentration) in fish were estimated based on bioconcentration factors (BCFs) from the water column. BCFs were calculated for fish (see Section 4.11.1.4), so they are also applicable to the shortnose and Atlantic sturgeon. All modeled munitions concentrations in fish in the PRTR were thousands to more than a trillion times below concentrations potentially resulting in adverse effects, as shown in Table 4.11-11.

Disturbance of shortnose and Atlantic sturgeon habitat by projectiles entering the river bottom is not anticipated to impact benthic (river bottom) invertebrate communities (see Section 3.11.3), which serve as a food source for sturgeon. Recolonization of impacted areas by benthic invertebrates is expected to be rapid, as most benthic invertebrate communities have been shown to recover rapidly from disturbance, generally within one year (e.g., Gore, 1979; Niemi et al., 1990). Localized areas where projectiles enter the river bottom would be quickly recolonized from adjacent areas. Therefore, habitat disturbance would be temporary, and shortnose and Atlantic sturgeon would not experience any decrease in prey due to localized ordnance activities. Most detonations would occur on land ranges (infrequently, detonations take place on barges in the PRTR), which would have no impact on shortnose or Atlantic sturgeon.

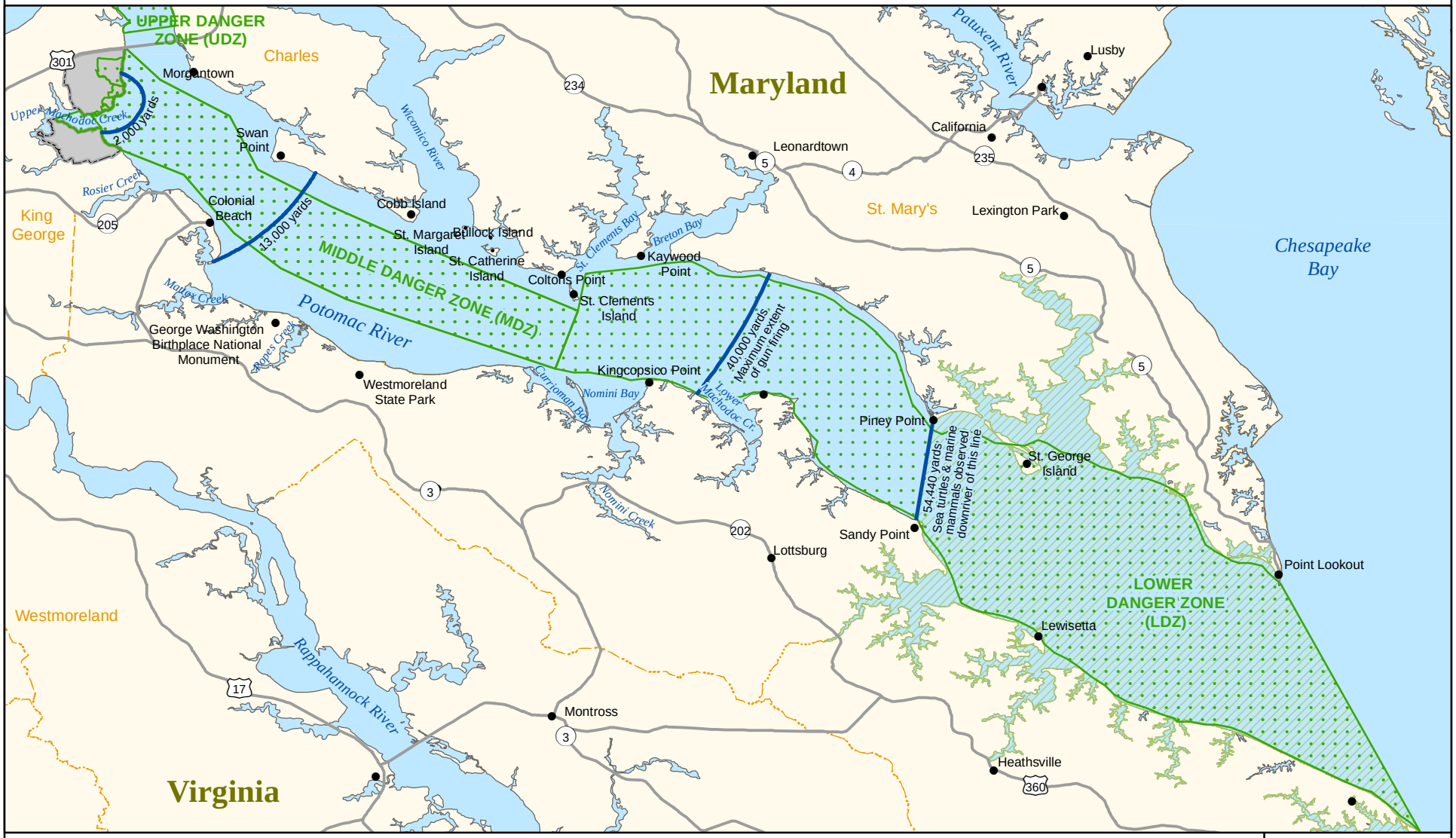
There is no evidence that sturgeon are spawning in the Potomac River. However, if they were, ordnance activities on the PRTR would not disrupt potential spawning of the shortnose or Atlantic sturgeon. There is no physical overlap between the PRTR and potential spawning grounds located at the head of tide in the vicinity of Little Falls above Washington, DC, many miles upriver of the PRTR.

Therefore, under Section 7 of the ESA, the effect of ordnance activities on the shortnose sturgeon and Atlantic sturgeon under the No Action Alternative is expected to be insignificant or discountable. In a letter dated January 11, 2012, NMFS concurred that RDT&E activities covered by this EIS may affect, but are not likely to adversely affect any listed species under NMFS jurisdiction (Morris, January 11, 2012). In accordance with NEPA, ordnance activities under the No Action Alternative would have negligible, long-term, direct and indirect, negative impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

As discussed in Section 3.14.3.2, three species of sea turtles are known to occur in the lower Potomac River based on reported stranding incidents: loggerhead, Kemp's ridley, and, to a lesser extent, the green turtle. No ordnance is fired into the lower LDZ, where sea turtles occur (Figure 4.14-1, Distance to Areas of Sea Turtle and Marine Mammal Occurrence). The maximum extent of projectile testing (40,000 yds from the Main Range gun line) takes place and would continue to occur in the future more than 6.5 NM (13,165 yds) upriver of where sea turtles may be present. Therefore, there would be no possibility of a sea turtle's being in the vicinity of a detonation and no potential for direct effects.

Distance to Areas of Sea Turtle and Marine Mammal Occurrence



Potomac River Test Range (PRTR) Complex

Sea Turtle and Marine Mammal Distribution Area

Naval Support Facility (NSF) Dahlgren

6 0 6 Miles

10 0 10 Kilometers

NSWCDD EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDD GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 4.14-1

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Under all alternatives of the Proposed Action, the number of large-caliber projectiles fired annually in the PRTR would be similar to the levels of the last 15 years. Indirect effects on sea turtles from testing are potential increases in suspended sediments in the water column and water and/or sediment quality impairment from munitions constituents. The levels of suspended sediments in the water column and concentrations of munitions constituents in water and sediments would be lower than those described above for the shortnose and Atlantic sturgeon. Concentrations would be diluted to undetectable levels by the time they reach Sandy Point, Virginia/Piney Point, Maryland in the lower LDZ, the upper limit of where sea turtles have been observed in the Potomac River (discussed in Section 4.14.1).

Sea turtle auditory sensitivity is not well studied, although research completed to date suggests that it is limited to low-frequency bandwidths. Studies using green, loggerhead, and Kemp's ridley turtles found that sensitivity varies slightly by species and age class (Ketten and Bartol 2006). Sea turtles possess an overall hearing range of approximately 100 to 1,000 Hz, with an upper limit of 2,000 Hz (Ridgway et al., 1969; Ketten and Bartol, 2006).

Sound travels about 4.5 times faster in water than in air, at a speed of about 1,500 m per second, depending on the depth, temperature, and salinity of the water (OceanLink, 2011). Sea turtles are likely to hear low frequency explosions underwater, but given the current ambient sound levels in the Potomac River, the amount of sound contributed by ordnance RDT&E activities is considered to be low. Preliminary data examining computerized tomography scan images of a 100 lbs per square inch shock wave exposure on a small (12-in long) Kemp's ridley carcass showed no ear or lung damage was evident on the scans (NOAA Fisheries Service, 2011). A dolphin would have shown obvious damage at this level, indicating that turtles are less sensitive to explosions than marine mammals (NOAA Fisheries Service, 2011). It is not anticipated that sea turtles would suffer any long-term consequences from ordnance sound, particularly because projectiles would be fired a minimum of 6.5 NM upriver of the area of the river where sea turtles may be found.

As described in Section 4.11.1.1, modeled concentrations of metals and explosives contributed by munitions activities in the PRTR are 5 to billions of times below target water and sediment quality criteria values for both metals and explosives in the dense and diffuse zones of the MDZ. Concentrations would be even lower in the LDZ due to dilution, resulting in background level concentrations of metals and no detection of explosives from NSWCDD activities and would have negligible, if any, effects on sea turtles.

Based on the location of ordnance activities relative to the occurrence of sea turtles, in accordance with Section 7 of the ESA, potential effects of ordnance activities under the No Action Alternative are considered to be insignificant or discountable. In a letter dated January 11, 2012, NMFS concurred that RDT&E activities covered by this EIS may affect, but are not likely to adversely affect any listed species under NMFS jurisdiction (Morris, January 11, 2012). In accordance with NEPA, ordnance activities under the No Action Alternative would have no direct and negligible, short-term, indirect negative impacts on sea turtles.

Birds

Migratory birds are commonly found at NSF Dahlgren, particularly around the Potomac River and other waters. Federal species of concern that may occur within a four-mile radius of the installation include the loggerhead shrike (*Lanius ludovicianus*), black rail (*Laterallus*

jamaicensis), and cerulean warbler (*Dendroica cerulean*) (Table 3.14-1). Nine bird species listed as state threatened or state species of special concern have been observed at NSF Dahlgren (NSF Dahlgren, 2007). Potential impacts on migratory birds and other protected bird species are discussed in Section 4.12. However, as there is a specific management plan for the bald eagle at NSF Dahlgren (NSF Dahlgren and NAVFAC Washington, 2007), this discussion focuses on impacts on the bald eagle, which while no longer an ESA-listed species, is protected at the federal level by the Bald and Golden Eagle Protection Act (BGEPA), the Lacey Act, and the Migratory Bird Treaty Act (MBTA).

Three of the SIAs at NSF Dahlgren, which are located away from firing ranges and detonation areas, provide nesting habitat for bald eagles. Nesting has also been observed outside of the SIAs (Figure 3.12-3), indicating that suitable habitat is not restricted to this area, and that activities conducted in other areas of NSF Dahlgren have not discouraged bald eagle nesting, despite noise associated with firing. Protection zones are established around of all bald eagle nests, with the first protection zone (PZ1) extending from the nest tree to a radius of 750 ft and the second zone (PZ2) extending from 750 ft to 1,320 ft or a quarter-mile in radius (NSF Dahlgren and NAVFAC Washington, 2007).

As discussed in Section 3.12.3.1, the number of bald eagles along the Potomac River has been steadily rising since surveys began in 1977. The number of nests documented at NSF Dahlgren increased from 1 to 11 between 1983 and 2008. The bald eagle population at NSF Dahlgren, in and outside of the SIAs, shows no evidence of being affected by current ordnance activities. Individual bald eagles could be hit by projectiles – although the probability of this would be very low – or the behavior of individuals could be affected by the noise of gun firings; however, no behavioral changes have been observed.

Ordnance activities under the No Action Alternative would not affect the bald eagle, which is protected by the BGEPA and the Lacey Act. Nor would ordnance activities affect ESA-listed bird species, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, ordnance activities under the No Action Alternative would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

As discussed in Section 3.14.5, four species of marine mammals have been sighted or stranded in the Potomac River: bottlenose dolphin, harbor porpoise, Risso's dolphin, and minke whale. These species are not ESA-listed, nor are they considered depleted under the Marine Mammal Protection Act (MMPA).

Four marine mammal species that occur rarely or regularly in the Chesapeake Bay are listed as endangered under the ESA. These include three baleen whale species – North Atlantic right whale (*Eubalaena glacialis*), humpback whale (*Megaptera novaeangliae*), and fin whale (*Balaenoptera physalus*) – and the West Indian manatee (*Trichechus manatus*). These three species of whales are known to migrate past the mouth of Chesapeake Bay, and, on rare occasions, they enter the bay and have been sighted or recorded as stranded (DoN, 2009). The three large whale species are transient within the Bay, but there are no records of their occurring in the Potomac River (DoN, 2009). Historical marine mammal sighting records include two sightings of the West Indian manatee in the Potomac River, with the last sighting in August 1980 (DoN, 2009). However, the Chesapeake Bay area is outside of the

normal range of the manatee, which prefers warmer waters, and these two sightings are considered atypical. As there is no spatial overlap between the PRTR and ESA-listed marine mammals under normal conditions, they are not discussed further here.

According to NOAA Ocean Service maps (NOS, 2005), marine mammals are found in the lower Potomac River from the mouth to Sandy Point, Virginia and Piney Point, Maryland (Figure 4.14-1), which coincides with the lower part of the LDZ. NSWCDD range control boat operators, who are on the river in the MDZ five days a week, confirm that marine mammals are not sighted in this most active part of the PRTR (Patteson, pers. comm., August 4, 2008).

Bottlenose dolphins are the only marine mammal regularly sighted in the lower Potomac River. Nearshore bottlenose dolphins occur in the Chesapeake Bay and its tributaries from April to November (VDEQ, 1997).

Since 1995, there have been only two reported strandings of harbor porpoises, one of a Risso's dolphin, and one of a minke whale in the Potomac River (Collins-Payne, pers. comm., March 23, 2006, May 23, 2007, and October 13, 2009). All stranded individuals were found dead and therefore they may have drifted to the locations at which they were found (see Table 3.14-4).

The normal ranges of Risso's dolphin and the minke whale do not include the Chesapeake Bay, so these species are considered "extralimital" in this area (occurring outside their normal range) (DoN, 2009). Based on the feeding and habitat preferences of harbor porpoises and the low incidence of sightings and strandings in the lower Potomac River, harbor porpoises occur very rarely on the PRTR (see Section 3.14.5). Because the ranges of these species normally do not include the lower Potomac River, under all alternatives, no impacts to harbor porpoises, Risso's dolphins, and minke whales are anticipated – only potential impacts to bottlenose dolphins are evaluated further.

As discussed in Section 3.14.1, the National Defense Authorization Act of fiscal year 2004 (Public Law 108-136) amended the definition of harassment under the MMPA as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government, consistent with Section 104(c)(3) [16 U.S.C. §1374 (c)(3)]. The fiscal year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the fiscal year 2003 National Defense Authorization Act (Public Law 107-314). The Proposed Action constitutes a military readiness activity as that term is defined in Public Law 107-314, as the Proposed Action constitutes "training and operations of the Armed Forces that relate to combat" and constitutes "adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use."

For military readiness activities, MMPA Level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. As defined in prior rulings (NOAA, 2001, 2002), injury is the destruction or loss of biological tissue. Consistent with prior actions and rulings (NOAA, 2001), this analysis assumes that all injuries (slight to severe) are considered Level A harassment under the MMPA. MMPA Level B harassment includes all actions that disturb or are likely to disturb a marine mammal or marine mammal stock in the wild through the disruption of natural behavioral patterns. This includes, but is not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered. The noise from underwater detonations may have potential adverse effects on marine mammals, resulting in Level A or Level B harassment.

Areas in which Level A and Level B harassment are predicted to occur are described as harassment zones. The Level A harassment zone extends from the source out to the distance and exposure at which the slightest amount of injury is predicted to occur. The acoustic exposure that produces the slightest degree of injury is, therefore, the threshold value defining the outermost limit of the Level A harassment zone. Use of the threshold associated with the onset of slight injury as the most distant point and least injurious exposure takes account of all more serious injuries by inclusion within the Level A harassment zone.

The Level B harassment zone begins just beyond the point of slightest injury and extends outward from that point to include all animals with the potential to experience Level B harassment. The animals predicted to be in the portion of the zone where temporary impairment of sensory function (altered physiological function) is expected are all assumed to experience Level B harassment because of the potential impediment of behaviors that rely on acoustic cues. Beyond that distance, the Level B harassment zone continues to the point at which no biologically-significant behavioral disruption is expected to occur.

Table 4.14-1 provides estimated impact areas associated with harassment thresholds for dolphins for the detonation of a single 155 mm explosive round (22.47 lbs net explosive weight [NEW] – about twice the weight of explosives typically contained in the type of 155 mm round NSWCDD generally fires). If a 155 mm explosive round detonated at the maximum downriver extent of firing on the PRTR – 40,000 yds from the Main Range gun line – the most extensive impact radius indicated in Table 4.14-1 of 692 ft would end approximately 6.5 NM upstream of the area where marine mammals are known to occur (Figure 4.14-1). There would be no overlap between ordnance testing and the occurrence of bottlenose dolphins. Therefore, continued testing under the No Action Alternative would not result in Level A or B harassment.

Table 4.14-1
Estimated Impact Radii for Dolphins for a 155 mm Detonation

Impact Criterion and Threshold	Estimated Impact Radius (ft)	
	Summer	Winter
Injurious Physiological Effects		
Mortality – Onset extensive lung injury (30.5 psi-ms)	66	66
Onset slight lung injury (indexed to 13 psi-ms)	102	102
50% tympanic-membrane rupture (205 dB re 1 μPa^2-s)	125	112
Non-injurious Physiological Effects		
Temporary Threshold Shift – Energy (182 dB re 1 μPa^2-s)	413	351
Temporary Threshold Shift – Peak pressure (23 psi)	692	686
Source: Based on MCB Camp Lejeune, 2009, Table 5-2.		

Modeled concentrations of metals and explosives contributed by munitions activities in the PRTR are range from about 5 to more than a billion times below target water and sediment quality criteria values (Tables 4.11-5 to 4.11-8) for both metals and explosives in the dense and diffuse zones of the MDZ. Concentrations would be even lower in the LDZ due to dilution,

resulting in background level concentrations of metals and no detectable explosives from NSWCDD activities.

Based on these analyses, there are no reasonably foreseeable takes of marine mammals associated with ordnance activities in accordance with the MMPA. In accordance with NEPA, ordnance activities would have no direct or indirect impacts on marine mammals.

Insects

The USFWS Virginia Ecological Services Field Office identified the Northeastern beach tiger beetle in a species list that enumerates threatened, endangered, and proposed species, designated critical habitat, and candidate species that may be present in the project area or may be affected by the Proposed Action (USFWS, January 21, 2013; see Appendix G page G-65). USWFS species lists are not entirely based upon the current range of a species and may also take into consideration actions that affect a species downstream.

Northeastern beach tiger beetle populations have been observed on beaches near the mouth of the Potomac River, along the Virginia side of the LDZ (Figure 3.14-4), more than 9 NM below the farthest downriver extent of gun-firing (Figure 4.14-1). The LDZ is a water range and does not include any land areas. Suitable habitat for the tiger beetle, consisting of open, undisturbed beaches, sand flats, dunes, water edges, woodland paths, and sparse grassy areas, is absent within the range areas where RDT&E activities would occur.

Ordnance activities would not directly or indirectly affect Northeastern beach tiger beetle suitable habitat along the PRTR LDZ, as NSWCDD's ordnance activities would take place in deep water well away from the LDZ shoreline.

Modeled concentrations of metals and explosives contributed by munitions activities in the PRTR are orders of magnitude below target water and sediment quality criteria values (Tables 4.11-5 to 4.11-8) for both metals and explosives in the dense and diffuse zones of the MDZ. Based on the low concentrations of munitions constituents, there would be no indirect effects on tiger beetles potentially occurring downstream along the LDZ shoreline.

A USFWS Virginia Ecological Services Field Office online project review of the Proposed Action conducted by NSWCDD determined that because no suitable habitat is present within the project area, the Proposed Action would have no effect on the Northeastern beach tiger beetle (Wray, January 23, 2013; see Appendix G page G-83). The USFWS Virginia Ecological Services Field Office concurred with the determination on February 19, 2013 (Drummond, February 19, 2013; see Appendix G page G-101).

In accordance with Section 7 of the ESA, ordnance activities under the No Action Alternative would have no effect on listed insect species. In accordance with NEPA, ordnance activities would have no direct or indirect impacts on tiger beetles.

Plants

The USFWS Virginia Ecological Services Field Office identified sensitive joint-vetch, an annual plant found in tidal wetlands along the shoreline of the Potomac River, in a species list that enumerates threatened, endangered, and proposed species, designated critical habitat, and

candidate species that may be present in the project area or may be affected by the Proposed Action (USFWS, January 21, 2013; see Appendix G page G-65). This determination was based on screening information and not actual species occurrences. A USFWS Virginia Ecological Services Field Office online project review of the Proposed Action conducted by NSWCDD determined that the Proposed Action may adversely affect the sensitive joint-vetch (Wray, January 23, 2013; see Appendix G page G-83). This determination was the only outcome possible in the online review process, because suitable habitat exists for the sensitive joint-vetch within NSF Dahlgren and no recent surveys have been conducted that demonstrate that the species is not present on the installation. The USFWS Virginia Ecological Services Field Office concurred with the determination on February 19, 2013 (Drummond, February 19, 2013; see Appendix G page G-101). However, based on site- and project-specific information, the Proposed Action would have no effect on this species for the reasons discussed in the following paragraphs.

Although potential habitat exists for rare plants on NSF Dahlgren, no rare plants were found on the installation during a survey performed in 2004 (DoN, 2004b). To confirm that this species is not present, the sensitive joint-vetch, which is an annual (a plant that lives for only one growing season), requires a field survey performed within the last year. Therefore, consistent with USFWS Virginia Ecological Services Field Office guidelines (USFWS, 2004), the 2004 rare, threatened, and endangered plant species survey is not sufficiently recent to confirm that sensitive joint-vetch is not present. However, even if this species occurs in tidal wetlands on the installation, it is unlikely to be present in the range areas used for ground-disturbing activities, as discussed in Section 3.14.7, as there is no suitable habitat in these areas. If a rare plant were to be discovered at NSF Dahlgren, it is likely that an exclusion zone would be placed around it.

No new construction or ranges are associated with any of the proposed activities covered in this EIS, minimizing potential impacts on habitat. Ordnance activities on the PRTR would not affect plants along the shoreline and in wetlands, including any protected species that may be present, because the target and detonation areas are distant from the shoreline and wetlands, as well as distant from suitable habitat for protected plants. There would be no direct impacts from projectiles or bullets on rare plants. There also would be no indirect impacts from munitions constituents on plants, as any potential munitions constituents reaching them in the surface water or sediments would be at or below background concentrations.

In accordance with Section 7 of the ESA, ordnance activities under the No Action Alternative would have no effect on sensitive joint-vetch. In accordance with NEPA, ordnance activities under the No Action Alternative would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.1.2 EM Energy Activities

Under the No Action Alternative NSWCDD would continue to use three main outdoor facilities for electromagnetic environmental effects (E3) and hazards of electromagnetic radiation to ordnance (HERO) activities: NOTES, MOATS, and two ground planes. MOATS and the two ground planes are in highly-developed areas with little or no natural habitat surrounding them, whereas NOTES is surrounded by forest in an area with little human activity. All three facilities are located on land in the Mission Area or land ranges, away from the PRTR, and their use would not affect aquatic organisms or aquatic habitats. Radars are tested at the STSTS on Main Range and would continue to operate over the PRTR. The EM energy from these radars may

strike the water surface. EM launchers RDT&E takes place at the EMLF, which beyond a safety zone, is surrounded by forest.

The NDEC and the CETFAC transmit directed energy (microwaves, RF, and lasers) outdoors across the waters of the Potomac River within the PRTR, near the mouth of Upper Machodoc Creek (see Figure 1-7). For directed energy activities over the water, beams of directed energy are transmitted above the water and predominantly would not strike or penetrate the water surface. Activities are tightly controlled and the likelihood of directed energy beams' straying from the target and target platform and hitting the surface of the water is extremely small.

Should EM energy from radars or from directed energy tests strike the water surface, it would be incidental. For the reasons discussed in Section 4.11.1.2, the potential harmful effects of EM energy on aquatic organisms would be highly localized and would be limited to the uppermost water layer. Waves of EM energy that strike the surface of the water may be reflected at the air-water boundary, but would be scattered upon hitting the rough surface of the water, as shown in Figure 1-8a. EM energy that breaches the water surface would be propagated and attenuated, rapidly decreasing in amount and intensity as it travels through the water.

The only EM sensor activity that would be conducted below water is the occasional deployment of modified passive sonobuoys in the PRTR. The sonobuoys are about a foot high and float. The use of passive sonobuoys, which only receive sound, would not generate additional sounds or other EM energy on the PRTR. The sonobuoys used in the Potomac River would be recovered for reuse at the conclusion of the events.

Fish

EM energy activities would have no direct contact with the shortnose or Atlantic sturgeon or their habitat. EM energy that enters the water would dissipate well before it reaches the river bottom where sturgeon are usually found. Sonobuoys float on the surface, so that sturgeon would have limited physical contact with them. Because they spend most of their time on and near the river bottom, shortnose and Atlantic sturgeon also would be out of the range of any non-thermal EM effects and any potential effects on navigation and orientation.

Under the No Action Alternative, in accordance with Section 7 of the ESA, EM energy activities would have no effect on the shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, EM energy activities under the No Action Alternative would have no direct or indirect impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

NSWCDD would continue to use active EM energy sensors (e.g., radar) above the water, occasionally on boats, ships, and aircraft in the LDZ, and passive sonobuoys occasionally may be deployed on the LDZ. Although sea turtles are known to occur in the LDZ, the passive EM energy would not affect sea turtles.

In accordance with Section 7 of the ESA, under the No Action Alternative, EM energy activities would have no effect on sea turtles. In accordance with NEPA, EM energy activities would have no direct or indirect impacts on sea turtles.

Birds

While most of the EM energy facilities are in developed areas, NOTES, CETFAC, and EMLF are close to forested areas with less human activity. As discussed in Section 4.12.1.2, birds flying above EM energy test facilities are unlikely to be exposed to high electric or magnetic fields, as exposure levels rapidly dissipate with distance and the duration of the EM energy emission is brief. In the unlikely event that a bald eagle nest were to be established near an EM energy test facility, NSWCDD would consult with the USFWS and the VDGIF; however, as discussed in Section 3.12 EM energy facilities are outside of bald eagle nest buffer zones.

EM energy activities under the No Action Alternative would not affect the bald eagle, which is protected by the BGEPA. Nor would EM energy activities affect ESA-listed bird species protected under Section 7 of the ESA, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, EM energy activities under the No Action Alternative would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

As noted above, targets on vessels or passive sonobuoys may occasionally be deployed on the LDZ; however marine mammals would have no contact with the targets as their range does not overlap with target areas, as shown on Figure 4.14-1. Active EM sensors would operate above the water surface where dolphins would not be exposed, and sonobuoys deployed are passive (i.e., do not emit EM energy). Any bottlenose dolphins in the LDZ would not interact with them.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with EM energy activities. In accordance with NEPA, EM energy activities would have no direct or indirect impacts on marine mammals.

Insects

EM energy activities in the LDZ take place in deeper waters; no landings on shore take place. Therefore, there would be no potential for interaction with northeastern beach tiger beetles on the beaches of the lower LDZ as there would be no spatial overlap.

In accordance with Section 7 of the ESA, under the No Action Alternative, EM energy activities would have no effect on listed insect species. In accordance with NEPA, EM energy activities would have no direct or indirect impacts on northeastern beach tiger beetles.

Plants

Two of the three main outdoor facilities for E3 and HERO activities, MOATS and the two ground plane areas, are in highly-developed areas with little or no natural habitat surrounding them. In contrast, NOTES is surrounded by forest. Operations at NOTES take place once or twice a year and most of the field energy is contained within the facility structure (see Section 1.5.2.3). Sensitive joint-vetch is not found in forested areas and would not be present here. However, even if protected plants are found nearby, the EM energy would not affect them as it decreases exponentially from the source and would be at a very low level by the time it reached individual plants.

In accordance with Section 7 of the ESA, EM energy activities under the No Action Alternative would have no effect on sensitive joint-vetch. In accordance with NEPA, EM energy activities

under the No Action Alternative would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.1.3 Laser Activities

Two of NSWCDD's five current laser corridors are on the PRTR's developed land ranges, and three cross the waters of Upper Machodoc Creek and the Potomac River through the PRTR. Research in aquatic areas currently is and will continue to be conducted above the surface of the water.

For No Action Alternative activities, both the laser emitter and the target/backstop is fixed and the laser emits almost horizontally. The laser is pre-aimed and is able to move, except for minute corrections to the aim point. Under the current maximum power (100 kW), for over-water activities, the laser beam begins at least 12 ft above mean water level and terminates at least 9 ft above mean water level. The eye-hazard area around the laser beam is about 6 ft in diameter and at least 6 ft above mean water level (see Figure 1-10). Neither the laser beam nor the eye-hazard zone would come in contact with the water. For overland activities, the laser beam is a minimum of 6 ft above ground level.

As with EM energy, laser activities are tightly controlled and the likelihood of a laser beam's straying from the target/backstop and hitting the surface of the water is extremely small. Should EM energy from laser tests strike the water surface it would be incidental and most of it would be reflected at the air-water boundary where it would be scattered upon hitting the rough surface of the water, (see Figure 1-8a). EM energy that breaches the water surface would be propagated and attenuated, rapidly decreasing in amount and intensity as it travels through the water.

Fish

Under the No Action Alternative, laser activities have no direct contact with the shortnose or Atlantic sturgeon. Laser energy that enters the water would be dissipated well before it reached the lower depths of the river, where sturgeon are usually found.

Under the No Action Alternative, in accordance with Section 7 of the ESA, laser activities would have no effect on shortnose and Atlantic sturgeon. In accordance with NEPA, laser activities under the No Action Alternative would not have direct or indirect impacts on shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

Under the No Action Alternative, laser activities would not occur in the LDZ, where sea turtles are known to occur. Therefore, in accordance with Section 7 of the ESA, laser activities would have no effect on sea turtles. In accordance with NEPA, laser activities under the No Action Alternative would not have direct or indirect impacts on sea turtles.

Birds

All over-land laser activities occur in developed or maintained areas with a clear line of sight. The possibility of a laser hitting a flying eagle is considered remote, as during each laser test, a visual observer trained by the NSF Dahlgren's natural resources manager would watch for eagles, ospreys, other birds, and wildlife that may wander into the laser corridor, as discussed in

Section 4.12.1.3. In the unlikely event that a bald eagle nest were to be established near a laser corridor NSWCDD would consult with the USFWS and the VDGIF; however, as seen in Figure 3.12-3 existing nests are well away from laser corridors.

Laser activities under the No Action Alternative would not affect the bald eagle, which is protected by the BGEPA. Nor would laser activities affect ESA-listed bird species under Section 7 of the ESA, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, laser activities under the No Action Alternative would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

Under the No Action Alternative, laser activities would not occur in the LDZ, where bottlenose dolphins are known to occur. There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with laser activities. In accordance with NEPA, under the No Action Alternative, laser activities would have no direct or indirect impacts on marine mammals.

Insects

All documented northeastern beach tiger beetle occurrences are along the Virginia shore of the southern reaches of the LDZ. In accordance with Section 7 of the ESA, laser activities under the No Action Alternative would have no effect on listed insect species. In accordance with NEPA, under No Action Alternative laser activities would have no direct or indirect impacts on northeastern beach tiger beetles as there would be no spatial overlap.

Plants

NSWCDD's laser corridors are located on the PRTR's developed land ranges, with three corridors crossing the waters of Upper Machodoc Creek and the Potomac River. The sensitive joint-vetch is not found in developed areas and would not be present in open water. Lasers would be fired above vegetation on the shoreline and would not impact sensitive joint-vetch in the event it were found in the area.

In accordance with Section 7 of the ESA, laser activities under the No Action Alternative would have no effect on sensitive joint-vetch. In accordance with NEPA, laser activities under the No Action Alternative would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.1.4 Chemical Defense Activities

Outdoor chemical defense activities using simulants would occur under the No Action Alternative.

Fish

The quantities of chemical simulants released from a boat on the PRTR were modeled to determine potential chemical concentrations deposited in the river. Modeled concentrations and field measurements of chemical simulants were well below levels that could result in adverse effects to aquatic life, inclusive of fish, as described in Section 4.11.1.4. Current use of chemical

simulants has not resulted in any observable environmental effects during or after events (NSWCDL, 2004; NSWCDL, 2005; NSWCDL, 2009).

Under the No Action Alternative in accordance with Section 7 of the ESA, chemical defense activities would have no effect on shortnose and Atlantic sturgeon. In accordance with NEPA, under the No Action Alternative, chemical defense activities would have no direct or indirect impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

NSWCDD does not currently and would not in the future conduct chemical defense activities on the LDZ. Concentrations of simulants emitted over the MDZ would be diluted to background levels by the time they reach the lower portion of the LDZ, where sea turtles are known to occur, located more than 23 NM downriver from the chemical defense testing area.

Therefore, in accordance with Section 7 of the ESA, chemical defense activities would have no effect on sea turtles under the No Action Alternative. In accordance with NEPA, under the No Action Alternative chemical defense activities would have no direct or indirect impacts on sea turtles.

Birds

Chemical simulants are not tested in the bald eagle protection zones. Any chemical simulants that bald eagles come into contact with would be at concentrations equivalent to background levels, below concentrations that would cause adverse effects.

Chemical defense activities under the No Action Alternative would not affect the bald eagle, which is protected by the BGEPA. Nor would chemical defense activities affect ESA-listed bird species under Section 7 of the ESA, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, chemical defense activities would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

NSWCDD does not currently and would not in the future conduct chemical defense activities on the LDZ, where bottlenose dolphins are known to occur. Concentrations of simulants would be diluted to background levels by the time they reach the lower portion of the LDZ, where marine mammals are known to occur, located more than 23 NM below the chemical defense testing area.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with chemical defense activities. In accordance with NEPA, chemical defense activities under the No Action Alternative would have no direct or indirect impacts on marine mammals.

Insects

Northeastern beach tiger beetles have only been observed on beaches in the lowest portion of the LDZ, near the mouth of the river. Simulants released over the MDZ would be rapidly dispersed and diluted to concentrations that are less than what would cause toxicity, and any incidental

simulants reaching the beetle habitat would be orders of magnitude below what is considered toxic.

Therefore, in accordance with Section 7 of the ESA, chemical defense activities under the No Action Alternative would have no effect on listed insect species. In accordance with NEPA, chemical defense activities under the No Action Alternative would have no direct or indirect impacts on tiger beetles.

Plants

Chemical simulants released during testing would be rapidly dispersed and diluted to concentrations below those associated with toxic effects. Concentrations of chemical simulants would be at background levels by the time they reach wetlands where sensitive joint-vetch may potentially be found.

In accordance with Section 7 of the ESA, chemical defense activities under the No Action Alternative would have no effect on sensitive joint-vetch. In accordance with NEPA, chemical defense activities under the No Action Alternative would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.1.5 PRTR Use

Under the No Action Alternative, PRTR use for RDT&E activities would remain at present levels. NSWCDD would restrict public access to some or all of the MDZ approximately 750 hours per year.

Fish

Incidental vessel strikes, which have the potential to occur during adult sturgeon breaching behavior (i.e., not during spawning or migration), are not expected to occur during RDT&E activities because of the low number of shortnose and Atlantic sturgeon found in the Potomac River, the limited breaching associated with these individuals, and the overall reduction in vessel traffic when NSWCDD is conducting operations because the range is restricted. As sturgeon are generally found in the deeper areas of the river channel, it is extremely unlikely that an interaction between an individual shortnose sturgeon and a vessel will occur as vessels will not be operating close to the river bottom where sturgeon are likely to occur.

Therefore, in accordance with Section 7 of the ESA, PRTR use under the No Action Alternative may affect, but is not likely to adversely affect the shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, PRTR use under the No Action Alternative would have negligible, long-term, direct and indirect, negative impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

The only NSWCDD activities that potentially would affect sea turtles are the use of range boats and operational vessels, such as barges, on the LDZ that may incidentally strike a sea turtle swimming or feeding at or near the water surface. The probability of any one of these vessels coming into contact with a sea turtle is the same as any other vessel near the mouth of the Potomac River and is anticipated to be extremely low. Also, when the range boats are active, public vessel traffic is restricted, so overall vessel use would be lower than normal.

Boat engine noise associated with military vessel activities on the waters of the LDZ may have temporary behavioral effects on sea turtles, but as the overall vessel traffic on the PRTR would otherwise decrease during activities, the overall noise level that sea turtles would be exposed to would be lower than usual.

Because this area is beyond the range of NSWCDD's guns and distant from the installation, activities in this portion of the PRTR are infrequent. Also, sea turtles only occur in the Potomac River during summer and fall, further reducing the probability that a sea turtle would be in the immediate area during the infrequent use of the LDZ for NSWCDD activities. Therefore, while adverse effects may occur in the event of a vessel strike, there would be a very low probability of such strikes.

In accordance with Section 7 of the ESA, PRTR use under the No Action Alternative would have no effect on sea turtles. In accordance with NEPA, under the No Action Alternative, PRTR use would have no direct or indirect impacts on sea turtles.

Birds

Bald eagles may use the PRTR for foraging. Vessels using the PRTR would not interfere with foraging. The probability of an eagle's overlapping in space with a UAV is low, particularly as UAVs do not fly low over surface waters, and eagles are likely to avoid them.

PRTR use under the No Action Alternative would not affect the bald eagle, which is protected by the BGEPA. Nor would PRTR use affect bird species listed under the ESA, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, PRTR use would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

The only NSWCDD activities that potentially would affect marine mammals on the LDZ are the use of boats that may incidentally strike a marine mammal swimming, breaching, or feeding at or near the water surface. In general, dolphins are able to avoid boats and, if they are struck, usually escape with no more than a propeller scar. The 2008 stock assessment report for western North Atlantic coastal stocks of bottlenose dolphins records no serious injuries or mortality resulting from vessel interactions throughout the range of this coastal type (Waring et al., 2009). While certain behaviors (e.g., diving, feeding) may be affected in heavily-trafficked waters, the few NSWCDD range control boats and other boats that would be active during activities would not incrementally increase vessel traffic to levels that would result in behavioral impacts. Also, when the range boats are active, public vessel traffic is restricted, so overall vessel use would be lower than normal.

As stated above, marine mammals – predominantly bottlenose dolphins – are found in the lower reaches of the LDZ, where activities would continue to occur infrequently. In addition, bottlenose dolphins occur in the Potomac River only from April to November, further reducing the probability that a dolphin would be in the immediate area during the infrequent use of the LDZ for NSWCDD activities. Therefore, under the No Action Alternative, while adverse effects may occur in the event of a vessel strike, there would be a very low probability of such strikes.

Boat engine noise associated with small-boat activities (commercial, recreational, and military) on the waters of the LDZ may have temporary behavioral effects on bottlenose dolphins and

other marine mammals, but likely routinely occurs without long-term adverse impacts. Marine mammals react to vessel-generated sounds in a variety of ways. Some respond negatively by retreating or engaging in antagonistic responses, while other animals ignore the stimulus altogether (Watkins, 1986; Terhune, 1999). Some studies have ascertained the short-term response to vessel sound and vessel traffic (Watkins et al., 1981; Magalhães et al., 2002), but the long-term implications of ship sound on marine mammals are largely unknown.

Human-generated sound has increased in the marine environment over the past 50 years (Richardson et al., 1995; NRC, 2003). Given the current ambient sound levels in the marine environment, the increment of sound contributed by the use of NSWCDD range control boats and other vessels that would be active during activities would be very low. It is anticipated that any marine mammals exposed may exhibit only short-term reactions and would not suffer any long-term consequences from boat sound.

Further, UAVs flying over the LDZ do not fly low over surface waters, and are only audible when the receiver (e.g., a person or a marine mammal) is close to the UAV. Therefore, the noise emitted from UAVs would not affect bottlenose dolphins.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with PRTR use. In accordance with NEPA, PRTR use would have no direct or indirect impacts on marine mammals.

Insects

Northeastern beach tiger beetles have only been observed on beaches in the lowest portion of the LDZ, near the mouth of the river. As such there is no spatial overlap with PRTR use, which would occur in the deeper waters of the LDZ, not near beaches.

In accordance with Section 7 of the ESA, PRTR use under the No Action Alternative would have no effect on listed insect species. In accordance with NEPA, PRTR use under the No Action Alternative would have no direct or indirect impacts on tiger beetles.

Plants

Sensitive joint-vetch, if present along the Potomac River, would be found in the intertidal zone and not in the part of the PRTR frequented by vessels. Based on habitat preferences, there is no spatial overlap with PRTR use and the potential occurrence of rare, threatened, or endangered plants.

In accordance with Section 7 of the ESA, PRTR use under the No Action Alternative would have no effect on sensitive joint-vetch. In accordance with NEPA, PRTR use under the No Action Alternative would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.2 Alternative 1

4.14.2.1 Ordnance Activities

The use of large-caliber guns and projectiles would remain at current levels. Small-caliber gun use would increase from an average of 6,000 bullets fired a year under the No Action Alternative

to 25,500 bullets fired a year. Approximately 2,550 bullets (10 percent) would be fired from land into the river. Under Alternative 1, detonations would increase from 190 events to 200 events, as described in Section 2.5.1.

Fish

Under Alternative 1, impacts to shortnose and Atlantic sturgeon from the firing of large-gun projectiles would be the same as the impacts resulting from the No Action Alternative, described above in Section 4.14.1.1. The likelihood of an underwater explosion's affecting sturgeon or of directly hitting a sturgeon would be very low. Indirect impacts to the shortnose and Atlantic sturgeon associated with large-gun projectiles, including potential increases in suspended sediments, effects on water and sediment quality, disruption of spawning and/or migration, and habitat disturbance, also would be negligible. Although a greater number of small-caliber bullets would enter the PRTR, the probability of directly hitting a sturgeon would be minimal. Most detonations would occur on land ranges and would have no impact on shortnose and Atlantic sturgeon.

Therefore, under Section 7 of the ESA, the effect of ordnance activities on the shortnose sturgeon and Atlantic sturgeon under Alternative 1 is expected to be insignificant or discountable. In a letter dated January 11, 2012, NMFS concurred that RDT&E activities covered by this EIS may affect, but are not likely to adversely affect any listed species under NMFS jurisdiction (Morris, January 11, 2012). In accordance with NEPA, ordnance activities would have negligible, long-term, direct and indirect, negative impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

Under Alternative 1, projectile testing would continue to occur a minimum of 6.5 NM upriver of the area where sea turtles have been sighted, providing an ample margin of safety.

Based on the location of ordnance activities relative to the occurrence of sea turtles, in accordance with Section 7 of the ESA, the effect of ordnance activities under Alternative 1 would be insignificant or discountable. In a letter dated January 11, 2012, NMFS concurred that RDT&E activities covered by this EIS may affect, but are not likely to adversely affect any listed species under NMFS jurisdiction (Morris, January 11, 2012). In accordance with NEPA, ordnance activities under Alternative 1 would have no direct and negligible, short-term, indirect negative impacts on sea turtles.

Birds

Ordnance testing of large-caliber projectiles under Alternative 1 would be the same as under the No Action Alternative. The bald eagle population at NSF Dahlgren, in and outside of the SIAs, which has been growing for years, shows no evidence of being affected by current ordnance activities. The increase in small-arms firing is unlikely to impact birds as there is limited vegetative cover in front of Machine Gun Range. The standard operating procedure (SOP) ensures there is a lookout during firing to make sure that birds and wildlife are not in the area.

Ordnance activities under Alternative 1 would not affect the bald eagle, which is protected by the BGEPA. Nor would ordnance activities affect ESA-listed bird species, or bird species protected

by the MBTA or the Lacey Act. In accordance with NEPA, ordnance activities would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

Under Alternative 1, projectile testing would continue to take place a minimum of 6.5 NM upriver of the area where bottlenose dolphins are known to occur. Therefore, there would be no overlap between ordnance activities and marine mammals.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with ordnance activities under Alternative 1. In accordance with NEPA, ordnance activities under Alternative 1 would have no direct or indirect impacts on marine mammals.

Insects

All documented northeastern beach tiger beetle occurrences in the vicinity of the PRTR are along beaches in the southern reaches of the LDZ, where there is no overlap with ordnance activities that would occur in the LDZ water range.

In accordance with Section 7 of the ESA, ordnance activities under Alternative 1 would have no effect on listed insect species. In accordance with NEPA, ordnance activities under Alternative 1 would have no direct or indirect impacts on tiger beetles.

Plants

Ordnance testing of large-caliber projectiles under Alternative 1 would be the same as under the No Action Alternative. Small-caliber testing would increase, but would occur on heavily-used land areas of ranges, such as the Machine Gun Range, not near the tidal wetlands habitat necessary to support sensitive joint-vetch. Detonations would increase, but they, too, would take place on the previously-disturbed EEA land ranges, which are not near the tidal wetlands habitat necessary for sensitive joint-vetch.

In accordance with Section 7 of the ESA, ordnance activities under the Alternative 1 would have no effect on sensitive joint-vetch. In accordance with NEPA, ordnance activities under Alternative 1 would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.2.2 EM Energy Activities

Under Alternative 1, the number of EM energy events would increase from 490 to 590 per year, the power of the EM energy events would increase, and activities would increase as described in Section 2.5.2.

Fish

EM energy activities would have no direct contact with the shortnose or Atlantic sturgeon. EM energy that enters the water would dissipate quickly – well before it reached the river bottom where sturgeon typically are found. The possibility that a sturgeon would breach the surface at the precise moment and location that an EM energy beam misses its intended target is considered negligible.

In accordance with Section 7 of the ESA, under Alternative 1 EM energy activities would have no effect on shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, EM energy activities under Alternative 1 would have no direct or indirect impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

Sonobuoys located in the lower LDZ, where sea turtles are present, are passive and only receive, but do not emit EM energy. EM energy could be directed at targets on platforms in the LDZ, but there would be no targets directly on the surface water. Any residual energy around the target would quickly dissipate or be absorbed by the water. Lower-power directed energy would be used for initial operations, with gradual increases in power levels as RDT&E progresses.

In accordance with Section 7 of the ESA, EM energy activities under Alternative 1would have no effect on sea turtles. In accordance with NEPA, EM energy activities under Alternative 1 would have no direct or indirect impacts on sea turtles.

Birds

As discussed previously, EM testing is not expected to have any impacts on birds in flight. If a bald eagle nest were to be established near an EM energy test facility NSWCDD would consult with the USFWS and the VDGIF; however, as discussed in Section 3.12 EM energy facilities are outside of bald eagle nest buffer zones.

Under Alternative 1, EM energy activities would not affect the bald eagle, which is protected by the BGEPA. Nor would EM energy activities affect ESA-listed bird species, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, EM energy activities under Alternative 1 would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

Sonobuoys located in the lower LDZ, where bottlenose dolphins are present, do not emit EM energy. All active EM energy use would be above the surface of the water and have no overlap with marine mammals. EM energy could be directed at targets on platforms in the LDZ, but there would be no targets directly on the surface water. Any residual energy around the target would quickly dissipate or be absorbed by the water.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with EM energy activities under Alternative 1. In accordance with NEPA, EM energy activities under Alternative 1 would have no direct or indirect impacts on marine mammals.

Insects

Because all documented northeastern beach tiger beetle occurrences are along beaches in the southern reaches of the LDZ, in accordance with Section 7 of the ESA, under Alternative 1 EM energy activities would have no effect on listed insect species. In accordance with NEPA, EM energy activities under Alternative 1 would have no direct or indirect impacts on northeastern beach tiger beetles.

Plants

Increasing EM energy activities would not result in any spatial overlap between potential habitat for the sensitive joint-vetch and EM energy activities. In accordance with Section 7 of the ESA, under Alternative 1 EM energy activities would have no effect on sensitive joint-vetch. In accordance with NEPA, EM energy activities under Alternative 1 would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.2.3 Laser Activities

Under Alternative 1, the number of HE laser events would increase from the current 60 annually to 125 annually, power levels would increase, and activities would expand as described in Section 2.5.3.

Fish

Although laser activities under Alternative 1 would include directing laser beams at targets on platforms on the water, the beams would be highly unlikely to strike the water surface because of many safeguards, although reflected backscatter energy may strike the water. In the event that a laser bounced off a UAV breaches the water surface, the energy would be rapidly absorbed, scattered, or reflected. Laser activities would have no direct contact with the shortnose or Atlantic sturgeon, which generally stay near the bottom of the river. The possibility that a sturgeon would breach the surface at the precise moment and location that laser beam misses its intended target is considered negligible.

In accordance with Section 7 of the ESA, laser activities under Alternative 1 would have no effect on shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, laser activities under Alternative 1 would have no direct or indirect impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

As noted for sturgeon, the probability of a laser's hitting the water is very low due to safeguards, and in the event that a laser strikes the water the energy would be rapidly absorbed, scattered, or reflected. In addition, the probability of a sea turtle's being in the vicinity of a test platform in the LDZ during testing is extremely low due to the low density of sea turtles and the limited time those individuals spend at the surface, the large area covered by the PRTR, and small amount of time that testing occurs.

In accordance with Section 7 of the ESA, laser activities under Alternative 1 would have no effect on sea turtles. In accordance with NEPA, laser activities under Alternative 1 would have no direct or indirect impacts on sea turtles.

Birds

All over-land laser activities would continue to occur in developed or maintained areas with a clear line of sight. The possibility of a laser hitting a flying eagle is considered remote, as during each laser test, a visual observer trained by the NSF Dahlgren's natural resources manager would watch for eagles, ospreys, other birds, and wildlife that may wander into the laser corridor, as discussed in Section 4.12.1.3. In the unlikely event that a bald eagle nest were to be established

near a laser corridor NSWCDD would consult with the USFWS and the VDGIF; however, as seen in Figure 3.12-3 existing nests are well away from laser corridors.

Laser activities under Alternative 1 would not affect the bald eagle, which is protected by the BGEPA. Nor would laser activities affect ESA-listed bird species, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, laser activities under Alternative 1 would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

As noted for sturgeon and sea turtles, the probability of a laser's hitting the water is very low due to safeguards, and in the event that a laser strikes the water, the energy would be rapidly absorbed, scattered, or reflected. In addition, the probability of a bottlenose dolphin's being in the vicinity of a test platform in the LDZ during testing is considered negligible due to the low density of dolphins, the limited time those individuals spend at the surface, the large area covered by the PRTR, and small amount of time that testing occurs.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with laser activities under Alternative 1. In accordance with NEPA, laser activities under Alternative 1 would have no direct or indirect impacts on marine mammals.

Insects

All documented northeastern beach tiger beetle occurrences are along beaches in the southern reaches of the LDZ, while all laser activities would occur in the LDZ, which is a water range.

In accordance with Section 7 of the ESA, laser activities under Alternative 1 would have no effect on listed insect species. In accordance with NEPA, laser activities under Alternative 1 would have no direct or indirect impacts on northeastern beach tiger beetles.

Plants

Under Alternative 1, there would be no spatial overlap between expanded laser activities and the potential habitat of sensitive joint-vetch.

In accordance with Section 7 of the ESA, laser activities under Alternative 1 would have no effect on sensitive joint-vetch. In accordance with NEPA, laser activities under Alternative 1 would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.2.4 Chemical and Biological Defense Activities

Under Alternative 1, activities using chem/bio simulants outdoors would increase from the current baseline of 12 events annually using chemical simulants to 60 events annually using chemical and biological simulants separately, as described in Section 2.5.4. The areas in which the activities would take place would expand and could take place anywhere in the MDZ.

Fish

As described under the No Action Alternative, modeled concentrations and field measurements of chemical simulants were well below levels that could result in adverse effects to aquatic life, inclusive of fish (see Section 4.11.1.4). Current use of chemical simulants has not resulted in any

observable environmental effects during or after events (NSWCDL, 2004; NSWCDL, 2005; NSWCDL, 2009). In addition, concentrations of chemical and biological simulants would be diluted to even lower concentrations well before they reach the river bottom, where sturgeon are found.

No modeling was performed for biological simulants, as NSWCDD would use only BSL-1 simulants. Many of these simulants, such as the bacteria, are ubiquitous and often found in high concentrations in nature, including in water (CRI, 2004; USEPA, 1997). There are no published reports of disease associated with these biological simulants in aquatic plants or animals, nor are they considered to be disease-causing agents. The small concentrations of these simulants deposited on the water would not cause any significant increase in the environment and no adverse effects are anticipated from temporary increases.

In accordance with Section 7 of the ESA, under Alternative 1 chem/bio defense activities would have no effect on the shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, chem/bio defense activities under Alternative 1 would have no direct or indirect impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

NSWCDD would not conduct chem/bio defense activities on the LDZ, where sea turtles are known to occur. Concentrations of chem/bio simulants would be diluted to background concentrations well before they reach the lower portion of the LDZ, where sea turtles are known to occur, located about 11 NM downriver from the chem/bio defense testing area.

In accordance with Section 7 of the ESA, under Alternative 1, chem/bio defense activities would have no effect on sea turtles. In accordance with NEPA, chemical defense activities under Alternative 1 would have no direct or indirect impacts on sea turtles.

Birds

Under Alternative 1, the number of events and types of chem/bio simulants tested would increase, but no tests would be conducted near bald eagle nests and based on the release height, there would be no overlap between flying bald eagles and the simulant release. Any chemical or biological simulants that reach bald eagle nests would be at concentrations equivalent to background levels.

Chem/bio defense activities under Alternative 1 would not affect the bald eagle, which is protected by the BGEPA. Nor would chem/bio defense activities affect ESA-listed bird species, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, chem/bio defense activities would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

NSWCDD does not currently and would not in the future conduct chem/bio defense activities on the LDZ, where bottlenose dolphins are known to occur. Concentrations of chem/bio simulants would be diluted to background concentrations well before they reach the lower LDZ, where marine mammals are known to occur, located about 11 NM below the chem/bio defense testing area.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with chem/bio defense activities under Alternative 1. In accordance with NEPA, chem/bio defense activities under Alternative 1 would have no direct or indirect impacts on marine mammals.

Insects

Because all documented northeastern beach tiger beetle occurrences are along beaches in the southern reaches of the LDZ, in accordance with Section 7 of the ESA, chem/bio defense activities under Alternative 1 would have no effect on listed insect species. In accordance with NEPA, chem/bio defense activities would have no direct or indirect impacts on northeastern beach tiger beetles.

Plants

Chemical and biological simulants released during testing would be rapidly dispersed and diluted to concentrations below levels associated with toxic effects. Concentrations of chemical simulants reaching tidal wetlands where sensitive joint-vetch could potentially be found would be at background levels. All biological simulants used would be BSL-1, which rarely cause reactions or diseases and may be commonly found in the environment.

In accordance with Section 7 of the ESA, chem/bio defense activities under Alternative 1 would have no effect on sensitive joint-vetch. In accordance with NEPA, chem/bio defense activities under Alternative 1 would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.2.5 PRTR Use

Under Alternative 1, NSWCDD would restrict public access to the PRTR danger zones for approximately 870 hours per year, usually some part or all of the MDZ.

Fish

Incidental vessel strikes, which have the potential to occur during adult sturgeon breaching behavior (i.e., not during spawning or migration), are not expected to occur during RDT&E activities because of the low number of shortnose and Atlantic sturgeon found in the Potomac River, the limited breaching associated with these individuals, and the overall reduction in vessel traffic when NSWCDD is conducting operations.

In accordance with Section 7 of the ESA, PRTR use under Alternative 1 may affect, but is not likely to adversely affect the shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, PRTR use under Alternative 1 would have negligible, long-term, direct and indirect, negative impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

While adverse effects may occur in the event of a vessel strike, there would be a very low probability of such strikes, due to the limited number of tests in the lower LDZ and the infrequent, seasonal occurrence of sea turtles. Boat engine noise associated with military vessel

activities on the waters of the LDZ may have temporary behavioral effects on sea turtles, but the overall vessel traffic on the PRTR would otherwise decrease during activities.

In accordance with Section 7 of the ESA, PRTR use under Alternative 1 would have no effect on sea turtles. In accordance with NEPA, PRTR use under Alternative 1 would have no direct or indirect impacts on sea turtles.

Birds

Bald eagles may use the PRTR for foraging. Vessels using the PRTR would not interfere with foraging. The probability of an eagle's overlapping spatially with a UAV is low, particularly as UAVs do not fly low over surface waters and eagles are likely to avoid them.

PRTR use under Alternative 1 would not affect the bald eagle, which is protected by the BGEPA. Nor would PRTR use affect ESA-listed bird species, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, PRTR use would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

While adverse effects may occur in the event of a vessel strike, there would be a very low probability of such strikes, due to the limited number of tests in the lower LDZ and the infrequent, seasonal occurrence of bottlenose dolphins. Engine noise associated with military vessel use on the waters of the LDZ may have temporary behavioral effects on dolphins. However, the overall vessel traffic on the lower PRTR would otherwise decrease during activities.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with PRTR use. In accordance with NEPA, PRTR use under Alternative 1 would have no direct or indirect impacts on marine mammals.

Insects

Northeastern beach tiger beetles have only been observed on beaches in the lowest portion of the LDZ, near the mouth of the river. As there is no spatial overlap with PRTR use, in accordance with Section 7 of the ESA, there would be no effect on listed insect species. In accordance with NEPA, PRTR use under Alternative 1 would have no direct or indirect impacts on northeastern beach tiger beetles.

Plants

Sensitive joint-vetch, if present along the Potomac River, would be found in the intertidal zone and not in the deeper waters of the PRTR. Therefore, this species would not have any spatial overlap with NSWCDD's PRTR use.

In accordance with Section 7 of the ESA, PRTR use under Alternative 1 would have no effect on sensitive joint-vetch. In accordance with NEPA, PRTR use under Alternative 1 would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.3 Alternative 2

4.14.3.1 Ordnance Activities

The use of large-caliber guns and projectiles would remain at current levels. The use of small arms would increase, with the number of bullets expended annually increasing to 30,000; approximately 3,000 bullets would be fired from land into the river. Detonations would increase from 190 events to 230 events under Alternative 2, as described in Section 2.6.

Fish

Continuation of large-gun firings at current levels and small-arms activities at increased levels would have negligible impacts on shortnose and Atlantic sturgeon and their habitat. Because most detonations would occur over land ranges (infrequently, detonations would take place on a barge in the PRTR), there would be no impacts on shortnose or Atlantic sturgeon.

Therefore, under Section 7 of the ESA, the effect of ordnance activities on the shortnose sturgeon and Atlantic sturgeon under Alternative 2 is expected to be insignificant or discountable. In a letter dated January 11, 2012, NMFS concurred that RDT&E activities covered by this EIS may affect, but are not likely to adversely affect any listed species under NMFS jurisdiction (Morris, January 11, 2012). In accordance with NEPA, ordnance activities under Alternative 2 would have negligible, long-term, direct and indirect, negative impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

Under Alternative 2, projectile testing would take continue to place at least 6.5 NM upriver of the area where sea turtles are known to occur.

Based on the location of ordnance activities relative to the occurrence of sea turtles, in accordance with Section 7 of the ESA, the effect of ordnance activities under Alternative 2 is expected to be insignificant or discountable. In a letter dated January 11, 2012, NMFS concurred that RDT&E activities covered by this EIS may affect, but are not likely to adversely affect any listed species under NMFS jurisdiction (Morris, January 11, 2012). In accordance with NEPA, ordnance activities under Alternative 2 would have no direct and negligible, short-term, indirect negative impacts on sea turtles.

Birds

The bald eagle population at NSF Dahlgren has been growing since 1983 as well as along the PRTR and shows no evidence of being affected by current ordnance activities. Individual bald eagles could be hit by projectiles – although the probability of this would be very low – or the behavior of individuals could be affected by the noise of gun firings, but the total number of birds affected would be too small to cause population-level impacts. Similar to Alternative 1, the increase in small-arms firing is unlikely to impact birds as there is limited vegetative cover in front of Machine Gun Range. The SOP ensures there is a lookout during firing to make sure that birds and wildlife are not in the area.

Ordnance RDT&E activities under Alternative 2 would not affect the bald eagle, which is protected by the BGEPA. Nor would ordnance activities affect ESA-listed bird species, or bird

species protected by the MBTA or the Lacey Act. In accordance with NEPA, ordnance activities would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

Under Alternative 2 projectile testing would continue to take place a minimum of 6.5 NM upriver of the area where bottlenose dolphins are known to occur.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with ordnance activities under Alternative 2. In accordance with NEPA, ordnance activities under Alternative 2 would have no direct or indirect impacts on marine mammals.

Insects

All documented northeastern beach tiger beetle occurrences in the vicinity of the PRTR are along beaches in the southern reaches of the LDZ, where there is no overlap with ordnance activities that would occur in the LDZ water range.

In accordance with Section 7 of the ESA, ordnance activities under Alternative 2 would have no effect on listed insect species. In accordance with NEPA, ordnance activities under Alternative 2 would have no direct or indirect impacts on tiger beetles.

Plants

Ordnance testing of large-caliber projectiles under Alternative 2 would be the same as under the No Action Alternative. Small-caliber testing would increase, but would occur on heavily-used areas of ranges, such as the Machine Gun Range, where no tidal wetlands that may support sensitive joint-vetch occur. Detonations would increase, but they would take place on the EEA land ranges, not in the vicinity of tidal wetlands where sensitive joint-vetch may occur.

In accordance with Section 7 of the ESA, ordnance activities under Alternative 2 would have no effect on sensitive joint-vetch. In accordance with NEPA, ordnance activities under Alternative 2 would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.3.2 EM Energy Activities

Under Alternative 2, the number of EM energy events would increase from 490 to 680 per year, the power of the EM energy devices would increase, and activities would increase as summarized in Section 2.6.

Fish

EM energy activities would have no direct contact with shortnose or Atlantic sturgeon or their habitat. EM energy that enters the water would be dissipated well before it reached the river bottom where shortnose and Atlantic sturgeon are usually found. The possibility that a sturgeon would breach the surface at the precise moment and place that an EM energy beam misses its intended target is considered negligible.

In accordance with Section 7 of the ESA, under the Alternative 2 EM energy activities would have no effect on shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, EM

energy activities under Alternative 2 would have no direct or indirect impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

Sonobuoys occasionally used in the lower LDZ, where sea turtles are present, are passive and only receive, but do not emit EM energy. EM energy could be directed at targets on platforms in the LDZ, but there would be no targets directly on the surface water. Any residual energy around the target would quickly dissipate or be absorbed by water.

In accordance with Section 7 of the ESA, under Alternative 2, EM energy activities would have no effect on sea turtles. In accordance with NEPA, EM energy activities would have no direct or indirect impacts on sea turtles.

Birds

As discussed previously, there would be little or no contact between flying eagles and EM testing areas. If a bald eagle nest were to be established near an EM energy test facility NSWCDD would consult with the USFWS and the VDGIF; however, as discussed in Section 3.12 EM energy facilities are outside of bald eagle nest buffer zones.

Under Alternative 2, EM energy activities would not affect the bald eagle, which is protected by the BGEPA. Nor would EM energy activities affect ESA-listed bird species, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, EM energy activities would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

Sonobuoys located in the lower LDZ, where bottlenose dolphins are present, are passive and only receive, but do not emit EM energy. EM energy could be directed at targets on platforms in the LDZ, but there would be no targets directly on the surface water. Any residual energy around the target would quickly dissipate or be absorbed by the water.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with EM energy activities under Alternative 2. In accordance with NEPA, EM energy activities would have no direct or indirect impacts on marine mammals.

Insects

Because all documented northeastern beach tiger beetle occurrences are along beaches in the southern reaches of the LDZ, and EM energy would be used for RDT&E in deeper waters – not near beaches – in accordance with Section 7 of the ESA, under Alternative 2 EM energy activities would have no effect on listed insect species. In accordance with NEPA, EM energy activities would have no direct or indirect impacts on tiger beetles.

Plants

Increasing EM energy activities under Alternative 2 would not result in any spatial overlap with the potential habitat of the sensitive joint-vetch. In accordance with Section 7 of the ESA, under Alternative 2 EM energy activities would have no effect on the sensitive joint-vetch. In

accordance with NEPA, EM energy activities under Alternative 2 would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.3.3 Laser Activities

Under Alternative 2, the number of HE laser events would increase from 60 to 145 events per year, power levels would increase, and activities would be expanded, as summarized in Section 2.6.

Fish

Alternative 2 includes directing laser beams at targets on platforms on the water. These beams would be highly unlikely to strike the water surface because of many safeguards built into the RDT&E program, although reflected backscatter energy may strike the water. In the event that a laser bounced off a UAV breaches the water surface, the energy would be rapidly absorbed, scattered, or reflected. The possibility that a sturgeon would breach the surface at the precise moment and location that a laser beam misses its intended target is considered negligible. Laser activities would have no direct contact with the shortnose or Atlantic sturgeon, which generally stay near the bottom of the river.

In accordance with Section 7 of the ESA, laser activities under Alternative 2 would have no effect on shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, laser activities under Alternative 2 would have no direct or indirect impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

As noted for fish, the probability of a laser's hitting the water is very low due to safeguards, but any laser energy's striking the water would be rapidly absorbed, scattered, or reflected.

In accordance with Section 7 of the ESA, laser activities under Alternative 2 would have no effect on sea turtles. In accordance with NEPA, laser activities under Alternative 2 would have no direct or indirect impacts on sea turtles.

Birds

All over-land laser activities would continue to occur in developed or maintained areas with a clear line of sight. The possibility of a laser hitting a flying eagle is considered remote, as during each laser test, a visual observer trained by the NSF Dahlgren's natural resources manager would watch for eagles, ospreys, other birds, and wildlife that may wander into the laser corridor, as discussed in Section 4.12.1.3. In the unlikely event that a bald eagle nest were to be established near a laser corridor NSWCDD would consult with the USFWS and the VDGIF; however, as seen in Figure 3.12-3 existing nests are well away from laser corridors.

Laser activities under Alternative 2 would not affect the bald eagle, which is protected by the BGEPA. Nor would laser activities affect ESA-listed bird species, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, laser activities under Alternative 2 would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

As noted for sturgeon and sea turtles, the probability of a laser beam's striking the water is very low due to safeguards, and any laser energy's striking the water would be rapidly absorbed, scattered, or reflected.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with laser activities under Alternative 2. In accordance with NEPA, laser activities under Alternative 2 would have no direct or indirect impacts on marine mammals.

Insects

Because all documented northeastern beach tiger beetle occurrences are along beaches in the southern reaches of the LDZ, while RDT&E would take place in deeper waters, in accordance with Section 7 of the ESA, laser activities under Alternative 2 would have no effect on listed insect species. In accordance with NEPA, laser activities under Alternative 2 would have no direct or indirect impacts on northeastern beach tiger beetles.

Plants

Under Alternative 2, there would continue to be no spatial overlap between increased laser activities and the potential habitat of sensitive joint-vetch. In accordance with Section 7 of the ESA, laser activities under Alternative 2 would have no effect on sensitive joint-vetch. In accordance with NEPA, laser activities under Alternative 2 would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.3.4 Chemical and Biological Defense Activities

Under Alternative 2, the number of events using chem/bio simulants would increase from the current baseline of 12 events annually using chemical simulants to 70 events annually using both chemical and biological simulants together, as summarized in Section 2.6.

Fish

As described under the No Action Alternative and Alternative 1, modeled concentrations and field measurements of chemical simulants were well below levels that could result in adverse effects to aquatic life, inclusive of fish. Many BSL-1 organisms are ubiquitous and often found in high concentrations in nature, including in water (CRI, 2004; USEPA, 1997). There are no published reports of disease associated with these biological simulants in aquatic life, nor are any synergistic interactions between chemical simulants and BSL-1 organisms known. The small concentrations of these simulants deposited on the water would not cause any significant increase in the environment and no adverse effects are anticipated from temporary increases of them.

In accordance with Section 7 of the ESA, under Alternative 2 chem/bio defense activities would have no effect on the shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, chem/bio defense activities under Alternative 2 would have no direct or indirect impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

NSWCDD would not conduct chem/bio defense activities on the LDZ, where sea turtles are known to occur. Concentrations of chem/bio simulants would be diluted to background concentrations well before they reach the lower LDZ, where sea turtles are known to occur, located about 11 NM downriver from the chem/bio defense testing area.

In accordance with Section 7 of the ESA, under Alternative 2 chem/bio defense activities would have no effect on sea turtles. In accordance with NEPA, chem/bio defense activities under Alternative 2 would have no direct or indirect impacts on sea turtles.

Birds

Under Alternative 2, the number of events and types of chem/bio simulants tested would increase, but no tests would be conducted near bald eagle nests. Any chemical or biological simulants that reach bald eagle nests would be at concentrations equivalent to background levels.

Chem/bio defense activities under Alternative 2 would not affect the bald eagle, which is protected by the BGEPA. Nor would chem/bio defense activities affect ESA-listed bird species, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, chem/bio defense activities would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

NSWCDD does not currently and would not in the future conduct chem/bio defense activities on the LDZ, where bottlenose dolphins are known to occur. Concentrations of chem/bio simulants released in the MDZ would be diluted to background concentrations well before they reach the lower LDZ, where marine mammals are known to occur, located about 11 NM below the chem/bio defense testing area.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with chem/bio defense activities under Alternative 2. In accordance with NEPA, chem/bio defense activities under Alternative 2 would have no direct or indirect impacts on marine mammals.

Insects

As all documented northeastern beach tiger beetle occurrences are along beaches in the southern reaches of the LDZ, and chem/bio defense activities would not be conducted in the LDZ.

In accordance with Section 7 of the ESA, chem/bio defense activities under Alternative 2 would have no effect on listed insect species. In accordance with NEPA, chem/bio defense activities under Alternative 2 would have no direct or indirect impacts on northeastern beach tiger beetles.

Plants

Chemical and biological simulants released during testing would be rapidly dispersed and diluted to concentrations below levels associated with toxic effects. Concentrations of chemical simulants reaching tidal wetlands where sensitive joint-vetch could potentially be found would be at background levels. All biological simulants used would be BSL-1 and some of them are

commonly found in the environment. The use of chemical and biological simulants together is not associated with any adverse effects.

In accordance with Section 7 of the ESA, chem/bio defense activities under Alternative 2 would have no effect on sensitive joint-vetch. In accordance with NEPA, chem/bio defense activities under Alternative 2 would have no direct or indirect impacts on rare, threatened, or endangered plants.

4.14.3.5 PRTR Use

Under Alternative 2, NSWCDD would restrict public access to the PRTR danger zones, usually some or all of the MDZ, for approximately 1,000 hours per year, as summarized in Section 2.6.

Fish

Incidental vessel strikes, which have the potential to occur during adult sturgeon breaching behavior (i.e., not during spawning or migration), are not expected to occur during RDT&E activities because of the low number of shortnose and Atlantic sturgeon found in the Potomac River, the limited breaching associated with these individuals, and the overall reduction in vessel traffic when NSWCDD is conducting operations.

In accordance with Section 7 of the ESA, PRTR use associated with Alternative 2 may affect, but is not likely to adversely affect the shortnose sturgeon and Atlantic sturgeon. In accordance with NEPA, PRTR use under Alternative 2 would have negligible, long-term, direct and indirect, negative impacts on the shortnose sturgeon and Atlantic sturgeon.

Sea Turtles

While adverse effects may occur in the event of a vessel strike of a sea turtle, there would be a very low probability of such strikes, due to the limited number of tests in the LDZ and the infrequent, seasonal occurrence of sea turtles. Vessel engine noise associated with military vessel activities on the waters of the LDZ may have temporary behavioral effects on sea turtles, but the overall vessel traffic on the PRTR would decrease during activities.

In accordance with Section 7 of the ESA, PRTR use under Alternative 2 would have no effect on sea turtles. In accordance with NEPA, PRTR use under Alternative 2 would have no direct or indirect impacts on sea turtles.

Birds

Bald eagles may use the PRTR for foraging. PRTR use under Alternative 2 would not affect the bald eagle, which is protected by the BGEPA. Nor would PRTR use affect ESA-listed bird species, or bird species protected by the MBTA or the Lacey Act. In accordance with NEPA, PRTR use under Alternative 2 would have no direct or indirect impacts on the bald eagle or other protected species.

Marine Mammals

While adverse effects may occur in the event of a vessel strike, there would be a very low probability of such strikes, due to the limited number of tests in the LDZ and the infrequent, seasonal occurrence of bottlenose dolphins. Vessel engine noise associated with military vessel

activities on the waters of the LDZ may have temporary behavioral effects on dolphins, but the overall vessel traffic on the PRTR would decrease during activities.

There are no reasonably foreseeable takes of marine mammals in accordance with the MMPA associated with PRTR use under Alternative 2. In accordance with NEPA, PRTR use would have no direct or indirect impacts on marine mammals.

Insects

Northeastern beach tiger beetles have only been observed on beaches in the lowest portion of the LDZ, near the mouth of the river. The LDZ is a water range and has no spatial overlap with these beaches.

In accordance with Section 7 of the ESA, there would be no effect on listed insect species. In accordance with NEPA, PRTR use under Alternative 2 would have no direct or indirect impacts on northeastern beach tiger beetles.

Plants

Sensitive joint-vetch, if present along the Potomac River, would be found in the intertidal zone and not in the deeper waters of the PRTR. Therefore, this species would not have any spatial overlap with PRTR activities.

In accordance with Section 7 of the ESA, PRTR use under the Alternative 2 would have no effect on sensitive joint-vetch. In accordance with NEPA, PRTR use under Alternative 2 would have no direct or indirect impacts on rare, threatened, or endangered plants.

5 CUMULATIVE IMPACTS AND NEPA CONSIDERATIONS

The approach taken in this analysis of cumulative effects follows the objectives of NEPA, Council on Environmental Quality (CEQ) regulations, and CEQ guidance. The CEQ regulations (40 Code of Federal Regulations [CFR] §§ 1500-1508) implementing the procedural provisions of NEPA define cumulative impact as:

> Cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR § 1508.7).

The analysis of cumulative effects may go beyond the scope of project-specific direct and indirect effects to include expanded geographic and time boundaries, and a focus on broad resource sustainability. The true geographic range of an action's effect may not be limited to an arbitrary political or administrative boundary. Similarly, the effects of an action may continue beyond the time the action ceases. This "big picture" approach is becoming increasingly important as growing evidence suggests that the most significant effects to natural and socioeconomic resources result not from the direct effects of a particular action, but from the combination of individual, often minor, effects of multiple actions over time. The underlying issue is whether or not a resource can adequately recover from the effect of a human action before being exposed to subsequent action or actions.

Consistent with CEQ (1997) guidance, this analysis focuses on potential cumulative effects that are "truly meaningful" rather than analyzing the cumulative effects of the Proposed Action "on the universe." In part through the public involvement and scoping process (see Section 1.9), the Navy has identified as truly meaningful, for the purposes of this analysis, the following potential cumulative effects:

- NSWCDD range activities
- Recreational and commercial use of the Potomac River
- Property values, development, and preservation efforts along the Potomac River
- Electric power capacity on NSF Dahlgren
- Noise in the vicinity of NSF Dahlgren and the PRTR
- Health and safety of residents near NSF Dahlgren and the PRTR
- Potomac River surface water quality

- Natural resources on NSF Dahlgren
- Aquatic biological resources of the Potomac River
- Protected species

In this chapter, an effort has been made to identify past and present actions associated with the resources analyzed in Chapter 4, plus those actions that are in the planning phase – limited to future actions that are reasonably foreseeable (not speculative). Additionally, only actions that have the potential to interact with the proposed Navy action are addressed in this cumulative analysis. Specific emphasis was placed on actions in and adjacent to NSF Dahlgren and the PRTR. The cumulative impact analysis evaluates only actions with potential effects on the environment that are fundamentally similar to the anticipated outdoor RDT&E effects of the Proposed Action, in terms of the nature of the effects, the geographical area affected, and the timing of the effects. The past, present, and reasonably foreseeable future actions evaluated in this analysis are shown on Figure 5-1, Contributing Actions.

For the purposes of assessing cumulative impacts, the Navy reviewed all relevant and available environmental documentation pertaining to actions considered in the cumulative effects analysis. The level of information available for the different actions varies. The best available data are used in the analysis.

Ideally, the effects of all actions would be quantifiable, and the cumulative results combined as appropriate. In reality, quantifiable data are available for only a portion of the activities. The cumulative analysis incorporates specific numbers and values for potential effects, where available; descriptive information is used in place of quantitative measures where they are unavailable. This approach provides the decision-maker with the most current information to evaluate the consequences of the Proposed Action.

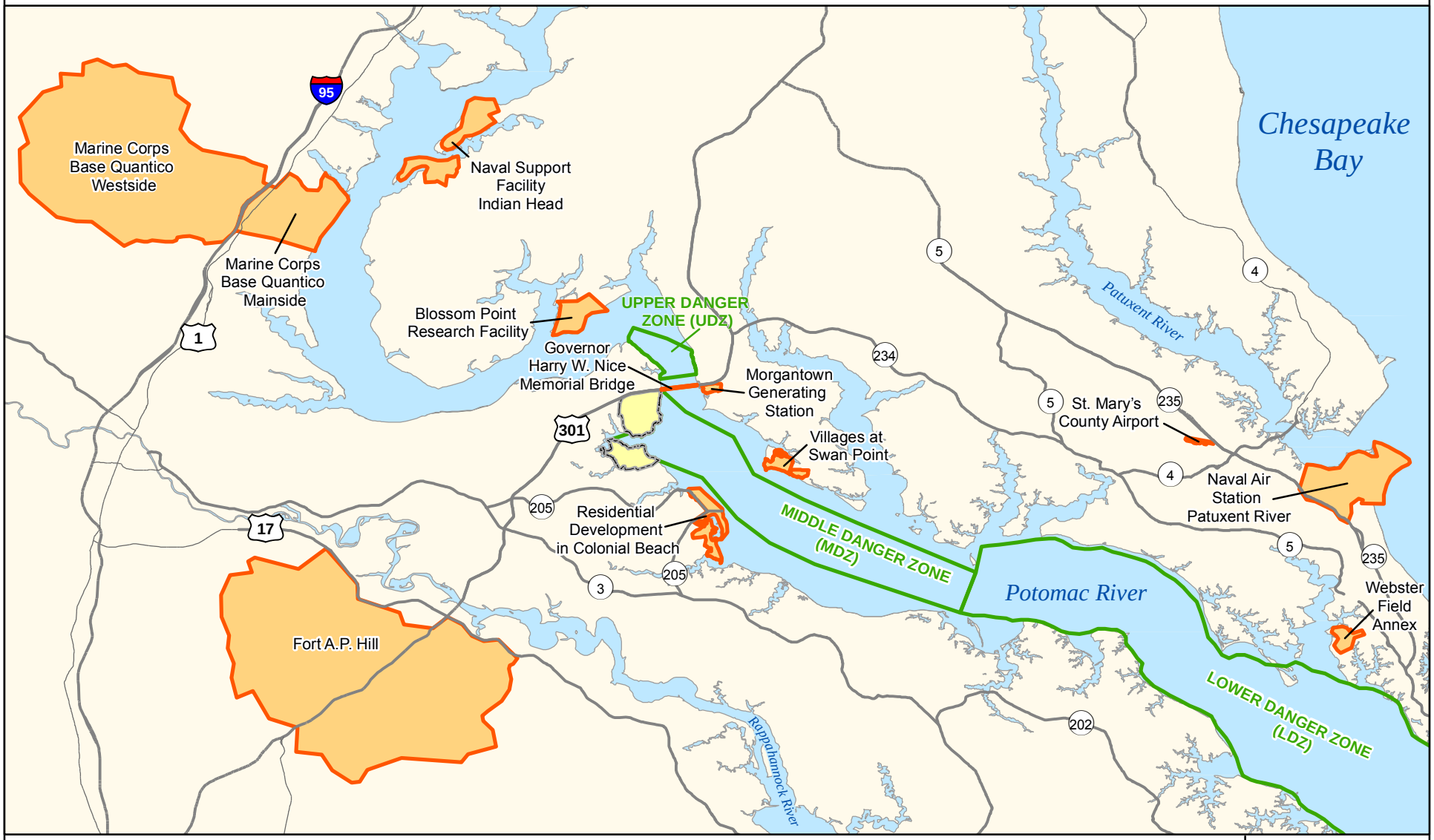
At this time, environmental impact analyses have not been conducted for several of the past and present, and reasonably foreseeable future actions identified in Sections 5.1 and 5.2. Therefore, assessments of the environmental effects of these projects are not currently available for consideration within the analysis of cumulative effects.

5.1 Past and Present Actions

A number of actions unrelated to the Proposed Action, occurring historically and up to the present time, have the potential to influence the resources affected by the Proposed Action, as identified in Chapter 4. Several such actions were identified. The relevant past and present actions identified can be categorized as follows:

- Activities on NSF Dahlgren or at nearby military installations that may constrain NSWCDD activities, affect use of the Potomac River or development along the river, affect the public in the vicinity of NSF Dahlgren or the PRTR, affect the resources of the Potomac River, or affect protected species in the region
- Private development or projects that may encroach on use of the ranges and the Mission Area at NSF Dahlgren, affect use of the Potomac River or development along the river, affect the public in the vicinity of NSF Dahlgren or the PRTR, affect resources of the

Contributing Actions



Contributing Action

Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR) Complex

8.5 0 8.5 Miles

13.5 0 13.5 Kilometers

Source: NSWCDD GIS (2008 - 2011)

NSWCDD EIS

Figure 5-1

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Potomac River, affect natural resources on NSF Dahlgren, or affect protected species in the region

A brief description of these actions follows, with an emphasis on components of the activity that are relevant to the effects previously identified. When determining whether a particular activity may contribute cumulatively and significantly to the effects identified in Chapter 4, the following attributes are considered: geographical distribution, intensity, duration, and the historical effects of similar activities.

5.1.1 NSF Indian Head Activities

NSF Indian Head (Indian Head) occupies 3,500 acres (ac) on the eastern shore of the Potomac River, approximately 20 mi northwest of NSF Dahlgren (Figure 3.1-5). As described in Section 3.6.4, the Navy's main gun proving range was located at Indian Head from 1890 until the proving range at Dahlgren, Virginia was commissioned in 1918 as "the lower range."

The installation consists of two parcels: Cornwallis Neck, on the peninsula formed by Mattawoman Creek and the Potomac River, and Stump Neck across the creek's mouth. Cornwallis Neck includes an operational area and a restricted area in the southern part of the peninsula, where munitions explosive testing is performed. Indian Head also conducts open burn activities on Cornwallis Neck. Stump Neck is the primary location for the Naval Explosive Ordnance Disposal Technology Division and Range 3, where the division performs open detonations of foreign ordnance.

Major Indian Head tenants include Indian Head Division, Naval Surface Warfare Center (a sister organization to NSWCDD), the mission of which is to provide primary technical capability in energetics for all warfare centers and secondary technical capability through RDT&E for energetic materials, ordnance devices and components, and related ordnance engineering standards to include chemicals, propellants and their propulsion systems, explosives, pyrotechnics, warheads, and simulators; Naval Explosive Ordnance Disposal Technology Division, whose core functions center on explosive ordnance disposal (EOD) and whose activities include open detonations of up to 60 pounds (lbs); and the Marine Corps Chemical-Biological Incident Response Force, whose mission is to respond to a chemical, biological, radiological, nuclear, or high-yield explosive incident and whose training and deployment activities include landing craft air-cushion activities on the Potomac River, limited helicopter activities, and deployment of truck caravans.

Environmental impact analysis has been conducted for activities on this installation.

5.1.2 Marine Corps Base Quantico Activities

Marine Corps Base Quantico (MCB Quantico), a major Marine Corps training base, occupies about 59,000 ac, approximately 20 mi northwest of NSF Dahlgren on the western shore of the Potomac River (Figure 3.1-5). The base consists of two major areas on either side of Interstate 95: Mainside, east of the interstate and on the west shore of the Potomac River, and Westside, west of the interstate. Mainside is home to numerous administrative support functions and some training functions. A major tenant, Marine Corps Air Facility Quantico, is located on the eastern

edge of Mainside, by the waterside. The air facility is home to Marine Helicopter Squadron 1 (HMX-1), whose mission is to provide helicopter support for the President and the Vice-President of the United States, Marine Corps Development Command schools, and various government officials in the Washington, DC area. HMX-1 also tests and evaluates helicopter systems and products destined for the Marine Corps Expeditionary Forces. Westside is used primarily for military training. Largely undeveloped, it consists mostly of training areas and ranges used for a wide array of training activities, including small arms and artillery training, demolition training, and air-to-ground training. Besides the Marine Corps, the Federal Bureau of Investigation (FBI) and the Drug Enforcement Administration (DEA) have facilities and train at Quantico (MCB Quantico, 2008).

In April 2008, the US Marine Corps released a final environmental impact statement (FEIS) (MCB Quantico, 2008) that assesses the potential environmental effects of the development of the Westside, including impacts due to the 2005 Base Closure and Realignment (BRAC) action at MCB Quantico. The development evaluated would encompass the construction of new facilities within the Westside to accommodate either the relocation of approximately 3,000 personnel directed to MCB Quantico by the BRAC (Alternative A) or an additional 2,000 personnel plus the 3,000 personnel directed to MCB Quantico under BRAC (Alternative B). Each Alternative considered two locations on the Westside (Option 1: Russell Road and Option 2: MCB-1). The US Marine Corps' preferred alternative is Alternative B, Option 1, under which all 3,000 personnel were relocated to what is referred to as the Russell Road Area and the additional 2,000 personnel would be sited in what is referred to as the MCB-1 Area. The relevant findings of the FEIS for the preferred alternative follow (MCB Quantico, 2008):

- **Electric power capacity** – The preferred alternative would require approximately 17.5 megawatts (MW) or more of electrical power. Dominion Virginia Power would be the primary supplier and there would be adequate regional electric power capacity existing to supply the required power to MCB Quantico.
- **Noise** – Independent of the proposed action, the Charlie Demolition Range and the Weapons Training Battalion, which is located approximately 1,000 feet to the south of the main MCB-1 Area, impact the proposed construction area under the preferred alternative. The noise from the weapons range is expected to increase, by 2009, due to the introduction of new aircraft (MV-22) and increased ordnance use. Noise studies in 2006 indicate that, by 2009, the noise contours would expand and all of the main MCB-1 Area, approximately 50 percent of the Northern MCB-1 Site, and approximately 10 ac in the western portion of the Southern Russell Road Site are projected to be within Noise Zone 2. Noise Zone 2 is where social surveys show between 15 percent and 39 percent of the population are expected to be highly annoyed by noise. The projected use of 50-lb demolition charges would extend these contours. Measures are proposed that are designed to attenuate both noise and impulse levels, resulting in a minimum of 20-decibel (-dB) noise level reduction.

  Adverse effects on the noise environment at MCB Quantico due to implementation of the preferred alternative would be limited to temporary increases in noise generated during construction and long-term noise impacts due to increased traffic.

- **Surface water quality** – The preferred alternatives is located in the Chopawamsic Creek and Beaverdam Run watersheds. Both of these watersheds ultimately drain into the Potomac River, and then the Chesapeake Bay. The proposed development would increase the amount of impervious surfaces that could result in an increase in stormwater runoff, which would carry pollutants to streams. In addition, construction activities could result in sediments or fill entering nearby stream flows and being carried downstream into larger water bodies. To mitigate any impact to surface water quality, keep in compliance with state and federal water quality requirements, and have no significant impact to water quality, erosion and sediment control and stormwater management plans would be implemented.
- **Aquatic biological resources** – There are numerous water bodies at MCB Quantico that contain various native non-game fish species. The lower Chopawamsic Creek, in particular, expands into a tidal open water and riverine wetland that is considered an important nursery area for fish in the Potomac River.

  Construction activities and the creation of additional impervious surfaces could increase the potential for erosion and transport of pollutants into the surface water at MCB Quantico. Any impact in surface water quality could impact fish habitats. As with surface water mitigation, enacting erosion and sediment control and stormwater management plans would minimize any negative impacts to aquatic biology.
- **Protected species** – Three populations of small whorled pogonia, a federally-listed threatened species, were found during a 1990-1991 survey conducted by the Virginia Department of Conservation and Recreation (VDCR). The proposed road construction within the Russell Road Area could impact this species by encroaching into its protection zone. However, with specific mitigation this potential would be eliminated. There are no other threatened or endangered species within the proposed development areas.

5.1.3 Blossom Point Research Facility Activities

The US Army's Blossom Point Research Facility (BPRF) is a sub-installation to the US Army Garrison Adelphi Laboratory Center (USAG ALC). The approximately 1,600-ac BPRF, located about 7 mi to the north of NSF Dahlgren, is situated on the southern portion of Cedar Point Neck, the peninsula formed by the confluence of Nanjemoy Creek and the Potomac River (Figures 3.1-3a and 3.1-5). The installation is an active ordnance and electronics research and development facility of the US Army Research Laboratory, the Army's corporate basic and applied research laboratory.

Under an operating permit from the Army, the Naval Research Laboratory (NRL), through its satellite control network, manages NRL and Navy satellites at the 265-ac Blossom Point Satellite Tracking and Command Station on BPRF. Potential interference with the sensitive satellite antenna radio receivers is minimized by a 2,000-foot (-ft)-radius buffer zone and sound easement around the NRL site (Federal Laboratory Consortium Mid-Atlantic Region, 2008; Long, pers. comm., June 22, 2010).

From 1942 until 1976, BPRF served as a national defense facility with the mission of testing small, experimental proximity fuzes and fuze components (US Army Environmental Command [USAEC] and United States Army Corps of Engineers [USACE] Baltimore District, 2008). Parts

of the Potomac River and Nanjemoy Creek were used as impact areas for ordnance testing at Blossom Point. A 6.4-square nautical mile (-sq NM) water range comprised 14 distinct range firing fans used for experimental testing of 60-millimeter (mm), 80-mm, and 4.2" mortars; 2.75", 3.25", 3.5", 4.5", and 5" rockets; 20-, 30-, 40-, 75-, and 105-mm projectiles; and 20- and 750-lb bombs (USAEC, 2009b). Results of a review of historical records indicated the potential presence of munitions and explosives of concern, material potentially presenting an explosive hazard, and munitions debris. A magnetometer-assisted visual survey of the historical water range found likely elevated unexploded ordnance densities along the shore at Cedar Point and extending east into the Potomac River, upstream of the UDZ (Nelson, 2009). The US Army implemented a non-time critical removal action that was completed in August 2011 (USAEC, 2013).

BPRF closed from 1976 to 1978 (Long, pers. comm., June 22, 2010). Since reopening, BPRF has conducted explosives research and development studies, conducted acoustic and optical research, developed mine clearing systems, refined target acquisition technology, and developed personnel and equipment detection devices. The installation's current operational range complex comprises eight land ranges – a small-caliber range, an observation tower, an indirect-firing range, an impact area, an acoustic and optical test area, two open burn/open detonation (OB/OD) areas, and a maneuver and training area – encompassing approximately 1,555 ac (USAEC and USACE Baltimore District, 2008). In addition, two non-operational areas total 44 ac.

In September 2008, the Army issued an Operational Range Assessment Program Phase I Qualitative Assessment Report for BPRF (US Army and USACE, 2008). The operational range qualitative assessment evaluated the operational range area at the installation to assess whether further investigation is needed to determine if munitions constituents of potential concern (MCOPCs) are or could be migrating off range at levels that may pose an unacceptable risk to human health or the environment. The relevant findings of the assessment follow (US Army and USACE, 2008):

- **Surface water quality** – Primary MCOPC source areas identified at BPRF are from historical firing activities within the boundaries of all eight current operational ranges; whereas current munitions use, which involves limited use of live-fire munitions, does not constitute a primary source. Historical firing activities impacted surface water and sediment both directly – e.g., by direct deposition of MCOPCs into streams and wetlands – and indirectly through the release of MCOPCs from soil – e.g., by soil erosion and runoff to streams, the Potomac River, and Nanjemoy Creek. However, based on the limited human use of or access to shoreline areas around BPRF, as well as the large volume of water in and the high flow rates of the river and creek relative to the minimal volume and flow of water exiting the installation, it is unlikely that potential MCOPCs would interact with human or ecological receptors located down gradient.

In November 2009, the Army released a Draft EA (USAG ALC, 2009) to assess the potential environmental effects of the implementation of the updated real property master plan (RPMP) for the USAG ALC and the BPRF. The Army's preferred alternative comprised the implementation of the RPMP, in its entirety, at the two installations to provide overall support for certain infrastructure improvements – e.g., maintenance, repair, upgrades, demolition, and construction – that are needed to address issues such as maintenance of aging infrastructure, deficit of space, semi-permanent facilities, and shoreline erosion. Implementation of the RPMP and the component infrastructure improvements are needed to minimize or resolve existing

inefficiencies and incompatibilities, to remain on the cutting edge of science and technology, and to provide an efficient, sound framework to evaluate future development projects. Proposed master plan projects at the BPRF that are pertinent to this cumulative effects analysis include the following (USAG ALC, 2009):

- Construct a travel camp for recreational vehicle and cabin camping
- Lease 15 additional ac by the NRL for four antenna pads
- Construct a 10-lane, 1,000-yd small arms research range
- Construct a boat dock on Nanjemoy Creek
- Reengineer the existing unmanned aerial vehicle (UAV) testing runway
- Pave 2 mi of Blossom Point Road and maintain the road to a minimum width of 20 ft
- Coordinate with multiple agencies on submerged aquatic vegetation (SAV) research
- Construct approximately 800 ft of stone revetment and eight stone offshore breakwaters along 1 mi of Nanjemoy Creek
- Use low-impact, bioengineering approaches to stabilize the shoreline along portions of Nanjemoy Creek and the Potomac River
- Replace the existing Ordnance Loading Building with a new materials transfer facility for receiving and handling hazardous and explosive materials

The proposed boat dock is needed to launch small craft used to keep the safety danger zone on the Potomac River clear as a precaution when firing mortars and for shoreline security and safety during research activities (USAG ALC, 2009; Long, pers. comm., June 22, 2010). As the waterways around the installation are not restricted, during tests BPRF personnel on small craft verbally communicate to boaters that a test is in progress and request that the boaters move elsewhere (Long, pers. comm., June 22, 2010). This occurs approximately twice a year, for the duration of the two- to three-day tests. The UAV testing runway is used for two to three days twice a month (Long, pers. comm., June 22, 2010).

Under the Joint Land Use Study, a component of the RPMP, the ALC also proposes to acquire 1,768 ac on the north and east side of the BPRF. The additional acreage would improve noise buffer zones, sustain safety fans, minimize electromagnetic (EM) interference, enable compliance with Department of Defense (DoD) Directives 3200.15 and 4715.11 (pertaining to sustainment of and environmental and explosives safety management on operational ranges), increase security for low-visibility programs, and increase availability for larger project footprints.

The relevant findings of the Draft EA follow (USAG ALC, 2009):

- **Electrical power capacity** – The preferred alternative would replace the installation's electrical distribution system, which is disparate, out of date, and out of compliance with rural electrical standards. Any changes in demand for electrical power resulting from the proposed infrastructure improvements would be minimal.
- **Noise** – Ordnance firing activities are a major noise generator on the installation. Firing is performed Monday through Friday between 8 am and 5 pm. Firing is intermittent and includes various numbers of rounds, and some activities require firing high-explosive

projectiles. Noise contours for existing detonation activities indicate that all unacceptable noise levels (Zone III) are confined to the installation and a small portion of levels considered normally unacceptable (Zone II) extend outside the installation boundary, but only into the edge of the Potomac River. All off-installation sensitive receptors are located in areas with noise levels that are acceptable for noise-sensitive land uses (Zone I).

When operating at full power and during enhanced propagation conditions, higher-frequency (10 hertz [Hz] or greater) acoustical testing can generate noise that may be heard across the Potomac River by the residents of the Mathias Point Neck area. However, the sound generation system is not normally operated at full power under enhanced propagation conditions.

Construction projects would temporarily increase the noise levels on the installation and potentially would affect nearby residences without adverse impacts. The new small arms research range would increase noise levels on the installation.

- **Health and safety** – The existing Ordnance Loading Building is in danger of falling into the Potomac River and the building's existing 670-ft explosive safety quantity distance (ESQD) arc extends over the water. The proposed replacement of the building with a new materials transfer facility would reduce risks to boaters.
- **Surface water quality** – Full implementation of the RPMP and the component infrastructure improvements would increase impervious surface area on the installation; however, the increase would not be substantial and would have little effect on overall stormwater runoff quantity or quality. Implementation of shoreline erosion control along Nanjemoy Creek and the Potomac River would reduce sediment loading and, thereby, would beneficially affect the water quality of both water bodies, as well as that of the Chesapeake Bay.
- **Protected species** – Constructing the small arms research range, boat dock, and travel camp and paving Blossom Point Road would occur in the vicinity of bald eagle nests. These infrastructure improvements would be coordinated with the Maryland Department of Natural Resources (MDNR) and, depending on the actual proximity of the construction activities to the nests, construction may need to be limited to the non-nesting period.

The Army completed and is implementing three of the five components of the RPMP for the USAG ALC and the BPRF, specifically the Long Range Component, Short Range Component, and Installation Design Guide (Sturtz, pers. comm., April 5 and 9, 2012). The two remaining components – the Real Property Digest and the Capital Investment Strategy – are outdated, precluding completing the EA. The Army withdrew the Draft EA in December 2009 (Krake, pers. comm., April 5, 2012).

5.1.4 Fort A.P. Hill Activities

Fort A.P. Hill is a US Army field training installation located approximately 20 mi to the southwest of NSF Dahlgren (Figure 3.1-5). The installation encompasses 75,794 contiguous ac and leases an additional 111 ac for specialized training along the Rappahannock River (US

Army, 2004; USACE, Mobile District, 2007). The primary mission of Fort A.P. Hill is to provide firing ranges and maneuver areas for training Active Army and Reserve Component units. The vast majority of the installation's training load comes from units or organizations stationed elsewhere that come to Fort A.P. Hill for certain aspects of their training. It is also used for training by other military services, law enforcement agencies, and civilian organizations.

The southern portion of the installation is used for live-fire munitions training; whereas the primary use of the northern portion is for non live-fire troop and vehicle training in a variety of wartime maneuver simulations (USAEC, 2009c). The range complex is primarily for small arms, direct-fire weapons, anti-tank missiles, artillery, and aerial gunnery (US Army, 2004; USACE, Mobile District, 2007). In addition, ample tactical landing zones, parking areas, and refueling facilities for rotary-wing aircraft are available. The Fort A.P. Hill Airfield is located on the southeast side of US Route 301 and is used by rotary-wing aircraft. In addition, C-130 aircraft originating at other airfields train two or three times a year at the assault airstrip in the installation's drop zone (US Army, 2004).

In February 2007, the Army released an FEIS (USACE, Mobile District, 2007) to assess the potential environmental effects of the implementation of the BRAC recommendations at Fort A.P. Hill and at Fort Lee, Virginia and a Record of Decision (ROD) was signed on May 11, 2007 (US Army, 2007). The FEIS identifies, evaluates, and documents the effects of facility construction, maintenance, management, and renovation on the environment, and economic and social conditions at the installations that would result from the implementation of the realignment actions mandated by the BRAC Commission. The Army's preferred alternative comprised the following major components: relocation of approximately 7,700 additional personnel to Fort Lee; construction of additional facilities at Fort Lee and Fort A.P. Hill to accommodate relocated personnel and functions; and conducting of training and other activities at the two installations. The relevant findings of the FEIS follow (USACE, Mobile District, 2007):

- **Noise** – The noise generated by industrial-type activities and the movement of heavy military vehicles does not have a considerable effect on the surrounding civilian communities or military housing areas at Fort A.P. Hill. The noise from military aircraft and weapons at Fort A.P. Hill extends to areas outside the installation boundary. Effects associated with aircraft noise are due to single, intrusive events of the installation and not the overall noise environment. The places where residents are most likely to be exposed to aircraft noise from Fort A.P. Hill training activities are along the installation boundary. The existing small-caliber weapons noise zone II (87-104 peak decibels [dBP]) extends beyond the eastern boundary approximately 1,203 yards (yds), beyond the southern boundary a maximum of 1,859 yds, and beyond the western boundary less than 328 yds. Large-caliber weapons noise zone II (62-70 C-weighted decibels [dBC]) extends beyond the southern boundary less than 328 yds. The existing large-caliber weapons 115-dBP contour extends beyond the northeastern and eastern boundary less than 2,625 yds and beyond the southern boundary less than 3,500 yds.

  Adverse effects on the noise environment at Fort A.P. Hill due to implementation of the preferred alternative would be due primarily to heavy equipment noise during construction and the operation of the proposed EOD range. Implementation of the preferred alternative would extend existing noise contours approximately 328 yds farther beyond the southern boundary and approximately 656 yds farther beyond both the

northern and eastern boundaries. Individuals within these areas would be exposed to a louder acoustical environment and more frequent noise, when compared to existing conditions.

- **Surface water quality** – Under the preferred alternative, long-term minor adverse effects on surface water quality of the streams, ponds, and lakes within Fort A.P. Hill are expected. Construction of facilities and infrastructure could increase runoff due to an increase in impervious surface area, increased soil erosion, and increases in sediment and pollutant loads.
- **Aquatic biological resources** – Surveys at Fort A.P. Hill have identified a total of 37 species of fish that inhabit the installation's streams, lakes, and ponds. Ecosystem-level impacts of the preferred alternative are expected to be negligible.
- **Protected species** – A comprehensive biological diversity inventory undertaken in 1992 and 1993 identified the state-listed threatened Bachman's sparrow (*Aimophila aestivalis*) on Fort A.P. Hill. According to the VDCR, recent studies at Fort A.P. Hill indicated the presence of three rare species – the rainbow snake (*Farancia erytrogramma*), carpenter frog (*Rana virgatipes*), and lesser siren salamander (*Siren intermedia*). As all three species identified by the VDCR are water and wetland dependent and impacts to wetlands and streams, including adjacent 100-ft-wide upland buffers, would be avoided, impacts to these species are not anticipated. Twelve active bald eagle nest sites have been documented on the installation; however, potential impacts to bald eagles would be precluded through avoidance of the primary (250-yd) and secondary (440-yd) protection zones around the nests.

From 2005 through 2008, the VDCR Division of Natural Heritage conducted a re-inventory of the natural heritage resources of Fort A.P. Hill (VDCR, 2010a). During the re-inventory, division personnel observed 71 occurrences of natural heritage resources involving 24 natural heritage resource elements comprising 6 natural community types, 11 rare plant taxa, and 7 rare animal taxa. Both the number of occurrences and the number of elements observed during the 2005-2008 re-inventory were reduced compared to those observed during the 1992-1993 inventory discussed in the February 2007 FEIS. The Division of Natural Heritage attributed this reduction to a variety of factors, including habitat alteration, revised definitions of occurrences, and changes in the elements tracked—e.g., data for American ginseng (*Panax quinquefolius*) and bald eagle nest sites were included in the 1992-1993 total, but were not included in the 2005-2008 tally (VDCR, 2010a).

5.1.5 Naval Air Station Patuxent River and Webster Field Annex Activities

The Patuxent River Complex supports naval aviation activities by researching, developing, testing, and evaluating aircraft, aircraft components, and related products. The complex includes Naval Air Station (NAS) Patuxent River with its flight and ground test facilities, runways, and associated airspace; Webster Field Annex with its flight test facilities, runways, and associated airspace; and the Chesapeake Test Range (CTR). NAS Patuxent River, with Webster Field Annex, hosts about 50 tenant commands and most components of the Naval Air Warfare Center, Aircraft Division (NAWCAD). NAWCAD is the Navy's principal RDT&E, engineering, and

fleet support activity for Navy and Marine Corps air vehicle systems and trainers. NAS Patuxent River occupies approximately 6,400 ac along 25 mi of shoreline on the broad headland at the confluence of the Patuxent River and the Chesapeake Bay, in the northeast corner of St. Mary's County – approximately 34 mi from NSF Dahlgren (Figure 3.1-5). Webster Field Annex is an 850-ac dependence located on the eastern shore of the St. Mary's River – approximately 35 mi to the southeast of NSF Dahlgren (Figures 3.1-3b and 3.1-5).

The CTR comprises restricted airspace, aerial and surface firing ranges, and Hooper, Hannibal, and Tangier Island targets. The airspace comprising the CTR overlies about 1,800 square miles (sq mi). About half of the CTR overlies the waters of the middle portion of the Chesapeake Bay and portions of its tributaries – including approximately the lower half of the LDZ in the Potomac River – and half overlies land in Maryland, Delaware, and Virginia.

In December 1998, the Navy released an FEIS (NAWCAD, 1998) to evaluate potential environmental impacts of increasing flight and related activities in test areas under the exclusive control and scheduling authority of NAWCAD. A ROD was signed on May 27, 1999 (Department of the Navy [DoN], 1999). The increases in flight and related activities would occur predominantly at NAS Patuxent River, Webster Field Annex, and in the CTR. The preferred alternative (Operational Alternative III) encompasses the largest amount of increased operational hours for both flight and ground activities. The relevant findings of the FEIS for the preferred alternative, and where applicable the no action alternative, follow (NAWCAD, 1998):

- **Use of the Potomac River** – Under the no action alternative, commercial fishing in small portions of the Chesapeake Bay would be prohibited during times of testing. The frequency and duration of target clearance under the no action alternative, which involves between 0.1 and 0.3 percent of the surface water areas underlying the CTR, would average 36 hours per month and about 13 percent of weekly daylight hours from June through September. Under the preferred alternative, the amount of hours that portions of the surface water underlying the CTR would be closed would increase by 22 to 36 hours. During June through September, implementation of the preferred alternative would result in the closure of segments of the Chesapeake Bay to commercial fishing for about 18 to 24 percent of weekly daylight hours.

  Recreational fishing and boating in the Chesapeake Bay are permitted within the aerial and surface firing range of the CTR and the non-prohibited sections of the Tangier Island target danger zone, when not in use. When in use, non-participating boats are cleared from the area. It has been estimated that closures total about 36 hours per month under the no action alternative. Under the preferred alternative, closure time would increase to approximately 13 to 16 hours a week.

  Due to federal regulations and the distance the shipping routes are from the targets within the CTR, there would be no significant impacts to commercial shipping within the Chesapeake.

- **Electric power capacity –** For the preferred alternative, 198,400 megawatt-hours (MWH) per year would be required. It is anticipated that the existing utility network would be adequate to accommodate the increased demand.

- **Noise** – The results of noise models for activities over the CTR indicate that there would be no significant noise impacts due to the no action and preferred alternatives. The

average noise levels produced by subsonic and supersonic flights would be below 55 dB (onset rate-adjusted monthly day-night average sound level). For subsonic flights, noise levels would be highest near the target areas and on the east side of the CTR. For supersonic flights, the highest level noise contour covers an area of approximately 46 sq mi, though impact at ground level would be negligible.

In general, for both the no action alternative and the preferred alternative, for locations within the CTR, 4 to 5 locations out of 20 locations studied would experience noise levels that would result in potential speech interference and 8 out of 20 locations would experience noise levels that would result in sleep disturbance. In addition, all measured noise levels at specific sensitive receptors within the CTR would be at or below 65 dB.

Over NAS Patuxent River, the total area within the 60 dB day-night average sound level (DNL) contour would be approximately 1,918 ac for the no action alternative and 2,527 ac for the preferred alternative. The estimated off-base population within the 60 dB contour would be approximately 2,750 for the no action alternative and 3,439 for the preferred alternative. The 75 dB DNL contour would not extend outside the property line under either alternative.

Over Webster Field, the total area within the 60 dB DNL contour would be approximately 51 ac for the no action alternative and 61 ac for the preferred alternative. The estimated off-base population within the 60 dB contour would be approximately 6 for both the no action alternative and the preferred alternative. The 70 dB DNL contour would not extend outside the property line.

- **Health and safety** – Under the preferred alternative, with increased flight and related activities, the potential for accidents on the ground and in the air could increase, although for UAVs the Navy specifically selects training areas to avoid overflights of densely populated areas. Due in part to increased engine reliability, the number of accidents has been reduced and there has been only minor property damage documented in the past.
- **Surface water quality –** Increasing the amount of flights and related activities would not significantly impact surface water quality. Specifically, the release of inert stores (signal cartridges), expended small arms rounds that contain lead, and the use of chaff (aluminum-coated and uncoated fiber material) and flares would have no significant impact. This non-significant impact determination also accounts for the fact that some stores have attached telemetry units which are battery-operated. The older nickel-cadmium batteries are being replaced over time by environmentally-friendly lithium iron disulfide batteries. Finally, there would be no significant impact to stormwater flow or collection systems or to any 100-year floodplain.
- **Aquatic biological resources** – The increased activities under the preferred alternative likely would increase the number of practice bombs dropped over target areas, including over water. However, this increase would not significantly increase the already extremely low probability of a direct strike on fish. Also, unrecovered and unrecoverable (buried) inert stores, expended military small-arms ammunition that contains lead, and the use of chaff and flares pose no significant threat to aquatic biology.
- **Protected species –** The increase in aircraft noise would have no significant impact on the northeastern beach tiger beetle, the bald eagle, or the peregrine falcon, though these

protected species are potentially located within the area. The northeastern beach tiger beetle is likely not breeding within the area and there have been no observed bald eagle or peregrine falcon nests. In addition, while the shortnose sturgeon and Atlantic sturgeon are present in the Chesapeake Bay, their populations are very small. Thus, the probability of a store (i.e., any item capable of being released or expended from aircraft) striking a sturgeon would be minimal and there would be no significant impact.

NAS Patuxent River periodically reviews the 1998 FEIS. As the types and tempo of air operations analyzed in the FEIS still pertain to current air operations and as the affected environment remains substantially unchanged, NAS Patuxent River has determined that the impact assessments remain valid today (Jarboe, pers. comm., March 4, 2010).

The Navy completed updated air installations compatible use zones (AICUZ) studies for the Webster Field Annex in 2006 (DoN, 2006) and for NAS Patuxent River in 2009 (DoN, 2009). The AICUZ updates were prepared to reflect changes in airfield operations since the last AICUZ update, in 1979 for both airfields, and to incorporate any reasonable projected mission changes. Consistent with Operational Alternative III of the 1998 FEIS, 91,546 annual NAS Patuxent River flight operations – approximately 70 percent fixed wing aircraft and 30 percent rotary-wing – and 69,836 annual Webster Field flight operations – approximately 75 percent rotary-wing aircraft, 21 percent fixed-wing, and 4 percent UAV or remotely operated aircraft – were used as the bases for the AICUZ studies. The relevant findings of the studies follow (DoN, 2006; 2009):

- **Noise** – The 60 dB and 65 dB DNL noise contours at NAS Patuxent River extend approximately 3 to 3.5 nautical miles (NM) northwest, northeast, southwest, and southeast from the runways, and result mostly from straight-in arrivals and projected operations of fixed-wing aircraft (DoN, 2009). The majority of the acreage encompassed by the 60 dB DNL contour and above is located over Navy-owned property or water. Approximately 3,608 ac are exposed to noise levels above 60 dB DNL off station, excluding area over water.

  At Webster Field, a portion of both the 60 dB and the 65 dB DNL noise contours result in off-annex noise impacts (DoN, 2006). This off-annex exposure is mainly due to the rotary-wing flight paths used by aircraft at Webster Field over the St. Inigoes Shores residential area. Approximately 60 ac, 45 housing units, and 115 people are exposed to noise levels above 60 dB DNL off the annex.

Most NAS Patuxent River air operations cover large areas and most pass over the Potomac River for some portion of the flight path. For all operations, the only component that occurs over the river is flight. The most frequent flight component over the Potomac River is final approaches and takeoffs – in particular, the Piney approach and departure, which cross over the Piney Point/St. George area (Jarboe, pers. comm., March 4, 2010). Other frequent flight operations over the Potomac are operations under visual flight rules.

Webster Field Annex is used primarily by Navy aircraft from NAS Patuxent River for a variety of military training and testing activities, including helicopter, fixed-wing, and UAV operations. Most of the helicopter and fixed-wing operations are touch-and-go operations (Jarboe, pers. comm., June 22, 2010), in which aircraft land and take off without coming to a full stop. During these operations, the aircraft remain close to the airfield. Typically, UAVs that take off from Webster Field proceed over the Potomac River and fly in the UAV operations area that overlies Northumberland County in Virginia (Jarboe, pers. comm., June 22, 2010). In addition, there are a

number of UAV routes available for training that extend down the river and across the Chesapeake Bay, and continue over Maryland's Eastern Shore. Rarely, boat operations using a diver originate from the annex, typically using the St. Mary's River, not the Potomac River, for operations (Jarboe, pers. comm., March 4, 2010).

NAS Patuxent River frequently closes the CTR surface danger zone in the Chesapeake Bay, although not the portion of the CTR that overlies the lower LDZ. When closures are needed, NAS Patuxent River typically closes only that portion of the surface hazard zone within the hazard pattern, delimited by the Range Safety Office for each operation. At most, closures are for up to one or two hours (Jarboe, pers. comm., March 4, 2010). Table 5-1 compares the frequency and duration of closures of the surface danger zone in the bay to the annual closures projected for the 1998 DEIS. From 2005 through 2009, the frequency and duration of closures were substantially lower than those projected, with the actual levels never exceeding approximately 36 percent of the projected.

Table 5-1
CTR Closures from 2005 to 2009

Closure	2005	2006	2007	2008	2009	FEIS Annual Projection
Number of Closures	118	94	107	39	63	324
Hours Cleared	195	167	173	78	117	840
Number of Watercraft Cleared	262	285	350	40	107	NA

Note:
NA = Not applicable – No annual FEIS projection specified.
Source:
NAWCAD, 2010.

5.1.6 Morgantown Generating Station Coal Barge Facility

The Morgantown generating station is located just south of the Harry Nice Bridge landing in Charles County, across the Potomac River from NSF Dahlgren (Figure 3.1-3a). In 2008, the owner of the generating station, Mirant Corporation, completed construction of and began operating a new offloading facility that supplements the station's railcar receiving system. The new facility allows the generating station to receive coal on large open barges that travel up the Potomac River and unload at this facility (Allen, pers. comm., February 19, 2009). Previously, the only option to transport coal to the station was by train. The barge facility also is used to export gypsum.

The coal barge unloading facility consists of a dock, an unloader, a transfer and distribution system, and a rail loading facility for shipping coal to Mirant's Chalk Point generating station in Prince George's County, on the Patuxent River at Swanson Creek (Maryland Power Plant Research Program [MPPRP], 2007). The unloading facility is located 336 ft offshore and is unconnected to land except by the conveying equipment. The dock extends approximately 836 ft into the Potomac River, and is 500 ft long and 50 ft wide. The unloading system feeds a 1,020-ft enclosed conveyor system, which moves the coal to an onshore transfer tower, from which two further conveyor systems carry the coal to the generating station's existing coal yards. At the new unloading facility, Mirant will unload no more than 5 million tons of coal per year, which is

the annual combined consumption rate of the Morgantown and Chalk Point generating stations (MPPRP, 2007).

The barge traffic generated by the project was estimated to be four to five 20,000-ton barges a week, dependent on commodity prices and transport costs, that would use the river's main channel to reach the offloading facility (MPPRP, 2007; Allen, pers. comm., August 26, 2009). However, actual coal deliveries vary and are very limited at this time – the majority of coal deliveries are by rail and, based on current market conditions, likely will remain so for the foreseeable future (Allen, pers. comm., June 3, 2010). In addition to the coal deliveries, beginning with the start of activities for the flue gas desulfurization system described below (Section 5.1.11), at least one dedicated barge a week has departed Morgantown, carrying synthetic gypsum to a wallboard manufacturing facility in New York (Allen, pers. comm., August 13, 2009; August 26, 2009; June 3, 2010). The gypsum (calcium sulfate) is formed during the desulfurization process (Mirant Mid-Atlantic, LLC, 2006).

The Navy has reached an operating agreement with Mirant and its barge unloading facility (J.L. McGettigan and J.L. Smith, letter, April 24, 2007). Mirant has agreed where feasible to schedule barge traffic through the PRTR outside the range's normal operating hours of Monday to Friday, 8 am to 4 pm and to coordinate alternate schedules with the Navy when PRTR operations would pose undue hardship to barge shipments. In addition, NSF Dahlgren and Mirant Corporation initiated a communication protocol to minimize conflicts between Navy activities and barge activities, and periodically will review the protocol and operational concerns (J.L. McGettigan and J.L. Smith, letter, April 24, 2007; Allen, pers. comm., February 19, 2009; August 13, 2009).

In March 2007, the MPPRP issued a draft environmental review (MPPRP, 2007) to assess the potential environmental effects of the proposed coal barge unloading facility at the Morgantown generating station. The relevant findings of the draft environmental review follow (MPPRP, 2007):

- **Range activities** – Barges in the lower Potomac River would navigate the main channel and would traverse the LDZ and the MDZ. Range activities may be delayed as barges transit the river between Point Lookout and the Potomac River Bridge, and when vessels navigate around Swan Point as all commercially navigable waters there are in the MDZ. It is unclear whether docking activities at the facility would increase such delays. Overall, operation of the facility was not expected to have a significant adverse effect on NSWCDD RDT&E activities.
- **Use of the Potomac River** – At a maximum, barge traffic would be about five barges per week. As commercial traffic on the Potomac River appears to be minimal – on the order of one or two vessels per week – the additional barge traffic servicing the facility was not expected to congest commercial traffic on the river. (See discussion of vessel traffic on the Potomac River in Section 4.2.1.2 – There are currently approximately 122 vessels per week transiting the river below Washington, DC [USACE, 2008].) Construction and operation of the facility would slightly restrict recreational boaters and fishermen from freely traveling the stretch of the river around the generating station's warm water discharge; however, no restrictions for recreational travel along the shoreline due to security were anticipated. Gill net stands located directly offshore from the generating station and commercial crabbing in the Morgantown vicinity of the Potomac River would not be adversely affected by construction or operation of the facility.

- **Noise –** Construction of the coal barge unloading facility was not expected to create adverse noise impacts. Noise emitted by operation of the facility would be similar in character to the existing site noise associated with coal handling and would not contribute to a noticeable increase in overall noise emissions from the facility, as experienced by nearby receptors. Based on a generic estimate of unloading and conveyor noise and the ¾-mi distance to the nearest residences, the facility likely would comply with state and county noise limits.
- **Surface water quality** – No change in Potomac River water quality parameters was expected due to the construction and operation of the coal barge unloading facility. The proposed conveyor represents state-of-the-art equipment for transferring coal over water, thus minimizing potential impacts from coal dust.
- **Aquatic biological resources** – Minor impacts to river bottom benthos may result as the pilings for the dock would be secured in the bed of the river. Due to the small size of the pilings – about 2 ft in diameter – impacts were expected to be minimal and would be concentrated around the area of the pilings. Should accidental coal spillage occur during the transfer of coal over water, lump coal may have some detrimental biological effects by altering sediment and decreasing sediment volumetric nutritional content. The proposed action was not expected to result in removing, altering, or restricting access to the Pascahanna Oyster Bar in the vicinity of the proposed facility, and coal dust that enters the water was not expected to result in adverse effects on oyster survival, growth, or filtration.

  There may be minimal impact to fish habitat during construction, and no impacts were expected on fish and fish habitat from the operation of the facility. There may be minimal, short-term construction impacts to waterfowl while the dock is under construction, whereas no operational impacts to waterfowl were expected. The light posts and pilings on the dock could provide additional perching habitat for sea birds.
- **Protected species** – The placement of 130 pilings to build the dock could result in the loss of forage items for the shortnose sturgeon. Construction of the new dock also could result in sediment accumulation and resuspension, hypoxic conditions (partial lack of oxygen), and elevated nitrogenous conditions, all conditions to which sturgeon are sensitive. However, construction and operational disturbances to the water column were expected to be minimal and to have no significant adverse effects on the shortnose sturgeon.

5.1.7 Morgantown Generating Station Flue Gas Desulfurization System

Another recent project at the Morgantown generating station (Figure 3.1-3a) was the installation of a flue gas desulfurization system and other associated facilities. The Mirant Corporation declared the desulfurization system operational on December 20, 2009 (Allen, pers. comm., June 3, 2010). The primary purpose of installing a flue gas desulfurization (FGD) system was to reduce sulfur dioxide (SO_2) emissions from the existing coal-fired steam-generating units in keeping with Maryland's Healthy Air Act (Mirant Mid-Atlantic, LLC, 2006). There also is a co-benefit in reducing mercury emissions.

The new FGD system was constructed on previously-disturbed areas within the existing generation station property. The system consists of a SO_2 scrubber absorber with the following associated facilities (Mirant Mid-Atlantic, LLC, 2006; Hare, 2007; Allen, pers. comm., August 13, 2009):

- Limestone receiving, handling, and storage facilities
- Limestone slurry preparation facility
- Gypsum byproduct storage, handling, and offloading facilities
- New makeup water supply
- Wastewater treatment system for scrubber wastewater
- Solid waste storage and handling system for scrubber and wastewater treatment solids
- New 410-ft-tall, dual-flue exhaust stack

The FGD system was projected to use about 1.54 million gallons per day (mgpd) (Mirant Mid-Atlantic, LLC, 2006; Rucker, 2007) or 1.72 mgpd (Hare, 2007) of water for process makeup water. Mirant Corporation proposed to obtain the required makeup water from wells in the Patuxent aquifer. However, the Water Management Administration of the Maryland Department of the Environment (MDE) determined that Mirant's proposed groundwater withdrawal would have an unreasonable impact on the aquifer and users of the aquifer (Hare, 2007). In response, Mirant Corporation elected to use Potomac River water from the generating station's existing river water intake, rather than groundwater, and built a reverse osmosis system on site to desalinate the river water prior to use (Allen, pers. comm., June 4, 2010). Although the desalination process was estimated to approximately triple the amount of water needed to operate the FGD system – to an estimated maximum withdrawal of 4.68 mgpd (Hare, 2007), the generating station is obtaining the needed water wholly under its previously-authorized surface water withdrawal allocation (Allen, pers. comm., June 4, 2010).

The FGD system also requires limestone, which is transported to the generating station by rail. At full station capacity, approximately 429,000 tons of limestone is required annually (Mirant Mid-Atlantic, LLC, 2006).

Mirant Corporation submitted an environmental analysis of the potential environmental effects of the proposed project (Mirant Mid-Atlantic, LLC, 2006) to the Public Service Commission of Maryland in October 2006, as part of its application for a certificate of public convenience and necessity. The relevant findings of the environmental analysis follow (Mirant Mid-Atlantic, LLC, 2006):

- **Noise** – The predicted noise levels due to project construction activities would be well below the Charles County code construction limit of 90 A-weighted decibels (dBA) and construction impacts at the identified noise receptors would be minimal.

  New noise sources would include twin booster fans, limestone ball mills, and a material handling system (conveyors, bulldozers, and loaders/unloaders), as well as truck and railway operations for bulk material handling. Noise impact modeling was performed to predict the maximum noise levels produced by the existing and proposed noise sources. The modeling results were combined with background noise levels measured at identified

receptors. The predicted noise level at the nearest residential property was below the Charles County noise standard.

- **Surface water quality** – The primary potential impacts to surface waters from site preparation and project construction activities would be erosion and sedimentation associated with earthmoving and material placement. Erosion and sedimentation impacts would be controlled and minimized through proper design and placement of runoff-control features. No direct impacts to surface waters would occur from construction activities.

  The scrubber wastewater treatment system would discharge approximately 125 gallons per minute (gpm) of effluent at a temperature of 95 degrees Fahrenheit (˚F) to the generating station's once-through cooling water discharge canal. As the average flow through the discharge canal is 1.0 million gpm, the treatment system discharge would be diluted by a factor of 8,333 before reaching the receiving waters of the Potomac River. Consequently, there would be no thermal impacts to the river and no impacts on the circulation patterns in the river.

  Process wastewater would be treated using biological reactors and clarifiers, and would be filtered prior to discharge to the Potomac River. In addition, the effluent would need to meet enhanced nutrient reduction standards of less than 4 milligrams per liter (mg/l) of total nitrogen at the discharge. The FGD system discharge would not likely cause a violation of state water quality criteria and no adverse water quality impacts were expected.

  The project would require updating and amending the generation station's stormwater pollution prevention plan (SWP3). The requirement of an updated and amended SWP3 would ensure that the project would be designed, constructed, and operated using best practices for controlling stormwater pollution and that there would be no significant environmental impacts.

In May 2007, the State of Maryland issued a proposed findings and final recommendations (Hare, 2007) that includes an assessment of the potential environmental effects of the FGD system. The relevant findings of the state's assessment follow (Hare, 2007):

- **Noise** – In a noise evaluation using conservative assumptions that tend to over-estimate noise impacts, the MPPRP evaluated the ability of the Mirant Corporation to operate the proposed FGD system in compliance with state and Charles County noise requirements. The MPPRP found that noise levels from operation of the proposed FGD system potentially could exceed the residential day and nighttime limits established by Charles County. The proposed findings and final recommendations recommended that Mirant Corporation be required to submit an updated noise analysis after the system components are selected and actual vendor specifications for noise characteristics are available. The analysis would be required to demonstrate that the equipment selection and engineering design incorporate sufficient noise mitigation to ensure that the project complies with all applicable noise regulations.

5.1.8 Morgantown Generating Station Coal Blending and Gypsum Loadout Facilities

Mirant Corporation also recently installed coal blending and gypsum loadout facilities at the Morgantown generating station (Figure 3.1-3a). The coal blending facilities use different types of coals to match the specifications of the boilers and air quality control equipment of the station's coal-fired steam-generating units. The facilities enable optimizing fuel flexibility while meeting Mirant Corporation's system-wide SO_2 emission reduction compliance plan, designed to meet the requirements of state-mandated emission reductions. The coal blending facilities include the following (Mirant Mid-Atlantic, LLC, 2008):

- Stackout facilities consisting of two transfer points
- Underground reclaim facilities in the north and south coal yards
- Reclaim transfer points to integrate the reclaim from the coal yards
- Refurbished and upgraded emergency reclaim
- Enclosed transfer locations with dust suppression

All of the coal blending facilities are installed within the generating station's coal yards.

The gypsum loadout facility supports the beneficial use and efficient transportation of synthetic gypsum, a byproduct formed during the desulfurization process – see Section 5.1.11. Gypsum from the Chalk Point generating station is transported to the Morgantown generating station by rail and, along with gypsum from Morgantown, is shipped by barge from the station's coal barge facility – see Section 5.1.10. The gypsum loadout facility conveys gypsum from gypsum storage to barges at the barge facility and includes the following (Mirant Mid-Atlantic, LLC, 2008):

- 1,000-ton per hour conveyor material handling system
- Five enclosed transfer towers
- One pier-located tripper conveyor system
- One telescoping barge loadout conveyor
- Rail unloading facility
- Rail unloading hopper and conveyor to support transport of Chalk Point-delivered gypsum to barge loadout

The gypsum loadout facility is installed at the perimeter of the coal yards and within the right-of-way of the coal barge unloader material handling system, within the generating station.

In August 2008, Mirant Corporation submitted an environmental analysis of the potential environmental effects of the proposed project (Mirant Mid-Atlantic, LLC, 2008) to the Public Service Commission of Maryland, as part of its application for a certificate of public convenience and necessity. The relevant findings of the environmental analysis follow (Mirant Mid-Atlantic, LLC, 2008):

- **Noise** – The predicted noise levels due to project construction activities would be well below the Charles County code construction limit of 90 dBA and construction impacts at the identified noise receptors would be minimal.

Noise from the operation of the coal blending facilities were expected to be lower than noise generated by the existing method of coal stacking and reclaiming in the coal yards. Noise from the operation of the gypsum loadout facility would not exceed typical noise levels generated by the existing transfer systems. The project would add minimal noise to the environment and the generating station would continue to comply with applicable noise regulations.

- **Surface water quality** – The primary potential impacts to surface waters from site preparation and project construction activities would be erosion and sedimentation associated with earthmoving and material placement. Erosion and sedimentation impacts would be controlled and minimized through proper design and placement of runoff-control features. No direct impacts to surface waters would occur from construction activities.

  The project would require updating and amending the generation station's SWP3. The requirement of an updated and amended SWP3 would ensure that the project would use BMPs for controlling stormwater pollution and that there would be no significant environmental impacts.

5.1.9 Residential Development in Colonial Beach

Over the last few years, the town of Colonial Beach, Virginia (Figure 1-3) has experienced substantial growth, and several major residential development projects have been initiated, including: the construction at Monroe Point of about 330 units on 51 ac and a 12-ac commercial site; the construction of 751 homes along Route 205 west of the creek separating Colonial Beach from the unincorporated parts of the county (Northern Neck Subdivision); and, nearby, Potomac Crossing, with 913 residential units, 182,000 sq ft of commercial space, a golf course, and a community recreation center (Colonial Beach Virginia Attractions, 2011; Delano, 2006 and 2007). However, in October 2007, the developer of Potomac Crossing announced the project was being put on hold due to unfavorable market conditions (Ficklin, 2007) and the project has remained on hold due to the economy (Colonial Beach Virginia Attractions, 2011).

5.2 Reasonably Foreseeable Future Actions Relevant to the Proposed Action

A number of actions reasonably expected to occur in the future may potentially contribute to cumulative effects to the resources identified in Chapter 4. The relevant, reasonably foreseeable future actions identified can be categorized as follows:

- NSF Dahlgren projects that may affect the public in the vicinity of the installation, affect resources of the Potomac River, or affect natural resources on the installation
- Projects at nearby military installations that may affect protected species in the region
- Public projects that may constrain NSWCDD activities, affect use of the Potomac River, affect the public in the vicinity of NSF Dahlgren or the PRTR, affect the resources of the Potomac River, or affect protected species in the region

- Private development projects that may encroach on the Navy's ranges at NSF Dahlgren, affect use of the Potomac River, affect resources of the river, or affect protected species in the region

A brief description of these actions follows, with an emphasis on components of the activity that are relevant to the effects previously identified. When determining whether a particular activity may contribute cumulatively and significantly to the effects identified in Chapter 4, the following attributes are considered: geographical distribution, intensity, duration, and the historical effects of similar activities.

5.2.1 Fort A.P. Hill Army Compatible Use Buffer Program

Under the Readiness and Environmental Protection Initiative, the Office of the Secretary of Defense (OSD) funds the armed services to implement compatible land use partnering projects – usually with state and local governments, and nonprofit organizations – that aim to relieve encroachment pressures on training, testing, and support activities at US military bases (OSD, 2007). The Army Compatible Use Buffer (ACUB) program creates land conservation partnerships between the Army and outside organizations to protect land from development that is incompatible with the military mission (USAEC, 2009a).

Encroachment

Encroachment refers to issues external to military operations that affect or have the potential to affect military installation testing, training, and other operations and overall military readiness (OSD, 2007).

The ACUB program at Fort A.P. Hill envisions creating an approximately 35,000-ac buffer around the installation, to prevent operational restriction that would occur if encroachment continues and to preserve the ecological integrity of the region (USAEC, 2009a). In 2006, under the program, Fort A.P. Hill and its conservation partners purchased an easement on a 1,320-ac tract. The Portabago Creek tract borders nearly 3 mi of the installation's eastern boundary, close to important firing ranges and the impact area (The Nature Conservancy, 2006). The Fort A.P. Hill ACUB program has contributed towards the permanent preservation of approximately 10,000 ac since 2006 (Kristine L. Brown, pers. comm., October 4, 2012).

All Fort A.P. Hill ACUB projects undergo NEPA review (Kristine L. Brown, pers. comm., October 4, 2012). To date, all of the projects have qualified under the Department of the Army final rule on environmental analysis of Army actions (67 Federal Register 15290, Department of the Army, 2002) for categorical exclusions (Kristine L. Brown, pers. comm., November 19, 2012), which "are categories of actions with no individual or cumulative effect on the human or natural environment, and for which neither an EA nor an EIS is required" (32 CFR § 651.28).

5.2.2 Potomac Land Conservation

Many land conservation programs have historically operated and currently operate in Maryland and Virginia, including within the Lower Potomac River basin, to protect natural resources, farmland, and open space. Table 5-2 summarizes the acreages of protected land in each of the counties in Maryland and Virginia that border the Lower Potomac River.

Various conservation initiatives and programs – in particular, the three discussed in the following paragraphs – are expected to bring additional areas along the Lower Potomac River under protection in the future.

Forest Legacy Program

The United States Forest Service administers the Forest Legacy Program in cooperation with state partners, including Maryland and Virginia. Through the use of voluntary conservation easements and fee-simple purchase, the incentive-based program protects environmentally-important and -sensitive forest lands, with emphasis on those that are threatened by conversion to non-forest uses. To maximize the benefits it achieves, the Forest Legacy Program focuses on the acquisition of partial interests in privately-owned forest lands (United States Forest Service, 2010). As of February 18, 2010, in Maryland 2,014 ac and in Virginia 5,971 ac of forest lands were protected under the program (United States Forest Service, 2010).

Table 5-2
Protected Land Area
in Counties Bordering the Lower Potomac River

County	County Land Area sq mi	Protected Area	
		ac	percent of county
Maryland			
Prince George's	485	15,128	4.9
Charles	461	19,497	6.6
St. Mary's	361	9,864	4.3
Virginia [1,2]			
Prince William	338	95,902	15.3
Stafford	270	94,181	18.1
King George	180	22,322	15.6
Westmoreland	229	19,344	13.2
Northumberland	192	3,487	2.8

Note:
1. Virginia protected area values are not split by county.
2. Virginia protected area values exclude military reservations.

Sources:
County land areas – United States Census Bureau, 2011.
Maryland protected areas – Davenport, pers. comm., April 26, 2010; MDNR, 2009.
Virginia protected areas – VDCR, 2010b.

To be eligible for the Forest Legacy Program, lands must be located within a Forest Legacy Area designated in a federally-approved assessment of need, prepared by the state. The Southern Forest Legacy Area in Maryland encompasses 254,699 ac of forest lands in Prince George's, Charles, and St. Mary's counties, and in Calvert County (Van Hassent, pers. comm., April 30, 2010). In Virginia, Forest Legacy Areas encompasses forest lands in Prince William, Stafford, King George, Westmoreland, and Northumberland counties. Forest lands within these areas are targeted for future protection.

Northern Virginia Regional Conservation Forum

The DoD Legacy Resource Management Program (DoD Legacy Program) was established by Congress in 1990 to protect, enhance, and conserve natural and cultural resources while preserving DoD's primary mission of military readiness (DoD, 2007b). The National Defense Authorization Act for fiscal year 1997 (Public Law 104-201, Section 2694) provided the flexibility to enter into cooperative agreements with public and private agencies, organizations, institutions, individuals, or other entities to carry out the program. The 1997 legislation also defined mandatory criteria for funding Legacy projects, including that projects must have regional or DoD-wide significance and involve more than one military department.

The DoD Legacy Program funded the State-wide Conservation Forums to Facilitate Cooperative Conservation project – Legacy Program Project 06-331 – for fiscal year 2006. This Office of the Secretary of Defense Legacy Program project provided for a conservation forum at the state-wide level in Virginia on December 15, 2006. The purpose of the forum was to launch regional conservation partnerships in support of the Governor of Virginia's land conservation initiative and military compatible land use and conservation buffers, and to coordinate future regional cooperative conservation partnerships in the Potomac River and York River watersheds (Cisar et al., 2007; DoD, 2007a). In April 2006, Governor Timothy M. Kaine had announced the goal of protecting an additional 400,000 ac of land across the Commonwealth during his term of office (Bryant and Bloxom, 2007), a goal that was surpassed with a total of 424,103 ac preserved by the end of 2009 (Appomattox News, 2010).

At the 2006 forum, attendees committed to a follow-on regional forum to explore specific conservation partnerships in the Northern Virginia area that includes MCB Quantico, Fort A.P. Hill, and NSF Dahlgren (DoD, 2007a). The Northern Virginia Regional Conservation Forum strives to identify strategic properties that need protection in the region (Richardson, pers. comm., June 3, 2008). However, the regional forum no longer is active; the last meeting having been held in 2010 (Richardson, pers. comm., October 24, 2012).

National Capital Region Land Conservation Act

On June 19, 2009, the National Capital Region Land Conservation Act was introduced to the United States House of Representatives and on July 28, 2009 the act was introduced to the United States Senate. The act would create a new $50 million grant program that would fund land preservation efforts. The act would authorize the Secretary of the Interior, acting through the Director of the National Park Service, to make grants to Maryland, Virginia, West Virginia, and the District of Columbia and their political subdivisions for assistance in acquiring lands and interests therein that affect or are within the National Capital Region and will be used for parks; open space; green space corridors that link public lands, lands subject to conservation

restrictions, or a combination of such lands; agriculture; forests; fish and wildlife habitat; watershed protection; historic preservation; sensitive environmental area protection; and public recreation. Virtually the entire National Capital Region is within the Potomac River watershed. The region includes the three Maryland counties – Prince George's, Charles, and St. Mary's – and two of the Virginia counties – Prince William and Stafford – that border the Lower Potomac River.

5.2.3 Governor Harry W. Nice Memorial Bridge Improvement Project

The two-lane Governor Harry W. Nice Memorial Bridge, which carries US Route 301 across the Potomac River and lands just north of NSF Dahlgren (Figures 1-1 and 3.1-3a), is the only bridge across the river south of the Woodrow Wilson Bridge, which carries Interstate I-495/the Washington Beltway. The Maryland Transportation Authority (MdTA) initiated planning for the Nice Memorial Bridge Improvement Project in 2006 to address the transportation conditions and capacity limitations at the bridge (MdTA, 2008). The purpose of the project is to (MdTA, 2010):

- Provide a crossing of the Potomac River that is geometrically compatible with the US Route 301 approach roadways
- Provide sufficient capacity to carry vehicular traffic on US Route 301 across the river in the design year 2030
- Improve traffic safety on US Route 301 at the approaches to the river crossing and on the bridge itself
- Provide the ability to maintain two-way traffic flow along US Route 301 during wide-load crossings, incidents, poor weather conditions, and when performing bridge maintenance and rehabilitation work

In 2009, the MdTA released an EA (MdTA, 2009) that evaluates alternatives to upgrade the bridge, and improve traffic flow and safety by adding two lanes of traffic. Four sets of alternatives were considered: Alternate 1 is the no-build alternative and would include extensive rehabilitation of the existing bridge; Alternates 2 and 4 would rehabilitate the existing two-lane bridge and build a new two-lane span adjacent to it; Alternates 3 and 5 would replace the existing two-lane bridge and build a new two-lane span adjacent to it; and Alternates 6 and 7 would build a new four-lane bridge and take the existing structure out of service. The build alternatives – Alternates 2 through 7 – provide reasonable tie-in points with the existing and planned highway network, capacity for 2030 traffic demand, the ability to maintain two-way traffic flow, improved safety on approach roadways and bridge, and the ability to comply with navigational channel guidelines. The build alternatives would require an alignment shift of the US Route 301 approach roadways to connect to the new bridge, and each includes a barrier-separated bicycle-pedestrian path (MdTA, 2009).

The EA does not identify a preferred alternative. However, in May 2010, the MdTA issued for review a draft Preferred Alternate/Conceptual Mitigation document (MdTA, 2010) that recommends Modified Alternate 7 – i.e., Alternate 7 with a modified bicycle/pedestrian option – as the preferred alternative. Modified Alternate 7 comprises the installation of a new four-lane bridge to the north of the existing bridge, with a single, barrier-separated, two-way

bicycle/pedestrian path on the south side of the new bridge. The existing bridge would be removed under Modified Alternate 7.

The draft Preferred Alternate/Conceptual Mitigation document presents the MdTA's rationale for identifying Modified Alternate 7 as the preferred alternative. The document also presents a summary of environmental impacts associated with the preferred alternative and the MDTA's proposed minimization and conceptual mitigation measures for the resources that would be affected by the preferred alternative. Quantitative impacts were updated with respect to those presented in the EA to reflect the minor changes to Alternate 7 that were incorporated into Modified Alternate 7; however, the qualitative discussions of impacts of Alternate 7 presented in the EA remain valid (MdTA, 2010). The relevant findings of the EA and the draft Preferred Alternate/Conceptual Mitigation document follow (MdTA, 2009; 2010):

- **Noise** – Dahlgren Wayside Park – immediately north of US Route 301 on the river, in Virginia – would experience design-year noise levels equal to or exceeding the impact criteria at picnic, beach, and lawn areas. Although the picnic and beach areas would be displaced by the preferred alternative, the remaining portion of the park could be used for recreation purposes; therefore, consideration of noise mitigation is appropriate. Feasibility and reasonableness of noise abatement was investigated for this location, resulting in a determination that a sound barrier at Dahlgren Wayside Park would not restrict access, cause safety or maintenance issues, or create drainage problems, could be constructed, would satisfy the criterion for a feasible sound barrier, and would be reasonable in terms of cost. It is MdTA policy to make final decisions on the construction of noise abatement during preliminary design.
- **Surface water quality** – The preferred alternative could affect the surface water quality in the study area. Construction impacts may include increased turbidity due to sedimentation from erosion or dredging activities, pollution from disturbed sediments, and runoff from impervious surfaces. Impacts to water quality during dredging and in-water demolition could include a temporary increase in turbidity, and potential release of nutrients and contaminants from bottom sediments. During construction, releases of sediment from land-disturbing activities would be minimized through erosion and sediment controls. Stormwater would be managed to limit downstream erosion and impairment of water quality.
- **Natural resources** – The preferred alternative would impact tidal open water, with impacts comprising permanent impact to 0.5 ac of Potomac River bed resulting from installing bridge piers and up to 65 acres of temporary impact to tidal waters from dredging for barge access. Minimization efforts during design would focus on reducing the number of piers and the required size of the dredge area. Prior to construction, the MdTA would obtain permits from the MDE and the USACE, and approval from the Maryland Critical Area Commission for the Chesapeake and Atlantic Coastal Bays for construction within the Potomac River. Mitigation for unavoidable impacts to waters would be required. Based on the findings of a draft compensatory mitigation plan and coordination with the regulatory agencies, out-of-kind mitigation through shoreline stabilization would adequately compensate for all functions and values lost from impacted resources.

The footprint of the preferred alternative would encompass approximately 8.4 ac of the 100-year floodplain of the Potomac River. However, the project would have a negligible effect on the floodplain because the majority of this floodplain acreage would be bridged. Construction of the proposed bridge and approach roadway would not accelerate shoreline erosion along the Potomac River.

- **Aquatic biological resources** – No impacts to SAV or oyster beds are anticipated. However, dredging activities necessary for bridge construction can entrain and destroy oyster eggs and larvae, particularly during spawning and spat periods, and larval oysters may become starved by ingesting sediment particles from increased sedimentation.

  To protect anadromous fish and potential overwintering sturgeon, dredging would be restricted to certain times of the year, with the time-of-year restrictions to be refined in coordination with the resource agencies. An essential fish habitat (EFH) assessment completed for juvenile and adult summer flounder, and juvenile bluefish found that the proposed improvement project is not likely to adversely affect EFH for these species. The assessment stated that construction activities can be mitigated through time-of-year restrictions, conditional blast design requirements, blast pressure wave maximum thresholds, and other methods. As the project progresses through the design phase, avoidance and minimization measures would be clarified in consultation with the National Marine Fisheries Service (NMFS), specifically with respect to the service's recommendations relating to the effects of pile driving and subaqueous blasting.

  The preferred alternative could affect waterfowl concentration areas, but direct impacts are unlikely. Overwintering waterfowl, which usually congregate near the bridge, may be affected by construction activities. Dredging and blasting windows would be coordinated with the MDNR and the Maryland CAC to attempt to protect waterfowl that might overwinter in the area.

- **Protected species** – Impacts to shortnose sturgeon habitat due to construction could include increased turbidity, and pollution from disturbed sediments and runoff from impervious surfaces. Sediment deposits and turbidity from dredging also could disrupt the sturgeon's foraging habitat.

  No direct impacts to bald eagle nests are anticipated. However, prior to construction, eagle nests would be surveyed and further coordination undertaken with the Virginia Department of Game and Inland Fisheries (VDGIF), MDNR, and United States Fish and Wildlife Service (USFWS). Such coordination may result in time-of-year restrictions or activity modifications for some construction operations, such as tree clearing, grading, and blasting. Coordination with the USFWS also would be undertaken prior to construction to evaluate potential project impacts to peregrine falcons, which are nesting and breeding on the bridge.

The MdTA study team coordinated with regulatory agencies to develop the final environmental document, which was approved by the Federal Highway Administration on November 27, 2012. The Nice Memorial Bridge Improvement Project final environmental document comprises two components: a Finding of No Significant Impact (MdTA, 2012) and a Final Section 4(f) Evaluation (Federal Highway Administration and MdTA, 2012). The relevant findings of the Final Section 4(f) Evaluation follow (Federal Highway Administration and MdTA, 2012):

- **Use of the Potomac River** – Dahlgren Wayside Park includes a 450-foot-long by 60-foot-wide sand beach along the Potomac River, boat access for small watercraft, and picnic tables, and provides the public opportunities for recreational activities including fishing and canoeing/kayaking. Modified Alternate 7 would require approximately 2.2 acres of land from the 14.7-acre park, 15 percent of the total park acreage, including a portion of the park entrance road, a parking area, a portion of the picnic area, and a portion of the beach area. However, mitigation measures were incorporated into Modified Alternate 7 for Section 4(f) uses that cannot be avoided or further minimized and were documented in a memorandum of agreement, executed in September 2011. The memorandum of agreement specifies that the Dahlgren Wayside Park entrance and parking lot will be relocated, and that hardscape features such as picnic tables, barbeque grills, and a replacement boat landing will be installed.

The Finding of No Significant Impact (MdTA, 2012) documented the Federal Highway Administration's determination that the MdTA preferred alternate, Modified Alternate 7, will have no significant impact on the environment.

5.2.4 Villages at Swan Point

US Steel Corporation and Brookfield Homes Corporation are proposing to build an expansion to a development project initiated in the 1980's at Swan Point in Issue, Maryland, which is approximately 7 mi southeast of NSF Dahlgren on the MDZ (Figures 1-3, 1-5, and 3.1-3a). The earlier development built the existing Swan Point Yacht and Country Club community, which consists of 322 homes, a golf course, and a marina. The project would add 1,500 homes to the 897-ac site on the Weir Peninsula, along with a hotel, a private beach, six observation piers, retail shops, restaurants, and a 150-slip marina on the Potomac River at Weir Creek (Degregorio, 2006; McConaty, 2007). The project also includes shoreline stabilization along the shore of the river and a bridge over Weir Creek.

One of the early concerns regarding the planned Villages at Swan Point was that the 0.07-mgpd capacity of the Swan Point Wastewater Treatment Plant was insufficient to accommodate the influx of people that would live in the new development. To accommodate the planned development, the plant, which discharges to Cuckold Creek, was upgraded to a 0.6-mgpd enhanced nutrient removal wastewater treatment plant, capable of achieving an effluent with a total nitrogen goal of 3 mg/l and a total phosphorus goal of 0.3 mg/l (MDE, 2009). MDE data show a marked decrease in nitrogen and phosphorus loading in Cuckold Creek since the upgrade was completed in 2007 (MDE, 2009).

Approximately 160 ac of the Villages at Swan Point are within the designated critical area (Degregorio, 2006). The Maryland Critical Area Act, passed in 1984, identified the critical area as all land within 1,000 ft of the mean high water line of tidal waters or the landward edge of tidal wetlands, and all waters of and lands under the Chesapeake Bay and its tributaries (CAC, 2008, 2009). The act also created the Maryland CAC, which reviews and approves state or local agency actions resulting in major development on private lands or lands owned by local jurisdictions.

The Villages at Swan Point is located in a portion of the critical area that was designated as resource conservation area. Resource conservation area is the most restrictive development

overlay in the critical area as it limits the density and use that is allowed. The Critical Area Act allows each county to up-zone 5 percent of its resource conservation area to a less-restrictive development overlay – i.e., a limited development area or an intensely developed area – and thereby enable more intensive use, a process termed "growth allocation." To accommodate the Villages at Swan Point development plan, the developer needed to change the resource conservation area designation to both limited development area and intensely developed area designations. The Charles County Commissioners, in June 2006, and the Maryland CAC, in March and April 2007, approved with conditions the use of growth allocation for the re-designation (Umling, pers. comm., April 24, 2007; Charbonneau, pers. comm., August 25, 2009). These approvals were needed for the project proponent to proceed through Charles County preliminary and final plan approvals for the site development plans.

In 2006, Charles County had approved a master plan and general development plan for the Villages at Swan Point (Dailey, pers. comm., June 3, 2010). The preliminary subdivision plan for the first phase of the development was presented to the county planning commission and reviewed in September 2008. However, certain habitat protection requirements that were imposed as conditions on the growth allocation approvals need to be fulfilled prior to the approval by the county of the first Villages at Swan Point preliminary subdivision plan or preliminary site plan. The requirements pertain to, for example, the following (Umling, pers. comm., April 24, 2007; Dailey, pers. comm., June 3, 2010):

- Submitting for review and approval a detailed critical area buffer management plan
- Addressing the required 404 ac of forest interior dwelling species mitigation in a revised habitat management plan
- Addressing the protection of an active bald eagle nest
- Submitting for review and approval a final habitat management plan
- Establishing a permanent conservation easement

The Charles County Department of Planning and Growth Management currently awaits resolution of the habitat protection requirements (Dailey, pers. comm., June 3, 2010). The requirements will be carried over to each subsequent development phase. Additionally, the growth allocation approvals include a condition that at the time of each preliminary plan, should any additional habitat protection requirements become applicable based upon species migration or new information, the project proponent will be required to amend the habitat protection plan accordingly (Umling, pers. comm., April 24, 2007; Dailey, pers. comm., June 4, 2010).

Initiation of construction of all components of the development has been delayed because of the state of the economy and the housing market. Brookfield Homes anticipates that construction will begin in 2012 (Lannin, pers. comm., July 27, 2010).

Environmental reports have been requested from Brookfield Homes.

5.2.5 St. Mary's County Regional Airport

St. Mary's County Regional Airport is located four miles northeast of Leonardtown, Maryland and approximately 53 miles southeast of Washington, D.C. (Figure 5-1). The airport, owned and

operated by St. Mary's County, has one partial parallel taxiway, three connector taxiways and a turnaround (St. Mary's County, Maryland, 2012).

The Airport Master Plan was updated in 2002 to enable the airport to accommodate growth in aviation demand (Delta Airport Consultants Inc., 2002). As part of future airport improvements, Runway 11-29 will be lengthened and strengthened. St. Mary's County, in conjunction with the FAA and the Maryland Aviation Administration, is working to achieve an Airport Reference Code (ARC) designation of B-II (approach speed of 91-120 knots and a wingspan of 49 -78 ft) with a non-precision instrument approach (i.e., lateral course information only) of 0.5 mile for Runway 11, which will be extended by 1,200 feet from its current condition, and an non-precision instrument approach of one mile for Runway 29.

NSWCDD's special use airspace (Figure 1-6) does not overlap with St. Mary's County Regional Airport. The Proposed Action would not change the hours that airspace is restricted annually. Because the SUA under the Proposed Action would be used more frequently than under the other alternatives, the hours during it would be released to FAA control for potential use by civilian aviation would be reduced. However, commercial airliners fly along long established routes that do not cross the SUA. Although general aviation pilots do have the option of checking whether the SUA is in effect when planning their flights, very rarely do so; as a matter of course, they consider the SUA to be off-limits at all times (see Section 4.1.3.3).There is not expected to be any appreciable adverse effect on civilian aviation, inclusive of current or future availability of instrument approaches and other airspace or operational matters concerning the St. Mary's County Regional Airport.

5.3 Summary of Cumulative Impacts Relative to the Proposed Action

Environmental effects associated with the proposed Navy action were thoroughly analyzed in Chapter 4. Most of these effects were determined to be individually non-significant. However, these actions, when combined with other similar actions occurring in the region of influence, may contribute to a cumulative significant effect on one or more environmental resources.

Table 5-3 shows in tabular format the potential environmental effects – identified previously in this chapter – of each action in the region of influence potentially contributing to a cumulative effect, the potential environmental effects of the Proposed Action, and the potential cumulative effects of all actions combined. A value of "NI" through "◆◆◆" was assigned to each action based on the intensity of its potential adverse effect to a specific resource area. (See the introduction to Chapter 4 for the qualitative framework used in this EIS to evaluate the intensity of impacts.) An explanation of each value is as follows:

- A "NI" value was given to an action that has no negative impacts to a particular resource.
- A "◆" was given to an action that has the potential for negligible or minor, but recoverable, negative impacts to a particular resource. A negative impact is recoverable if the affected resource could, over time, return to its pre-impact condition naturally – i.e., without human intervention – or through implementation of a restorative action.

- A "◆◆" was given to an action that has the potential for moderate, but recoverable, negative impacts to a particular resource.
- A "◆◆◆" was given to an action that has the potential for major, non-recoverable, negative impacts to a particular resource.

It is important to note that even if a resource was given a value of "◆◆" or "◆◆◆" for an individual action, it does not automatically generate a cumulative impact of "◆◆" or "◆◆◆." This is due to difference in space and time from other actions or the resource that is potentially affected. In determining the cumulative impacts of NSWCDD outdoor RDT&E activities in combination with other activities in the region, the following types of potential cumulative impacts were considered:

Table 5-3
Summary of Cumulative Impacts

	Range Activities	Use of the Potomac River	Property Values and Development	Electric Power Capacity	Noise	Health and Safety	Surface Water Quality	Natural Resources	Aquatic Biological Resources	Protected Species
Past and Present Actions										
NSF Indian Head Activities	NA	NI	◆	NI	NI	NI	NI	NI	NI	NI
MCB Quantico Activities	NA	NI	◆	◆	◆	NI	◆	NI	NI	NI
BPRF Activities	NI	◆	◆	NI	NI	◆	NI	NI	NI	NI
Fort A.P. Hill Activities	NA	NI	◆	NI	◆	NI	NI	NI	NI	NI
NAS Patuxent River and Webster Field Annex Activities	◆	NI	◆	NI	◆	◆	NI	NI	NI	NI
Morgantown Coal Barge Facility	◆	NI	◆	NI	◆	NI	◆	NI	◆	NI
Morgantown FGD System	NI	NI	◆	NI	◆	NI	◆	NI	NI	NI
Morgantown Coal Blending and Gypsum Loadout Facilities	◆	NI	◆	NI	◆	NI	◆	NI	◆	NI
Residential Development in Colonial Beach	◆	NI	NI	◆	NI	NI	◆	NI	NI	NI
Reasonably Foreseeable Future Actions										
Fort A.P. Hill ACUB Program	NA	NI	NI	NI	NI	NI	NI	NI	NI	NI
Potomac Land Conservation	NA	NI	NI	NA	NA	NA	NI	NI	NI	NI
Nice Memorial Bridge Improvement Project	◆	NI	◆	NI	◆	NI	◆	◆	◆	NI
Villages at Swan Point	◆	NI	NI	NI	◆	NI	◆	NI	◆	NI
St. Mary's Regional Airport	NA	NA	NI	NA	NI	NA	NA	NA	NA	NA
Proposed Action										
NSWCDD Outdoor RDT&E Activities	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Cumulative Impacts										
Cumulative Impacts of All Actions	◆	◆	◆	◆	◆	◆	◆	◆	◆	NI

Notes:
NA indicates not applicable.
NI indicates no negative impacts.
◆ indicates potential for negligible or minor, but recoverable, negative impacts.
◆◆ indicates potential for moderate, but recoverable, negative impacts.
◆◆◆ indicates potential for major, non-recoverable, negative impacts.

- Countervailing – negative impacts that are compensated for by beneficial effects
- Additive – the total loss of a resource from more than one incident
- Synergistic – when the total effect is greater than the sum of the effects taken independently

Potential cumulative effects are discussed below.

5.4 NSWCDD Range Activities

As the number of events on the ranges increases, scheduling RDT&E activities will become increasingly difficult. Other activities that require the use of the ranges or encroach on the ranges could further limit their availability for NSWCDD RDT&E activities.

NAS Patuxent River UAV activities out of the Webster Field Annex use airspace over a portion of the PRTR; however, these activities are limited to the LDZ, not the more-intensively utilized MDZ. Although the barge traffic generated by the Morgantown generating station coal barge facility would use the Potomac River's main channel and, as such, would pass through the PRTR, a communication protocol agreed to by NSF Dahlgren and Mirant Corporation is expected to minimize conflicts between Navy activities and barge activities. Further, to date, actual coal deliveries vary and are very limited. Encroachment of residential development in the vicinity of the ranges – e.g., residential development in Colonial Beach and the planned Villages at Swan Point, both along the edges of the PRTR – can affect NSWCDD activities on the range and may require increased deployment of range control boats to ensure the safety of the public.

5.4.1 Recreational and Commercial Use of the Potomac River

NSWCDD currently restricts public access to the PRTR danger zones, usually the MDZ, for testing approximately 750 hours per year, a value that could increase to approximately 1,000 hours per year under the Proposed Action. The difference in annual hours of river range usage can be expected to have some effect on marine commercial freight movements, commercial fishing, and recreational boating on the Potomac.

When firing mortars, the BPRF clears the installation's safety danger zone on the Potomac River approximately twice a year, for the duration of the two- to three-day tests. The Nice Memorial Bridge Improvement Project preferred alternate, Modified Alternate 7, would require approximately 2.2 acres of land from the 14.7-acre Dahlgren Wayside Park that provides the public opportunities for fishing and canoeing/kayaking in the Potomac River. However, the memorandum of agreement executed in September 2011 specifies that a replacement boat landing will be installed in the park. None of the other actions are expected to restrict recreational or commercial use of the Potomac River.

5.4.2 Property Values, Development, and Preservation Efforts Along the Potomac River

As discussed in Section 4.2, although future real estate development is likely to continue, some within proximity to NSF Dahlgren, one possibly foreseeable consequence of increased population encroachment with no economic affiliation to NSF Dahlgren is the potential for a growing negative reaction to the Navy's activities, and particularly to the noise associated with them. Increases in noise complaints can be expected, not from an increase in Navy activity, but rather from a changing population with little relationship to NSF Dahlgren. Conceivably, dissatisfaction with NSF Dahlgren as a neighbor could nominally depress property values in the area, dampen the rate of future residential development, and affect land use patterns and ongoing development projects.

However, to monitor and control noise from its outdoor RDT&E activities and, thereby, reduce noise complaints from surrounding communities, NSWCDD has developed and implemented a noise management process (Appendix C). The process is described in Section 3.5.3.5. Implementation of the noise management process is expected to minimize noise impacts and noise complaints resulting from NSWCDD outdoor RDT&E activities, and substantially preclude noise-related effects on land use, property values, and future residential development.

NAS Patuxent River airspace covers the lower portion of the LDZ. The NAS uses the airspace for helicopter, fixed-wing, and UAV activities originating from the air station or the Webster Field Annex. Although these activities also could contribute to a negative reaction to the Navy's activities, there is only limited geographic overlap with the NSWCDD RDT&E activities, which predominantly occur in the MDZ. As mentioned below in Section 5.3.5, noise from detonations on Fort A.P. Hill and at MCB Quantico, and NAS Patuxent River aircraft activities and bombing activities at the CTR occasionally disturbs residents that live along the PRTR. Non-Navy and non-military activities along the lower Potomac River also could affect property values and future development. The recent construction of the coal barge facility, the scrubber stack, and the coal blending and gypsum loadout facilities at the Morgantown generating station, the mooring of barges at the generating station, and barge traffic on the river could contribute to an impression that the lower Potomac is increasingly becoming industrialized. Construction and dredging activities associated with the Nice Memorial Bridge Improvement Project additionally could contribute to that concern.

5.4.3 Electric Power Capacity on NSF Dahlgren

Increasing electric power capacity will be required to support NSWCDD's RDT&E activities – particularly in consideration of large electrical pulses resulting from EM energy activities – although the actual future capacity requirements are difficult to predict. Dominion Virginia Power has applied for an application to build a new 230 kilovolt (kV) transmission source and substation at NSF Dahlgren (Dominion Virginia Power, 2011). This project will meet long-term installation power demands and support the continued growth and economic development of King George County. If approved and implemented, there would be no cumulative impacts on electric power capacity.

5.4.4 Noise in the Vicinity of NSF Dahlgren and the PRTR

As discussed in Section 3.5.3, although the vicinity of NSF Dahlgren is relatively quiet, the Morgantown generating station, traffic on US Route 301, aircraft flying overhead, and boats on the river add continuous and intermittent noise. In addition, NSWCDD activities generate impulsive noise, from small arms firing, large-caliber gun firing, EM launcher firing, and explosive detonation, and continuous noise, from helicopters using the NSF Dahlgren airfield, aircraft brought from other airfields to be used in tests, and UAVs launched from the PRTR Complex land ranges and flown within the special-use airspace.

Noise from detonations on Fort A.P. Hill, detonations at MCB Quantico, and NAS Patuxent River aircraft activities and bombing activities on the CTR occasionally disturb residents who live along the PRTR. Noise emitted by operation of the Morgantown generating station coal barge facility, FGD system, and coal blending and gypsum loadout facilities is not expected to contribute to a noticeable increase in overall noise emissions from the facility, as experienced by nearby receptors. Under each of the no-build and build alternatives, 2030 noise levels from the Nice Memorial Bridge Improvement Project are expected to equal or exceed the impact criteria at noise sensitive area 3 – Dahlgren Wayside Park, in the vicinity of NSF Dahlgren. Construction of the Villages at Swan Point would cause short-term noise impacts along the shore of the Potomac, in the vicinity of the PRTR.

5.4.5 Health and Safety of Residents near NSF Dahlgren and the PRTR

NSWCDD RDT&E activities would result in negligible impacts on human health and safety. All activities are conducted in accordance with Navy policies, and carefully-conceived management controls, operation-specific RHAs and SOPs. Activities conducted by other military installations – such as mortar firing at the BPRF and NAS Patuxent River helicopter, fixed-wing, and UAV activities in airspace over the PRTR – likewise would have negligible impacts.

5.4.6 Potomac River Surface Water Quality

As discussed in Section 4.8 and in Sections 4.10 through 4.14 of this EIS, NSWCDD evaluated the potential effects of munitions RDT&E on the PRTR on human health and the environment. As there is the potential for munitions fired into the Potomac River to accumulate in sediments, water, and aquatic organisms, range-specific screening-level risk assessments (RSSRAs) were performed. A subset of munitions constituents (MCs) was selected as MCOPCs based on their total mass (cumulative over the last 90 years), toxicity of constituents, and Navy guidance (see Appendix F).

The RSSRAs evaluated MCOPCs by comparing modeled concentrations in water, sediment, and fish tissues to risk-based screening concentrations. The results of the ecological and human health RSSRAs (see Sections 4.11 through 4.14 and Section 4.8, respectively) indicate that input of MCOPCs from munitions testing in the PRTR are orders of magnitudes (hundreds to billions of times) below concentrations that could cause adverse effects to human health or the environment. Hence, no further analyses are required at this time. Based on this conclusion,

continued use of the PRTR for ordnance activities is expected to have negligible impact on surface water.

Potomac River surface water quality could be impacted by development of the Westside of MCB Quantico, residential development in Colonial Beach, and construction of the Villages at Swan Point. Development would increase impervious surfaces and stormwater runoff, which would carry pollutants to the river. Construction activities could result in sediments or fill entering the Potomac. Construction, dredging, and in-water demolition associated with the Nice Memorial Bridge Improvement Project may temporarily increase turbidity and could release nutrients and contaminants to Potomac River surface waters.

5.4.7 Natural Resources on NSF Dahlgren

More intensive use of EM launchers and laser corridors would require maintenance of shrub-grass-herbaceous vegetation in order to clearly see the barricades across the roads in place during activities to stop noninvolved personnel from entering the area. These non-forested vegetation areas are cut with a bush hog every few years to keep the vegetation low enough to see over it down the roads, but the Proposed Action would cause this range vegetation maintenance to occur more frequently. No forests would be affected. The effect of increased vegetation maintenance, if required, in laser corridors is considered negligible. There would be no indirect impacts on wildlife.

Based on review of relevant and available environmental documentation pertaining to the actions considered in the cumulative effects analysis, none of the other actions are expected to impact natural resources on NSF Dahlgren. Therefore, no cumulative impacts are anticipated.

5.4.8 Aquatic Biological Resources of the Potomac River

NSWCDD RDT&E activities would result in negligible impacts on SAV, plankton, aquatic invertebrates, fish, and birds. As described in Section 4.11, RDT&E activities may adversely affect EFH, but likely would result in minimal adverse effects on EFH, as the resulting changes to EFH and its ecological functions would be relatively small and insignificant.

Accidental coal spillage during operation of the Morgantown generating station could result in minor impacts to river bottom benthos. Dredging activities requisite to the Nice Memorial Bridge Improvement Project could entrain and destroy oyster eggs and larvae, and dredging-related sedimentation could affect larval oysters. The bridge improvement project also could affect waterfowl concentration areas. Construction activities and increased stormwater runoff resulting from development of the Westside of MCB Quantico, residential development in Colonial Beach, and the Villages at Swan Point; accidental coal spillage during operation of the Morgantown generating station; and construction, dredging, and in-water demolition associated with the Nice Memorial Bridge Improvement Project could impact water column and benthic EFH.

5.4.9 Protected Species

NSWCDD RDT&E activities are not likely to adversely affect the shortnose sturgeon, Atlantic sturgeon, loggerhead turtle, Kemp's ridley turtle, and green sea turtle and would have no effect on the northeastern beach tiger beetle. Based on review of relevant and available environmental documentation pertaining to the actions considered in the cumulative effects analysis, none of the other actions are expected to impact protected species. Therefore, no cumulative impacts are anticipated.

5.5 Greenhouse Gas Emissions and Climate Change

NSWCDD RDT&E activities make an incremental contribution to greenhouse gas emissions, representing a very small percentage of total United States emissions. The potential effects of greenhouse gas emissions are by nature global and cumulative, as individual sources of greenhouse gas emissions are not large enough to have an appreciable effect on climate change. An appreciable impact on global climate change would only occur when proposed greenhouse gas emissions combine with emissions from other man-made activities on a global scale.

As discussed in Section 3.4.2, total greenhouse gas emissions from a source are often expressed as equivalent emissions of CO_2, or CO_2 equivalents. In 2008, total United States greenhouse gas emissions were 7,077.4 teragrams or million metric tons CO_2 equivalents (USEPA, 2012). From 2008 to 2010 total United States emissions decreased by 3.0 percent (211.9 teragrams) to 6,865.5 teragrams CO_2 equivalents.

In accordance with the USEPA final rule on mandatory reporting of greenhouse gases (74 Federal Register 56260, USEPA, 2009b), NSF Dahlgren estimated that in 2008 the facility generated a total of 9,702 metric tons of CO_2 equivalents, or 0.009702 teragrams CO_2 equivalents. Based on this estimate, NSF Dahlgren's facility-wide total greenhouse gas emissions in 2008 represented approximately 0.0001 percent of the total emissions for the country as a whole. NSWCDD RDT&E activities when combined with other past, present, and reasonably foreseeable future actions would have the potential for negligible, long-term, indirect, negative impacts on climate.

5.6 Unavoidable Adverse Impacts

Unavoidable adverse impacts of the action proposed in this EIS would include short-term localized disturbances to the river bottom due to the firing of inert ordnance. Inert ordnance would be buried in river sediments after firing and would be left there. A very small percentage of this ordnance may resurface over time, releasing small concentrations of munitions constituents into river sediments and water. Unavoidable adverse ecological impacts due to NSWCDD outdoor RDT&E activities on the PRTR would be minor, temporary, and not significant.

5.7 Relationship between Short-Term Uses of Man's Environment and the Enhancement of Long-Term Productivity

Adherence to the proposed mitigation measures (Chapter 6) would minimize the effects of NSWCDD outdoor RDT&E activities on the environment. Consequently, the majority of the effects of the activities would be temporary in nature (as described in Chapter 4) and would have no significant adverse long-term impacts on the maintenance and enhancement of long-term productivity. There would be some short-term adverse effects on the environment; however, they would be brief and localized.

5.8 Irreversible and Irretrievable Commitment of Resources

Irretrievably and irreversibly committed resources are those that are consumed during the construction and implementation of a project and that cannot be reused. Because their reuse is impossible, they are considered irretrievably and irreversibly committed to the development of the proposed project. These resources would include expendable materials necessary for construction, as well as fuels and other forms of energy that are utilized during project implementation.

During NSWCDD's outdoor RDT&E activities, non-renewable resources would be consumed. Since the reuse of these resources may not be possible, they could be considered irreversibly and irretrievably committed. The non-renewable resources would include energy resources necessary for the activities, and inert and live ordnance expended on the range.

6 PROTECTIVE MEASURES

In order to avoid, minimize, rectify, reduce, and eliminate the environmental impacts of current RDT&E activities, NSWCDD and NSF Dahlgren have developed environmental management processes, including the NSWCDD Environmental Management System (EMS) and Safety Program, the NSF Dahlgren Comprehensive Work Approval Process (CWAP), and protective measures. For the purposes of this chapter:

- *Protective measures* are actions taken by NSWCDD to protect sensitive resources, but that are not implemented in response to the impact findings of this EIS.
- *Mitigation measures* differ from protective measures in that they would be implemented specifically in response to the impact findings described in Chapter 4 of this EIS.

The protective measures already implemented for current No Action Alternative activities, which rely heavily on ongoing process improvements, would continue to be used as the means of mitigating environmental impacts for the Proposed Action alternatives. NSWCDD identifies environmental and safety risks for current No Action activities and responds with mitigation and protective measures based on experience from earlier RDT&E. Developing mitigation based on the projected risk when the RDT&E activity is being planned and then implementing these responsive measures when the activity takes place can effectively reduce the impact of the activity below that level at which the impact would be significant.

The impact findings described in Chapter 4 were determined in the context of the existing environmental management processes and protective measures that are integral to current and future NSWCDD RDT&E activities. Basically, mitigation is and would continue to be built into current activities and future activities under the Proposed Action. Because the protective measures in place reduce the impact of activities discussed in this EIS below the level at which the impact would be significant, no mitigation measures are necessary. NSWCDD is committed to applying the same processes used to mitigate safety and environmental impacts for current activities to all future activities under the No Action Alternative and Alternatives 1 and 2. NSWCDD's Safety and Environmental Office is responsible for carrying out these processes for NSWCDD's current activities and would do so for future activities.

Typically, there are substantial differences between protective and mitigation measures associated with a No Action Alternative and those developed for Proposed Action Alternatives. This is to be expected because the Proposed Action normally generates new and different impacts when compared to the No Action Alternative, driving the potential protective and mitigation measures developed. However, the Proposed Action activities in this EIS are in essence the same as those associated with the No Action Alternative. While the number of tests and events would increase and the conduct of some activities change somewhat under the Proposed Action, the activities and their impacts would remain similar under all three alternatives.

6.1 Environmental Management

NSWCDD's Environmental Policy is articulated as follows (NSWCDD, 2012):

The Naval Surface Warfare Center Dahlgren Division (NSWCDD) is committed to protecting the environment while carrying out its mission. All personnel share the responsibility to comply with environmental laws, regulations, and policies. Along with the Naval Support Activity South Potomac and Naval Air Station Oceana[1], through our Environmental Management System, we are committed to:

- *Integrating sound environmental practices into processes and business decisions, while maintaining efficient and successful mission execution.*
- *Complying with applicable federal, state, local, Department of Defense, and Department of Navy regulations and policies for which NSWCDD subscribes.*
- *Continuously improving environmental performance through effective environmental planning.*
- *Ensuring pollution prevention, preservation of our land, Chesapeake Bay sustainability, and protection of natural and cultural resources.*
- *Educating employees concerning their environmental protection responsibilities.*
- *Increasing public awareness of our commitment to protect the environment.*

6.1.1 NSWCDD Environmental Management System (EMS)

In accordance with Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, which was issued 24 January 2007, and subsequent Navy policy, NSWCDD has implemented an EMS. NSWCDD's EMS is a set of systematic processes and practices to ensure environmental compliance and improve environmental management built upon its environmental policy. NSWCDD works to minimize adverse environmental impacts from new RDT&E activities by integrating environmental management practices and procedures early in the planning process.

International Standard ISO 14001 is a worldwide standard that provides specifications for an EMS, and NSWCDD's EMS follows this standard. The ISO 14001 EMS Standard establishes requirements in 18 different element areas. These elements are grouped into five phases called Environmental Policy, Planning, Implementation and Operation, Checking, and Management Review.

NSWCDD's mission EMS provides the framework for reliably and consistently meeting Dahlgren's environmental obligations. EMS enables NSWCDD to:

- Identify and control the environmental impact of its activities.
- Improve its environmental performance continually.

[1] Naval Air Station Oceana is no longer applicable since Dam Neck has established their own EMS.

- Implement a systematic approach to setting and achieving environmental objectives and targets and to demonstrating that they have been achieved.

NSWCDD has implemented the EMS by identifying and ranking environmental aspects associated with activities, products, and services that are integral to the mission. These associated activities, products, and services include, for example, RDT&E activities, thermal treatment (Open Burn/Open Detonation) of explosive hazardous waste, training performed by qualified ordnance personnel, administrative activities, equipment maintenance, and typical office equipment use.

NSWCDD has developed objectives and targets necessary to manage those environmental aspects that have been identified as significant. Since EMS is a process of continual improvement, additional objectives and targets are developed as part of an ongoing EMS cycle at NSWCDD.

Each individual working or visiting NSWCDD, including full-time, part-time, and contract employees must be aware of the NSWCDD Environmental Policy and must comply with applicable federal, state, local, Department of Defense, and Department of the Navy regulations and policies. Depending on the nature of their work or visit, additional EMS training and responsibilities may be required. NSWCDD's EMS facilitates the reduction of environmental impacts and increases operating efficiency, thereby supporting the mission while ensuring compliance with all legal and other requirements. In addition, the EMS provides rigorous oversight and is a useful way of integrating monitoring efforts associated with the mitigation commitments/protective actions (CEQ, 2011), as described in the following sections.

6.1.2 NSWCDD Safety Program

This section summarizes NSWCDD's safety program and procedures associated with RDT&E activities. A full discussion of the safety measures employed to protect human health is provided in Section 3.8.

Safety measures cover occupational safety and health (OSH) as well as the general public and the environment. NSWCDD's OSH policy (NSWCDD, 2011) is to:

- Develop and maintain a safe and healthful workplace for all employees by integrating safety awareness and Operational Risk Management into all aspects of workplace activities and business decisions.
- Continuously improve workplace safety and health through process improvements and elimination of potential hazards to reduce injuries.
- Educate employees concerning their safety and health rights and responsibilities.
- Provide employees with controls and equipment essential to safe mission accomplishment
- Ensure compliance with relevant regulatory standards and laws.
- Foster communication and encourage participation throughout all organizational levels to achieve and maintain a safe and healthful workplace.

NSWCDD's OSH is in compliance with Navy policies (US Navy, 2010, 2011).

As described in Chapter 3.8, measures used by NSWCDD to protect human health and the environment can be divided into three main types:

- Safety procedures
- Protective equipment
- Safety zones.

The development and rigorous implementation of Risk Hazard Assessments (RHAs), Standard Operating Procedures (SOPs) or General Operating Procedures (GOPs) with associated Operation Procedures Supplements (OPSs) form the planning basis of NSWCDD's safety approach for hazardous operations. An RHA is prepared for every type of operation that has the potential to be hazardous. SOPs/GOPs/OPSs that spell out safety procedures are developed for operations for which hazards are identified in order to minimize risks. Every SOP/GOP/OPS undergoes an extensive review, validation, and approval process so that the documents meet all applicable requirements and are complete, accurate, and effective. Safety procedures ensure that activities are safely conducted and consider environmental issues so that RDT&E activities result in the least impact practicable.

The measures contained in SOP/GOP/OPSs are implemented every time the operation covered by the document is performed. Prior to the operation, personnel who will be directly involved are provided with the SOP/GOP/OPS and must sign and date a statement certifying they have read and understood the document and have received and understood the corresponding Hazard Control Brief. Within the same time frame, non-performing personnel are given the Hazard Control Brief and must sign a statement that they have received and understood the brief.

As specified in the SOP/GOP for each operation, to reduce exposure hazards to acceptable levels, personnel may be required to use personal protective equipment (PPE) if they are going to be near the site at which a hazardous operation is taking place. Health and safety concerns decrease rapidly as personnel move away from the operational sites to the point where PPE is no longer required. PPE may include one or more of the following: protective suits, coveralls, hoods, goggles, gloves, boots, respiratory equipment, eye protection, or ear protection.

Designated safety zones, that is areas with special access and land use restrictions designed to protect persons and property from the risks associated with certain facilities and operations, that have been established at NSF Dahlgren include:

- Potomac River Test Range (PRTR) – Upper Danger Zone (UDZ), Middle Danger Zone (MDZ), and Lower Danger Zone (LDZ)
- Airfield Safety Zones and Special Use Airspace (SUA)
- Explosive Safety Quantity Distance (ESQD) arcs
- Electromagnetic (EM) Hazard Arcs.

Safety zones typically are only in effect when an operation is taking place, but some safety zones bar access all the time.

6.1.3 NSF Dahlgren Comprehensive Work Approval Process (CWAP)

NSF Dahlgren's CWAP is an official work approval procedure for all proposed actions at NSF Dahlgren. While primarily used to coordinate construction and demolition – which is not the subject of this EIS – it also focuses on operational changes. The CWAP serves to:

- Document the NEPA review process for all actions.
- Establish an agreement among commands to define roles and responsibilities.
- Facilitate the planning process through efficient work review and approval.
- Prevent delays in project implementation/execution.
- Ensure informed decision making.

CWAP approval is required for projects that include the following:

- New construction (e.g., construction of buildings, parking lots, roads, equipment pads, training courses)
- Demolition (e.g., demolition of buildings, roads, parking lots, exterior equipment)
- Exterior and major interior building renovations (e.g., exterior door/window replacement, painting, roof renovations, asbestos abatement)
- Other outdoor work involving earth work (e.g., utility installation, road resurfacing, grading, tree clearing, fence installation)
- Operational changes (e.g., changes in waste generation, product output, new outdoor testing or training exercises)
- Personnel relocation (e.g., new personnel from another installation, new supported command).

The CWAP is initiated as early in the project planning process as possible to address potential project constraints (e.g., environmental, land use) and to fully define compliance requirements (e.g., explosives site approval, wetland permitting, site contamination cleanup) that could affect the schedule. The identification of potential issues early in the planning process assists in preventing delays and identifying additional project costs.

Completed CWAP applications are sent to an Interdisciplinary Review Team for review and approval, with a review period of typically one to two weeks, but can vary depending on the complexity of the project and project constraints. Once all questions and comments have been addressed, conditions of approval are included with either a preliminary or final signed CWAP approval document. A project is given preliminary CWAP approval if the scope of the project is not clearly defined and/or additional requirements must be met prior to final CWAP approval. A project receives final CWAP approval once the project scope is defined and requirements identified by the Interdisciplinary Review Team (e.g., full explosive site approval, archeological survey completion) are met.

6.2 Protective Measures

In order to minimize potential impacts, and consistent with NSWCDD's Environmental Policy and current environmental procedures, NSWCDD would include protective measures in the planning and implementation of activities under the Proposed Action.

6.2.1 General Safety and Environmental Protective Measures

NSWCDD would ensure that:

- All activities proposed under the Proposed Action strictly adhere to all health, safety, and environmental protocols, including RHAs, SOPs, GOPs and OPSs that cover RDT&E activities.
- All activities proposed strictly adhere to all safety zones – i.e., PRTR danger zones, Airfield Safety Zones and SUA, ESQD arcs, Unexploded Ordnance (UXO) areas, EM hazard arcs, and laser safety buffer zones.
- Members of the public and personnel not involved in a test are excluded from ranges and the Mission Area prior to and during tests on the waters of the PRTR through the use of patrol boats and range restrictions and on land through the use of lookouts, road barriers, and signs.
- The Range Operations Center (ROC) in general notifies the public in advance of upcoming range activities through the NSWCDD website and a toll-free telephone recording. The information given includes daily range schedules, types of tests, use of substances such as smoke or lights, hours of testing, where on the PRTR tests will take place, whether tests are on schedule, whether noise will be made, and contact numbers to obtain more information.
- The ROC notifies the public specifically of any activities that will restrict access within and from Upper Machodoc Creek or when any test is scheduled to take place before or after normal PRTR operating hours of 8 am to 5 pm weekdays. The ROC notifies the public through NSWCDD's range website, its toll-free information line, and by placing notices in local newspapers.
- The ROC coordinates with the operators of private vessels via the range control boats or marine radio to minimize delays when activities are taking place on the PRTR and public access to an operational area is restricted. The ROC allows vessels to pass through the operational area on the PRTR during lulls in testing; delays for smaller craft are normally no longer than one-half hour, and, for larger vessels that must use the shipping channel in the middle of the range, are normally no longer than one hour (and in most cases, less than these times).
- In accordance with the operating agreement the Navy has reached with Mirant Corporation and its barge unloading facility (J.L. McGettigan and J.L. Smith, letter, April 24, 2007), ROC coordinates alternate barge schedules with Mirant when PRTR operations would pose undue hardship to barge shipments; takes precautions to minimize limitations to commercial boat traffic, stopping barge traffic for up to one hour or advising barges to slow so that they do not reach the range until operations are

completed; and participates in a communication protocol established collaboratively with Mirant to minimize conflicts between Navy activities and barge activities.

- Noise from an activity does not exceed the standards in the Outdoor Noise Management Process (NSWCDL, 2011, included as Appendix C). When noise levels that may be higher than policy standards may be generated, mitigation measures are implemented to ensure that installation personnel and the public are not exposed to hazardous noise levels. Potential mitigation measures may include avoiding testing when weather conditions are likely to result in higher noise levels to avoid exposing the public to increased noise levels and/or single and double hearing protection for on-installation personnel conducting the testing.
- Impacts to wildlife during testing are avoided when possible or minimized. Before an activity begins, trained observers look for wildlife in the target area or test area, and alert operators if any are present. Either the test is postponed temporarily or the wildlife is startled using legally allowable means to encourage movement out of the area. Trained observers watch for wildlife that may move into the target area or operations area during tests, and the test is stopped while they clear the area. Dead animals are removed prior to tests on land to limit the chances of scavenging wildlife's entering the test area.
- Bald eagle protection zones around active bald eagle nests are respected during the planning and execution of test activities. Coordination with the US Fish and Wildlife Service (USFWS) and the Virginia Department of Game and Inland Fisheries (VDGIF) would take place if a new nest is established near a testing area.
- Testing of new ordnance and EM directed energy and high-energy (HE) laser equipment scales up gradually, and monitoring takes place to ensure that higher intensity levels do not generate impacts.
- Trees, shrubs, and taller grasses and herbaceous plants that grow in range and Mission Area operating areas and are obscuring lines-of-sight are trimmed prior to tests.

6.2.2 Activity-Specific Protective Measures

NSWCDD would ensure that for chemical/biological (chem/bio) defense activities under the Proposed Action:

- Weather conditions are monitored and stimulant releases modeled before chem/bio simulant tests to ensure that simulant releases stay on ranges and the Mission Area.
- Simulant concentrations are monitored during and after releases to provide feedback for future modeling and to verify that modeled levels are not exceeded. The SOP includes the distance at which vapors and aerosols are diluted to a safe level based on the simulants and maximum quantities used. It also specifies that release point will be selected so that the simulant cloud must travel this distance before landfall.
- Simulant releases are spaced so that no land or water area would be exposed multiple times to the same simulant.
- Prior to each chem/bio simulant operation, coordination takes place with the NSF Dahlgren Environmental, the Maryland Department of the Environment (MDE) and the

Virginia Department of Environmental Quality (VDEQ), as applicable, concerning the types and quantities of simulants proposed for use.

In addition, NSWCDD is developing and will implement a Project Environmental Review and Monitoring Process for new ordnance, EM energy, HE laser, and chemical and biological defense projects under the Proposed Action before a Record of Decision is issued for the Proposed Action. NSWCDD's Safety and Environmental Office will be responsible for carrying out the new process. The Project Environmental Review and Monitoring Process will utilize the NSWCDD SOP process, the NSF Dahlgren CWAP process, and other NSWCDD process to ensure that:

- New proposed outdoor RDT&E projects either will be covered under the scope of this EIS or will have sufficient independent environmental planning (NEPA) documentation.
- New proposed outdoor RDT&E projects will incorporate all applicable protective measures, as agreed to in the EIS record of decision and other decision documents and authorizations.
- Ordnance, EM energy, HE laser, and chemical and biological defense activity tempos and intensities will be tracked and compared to those analyzed in this EIS.

Protective measures will be implemented, continually assessed to determine effectiveness, and revised as needed to increase their effectiveness.

6.2.3 Summary

Implementation of the Proposed Action would enable NSWCDD to meet current and future mission-related warfare and force-protection requirements by expanding existing RDT&E of ordnance, EM energy systems, HE lasers, and chem/bio defense. As stated in the NSWCDD Environmental Policy, NSWCDD is committed to protecting the environment while carrying out its mission. Developing and applying a new, formalized Project Environmental Review and Monitoring Process and incorporating existing environmental and safety processes and protective measures into the implementation of the Proposed Action will ensure that environmental impacts from the Proposed Action remain below the level at which the impact would be significant..

The protective measures already implemented for current No Action Alternative activities, which rely heavily on ongoing process improvements, would continue to be used as the means of mitigating environmental impacts for the Proposed Action alternatives. The impact findings described in Chapter 4 were determined in the context of the existing environmental management processes and protective measures that are integral to current and future NSWCDD RDT&E activities. Mitigation is and would continue to be built into current activities and future activities under the Proposed Action, resulting in no significant impacts. NSWCDD is committed to applying the same processes used to mitigate safety and environmental impacts for current activities to all future activities under the No Action Alternative, and Alternatives 1 and 2. NSWCDD's Safety and Environmental Office is responsible for carrying out these processes for NSWCDD's current activities and will do so for future activities.

If at any point, monitoring under the Project Environmental Review and Monitoring Process indicates that mitigation commitments have not been implemented or have not had the results predicted, NSWCDD will work to remedy inadequacies by implementing remedial steps,

preparing supplemental NEPA analysis and/or documentation, consulting with appropriate agencies, or considering past experience in future actions, as outlined in CEQ guidance (CEQ, 2011).

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Source: <http://www.dnr.state.md.us/Bay/monitoring/zoop/index.html>. Accessed December 19, 2008.

Aquatic Invertebrates

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Bald Eagle

Source: <http://www.birdsandbloom.com>. Accessed December 19, 2008.

Osprey catching salmon

Source: <http://www.mnh.si.edu/exhibits/natures_best_2006/gallery/osprey.html> Accessed December 19, 2008.

Photographer: James A. Galletto.

Great Blue Heron

Source: <http://pinker.wjh.harvard.edu/photos/Florida/pages/great%20blue%20heron.htm>. Accessed November 3, 2011.

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Blue-faced Meadowhawk

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Photographer: Will Cook.

Green Tree Frog

Source: <https://www.denix.osd.mil/portal/page/portal/denix/environment/NR/conservation/PhotoVideoGallery?month=10&date=1&year=2008>

Photographer: Joe Mitchell.

Common Yellowthroat

Photographer: C.S. Robbins

White-tailed Deer

Source: <http://www.pgc.state.pa.us/pgc/cwp/browse.asp?a=465&bc=0&c=70124>

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New York Department of Environmental Conservation

Source: <http://pond.dnr.cornell.edu/nyfish/Acipenseridae/atlsturg.html>. Accessed November 3, 2011.

Atlantic Sturgeon

Source: New York Department of Environmental Conservation <http://pond.dnr.cornell.edu/nyfish/Acipenseridae/shortnose_sturgeon.html>. Accessed November 3, 2011.

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Source: <http://www.birdsandblooms.com/Article.aspx?ContentID=45655&r_d=y>. Accessed November 3, 2011.

Bottlenose Dolphin

Source: <http://www.copyright-free-images.com/fauna-animals-copyright-free-images/dolphins-copyright-free-images/bottlenose-dolphin.jpg.html" title="Bottlenose dolphin">Bottlenose dolphin by U.S. Fish and Wildlife Service. Accessed June 15, 2012.

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Daniel Sheehan, GIS Specialist: 7 years of experience as an environmental GIS specialist focused on data management and preparation for environmental impact studies. State University of New York College at Geneseo, BA, Geography; State University of New York, Buffalo, MA, Geography/Specialization in GIS.

Nancy A. Stehling, RPA, Senior Archaeologist: 34 years of experience in cultural resources and artifact analysis. State University of New York College at Potsdam, BA, Anthropology and

Geology; Rensselaer Polytechnic Institute, MS, Public Archaeology.

Lacey Tauber, Architectural Historian. 8 years of experience in urban preservation and historical research in compliance with Section 106 and NEPA. BJ, Journalism, University of Texas at Austin; MS, Historic Preservation, Pratt Institute School of Architecture.

Katherine Weber, GIS/Cartography: 8 years of experience in mapping using GIS, ArcView, ArcGIS, and PGS. Mary Washington College, BA, Geography.

Xiaojing Wei, GIS: 14 years of experience as a cartographer and GIS analyst specializing in mapping support for planning and engineering studies. MA, Geography, University of Connecticut; MS, Land Resources and Management, China Agricultural University – Beijing; BS, Soil Science, Shandong Agricultural University.

Fang Yang, Principal Air Quality and Noise Scientist: 24 years of experience preparing air quality and noise portions of environmental impact assessments for stationary and mobile source impacts. Fudan University, BS, Physics; New York University, MS, Atmospheric Science.

DTI Sector of Kratos Defense & Security Solutions

William Goss, NEPA Compliance, Project Review.

Richard Neil, NEPA Compliance, Project Review.

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