Missouri River Recovery Program

DRAFT

Missouri River Recovery Management Plan and Environmental Impact Statement

AGRICULTURE AND INTERIOR DRAINAGE ENVIRONMENTAL CONSEQUENCES ANALYSIS TECHNICAL REPORT

December 2016

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Missouri River Recovery Management Plan and Environmental Impact Statement

Agriculture and Interior Drainage Environmental Consequences Analysis

Technical Report

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1.0 Introduction

The USACE in cooperation with the USFWS are developing a Missouri River Recovery Management Plan and Draft Environmental Impact Statement (MRRMP Draft EIS). The purpose of the MRRMP Draft EIS is to develop a management plan that includes a suite of actions that removes or precludes jeopardy status for the piping plover, the interior least tern, and the pallid sturgeon using USACE authorities.

The purpose of the Agriculture and Interior Drainage Environmental Consequences Analysis Technical Report is to provide supplemental information on the Agriculture and Interior Drainage analysis and results in addition to the information presented in the MRRMP-EIS. Additional details on the National Economic Development (NED) and Other Social Effects (OSE) methodology and results are provided in this technical report. No Regional Economic Development (RED) or Environmental Quality (EQ) analyses were undertaken for Agriculture and Interior Drainage.

1.1 Summary of Alternatives

The MRRMP Draft EIS evaluates the following Management Plan alternatives. Detailed description of the alternatives is provided in the Draft EIS, Chapter 2.

- **No Action – Current System Operation and Current MRRP Implementation.** This is the no-action alternative, in which the Missouri River Recovery Program (MRRP) would continue to be implemented as it is currently, including a number of management actions associated with the MRRP and BiOp compliance. Management actions under No Action include creation of early life stage habitat for the pallid sturgeon and emergent sandbar habitat (ESH), as well as a spring plenary pulse. The construction of habitat will be focused in the Garrison and Gavins reaches for ESH (an average rate of 107 acres per year) and between Ponca to the mouth near St. Louis for early life stage habitat (3,999 additional acres constructed).
- **Alternative 2 – USFWS 2003 Biological Opinion Projected Actions.** This alternative represents the USFWS interpretation of the management actions that would be implemented as part of the 2003 Amended BiOp Reasonable and Prudent Alternative (USFWS, 2003). Whereas No Action only includes the continuation of management actions USACE has implemented to date for BiOp compliance, Alternative 2 includes additional iterative actions and expected actions that the USFWS anticipates would ultimately be implemented through adaptive management and as impediments to implementation were removed. Considerably more early life stage habitat (10,758 additional acres constructed) and ESH (an average rate of 3,546 acres per year) would be constructed under Alternative 2 than under No Action. In addition, a spring pallid sturgeon flow release would be implemented every year if specific conditions were met. Alternative 2 would also modify System operations to allow for summer flows that are sufficiently low to provide for early life stage habitat as rearing, refugia, and foraging areas for larval, juvenile, and adult pallid sturgeon.
- **Alternative 3 – Mechanical Construction.** The USACE would only create ESH through mechanical means at an average rate of 391 acres per year across the entire system. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from system operations. The average annual construction amount includes replacing ESH lost to erosion and vegetative growth, as

well as constructing new ESH. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 3. There would not be any reoccurring flow releases or pulses implemented under this alternative.

- **Alternative 4 – Spring ESH Creating Release.** The USACE would mechanically construct ESH annually at an average rate of 240 acres per year across the entire system. This amount represents the acreage necessary to meet the bird habitat targets after accounting for available ESH resulting from implementation of an ESH-creating reservoir release in the spring. Alternative 4 would be similar to No Action (current operations), with the addition of a spring release designed to create ESH for the least tern and piping plover. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 4.
- **Alternative 5 – Fall ESH Creating Release.** The USACE would mechanically construct ESH annually at an average rate of 309 acres per year across the entire system. This alternative is based on No Action (current operations), with the addition of a release in the fall designed to create sandbar habitat for the least tern and piping plover. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 5.
- **Alternative 6 – Pallid Sturgeon Spawning Cue.** The USACE would mechanically construct ESH annually at an average rate of 303 acres per year across the entire system. In addition, the USACE would attempt a spawning cue pulse every three years in March and May. These spawning cue pulses would not be started or would be terminated whenever flood targets are exceeded. An additional 3,380 acres of early life stage habitat for the pallid sturgeon would be constructed under Alternative 6.

1.2 USACE Planning Accounts

Alternative means of achieving species objectives will be evaluated including consideration for the effects of each action or alternative on a wide range of human considerations. Human considerations to be evaluated in the MRRMP-EIS alternatives are rooted in the economic, social, and cultural values associated with the natural resources of the Missouri River. The effects to human considerations evaluated in the MRRMP-EIS are required under the National Environmental Policy Act and its implementing regulations (40 CFR Parts 1500-1508). The 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) also served as the central guiding regulation for the economic and environmental analysis included within the MRRMP-EIS. Further guidance that is specific to the USACE is described in Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, which provides the overall direction by which USACE Civil Works projects are formulated, evaluated, and selected for implementation. These guidance documents describe four accounts that were established to facilitate evaluation and display the effects of alternative plans:

- The national economic development (NED) account displays changes in the economic value of the national output of goods and services expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.
- The regional economic development (RED) account registers changes in the distribution of regional economic activity (i.e., jobs and income).

- The environmental quality (EQ) displays non-monetary effects of significant natural and cultural resources.
- The other social effects (OSE) account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts. In a general sense, OSE refers to how the constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness are affected by some condition or proposed intervention.

The accounts framework enables consideration of a range of both monetary and non-monetary values and interests that are expressed as important to stakeholders, while ensuring impacts are not double counted. The USACE planning accounts evaluated for interior drainage include NED, RED, and OSE.

1.3 Approach for Evaluating Environmental Consequences of Missouri River Recovery Management Plan

Physical characteristics of the Missouri River and its floodplain that are particularly important to agriculture include reservoir elevations, river flows/stages, geomorphology, and flood risk management infrastructure (e.g. levees). Changes in these characteristics could result in changes in land use and agricultural conditions (beneficial or adverse), such as land use and management, land ownership, and present flooding hazards, including interior drainage to agricultural operations. Changes in land use and agricultural conditions could change agricultural operations, such as the number of harvested acres, farming expenses, cropping patterns, or crop yields, which could reduce income to farmers. Changes in agricultural production, net income to farmers, and employment could have implications for agricultural ways of life and community resiliency.

The conceptual flow chart shown in Figure 1 demonstrates, in a stepwise manner, how changes to the physical conditions of the Missouri River and its floodplain can impact interior drainage. This figure also shows the intermediate factors and criteria that were applied in assessing the NED, RED, and OSE consequences to interior drainage.

The approach for evaluating environmental consequences to interior drainage was initiated with an evaluation of thresholds which were developed to evaluate effects from changes in Missouri River flow and corresponding river stages, for any given event resulting from the alternatives. Effects on the built human environment were evaluated by the frequency and duration that certain damage thresholds were reached during flood or high water events under both without-project and with-project conditions. The results of this analysis were used to verify that further interior drainage analysis to estimate changes in NED, RED, and OSE impacts was warranted. This second step in the process estimated impacts associated with damage to structures and associated contents, agricultural losses, and population at risk. Figure 2 illustrates an overview of the approach for interior drainage.

CHANGES IN: Physical Components of Missouri River Watershed

- River flows and reservoir elevations (including frequency, depth, duration, and seasonality)
- Geomorphology
- River channel dimensions
- Flood risk management infrastructure (levees, dams, channel, non-structural)

Leads To

CHANGES IN: Land Use and Agricultural Conditions

- Land ownership, use, and/or management in the floodplain
- Hazards to agricultural operations – flooding, interior drainage, wildlife grazing to crops

Leads To

CHANGES IN: Agricultural Operations

- Acreage of crops or pasture lands
- Cropping patterns
- Crop yields
- Production or farming expenses

Leads To

CHANGES IN: Beneficial Effects and/or Costs

- National Economic Development (NED) – Agricultural net income, non-crop benefits

Leads To

CHANGES IN: Beneficial Effects and/or Costs

- Regional Economic Development (RED) – Economic output (revenues), income, employment by industry and region; tax revenues to local governments

Leads To

CHANGES IN: Benefits

- Other Social Effects (OSE) – Community resiliency, traditional ways of life (e.g. century farms), environmental justice

Figure 1. Flow Chart of Inputs Considered in Interior Drainage Evaluation

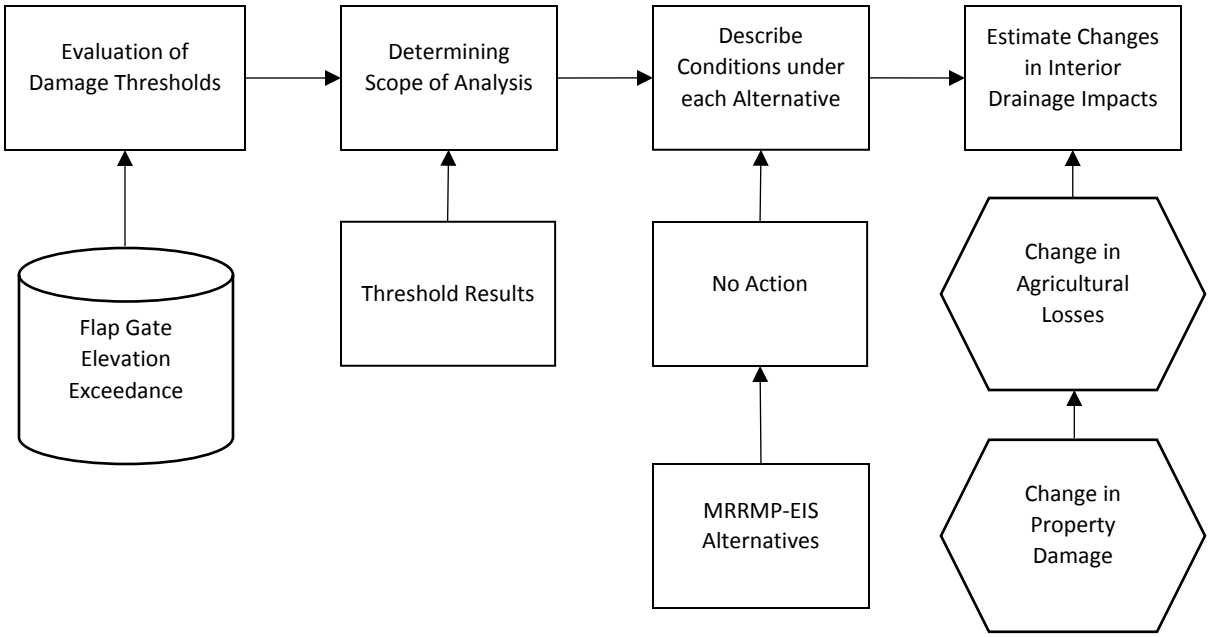

Figure 2. Evaluation of Interior Drainage Impacts

The one-time spawning cue test (Level 2) release that may be implemented under Alternatives 3, 4, and 5 was not included in the hydrologic modeling for these alternatives because of the uncertainty of the hydrologic conditions that would be present if implemented. Hydrologic modeling for Alternative 6 simulates reoccurring implementation (Level 3) of this spawning cue over the wide range of hydrologic conditions in the POR. Therefore, the impacts from the potential implementation of a one-time spawning cue test release would be bound by the range of impacts described for individual releases under Alternative 6.

2.0 Methodology and Assumptions

2.1 Assumptions

In modeling the environmental consequences to interior drainage from the MRRMP-EIS alternatives, the project team established a set of assumptions. The important assumptions used in the modeling effort are as follows.

- The economic analysis uses data from the hydrologic and hydraulic (H&H) modeling of the river and reservoir system. The analysis assumes that the H&H models reasonably estimate river flows and reservoir levels over the 82-period of record under each of the MRRMP-EIS alternatives as well as the No Action.
- The impacts for the No Action are for the purpose of providing a baseline and allowing for a comparison of the alternatives.
- Because the models are quite complex and time consuming to develop, it was not feasible to model every levee on the Missouri River. Therefore, a sub-set of the seven

sites evaluated for the Master Manual (USACE, 1998) were selected to be modeled in detail.

- Extrapolation from the four sites to other levee areas was problematic since the hydraulics, hydrology, and drainage varies and any potential damage-duration relationships would be difficult to define.

2.2 Risk and Uncertainty

Risk and uncertainty are inherent with any model that is developed and used for water resource planning. Much of the risk and uncertainty with the overall Management Plan is associated with the operation of the Missouri River system and the extent to which flows and reservoir levels will mimic conditions that have occurred over the 82-year period of record. Unforeseen events such as climate change and weather patterns may cause river and reservoir conditions to change in the future and would not be captured by the HEC-RAS models or carried through to the interior drainage model described is this document. The project team has attempted to address risk and uncertainty in the Management Plan by defining and evaluating a reasonable range of plan alternatives that include an array of management actions within an adaptive management framework for the Missouri River. All of the alternatives were modeled to estimate impacts to interior drainage.

2.3 Economic Analysis and Modeling

An interior drainage analysis was proposed to evaluate water surface elevations within federal levee areas along the Missouri River. Elevations within these leveed areas are affected by the ability to drain interior runoff into the Missouri River. Criteria for evaluation of interior areas of levee systems are specified in EM 1110-2-1413 and are applicable to the Missouri River Recovery Management Plan (MRRMP) to determine potential economic impacts of various habitat and or flow alternatives to existing leveed areas. Processes for interior drainage evaluation from EM 1110-2-1413 consist of generating continuous records to a level of detail commensurate with the type of study. In this case, existing interior areas were analyzed against alternative river geometries and/or flow alternatives from the mainstem dams, both of which could influence exterior river stages.

During the Master Manual update process, an interior drainage study was conducted on seven representative sites as documented in *Volume 11: Interior Drainage Study, Master Water Control Manual, Northwest Division, August 1998*. The analysis was performed with a hydrologic model, HEC-IFH, which is no longer supported and is not compatible with current computer operating systems. Furthermore, it was not possible to update the former model or extrapolate model results to current conditions. However, the sites were selected during the Master Manual as representative, some calibration parameters determined were useful, and repeating evaluation at those sites allowed for comparison to previous results.

Three programs (HEC-RAS, HEC-HMS, and HEC-FIA) were used to assemble models for evaluating interior drainage impacts to four sites. The HEC-HMS model was used to model rainfall for the period of record and determine runoff entering the levee interior area. Hydrologic parameters used in the previous HEC-IFH (Interior Flood Hydrology) analysis were utilized where applicable in order to expedite modeling. The HEC-RAS model was based on the current model in use for alternative analysis. The model utilized the runoff entering the levee cell, stage-storage for the area, Missouri River water levels, estimated seepage, and the hydraulic parameters of the drainage structures to perform computations of the drainage structures that

convey runoff from the interior drainage area into the Missouri River. Model results determined daily ponding levels for the entire period of record.

Once the four sites were refined in the HEC-RAS model, the daily ponding elevation information was used by the HEC-FIA model that was developed to compute property damage and agricultural losses occurring during two separate time windows:

1. Spring – This time window focused on the agricultural damages associated with the maximum 14-day duration for a spring stage event. This time window varied for each state based on typical planting dates obtained from the respective state's agricultural extension service.
2. Summer-Fall – This time window focused on the agricultural damages associated with the maximum 1-day duration for a summer or fall stage event. This time window varied for each state based on typical harvesting dates obtained from the respective state's agricultural extension service.

HEC-FIA evaluates impacts to a study area, with the damageable elements defined through the addition of user defined agricultural and structural inventories. The HEC-FIA model is able to estimate impacts associated with historical flood events through a set of geo-referenced hydrographs (stage or flow with accompanying rating curves) which represent a single event. For this specific analysis period, HEC-FIA estimated:

- Agricultural Losses – Losses sustained to crops. Damages can be related to a loss of a crop in the ground, the inability to plant a crop due to flooding, or the loss related to planting a crop later in the season due to flooding at planting time. These losses relate to the timing of the flood, duration of flooding, season, and type of crop.
- Direct Economic Losses – Losses directly related to damages sustained by structures, contents, equipment, vehicles, etc. These losses are essentially all damage to property.

For all of the selected sites, and under each alternative scenario, each individual year in the 82-year period of record was run in HEC-FIA for both time windows. The losses for each year were aggregated and averaged over the 82 years to estimate expected annual damages for each site across all the alternatives.

2.4 National Economic Development Methodology

National Economic Development (NED) effects are defined as changes in the net value of the national output of goods and services. In the case of interior drainage, the conceptual basis for the NED impacts analysis is an increase or decrease in risk of physical and non-physical damage from flooding. The measurement of national economic effects was based on the estimated change in flood risk to structures and associated property and agriculture as calculated in the HEC-FIA model, resulting from Management Plan alternatives.

Economic losses associated with direct damage to property were based on a structure inventory populated from the National Structure Inventory (NSI) that was developed by the HEC in coordination with FEMA's HAZUS database. The NSI converts Census block level data to a series of points, each representing a single structure. As part of the quality assurance and quality control process, these points were adjusted to ensure that they are located at their appropriate structure locations. Once the structure inventory was defined, HEC-FIA was run to

compute the property and infrastructure damages associated with the maximum 1-day duration stage event.

Agricultural losses were based on data downloaded from USDA's National Agricultural Statistics Service (NASS). HEC-FIA has a feature that accesses the NASS database to retrieve all the agricultural categories listed in the NASS website and the associated acreage for the study area. Once the desired crops for the study area were selected, several variables in the model's "Crop Loss Editor" needed to be inputted. Each crop had the planting (first and last) and harvesting dates defined. Another variable was the cost to produce the crop. This is split into fixed costs, variable costs for the first and last planting, and harvesting costs with the fixed and variable costs being defined on a monthly basis. Additionally, price and yield information were populated. The planting and harvesting dates were taken from the NASS Agricultural Handbook Number 628: "Field Crops: Usual Planting and Harvesting Dates". The cost and yield variables were all obtained from the respective state's agricultural extension service and in accordance with Corps of Engineers guidance, the U.S. Department of Agriculture's normalized agricultural prices were used. A seasonal duration-damage curve from the HEC's AGDAM (Agricultural Flood Damage Analysis) User's Manual was also used to define the percent of crop damage associated with the duration (in days) of inundation. After these inputs were established, HEC-FIA was run to compute agricultural losses related to a loss of a crop in the ground, the inability to plant a crop due to flooding, or the loss related to planting a crop later in the season due to flooding at planting time.

In conjunction with the tangible damages computed in the HEC-FIA model, there are other costs of flooding to the nation that need to be captured. The costs of flooding include emergency costs and disaster relief costs. Emergency cost savings can encompass savings related to a wide range of flooding impacts, including emergency personnel costs, flood fighting costs (sandbagging, for example), avoidance costs (raising or evacuation of property), temporary food and housing, debris cleanup, and damage to infrastructure items not otherwise included in the damage analysis such as sewer lines. Based on an analysis of approved USACE projects, it was assumed that emergency costs are equivalent to a maximum of nine percent of physical flood damages.

2.5 Regional Economic Development Methodology

The NED results were further evaluated to determine if regional economic conditions would be affected under the MRRMP-EIS alternatives. For all action alternatives, the differences in damages on average compared to No Action would result in negligible NED impacts. However, in some years there are small differences. Alternatives 3, 4, 5, and 6 for the four locations in the NED interior drainage assessment would result in negligible RED impacts when compared to No Action. For these alternatives, the largest adverse difference in agricultural and structural damage when compared to No Action was $103,000 (MRLS-488L), which would result in an impact of less than 1 job. The worst case difference in agricultural losses and structural damages under Alternative 2 relative to No Action would be $270,000 in MRLS-488L, which results in a loss of approximately 3 jobs. Because all impacts in any year would result in less than three jobs, a full RED analysis was not undertaken on the interior drainage NED impacts.

2.6 Other Social Effects Methodology

Changes in flood risk have a potential to cause other types of effects on individuals and communities in terms of individual and community safety, health, and well-being. The HEC-FIA

model was used to determine impacts to other social effects. Any changes to these areas of concern that would occur under MRRMP-EIS alternatives were examined to the extent possible. Inputs necessary for determining impacts to OSE were census block level data and the outputs of the RED and NED evaluation, which provide a sense of the magnitude of the impacts to the nation and to the regional area.

One aspect of other social effects related to flood risk is safety. A measure used to assess the safety of the population in the floodplain is population at risk. HEC-FIA estimates the number and location of people within the inundated area exposed to the flood hazard. This estimate is referred to as the population at risk and it includes people permanently residing the area, as well as workers, customers of area businesses, and people traveling through the area. Census block data was imported into the model with population evenly distributed to structures based on their occupancy type. The total population at risk is computed by determining the number of people associated with those structures that get inundated.

2.7 Environmental Quality Methodology

This account was not evaluated for interior drainage.

2.8 Geographic Areas

The four selected sample sites included:

Missouri River Levee System (MRLS) Unit 575-L

The MRLS 575-L levee is located in Fremont County, Iowa and is the largest interior drainage site modeled, comprising more than 93,000 acres with nearly 63.5 percent of the land use in to corn and soybean production.

MRLS 536-L

The MRLS 536-L levee is located in Atchison County, Missouri and is comprised of approximately 14,400 acres, the majority of which are agricultural including with nearly 80 percent of land use in corn and soybean production.

MRLS 488-L

The MRLS 488-L levee is located in Holt County, Missouri and is comprised of approximately 9,500 acres, the majority of which are agricultural with more than 81 percent of land use in corn and soybean production.

MRLS 246-L

The MRLS 246-L levee is located in Chariton County, Missouri and is comprised of approximately 32,000 acres, the majority of which are agricultural with nearly 68 percent of the land use in corn and soybean production.

3.0 NED Evaluation Results

3.1 No Action – Current System Operation and Current MRRP Implementation

Under No Action, the Missouri River Recovery Program would continue to be implemented as it is currently. This includes management actions that are in compliance with the BiOp. Management actions that may have impacts to interior drainage include ESH creation and spawning cue flow releases from Gavins Point Dam. The management actions included under No Action are focused on areas below Gavins Point Dam.

The impacts analysis for interior drainage under No Action is summarized in Table 1. Under No Action, average annual interior drainage NED impacts would range between $150,208 and $468,101 for the four selected sites. The average annual totals are particularly influenced by three modeled large flood events that would cause significant impacts at each of the sites: 1984, 1993, and 2011. Agricultural losses are the primary driver of the NED impacts.

Table 1. Summary of Interior Drainage Impacts under No Action

Interior Drainage Site	Average Annual Structure / Content Damages	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts
MRLS 246-L	$111,422	$10,028	$346,651	$468,101
MRLS 488-L	$21,207	$1,909	$241,491	$264,607
MRLS 536-L	$52,349	$4,711	$93,147	$150,208
MRLS 575-L	$63,858	$5,747	$223,684	$293,289
Total	**$248,836**	**$22,395**	**$904,974**	**$1,176,205**

Note: All totals are average annual at the Fiscal Year (FY) 2016 price level.

3.2 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

Alternative 2 represents the management actions that would be implemented as part of the 2003 Amended BiOp RPA. Alternative 2 includes additional iterative actions that USFWS anticipates would be implemented under an adaptive management philosophy. Actions included under this alternative that may have impacts to interior drainage include:

- Creation of emergent sand bar habitat
- Reservoir unbalancing
- Spring reservoir release
- Low nesting season release
- Spawning cue flows
- Low summer flow

The interior drainage NED analysis for Alternative 2 is summarized in Table 2. Overall, Alternative 2 would have a small, beneficial impact on interior drainage NED impacts relative to No Action with an average annual impacts reduction of 0.7 percent from No Action. The site with

the largest impact is MRLS 488-L, which would experience a decrease of $10,214 in average annual flood impacts.

Table 2. Summary of Interior Drainage NED Analysis for Alternative 2

Interior Drainage Site	Average Annual Structure / Content Damages	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Change in Average Annual NED Impacts from No Action	% Change from No Action
MRLS 246-L	$111,361	$10,022	$346,423	$467,807	-$295	-0.1%
MRLS 488-L	$20,320	$1,829	$232,243	$254,393	-$10,214	-3.9%
MRLS 536-L	$49,124	$4,421	$92,653	$146,198	-$4,010	-2.7%
MRLS 575-L	$65,286	$5,876	$228,044	$299,205	$5,917	2.0%
Total	**$246,091**	**$22,148**	**$899,363**	**$1,167,602**	**-$8,603**	**-0.7%**

Note: All totals are average annual the FY 2016 price level. Negative values indicate a decrease relative to No Action.

Figure 3 shows the difference of Alternative 2 from No Action for the years that were modeled for all sites. There is a noticeable increase in impacts in the 1986 modeled year, particularly to MRLS 488-L. Meanwhile in the 1993 simulated event, MRLS 536-L experienced a significant decrease in flood impacts relative to No Action.

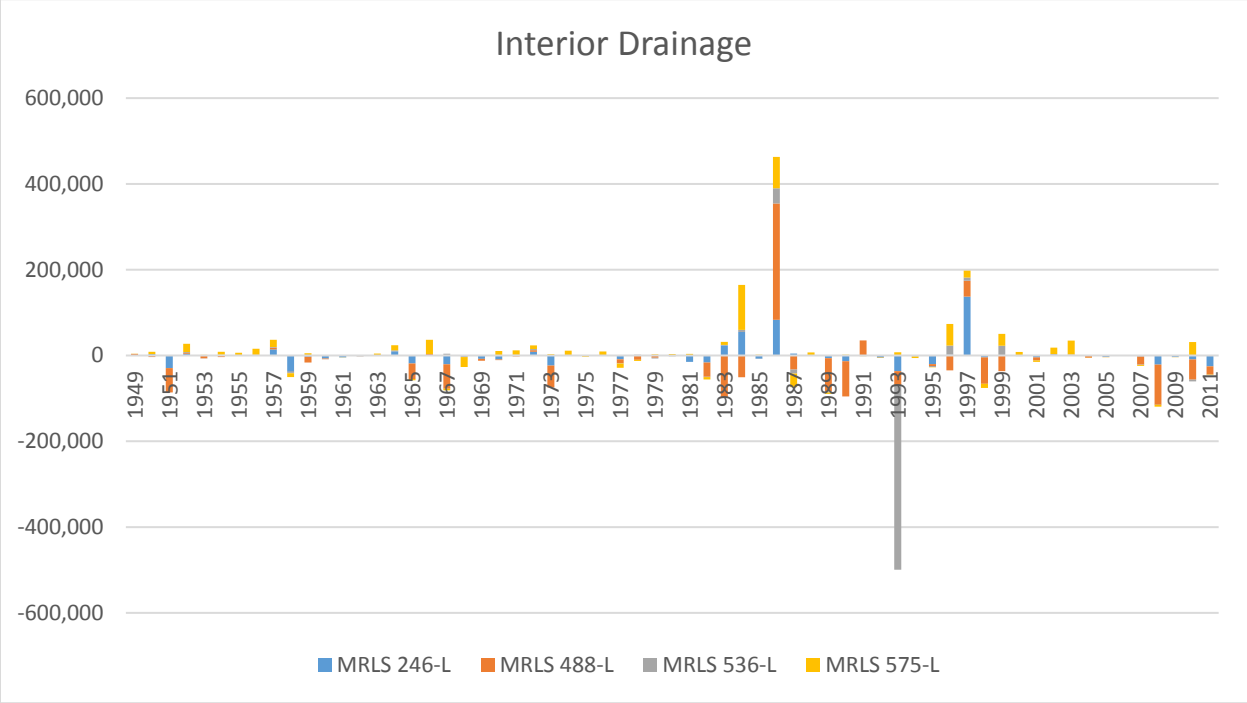

Figure 3. Alternative 2 Difference from No Action for Interior Drainage NED Impacts

In addition to the overall NED impacts, the interior drainage sites were analyzed to examine the difference in impacts during years when there is a release action and/or a low summer flow. These results are summarized and depicted in Figure 4. During the period of record, there were

10 years with a modeled full flow release plus low summer flow action. For the two furthest upstream sites, MRLS 536-L and MRLS 575-L, the impacts would be slightly adverse while for the furthest downstream sites, MRLS 488-L and MRLS 246-L, the impacts would be marginally beneficial on average compared to No Action.

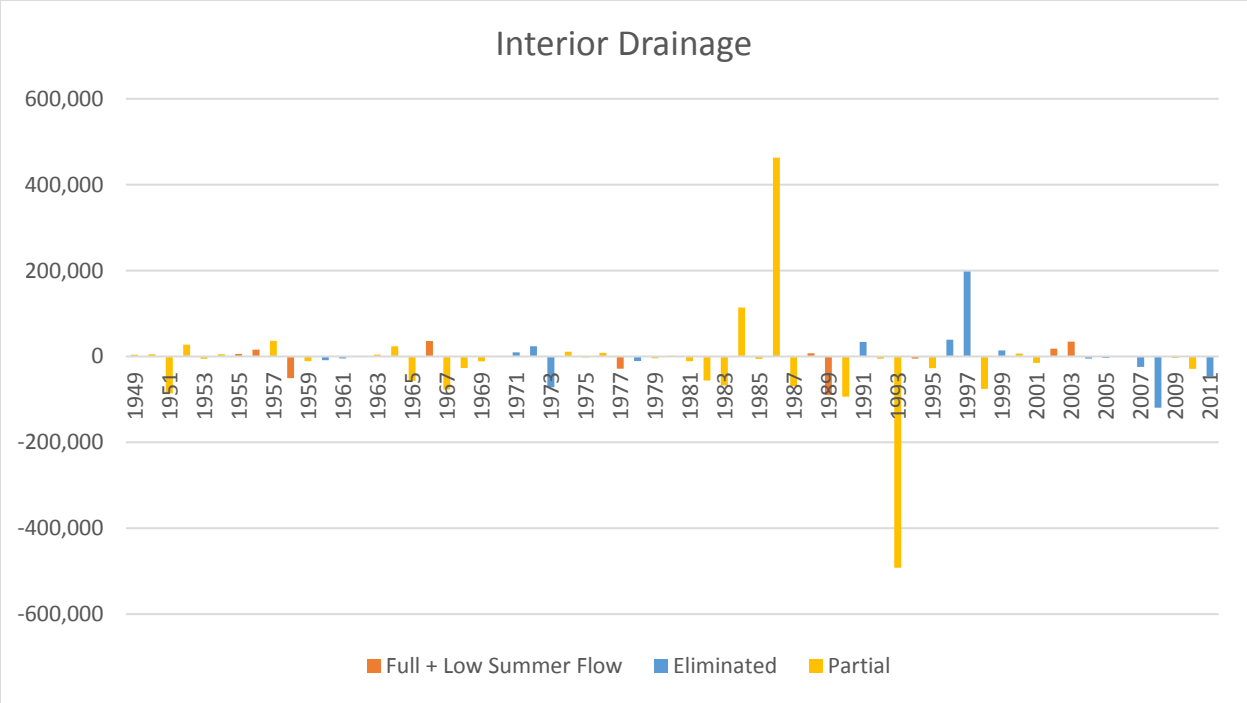

Figure 4. Alternative 2 Difference from No Action by Release Type

In addition to full flow release actions, there were 36 modeled years with partial flow releases. MRLS 246-L, MRLS 488-L, and MRLS 536-L would all exhibit a slight decrease in NED impacts relative to No Action. MRLS 575-L, on the other hand, would have an increase on average in NED impacts over No Action during partial flow release years.

3.3 Alternative 3 – Mechanical Construction Only

Management actions under Alternative 3 would include those that focus on the creation of ESH through mechanical means. Overall Alternative 3 would have a relatively negligible adverse impact on interior drainage relative to No Action with a total increase in average annual NED impacts of $1,183 or 0.1 percent. The interior drainage NED results for Alternative 3 are summarized in Table 3. The site with the largest impact is MRLS 536-L, which would experience an increase of $685 in average annual NED impacts under Alternative 3.

Table 3. Summary of Interior Drainage NED Analysis for Alternative 3

Interior Drainage Site	Average Annual Structure / Content Damages	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Change in Average Annual NED Impacts from No Action	% Change from No Action
MRLS 246-L	$111,564	$10,041	$346,704	$468,309	$207	0.0%
MRLS 488-L	$21,371	$1,923	$241,983	$265,277	$670	0.3%
MRLS 536-L	$52,740	$4,747	$93,406	$150,892	$685	0.5%
MRLS 575-L	$63,806	$5,743	$223,360	$292,909	-$380	-0.1%
Total	**$249,481**	**$22,453**	**$905,453**	**$1,177,388**	**$1,183**	**0.1%**

Note: All totals are average annual at the FY 2016 price level. Negative values indicate a decrease relative to No Action.

Figure 5 shows the difference of Alternative 3 from No Action for the years that were modeled for all sites. There is a noticeable increase in impacts in the 1993 modeled year, particularly to MRLS 536-L. Meanwhile in the 1997 simulated event, MRLS 488-L experienced a significant decrease in flood impacts relative to No Action.

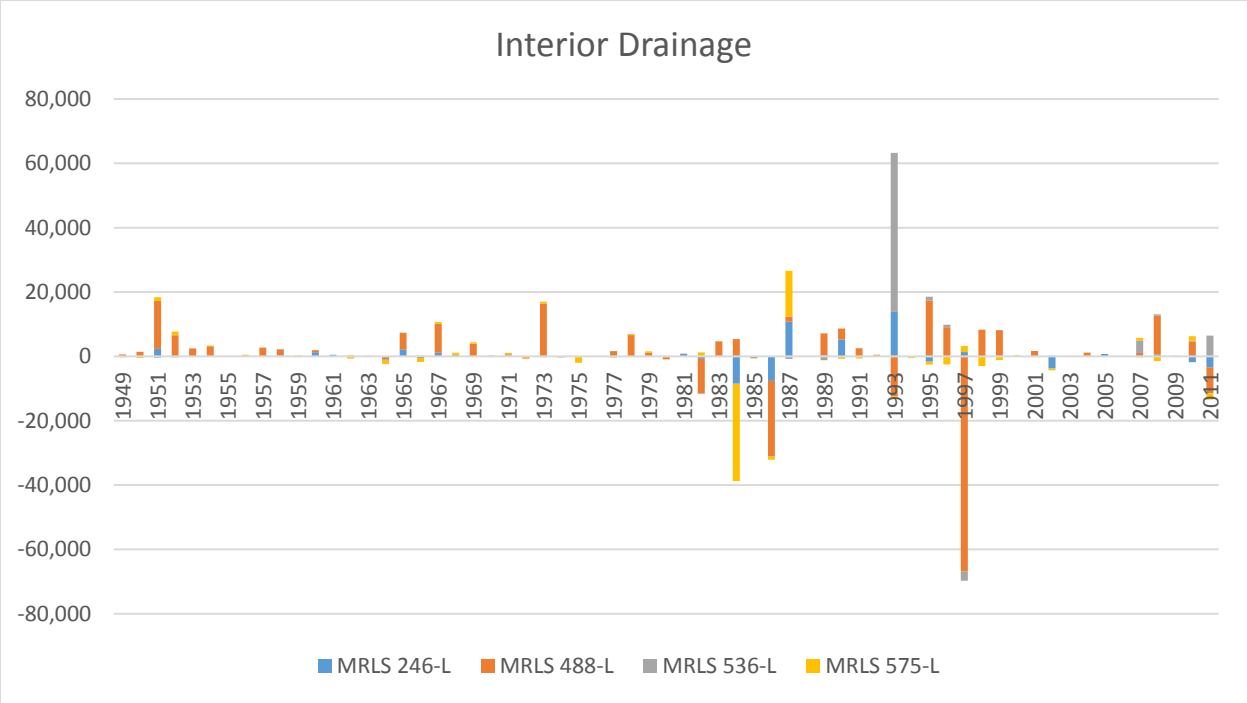

Figure 5. Alternative 3 Difference from No Action for Interior Drainage NED Impacts

3.4 Alternative 4 – Spring ESH Creating Release

Alternative 4 focuses on developing ESH habitat through both mechanical and reservoir releases that would occur during the spring months. Both actions have the potential to affect interior drainage flooding. Overall Alternative 4 would have a relatively negligible adverse impact

on interior drainage relative to No Action with a total increase in average annual NED impacts of $389 or less than 0.1 percent. The site with the largest impact would be MRLS 246-L, which would experience a decrease of $1,823 in average annual NED impacts under Alternative 4. The interior drainage NED results for Alternative 4 are summarized in Table 4.

Table 4. Summary of Interior Drainage NED Analysis for Alternative 4

Interior Drainage Site	Average Annual Structure / Content Damages	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Change in Average Annual NED Impacts from No Action	% Change from No Action
MRLS 246-L	$111,333	$10,020	$344,926	$466,279	-$1,823	-0.4%
MRLS 488-L	$21,561	$1,941	$242,382	$265,884	$1,277	0.5%
MRLS 536-L	$52,828	$4,755	$93,352	$150,934	$727	0.5%
MRLS 575-L	$65,263	$5,874	$222,359	$293,496	$208	0.1%
Total	**$250,985**	**$22,589**	**$903,019**	**$1,176,594**	**$389**	**0.0%**

Note: All totals are average annual at the FY 2016 price level. Negative values indicate a decrease relative to No Action.

Figure 6 shows the difference of Alternative 4 from No Action for the years that were modeled for all sites. The most noticeable impacts are the relatively significant decreases relative to No Action exhibited under the 1967, 1987, 2010 simulated events.

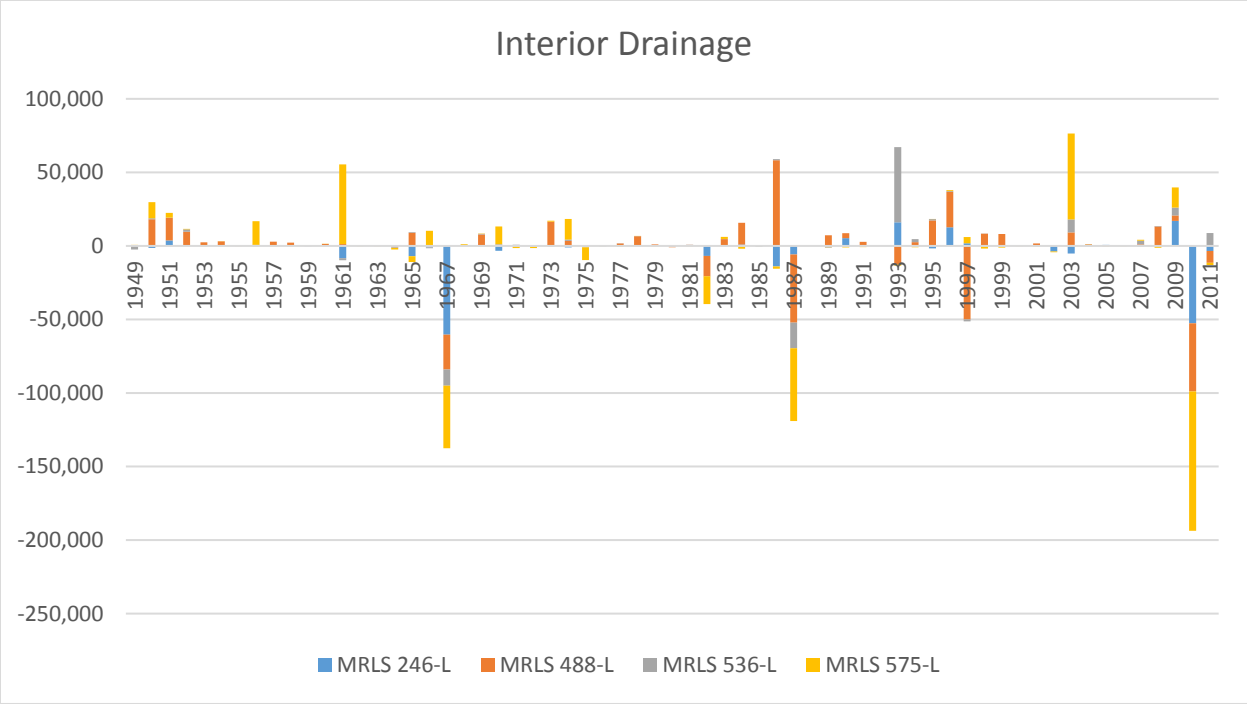

Figure 6. Alternative 4 Difference from No Action for Interior Drainage NED Impacts

Figure 7 shows the difference in annual NED impacts during years when there was a full or partial flow release action modeled. Under Alternative 4, there were 8 simulated years with a full

flow release action. MRLS 488-L, MRLS 536-L, and MRLS 575-L would all exhibit an increase in NED impacts relative to No Action with the largest adverse impacts occurring at MRLS 575-L. Meanwhile, the furthest downstream site, MRLS 246-L, showed a decrease in overall NED impacts compared to No Action under all 8 simulated full release action years.

In addition to full flow release actions, there were three modeled years with partial flow releases. At all four interior drainage sites, the partial release years would have an adverse NED impact.

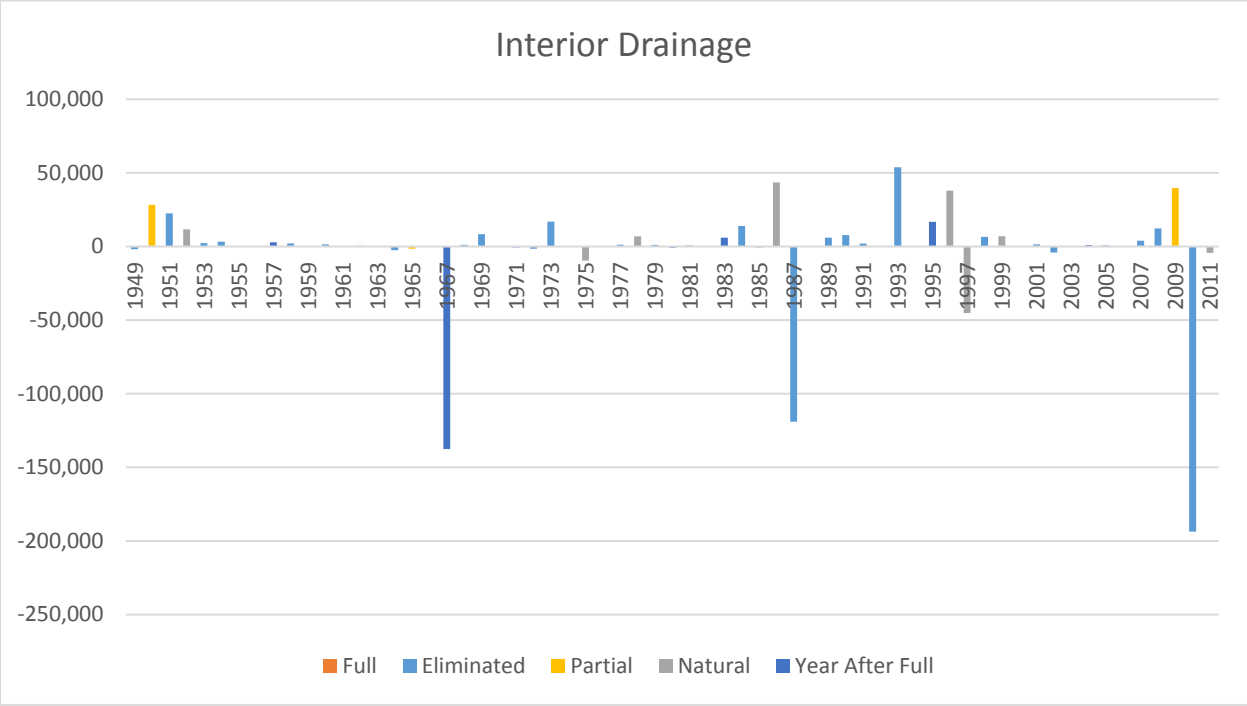

Figure 7. Alternative 4 Difference from No Action by Release Type

3.5 Alternative 5 – Fall ESH Creating Release

Alternative 5 would focus on developing ESH habitat through both mechanical and reservoir releases that would occur during the fall months. Both actions have the potential to affect interior drainage flooding. Alternative 5 would have a relatively negligible adverse impact on interior drainage relative to No Action with a total increase in average annual NED impacts of $1,050 or 0.1 percent. The site with the largest impact is MRLS 536-L, which would experience an increase of $724 in average annual NED impacts. The NED impacts analysis is summarized in Table 5.

Table 5. Summary of Interior Drainage NED Analysis for Alternative 5

Interior Drainage Site	Average Annual Structure / Content Damages	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Change in Average Annual NED Impacts No Action	% Change from No Action
MRLS 246-L	$111,586	$10,043	$346,271	$467,900	-$202	0.0%
MRLS 488-L	$21,353	$1,922	$241,985	$265,260	$653	0.2%
MRLS 536-L	$52,754	$4,748	$93,430	$150,932	$724	0.5%
MRLS 575-L	$63,811	$5,743	$223,609	$293,163	-$125	0.0%
Total	**$249,504**	**$22,455**	**$905,295**	**$1,177,255**	**$1,050**	**0.1%**

Note: All totals are average annual the FY 2016 price level. Negative values indicate a decrease relative to No Action.

Figure 8 shows the difference of Alternative 5 from No Action for the years that were modeled for all sites. The most noticeable impacts are the relatively significant decreases relative to No Action exhibited under the 1984 and 1997 simulated events.

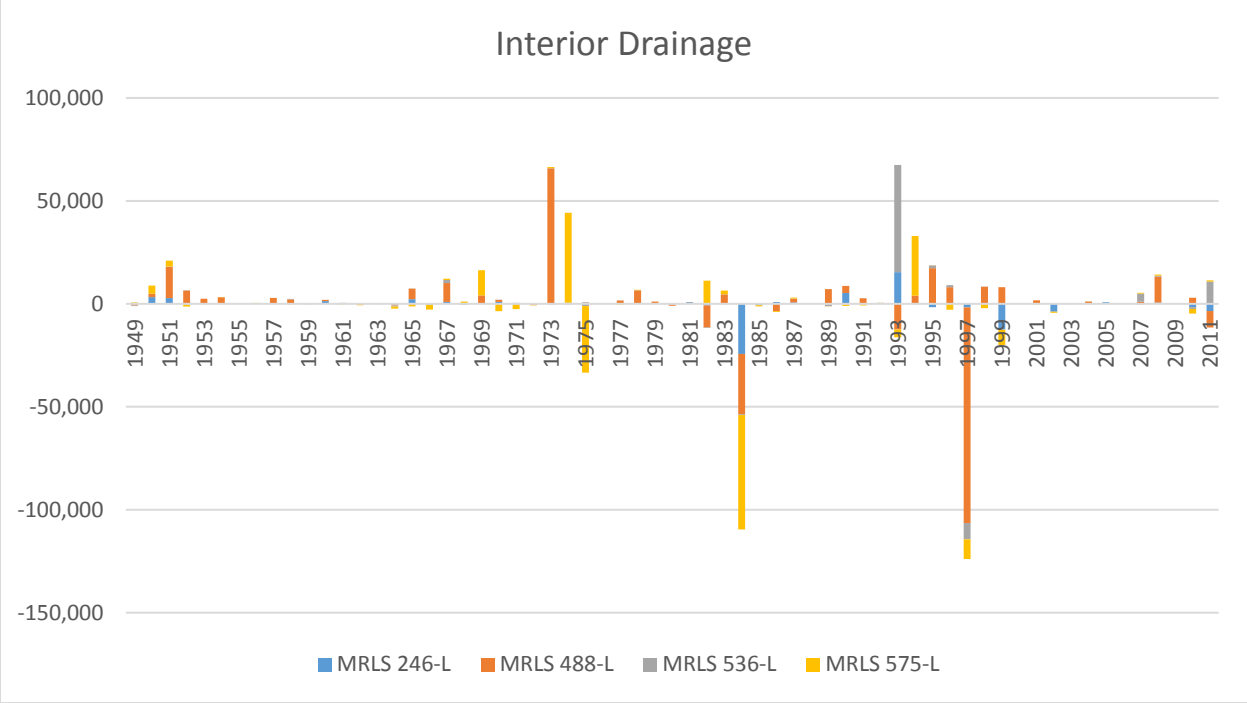

Figure 8. Alternative 5 Difference from No Action for Interior Drainage NED Impacts

Figure 9 shows the difference in annual NED impacts during years when there was a modeled full or partial flow release action. Under Alternative 5, there were five simulated years with a full flow release action. All four sites would experience an increase on average in NED impacts under the full flow release actions of Alternative 5. At MRLS 575-L, the highest modeled yearly increase in NED impacts relative to No Action was a full release year.

In addition to full flow release actions, there were 2 years modeled with partial flow releases. The most notable partial release year effect was at MRLS 488-L, which would experience its highest NED increase under a partial release action event.

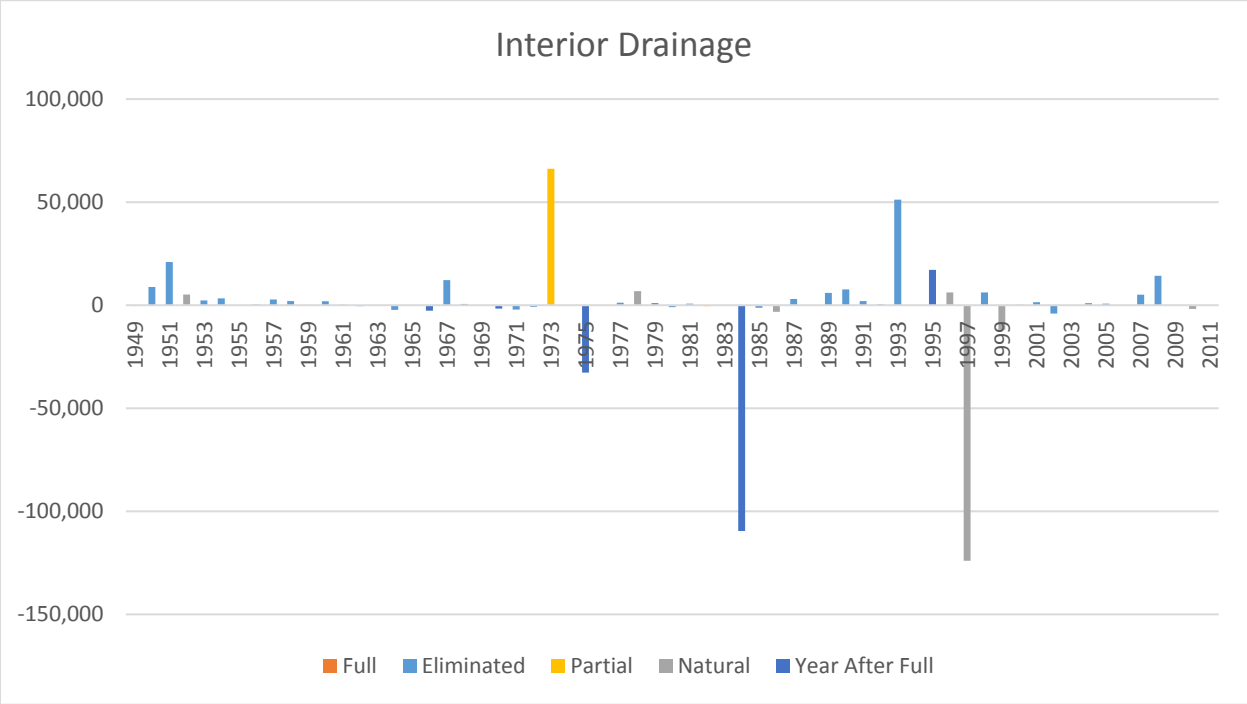

Figure 9. Alternative 5 Difference from No Action by Release Type

3.6 Alternative 6 – Pallid Sturgeon Spawning Cue

Alternative 6 includes actions that would develop ESH habitat through mechanical means and a spawning cue flow that would be mimicked through bi-modal pulses that would occur in March and May. Both of these management actions have the potential to impact interior drainage flooding. Overall Alternative 6 would have a small, adverse impact on interior drainage relative to No Action with a total increase in average annual NED impacts of $3,568 or 0.3 percent. The site with the largest impact is MRLS 488-L, which would experience an increase of $1,862 in average annual NED impacts. The interior drainage NED analysis results for Alternative 6 are summarized in Table 6.

Table 6. Summary of Interior Drainage NED Analysis for Alternative 6

Interior Drainage Site	Average Annual Structure / Content Damages	Average Annual Emergency Costs	Average Annual Agricultural Losses	Total Average Annual NED Impacts	Change in Average Annual NED Impacts from No Action	% Change from No Action
MRLS 246-L	$111,478	$10,033	$345,899	$467,410	-$691	-0.1%
MRLS 488-L	$21,548	$1,939	$242,981	$266,469	$1,862	0.7%
MRLS 536-L	$52,737	$4,746	$93,410	$150,893	$685	0.5%
MRLS 575-L	$64,935	$5,844	$224,222	$295,001	$1,712	0.6%
Total	**$250,698**	**$22,563**	**$906,512**	**$1,179,773**	**$3,568**	**0.3%**

Note: All totals are average annual at the FY 2016 price level. Negative values indicate a decrease relative to No Action.

Figure 10 shows the difference of Alternative 6 from No Action for the years that were modeled for all sites. The most noticeable impact is the increase in impacts exhibited under the 1953 modeled event, particularly in MRLS 488-L, and the decreases relative to No Action depicted in the 1967 and 1987 simulations.

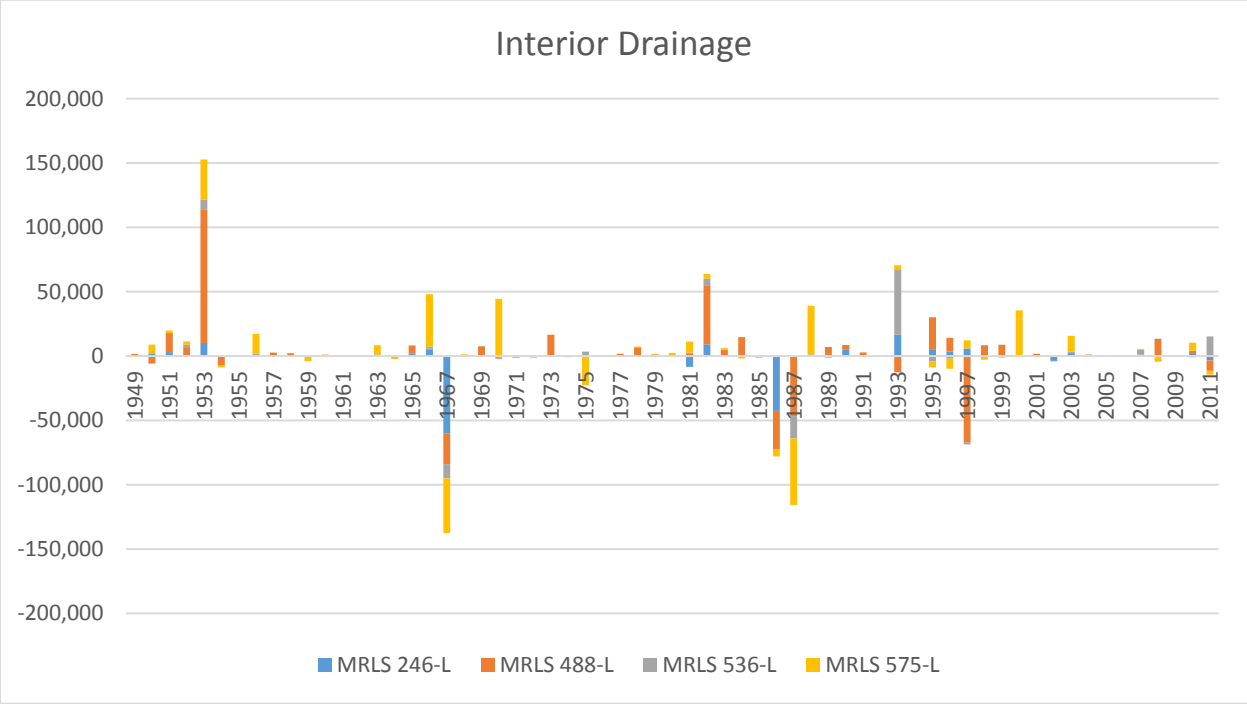

Figure 10. Alternative 6 Difference from No Action for Interior Drainage NED Impacts

The interior drainage impacts during years when there was a release action modeled are depicted in Figure 11. During the period of record, there were 10 years modeled with a full flow release action. All four sites would experience increases in NED impacts under Alternative 6 full release action years, with the two furthest upstream sites, MRLS 536-L and 575-L, displaying increases in 9 out of the 10 simulated years. MRLS 488-L had its highest modeled NED increase, $103,444, in a simulated full release action event year.

In addition to full flow release actions, there were 26 years modeled with partial flow releases. On average, the impacts of the partial flow release years would be more modest than the full release events with all four sites experiencing a slight decrease in average annual NED impacts relative to No Action. The largest decrease was located at MRLS 488-L, which would have a reduction of NED impacts of $67,291 under its worst year relative to No Action.

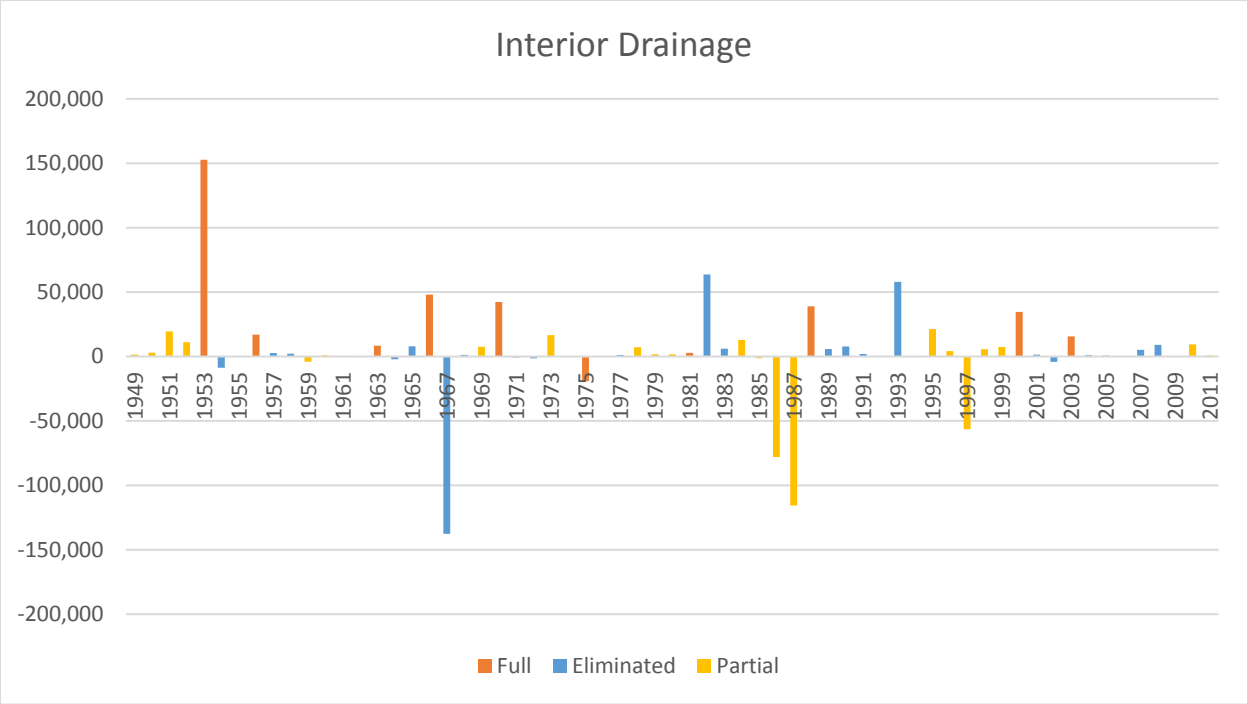

Figure 11. Alternative 6 Difference from No Action by Release Type

4.0 OSE Results

4.1 No Action – Current System Operation and Current MRRP Implementation

Since the interior drainage sites are primarily agricultural, the populations at risk totals are minimal for each of the sites. Under the largest modeled flood event, the maximum population at risk would be located at MRLS 246-L with 89 persons that could be affected by flooding. The population at risk for each site is summarized in Table 7.

Table 7. No Action PAR at Interior Drainage Sites

Interior Drainage Site	Maximum PAR	Average Annual PAR
MRLS 246-L	89	4
MRLS 488-L	4	1
MRLS 536-L	11	0
MRLS 575-L	11	1

4.2 Alternative 2 – USFWS 2003 Biological Opinion Projected Actions

For Alternative 2, there would be minimal changes in population at risk relative to No Action. MRLS 246-L would experience a 3 person maximum decrease, while MRLS 575-L would have a maximum decrease of 4 persons. Table 8 shows the PAR under Alternative 2 for each interior drainage site.

Table 8. Alternative 2 PAR at Interior Drainage Sites

Interior Drainage Site	Maximum PAR	Average Annual PAR	Maximum Increase Relative to No Action	Maximum Decrease Relative to No Action
MRLS 246-L	89	4	0	4
MRLS 488-L	4	1	0	0
MRLS 536-L	11	0	0	0
MRLS 575-L	11	1	0	3

4.3 Alternative 3 – Mechanical Construction Only

For Alternative 3, there would be minimal changes in population at risk relative to No Action. The only change would occur in MRLS 488-L, which would experience a maximum 4 person increase. Table 9 shows the PAR under Alternative 3 for each interior drainage site.

Table 9. Alternative 3 PAR at Interior Drainage Sites

Interior Drainage Site	Maximum PAR	Average Annual PAR	Maximum Increase Relative to No Action	Maximum Decrease Relative to No Action
MRLS 246-L	89	4	0	0
MRLS 488-L	4	1	4	0
MRLS 536-L	11	0	0	0
MRLS 575-L	11	1	0	0

4.4 Alternative 4 – Spring ESH Creating Release

For Alternative 4, there would be minimal changes in population at risk relative to No Action. MRLS 488-L would experience a 4 person maximum increase and a 4 person maximum decrease. MRLS 575-L, meanwhile, would experience a 3 person maximum increase and a 3 person maximum decrease. Table 10 shows the PAR under Alternative 4 for each interior drainage site.

Table 10. Alternative 4 PAR at Interior Drainage Sites

Interior Drainage Site	Maximum PAR	Average Annual PAR	Maximum Increase Relative to No Action	Maximum Decrease Relative to No Action
MRLS 246-L	89	4	0	0
MRLS 488-L	4	1	4	-4
MRLS 536-L	11	0	0	0
MRLS 575-L	11	1	3	3

4.5 Alternative 5 – Fall ESH Creating Release

For Alternative 5, there would be minimal changes in population at risk relative to No Action. Only MRLS 575-L would experience any changes, which would be an 11 person maximum increase and an 11 person maximum. Table 11 shows the PAR under Alternative 5 for each interior drainage site.

Table 11. Alternative 5 PAR at Interior Drainage Sites

Interior Drainage Site	Maximum PAR	Average Annual PAR	Maximum Increase Relative to No Action	Maximum Decrease Relative to No Action
MRLS 246-L	89	4	0	0
MRLS 488-L	4	1	0	0
MRLS 536-L	11	0	0	0
MRLS 575-L	11	1	11	11

4.6 Alternative 6 – Pallid Sturgeon Spawning Cue

For Alternative 6, there would be minimal changes in population at risk relative to No Action. MRLS 488-L would have a 4 person maximum increase and a 4 person maximum decrease. MRLS 575-L would also experience a 3 person maximum increase. Table 12 shows the PAR under Alternative 6 for each interior drainage site.

Table 12. Alternative 6 Population at Risk

Interior Drainage Site	PAR Max	Average Annual PAR	Maximum Increase Relative to No Action	Maximum Decrease Relative to No Action
MRLS 246-L	89	4	0	0
MRLS 488-L	4	1	4	4
MRLS 536-L	11	0	0	0
MRLS 575-L	11	1	3	0

5.0 EQ Results

This account was not evaluated for interior drainage.

6.0 Conclusion

While the magnitude of impacts would vary considerably from year to year as a result of the natural hydrologic cycles of precipitation and runoff, the interior drainage effects would be small to negligible on average annually for each of the alternatives.

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