MOFFAT
COLLECTION SYSTEM PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

Chapter 3:
Affected Environment

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3.0 INTRODUCTION

Chapter 3, Affected Environment, describes the existing physical, biological, and social and economic conditions of the environment within the Moffat Collection System Project (Moffat Project or Project) area that may be affected by implementation of the proposed Project and its alternatives. The resource descriptions provide the basis upon which environmental consequences are analyzed in Chapter 5, Moffat Project Effects. The affected environment is characterized for the following resources:

- Surface Water
- Water Quality
- Channel Morphology
- Groundwater
- Geology
- Soils
- Vegetation
- Riparian and Wetland Areas
- Wildlife
- Special Status Species
- Aquatic Biological Resources
- Transportation
- Air Quality
- Noise
- Recreation
- Land Use
- Visual Resources
- Cultural/Historical/Paleontological Resources
- Socioeconomics
- Hazardous Materials

The Project area is comprised of the following five study areas:

1. Reservoirs
2. Conveyance Systems
3. South Platte River Facilities
4. Denver Basin Aquifer Facilities
5. River Segments

The description of the existing environment in each study area is based on field studies conducted in 2005 and 2006, as well as available information obtained from published documents and coordination with resource agencies. Alternatives 8a, 10a, and 13a are alternatives that utilize potentially available South Platte River water supplies, as described in Chapter 2, Proposed Action and Alternatives. The major components, such as the pipeline corridors, Advanced Water Treatment Plants (AWTPs), gravel pit storage facilities, well facilities, etc., are representative designs for Project layouts. The exact alignments and/or footprints of these components would be selected to minimize interferences with environmentally sensitive areas, railroads, highways, watercourses, and property boundaries. Thus, the descriptions of the affected environment for these alternatives are based on reasonable characterizations of the resources. The following is a general description of each study area discussed in Chapter 3, Affected Environment. Chapter 3 is organized by resource and each resource is discussed by the affected study area. Refer to Chapter 2 for details on the alternatives.

1. **Reservoirs**

- **Gross Reservoir Study Area** – Gross Reservoir, located in Boulder County, is a component of all Environmental Impact Statement (EIS) action alternatives. The boundary of the study area is the current Federal Energy Regulatory Commission (FERC)-licensed project boundary modified to include all proposed facilities (Figure 2-3).
- **Leyden Gulch Reservoir Study Area** – The Leyden Gulch site, located in Jefferson County, is a component of Alternative 1c. The study area was defined to encompass all proposed facilities shown in Figure 2-7.

Although the Board of Water Commissioners' (Denver Water's) raw water system is not interconnected, the treated water system is. Thus, Denver Water's North and South systems operate in an integrated manner. The proposed operational changes associated with the Moffat Project would result in changes in reservoir contents and levels in the following reservoirs:

- Dillon Reservoir
- Williams Fork Reservoir
- Wolford Mountain Reservoir
- Antero Reservoir
- Eleven Mile Canyon Reservoir
- Cheesman Reservoir
- Strontia Springs Reservoir
- Ralston Reservoir
- Chatfield Reservoir

The reservoirs listed above are discussed under the river segment in which they are located (refer to item 5, River Segments below).

2. **Conveyance Systems**

The primary conveyance systems that would convey water from a proposed AWTP to the Moffat Collection System include Conduits M and O (Figure 2-1). The conduits would be constructed within existing roadways (curb-to-curb) and resources are generally described within the study area corridor, which is approximately 160 feet on either side of the conduit centerline.

- **Conduit M Study Area** – Conduit M, located in Adams and Jefferson counties, is a component of Alternative 10a. The pipeline would convey water approximately 18 miles from the proposed AWTP near the Denver Water Recycling Plant to the proposed Moffat Collection System delivery point near State Highway 72.
- **Conduit O Study Area** – Conduit O, located in Adams and Jefferson counties, is a component of Alternatives 8a and 13a. The pipeline would convey water approximately 25 miles from the proposed AWTP near the gravel pit storage

facilities in Adams County to the proposed Moffat Collection System delivery point. Approximately 9 miles of the alignment from Wadsworth Boulevard west to the proposed Moffat Collection System delivery point follows the same alignment as Conduit M.

Other proposed pipelines associated with the South Platte River Facilities and Denver Basin Aquifer Facilities are discussed under the respective study areas.

3. South Platte River Facilities

The South Platte River Facilities, located in Adams County, are components of Alternatives 8a and 13a (Figures 2-9 and 2-18, respectively). The study area contains four representative gravel pits and their associated pipeline network and pump stations, an AWTP, and a diversion structure on the South Platte River. The study area is defined by the associated construction disturbance footprint for each component.

The gravel pit storage facilities are intended to be representative of facilities located along the South Platte River. The representative gravel pits include the Worthing Pit, South Tower Pit, North Tower Pit, and Challenger Pit. These gravel pits are in various stages of mining and development. For purposes of the EIS analysis, it is assumed that when Denver Water acquires the gravel pits needed for the Project they would be completely mined and reclaimed as water storage facilities (i.e., slurry walls and reclaimed side slopes would be in place). It is assumed that the gravel pits would be empty and Denver Water would fill and operate the pits with newly acquired or existing water rights in accordance with the raw water sources identified for each alternative.

Chapter 3, Affected Environment, provides a general description of the existing conditions for each resource at the representative gravel pit sites as an understanding of the existing environment. However, for the impact analysis in Chapter 5, Moffat Project Effects, the baseline conditions are assumed to be reclaimed, empty water storage facilities.

4. Denver Basin Aquifer Facilities

The Denver Basin Aquifer Facilities consist of an aquifer storage and recovery system, located in the City and County of Denver. This storage system is a component of Alternative 10a. The study area includes 27 injection/recovery well facilities on 23 sites in the Denver Metropolitan area, 35 miles of distribution pipelines, and a proposed AWTP near the Denver Water Recycling Plant (Figure 2-15).

5. River Segments

In addition to the study areas where there would be direct effects related to ground-disturbing activities associated with the EIS alternatives, there are also several drainage basins that would be affected by stream flow alterations. Resources that may be affected by potential changes in stream flow (increase or decrease) directly related to an EIS alternative are as follows:

- 3.1 Surface Water
- 3.2 Water Quality
- 3.3 Channel Morphology

- 3.4 Groundwater
- 3.8 Riparian and Wetland Areas
- 3.9 Wildlife
- 3.10 Special Status Species
- 3.11 Aquatic Biological Resources
- 3.15 Recreation
- 3.17 Visual Resources
- 3.19 Socioeconomics

The geographic scope of the study area for the flow-related resources is described below.

- Overall Study Area – river segments that may be affected by the Moffat Project.
- Representative Sites – sampling sites along affected river segments for field data collection.

Overall Study Area Segments: This overall study area contains several river segments that may be affected by the Moffat Project because:

- Denver Water diverts water from these streams:
  - Fraser River and its upper tributaries
  - Williams Fork River and its upper tributaries
  - Blue River
  - South Platte River and its tributaries
  - South Boulder Creek
- Denver Water's diversions from the streams listed above may affect remaining downstream flows in the Colorado River, downstream of its confluence with the Fraser River and in the South Platte River.
- Denver Water delivers water to storage or treatment facilities in these streams:
  - South Platte River
  - North Fork South Platte River
  - South Boulder Creek
  - Vasquez Creek

The downstream extent of the study area on the Colorado River and South Platte River was initially determined based on an evaluation of average monthly hydrologic changes under the action alternatives. The average monthly changes in flow under the action alternatives would be less than 10 percent (%) in the Colorado River at the U.S. Geological Survey (USGS) gage near Kremmling (Kremmling gage) and South Platte River near the USGS gage at Henderson (Henderson gage). The exception to the downstream extent includes evaluation of recreation and special status species. The

evaluation of special status species also considered depletions that would affect four Federally listed endangered fish species that occur downstream of the study area in the Colorado River. In the Platte River Basin, the evaluation of special status species considered depletion effects on Federally listed species in Central Nebraska. Resource evaluations were conducted to determine impacts at the Kremmling gage and Henderson gage and assess the validity of the downstream study area extent. Results of the resource evaluations indicate effects would be negligible to minor at these locations; therefore, extension of the study area further downstream of these locations on the Colorado and South Platte rivers was not warranted. In addition, changes in flow are not significant as a percentage of the total stream downstream of these points because flows increase from contributing drainage basin and tributaries.

Table 3.0-1 lists the overall study area segments and Figure 3.0-1 shows the locations.

The characterization of existing conditions and analysis of impacts was conducted for the overall study area, however, more detailed evaluations and field work were conducted for areas that would experience the greatest flow change. Within the overall study area the characterization of existing conditions for the flow-related resources focused on those affected river segments that would experience an average annual flow increase or decrease of greater than 10% as a result of the Moffat Project, as determined from Platte and Colorado Simulation Model (PACSM) results (refer to Section 5.1). The purpose of identifying these segments was to focus the selection of sample sites, data collection, and field work in areas that experience the greatest flow change. Because the overall study area covers several river basins, it was impractical to collect data on each individual sub-reach of every affected stream. Several sampling sites (representative river reaches), which experience the greatest flow change were therefore identified for detailed data collection and evaluation. These sampling sites are described in the following section. The approach was to select a variety of sampling sites that were examples of or statistically representative of different resource conditions encountered in the study area. Data for the sampling sites were evaluated and extrapolated to the overall study area. River segments that experience flow changes greater than 10% based on average annual flow are listed in Table 3.0-1. Using the criterion of a 10% average annual flow change due to the Moffat Project alternatives, approximately 200 miles of river segments were identified along the mainstems and adjoining tributaries within the overall study area. In addition to these river segments, the Colorado River below the Williams Fork River, Blue River below Green Mountain Reservoir, and South Platte River below Chatfield Reservoir were analyzed in more detail due to flow changes caused by other reasonably foreseeable future actions.

Representative Sites – For specific field data collection efforts, Representative sites were identified within river segments that experience average annual flow changes greater than 10% to obtain specific information to further characterize the riparian habitat and stream channel dynamics (refer to Figures 3.0-2 through 3.0-4). The sites were selected based on a preliminary level assessment of the stream type and field reconnaissance to evaluate the site characteristics as representative of the overall study area. Other factors considered in site selection included a site's suitability for hydraulic modeling, the quality and type of riparian and wetland vegetation, land use or disturbance history, as well as accessibility to the site. A multidisciplinary approach was followed at the sampling sites so that

riparian vegetation sampling was coordinated with hydraulic analysis and the channel dynamics study. The Representative sites in each basin are as follows:

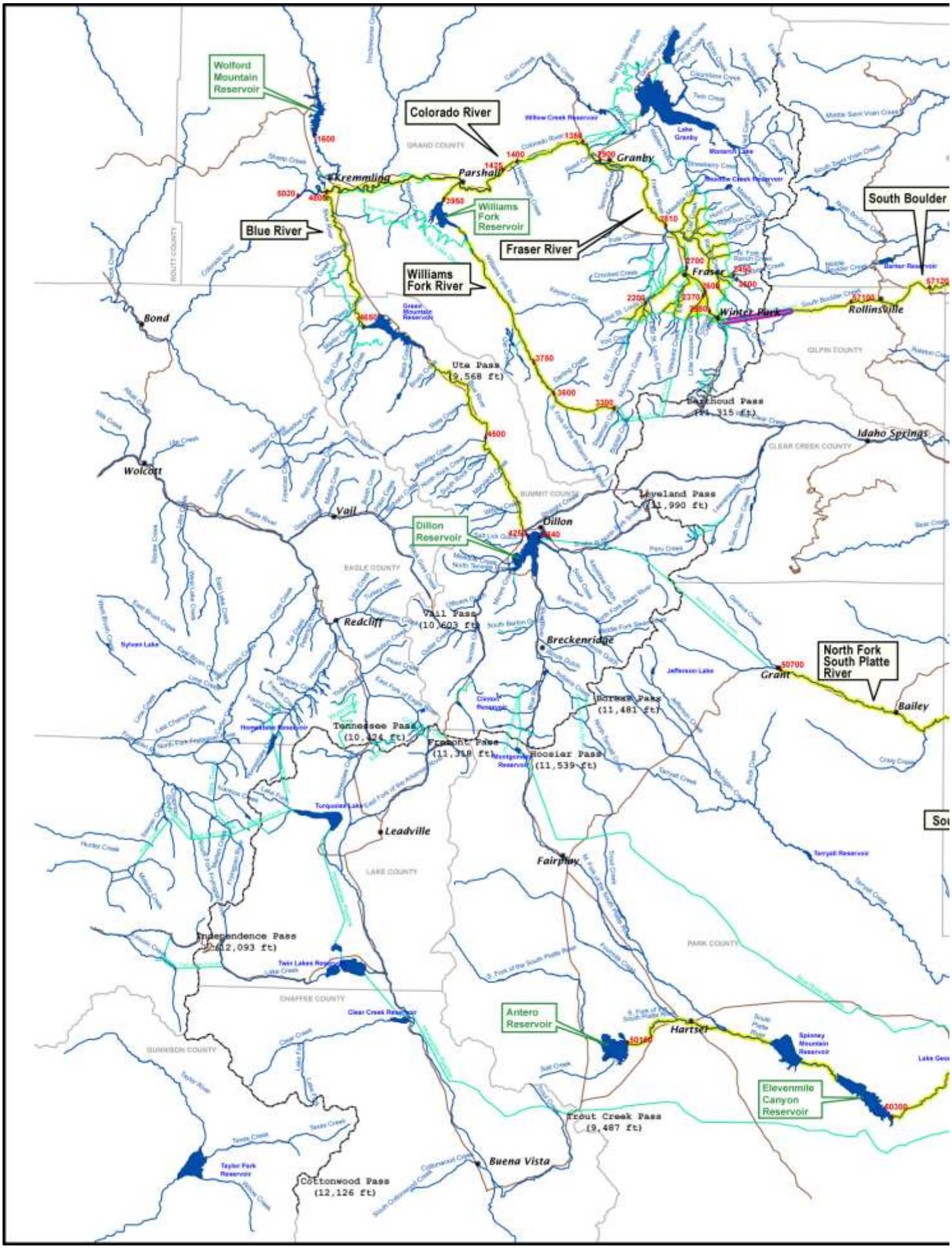
- Fraser River (FR)
  - Fraser River above Winter Park Gage (FR1)
  - Fraser River near Tabernash (FR2)
  - St. Louis Creek below West St. Louis Creek (FR3)
  - Ranch Creek below South Fork (FR4)
  - Fraser River below Denver Water's Diversion (FR5)
  - Jim Creek below Denver Water's Diversion (FR6)
  - Vasquez Creek above Denver Water's Diversion (FR7)
- Williams Fork River(WF)
  - Williams Fork River near Sugarloaf Campground (WF1)
  - Williams Fork River below Steelman Creek (WF2)
- Colorado River (CR)
  - Colorado River above Parshall (CR1)
  - Colorado River at Kemp-Breeze State Wildlife Area (SWA) (CR2)
- Blue River (BR)
  - Blue River below confluence with Boulder Creek (BR1)
- South Boulder Creek (SBC)
  - South Boulder Creek above Gross Reservoir (SBC1)
  - South Boulder Creek below Gross Reservoir (SBC3)
- North Fork (NF) South Platte River
  - North Fork South Platte River near Shawnee (NF1)
  - North Fork South Platte River near Pine (NF2)

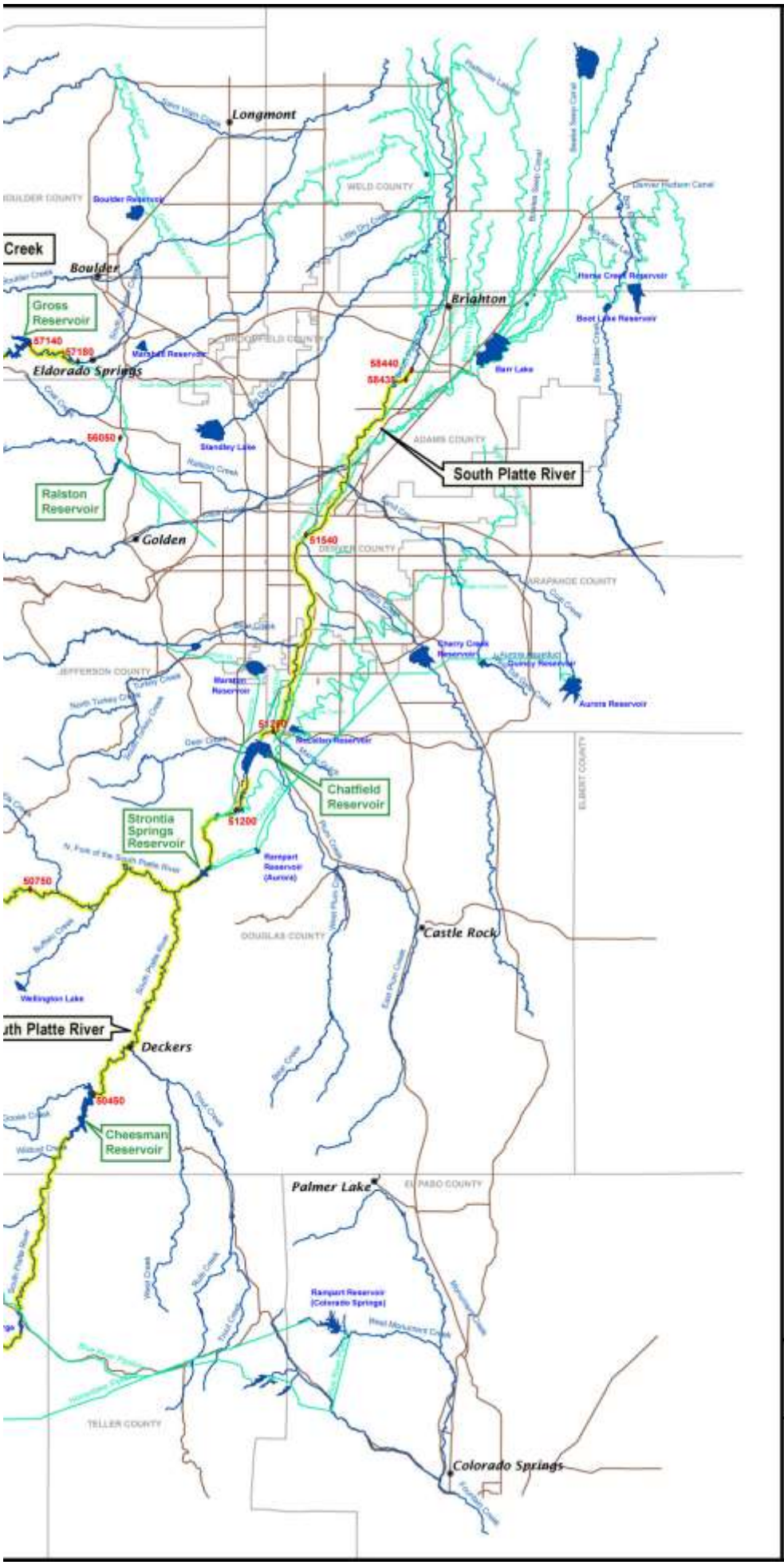
No Representative sites were selected in the South Platte River Basin due to results obtained from other sites and the relatively low flow changes predicted on the South Platte River.

Table 3.0-1
River Segments Study Area

River	Overall Study Area Segment[1]
Fraser River	Mainstem and upper tributaries downstream to the Colorado River
Williams Fork River	Mainstem from the upper tributaries downstream to the Colorado River
Colorado River	From confluence with Fraser River to the Kremmling gage
Blue River	From Dillon Reservoir downstream to its confluence with the Colorado River
South Boulder Creek	East Portal of the Moffat Tunnel to Gross Reservoir, and from Gross Reservoir to the South Boulder Diversion Canal
North Fork South Platte River	East Portal of the Roberts Tunnel to the confluence with the South Platte River
South Platte River	From downstream of Antero Reservoir to the Henderson gage

Note:
[1]Overall study area segments are defined as river segments where water is being diverted (Fraser River and its tributaries, Williams Fork River and its tributaries, Blue River, South Platte River, and South Boulder Creek), or used by Denver Water to deliver water to their storage or treatment facilities (South Boulder Creek, South Platte River, North Fork South Platte River, and Vasquez Creek, a tributary to the Fraser River). Diversions from some of these streams may affect downstream flow in the Colorado River, downstream of the confluence with the Fraser River.


Wolford Mountain Reservoir
Colorado River
Blue River
Williams Fork Reservoir
Fraser River
Williams Fork River
South Boulder
North Fork South Platte River
Dillon Reservoir
Antero Reservoir
Eleven Mile Canyon Reservoir
Kremmling
Parshall
Granby
Fraser
Winter Park
Rollinsville
Bond
Wolcott
Vail
Dillon
Redcliff
Breckenridge
Grant
Bailey
Idaho Springs
Leadville
Fairplay
Hartsel
Buena Vista
Ute Pass (9,568 ft)
Loveland Pass (11,990 ft)
Vail Pass (10,603 ft)
Tennessee Pass (10,424 ft)
Fremont Pass (11,318 ft)
Hoosier Pass (11,539 ft)
Boreas Pass (11,481 ft)
Independence Pass (12,093 ft)
Trout Creek Pass (9,487 ft)
Cottonwood Pass (12,126 ft)
GRAND COUNTY
SUMMIT COUNTY
EAGLE COUNTY
GILPIN COUNTY
CLEAR CREEK COUNTY
LAKE COUNTY
PARK COUNTY
CHAFFEE COUNTY
GUNNISON COUNTY
ROUTT COUNTY



Selected PACSM Nodes
Town
Major Stream of River
Major Canal or Tunnel
Major Road or Highway
Continental Divide
County Line
Lake or Reservoir
Overall Study Area Segments
Moffat Tunnel
Affected Reservoirs

NODE NUMBER	NODE NAME
1350	Windy Gap Diversion
1400	Hot Sulphur Springs Div/Dem
1425	Colorado River Below Hot Sulphur Springs
1600	Wolford Mountain Reservoir
2200	St Louis Creek Near Fraser Gage
2370	Cozen's Ditch/Vasquez Creek Gage
2490	No Fork Ranch and Dribble Creek Diversion
2500	Main Ranch Creek Diversion
2810	Fraser River Below Crooked Creek
2900	Fraser River At Granby Gage
3300	Williams Fork River Below Steelman Creek Gage
3600	Williams Fork Above Darling Creek Gage
3750	Henderson Mill Div (Williams Fork Nr Leal Gage)
3950	Williams Fork Reservoir
4240	West Portal Roberts Tunnel Diversion
4250	Dillon Reservoir
4500	Blue River Below Boulder Creek
4650	Green Mountain Reservoir
4800	Blue River At Mouth
5020	Colorado River Near Kremmling Gage
50150	Antero Reservoir
50300	Eleven Mile Reservoir
50450	Cheesman Reservoir
50700	North Fork South Platte Below Geneva Cr Gage
50750	North Fork South Platte Above Pine
51200	South Platte River At Waterton Gage
51290	South Platte Below Chatfield
51540	South Platte River At Denver Gage
56050	Leyden Gulch Reservoir
57100	South Boulder Creek Near Buckeye Mtn
57120	South Boulder Creek Native At Pinecliffe Gage
57140	Gross Reservoir
57180	South Boulder Cr Near Eldorado Springs Gage
58435	Downstream Storage
58440	South Platte River At Henderson Gage

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Graphic not to scale

Moffat Collection System Project FEIS

Figure 3.0-1
River Segments Overall Study Area

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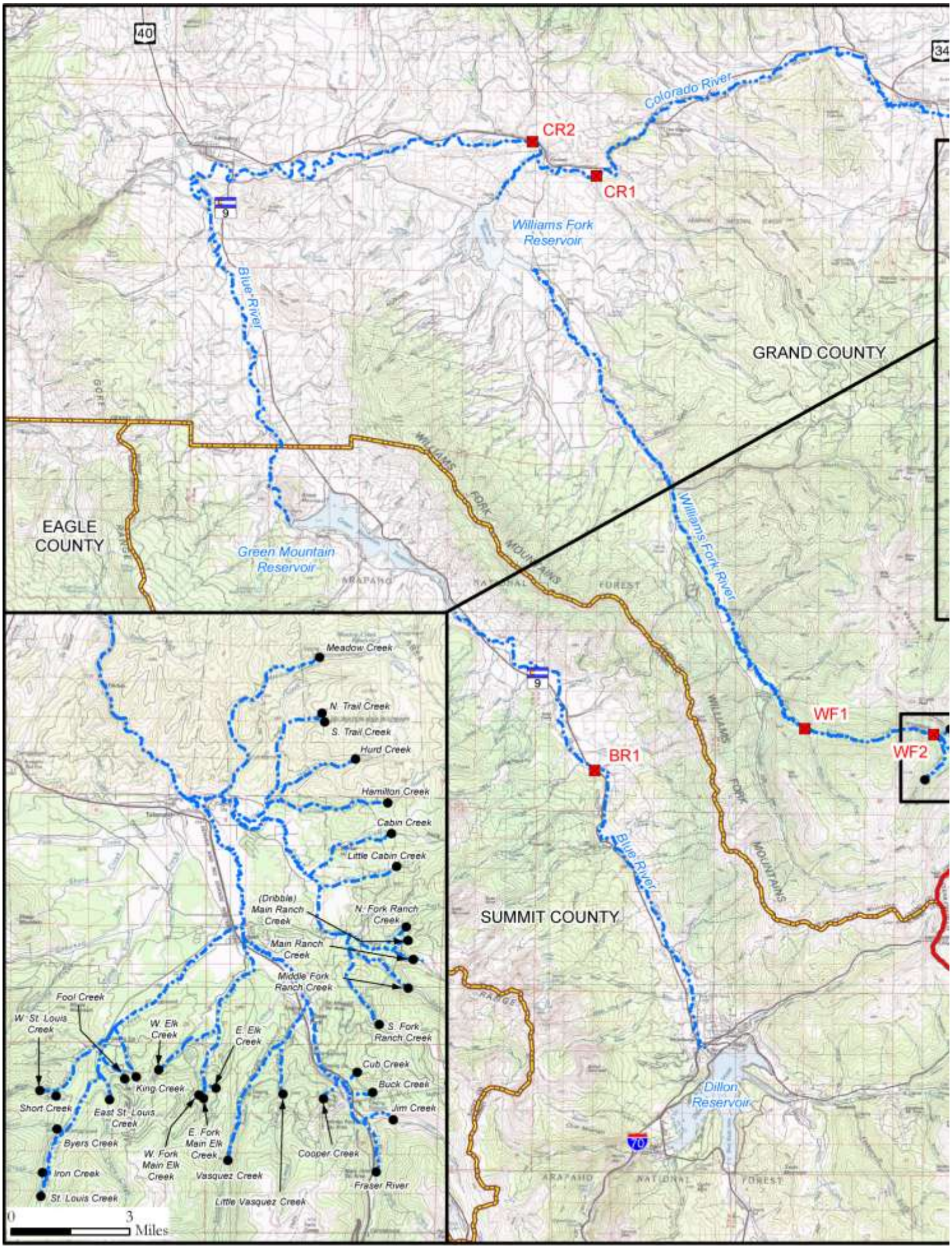
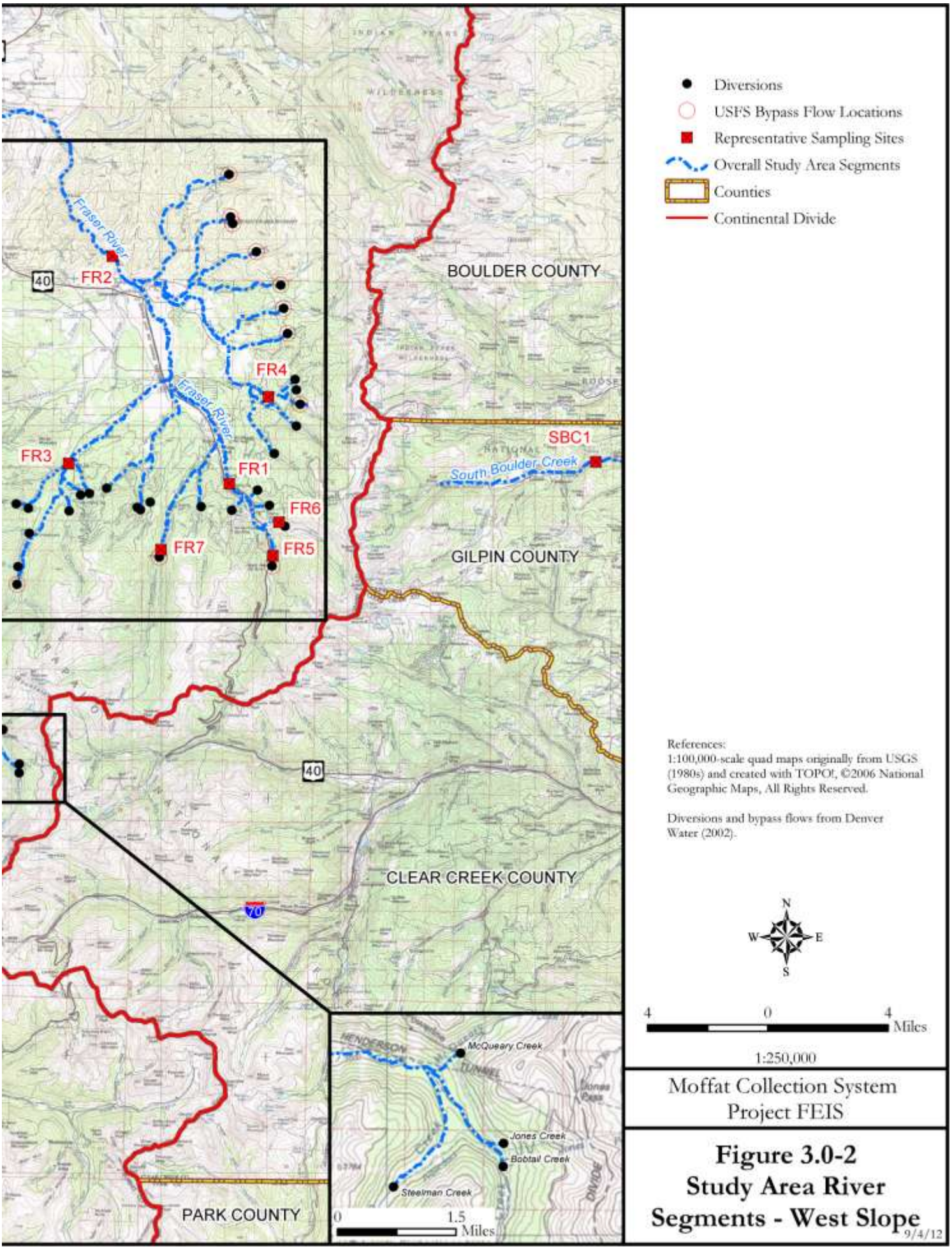
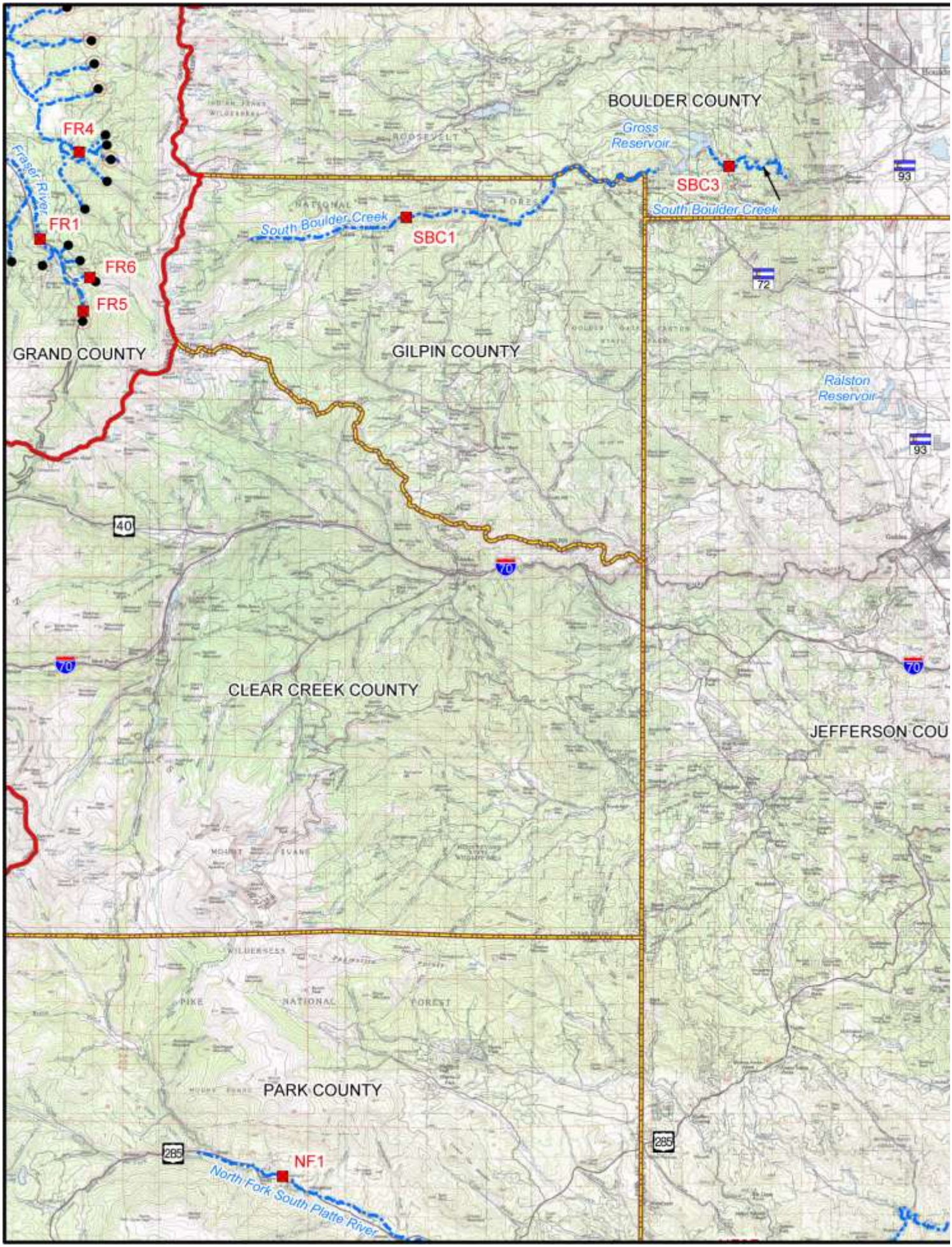

40
34
Colorado River
CR2
CR1
Williams Fork Reservoir
Blue River
GRAND COUNTY
EAGLE COUNTY
Green Mountain Reservoir
Williams Fork River
WF1
WF2
BR1
SUMMIT COUNTY
Dillon Reservoir
70
Meadow Creek
N. Trail Creek
S. Trail Creek
Hurd Creek
Hamilton Creek
Cabin Creek
Little Cabin Creek
(Dribble) Main Ranch Creek
N. Fork Ranch Creek
Main Ranch Creek
Middle Fork Ranch Creek
S. Fork Ranch Creek
Fool Creek
W. St. Louis Creek
W. Elk Creek
E. Elk Creek
King Creek
Short Creek
East St. Louis Creek
Byers Creek
W. Fork Main Elk Creek
E. Fork Main Elk Creek
Vasquez Creek
Cub Creek
Buck Creek
Jim Creek
Cooper Creek
Fraser River
Iron Creek
St. Louis Creek
Little Vasquez Creek
0
3
Miles

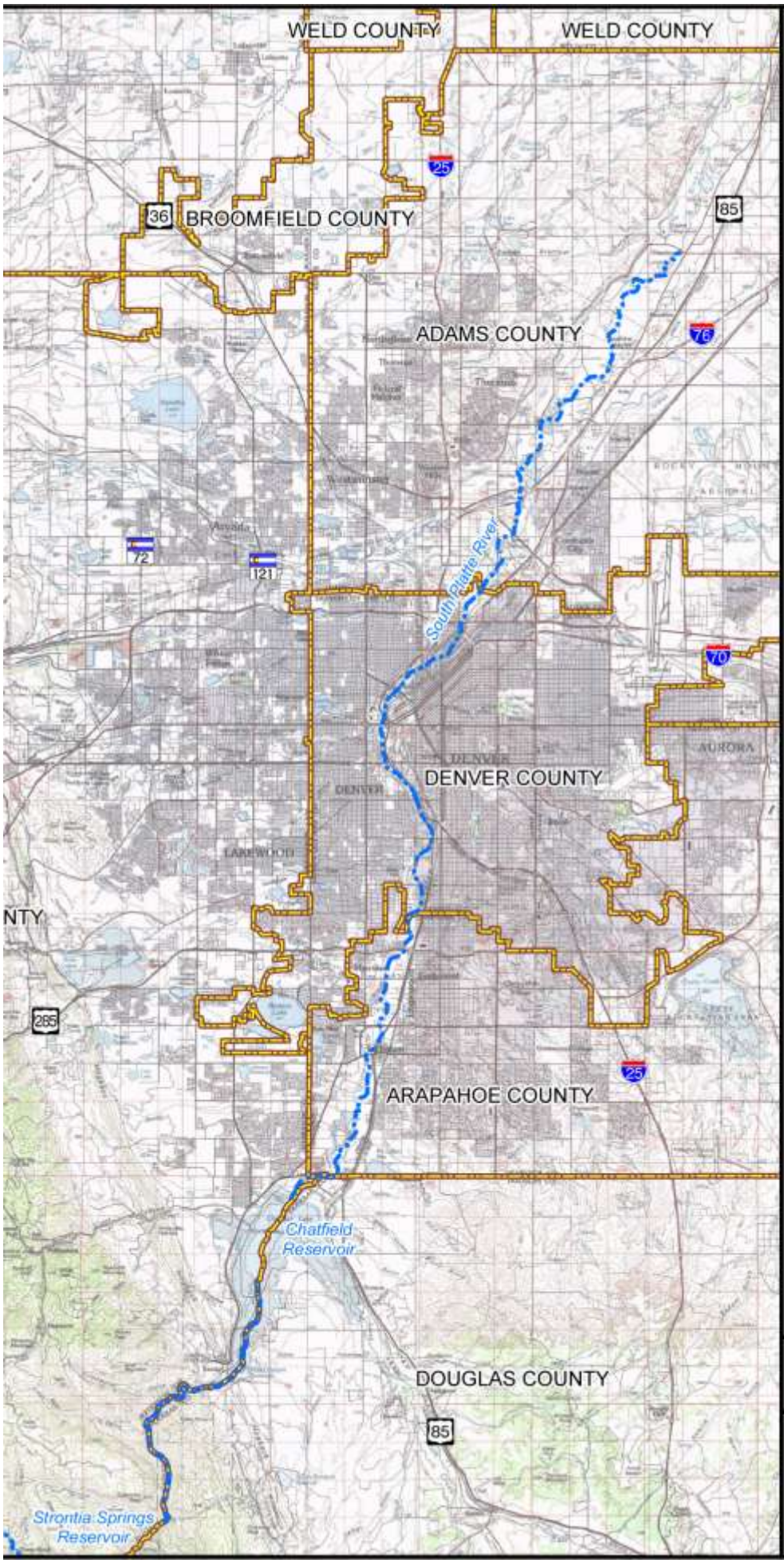


Moffat Collection System Project FEIS

Figure 3.0-2
Study Area River Segments - West Slope

9/4/12


BOULDER COUNTY
Gross Reservoir
SBC3
South Boulder Creek
South Boulder Creek
SBC1
FR4
Fraser River
FR1
FR6
FR5
GRAND COUNTY
GILPIN COUNTY
Ralston Reservoir
CLEAR CREEK COUNTY
JEFFERSON COU
PARK COUNTY
NF1
North Fork South Platte River
93
72
40
70
285



Diversions
USFS Bypass Flow Locations
Representative Sampling Sites
Overall Study Area Segments
Counties
Continental Divide

References:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Diversions and bypass flows from Denver Water (2002).

N
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4 0 4 Miles

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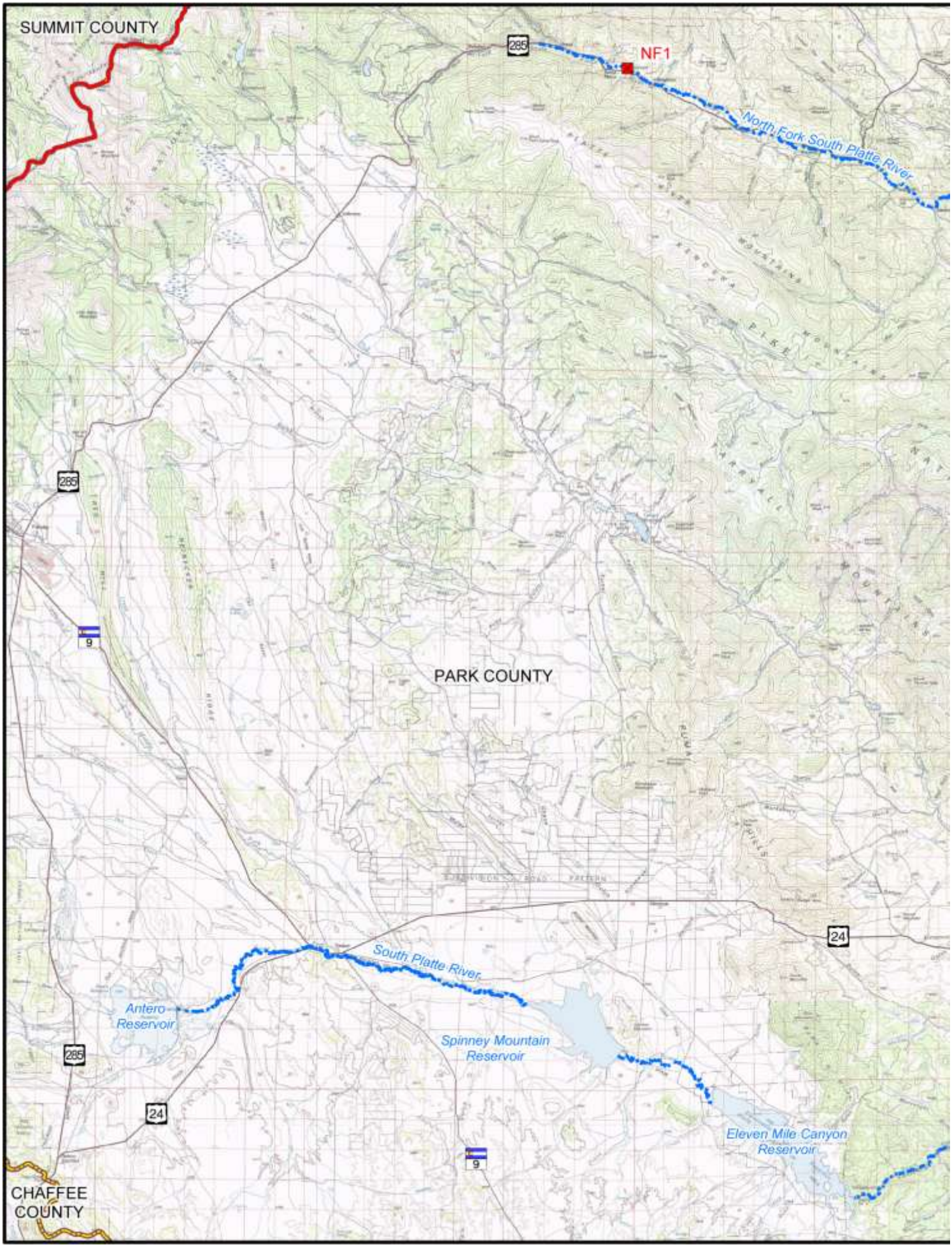
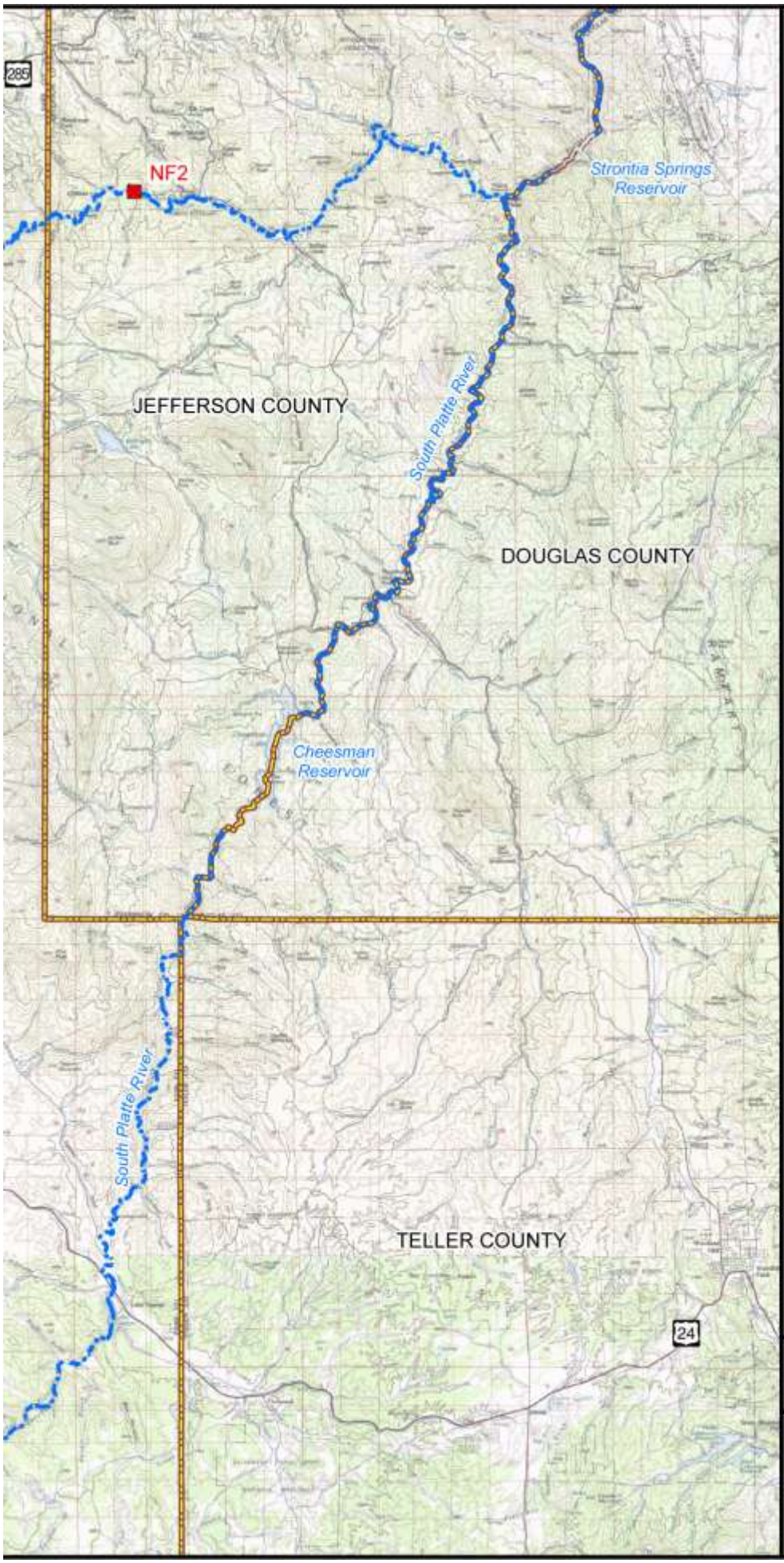
Moffat Collection System Project FEIS

Figure 3.0-3
Study Area River Segments - East Slope

9/4/12


SUMMIT COUNTY
285
NF1
North Fork South Platte River
285
9
PARK COUNTY
24
South Platte River
Antero Reservoir
Spinney Mountain Reservoir
285
24
9
Eleven Mile Canyon Reservoir
CHAFFEE COUNTY



Representative Sampling Sites
Overall Study Area Segments
Counties
Continental Divide

Reference:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

N
W E
S

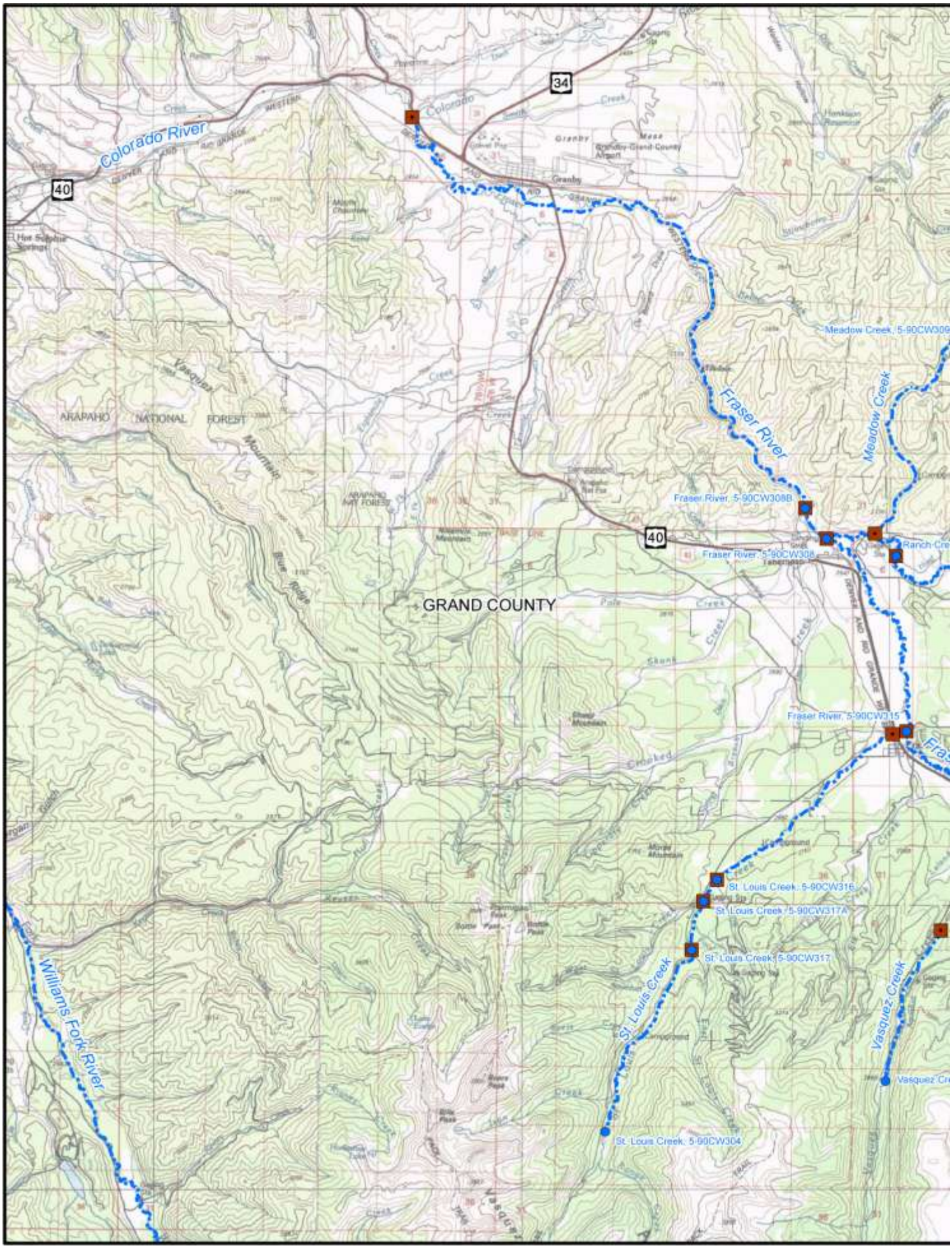
4 0 4 Miles

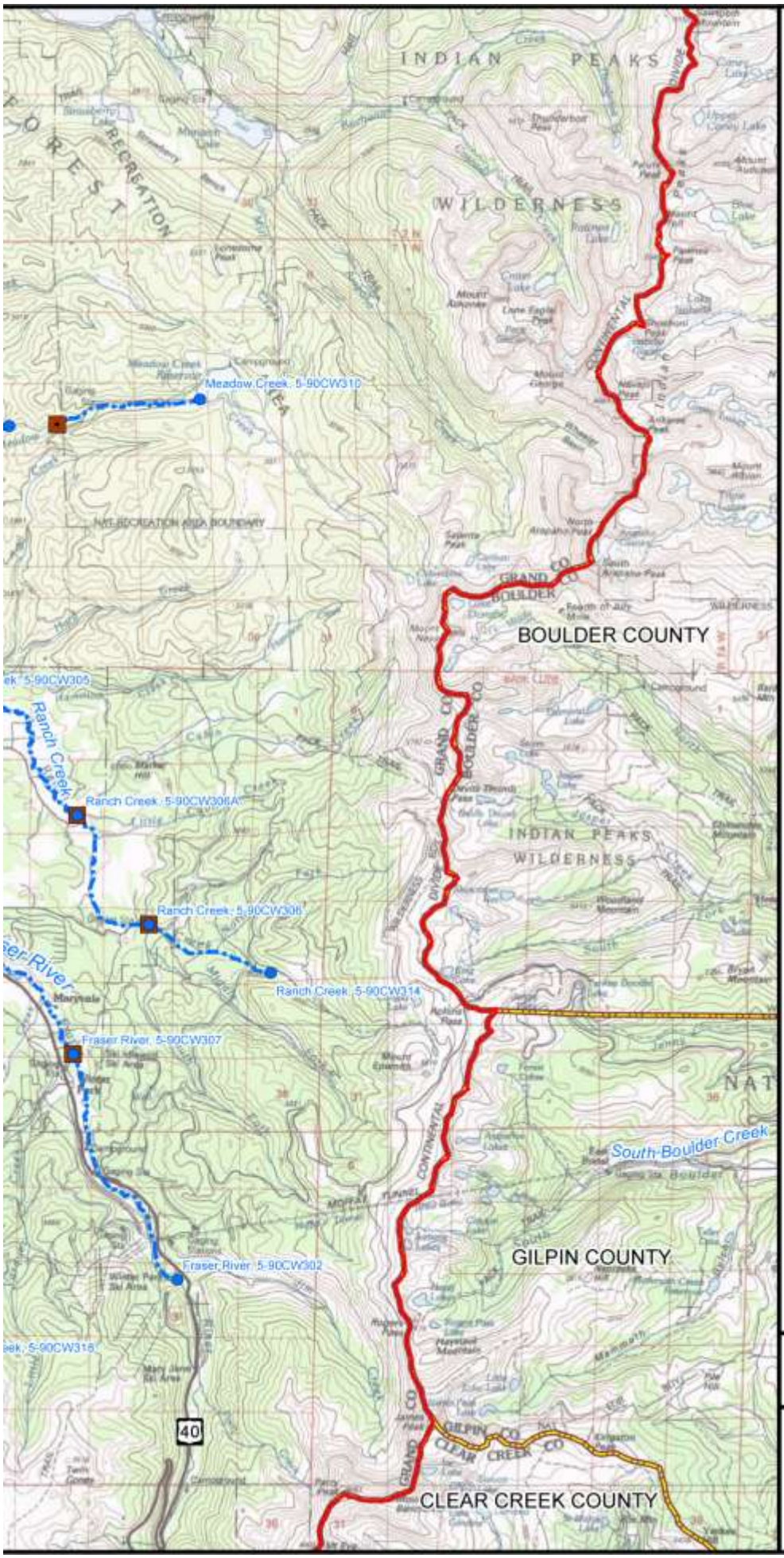
1:250,000

Moffat Collection System Project FEIS

Figure 3.0-4
Study Area River Segments - Platte River Basin

9/4/12


Colorado River
Colorado
34
40
Granby
Meadow Creek, 5-90CW309
Fraser River
Meadow Creek
ARAPAHO NATIONAL FOREST
Fraser River, 5-90CW308B
Fraser River, 5-90CW308
Ranch Cre
GRAND COUNTY
Fraser River, 5-90CW315
St. Louis Creek, 5-90CW316
St. Louis Creek, 5-90CW317A
St. Louis Creek, 5-90CW317
St. Louis Creek
Vasquez Creek
Vasquez Cr
St. Louis Creek, 5-90CW304
Williams Fork River



Instream Flow Locations - Upper Terminous

Instream Flow Locations - Lower Terminous

Instream Flow Stream Segments

Counties

Continental Divide

References:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Instream flow locations from Colorado Water Conservation Board (2009).

N
W E
S

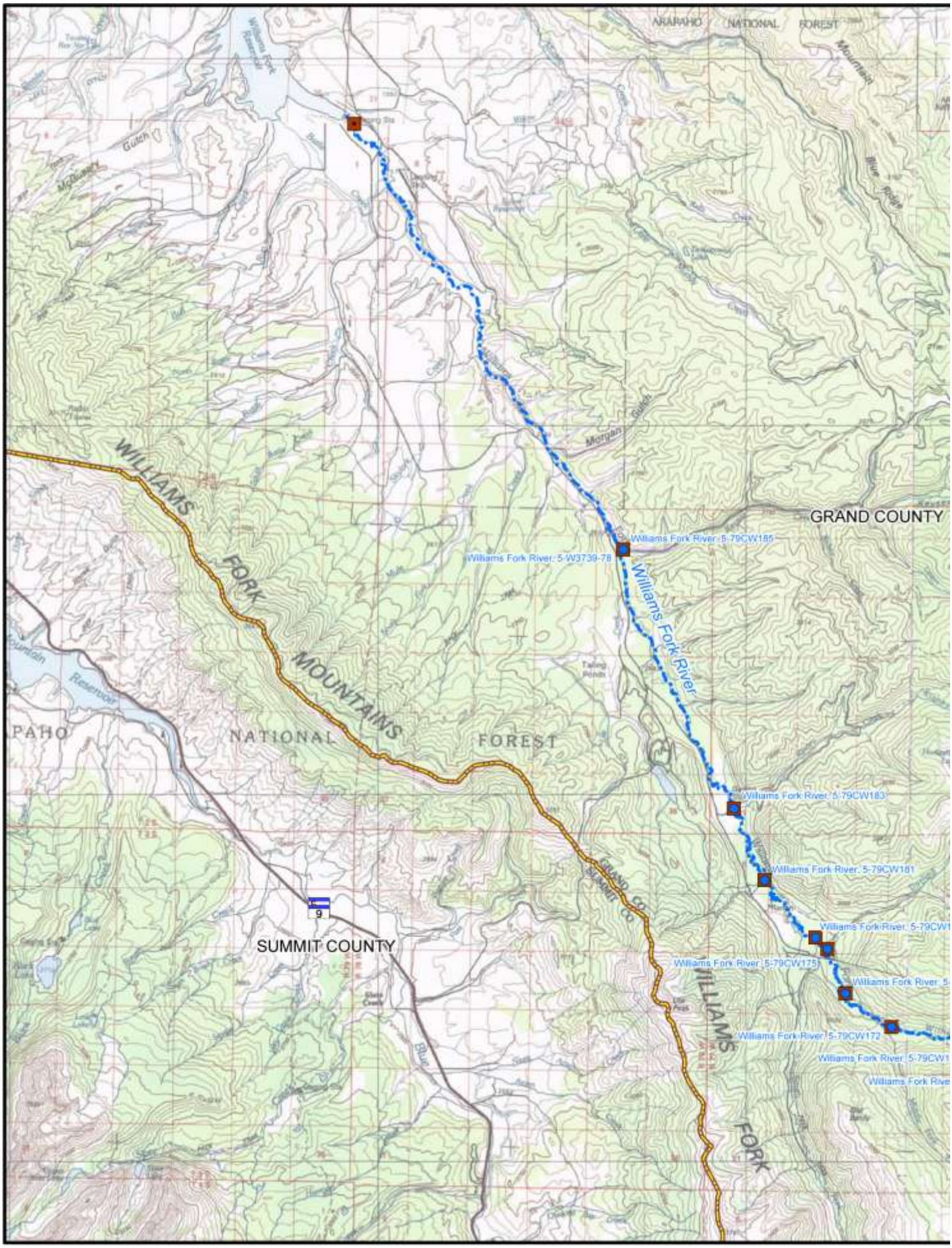
2 0 2 Miles

1:126,720

Moffat Collection System Project FEIS

Figure 3.0-5
Minimum Instream Flow Rights - Fraser River Basin

9/4/12


ARAPAHO NATIONAL FOREST
WILLIAMS FORK MOUNTAINS
GRAND COUNTY
Williams Fork River: 5-79CW185
Williams Fork River: 5-W3739-78
Williams Fork River
Morgan Gulch
Reservoir
NATIONAL FOREST
Williams Fork River: 5-79CW183
Williams Fork River: 5-79CW181
Williams Fork River: 5-79CW175
Williams Fork River: 5-79CW172
SUMMIT COUNTY
GRAND CO
SUMMIT CO
WILLIAMS FORK

Instream Flow Locations - Upper Terminous

Instream Flow Locations - Lower Terminous

Instream Flow Stream Segments

Counties

Continental Divide

References:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Instream flow locations from Colorado Water Conservation Board (2009).

N
W E
S

2 0 2 Miles

1:126,720

Moffat Collection System Project FEIS

Figure 3.0-6
Minimum Instream Flow Rights - Williams Fork River Basin

9/4/12

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3.1 SURFACE WATER

3.1.0 Overview

This section describes the surface water resources that could potentially be affected by implementation of any of the action alternatives or the No Action Alternative described in Chapter 2. The geographic scope of this section includes the overall study area for river segments, as described in the introduction to Section 3.0. The characterization of existing surface water conditions was focused on those affected river segments that would experience the greatest flow change. River segments may be affected by the Moffat Collection System Project (Moffat Project or Project) because:

- The Board of Water Commissioners (Denver Water) diverts water from these streams:
  - Fraser River and its upper tributaries
  - Williams Fork River and its upper tributaries
  - Blue River
  - South Platte River and tributaries
  - South Boulder Creek
- Denver Water's diversions from the streams noted above may affect remaining downstream flow in the Colorado River, downstream of the confluence with the Fraser River and in the South Platte River downstream of Antero Reservoir.
- Denver Water delivers water to storage or treatment facilities via these streams:
  - South Platte River
  - North Fork South Platte River
  - South Boulder Creek
  - Vasquez Creek

In addition, this section describes surface water features and resources within or close to the areas of disturbance associated with Environmental Impact Statement (EIS) alternative infrastructure components. Figure 3.0-1 shows surface water resources potentially affected by the Moffat Project. Surface water resources are described with respect to hydrology, water quality, and channel dynamics.

Hydrology

For each of the river segments and surface water features affected by EIS alternatives, regional surface water characterizations are provided which include:

- Overview of the drainage basins (location, drainage area, elevation range, major tributaries, flow sources, and major cities)
- Summary of stream flow characteristics (annual and monthly flow statistics)

- Summary of surface water use (major reservoirs, diversions, basin imports/exports, minimum instream flow and bypass requirements, and water users and water rights)
- Floodplain information (provided for the river segments study area)

3.1.1 Reservoirs

3.1.1.1 Gross Reservoir

The existing Gross Reservoir Dam spans South Boulder Creek, impounding its waters and those of Winiger Gulch and Forsythe Canyon, which are small tributaries to South Boulder Creek. In addition, the reservoir is filled with water delivered to upper South Boulder Creek by the Moffat Tunnel, having been diverted from the Williams Fork and Fraser river basins. Water is released from Gross Reservoir for diversion at the South Boulder Diversion Canal approximately 4.5 miles downstream. The South Boulder Diversion Canal delivers water to Ralston Reservoir. (Refer to Section 1.3 for details on Denver Water's raw Water Collection System.) Table 3.1-1 shows Denver Water's storage rights for South Boulder Creek water at Gross Reservoir. For additional Denver Water water rights information for the Fraser and Williams Fork river basins, see Table 3.1-7 and Table 3.1-12, respectively.

Table 3.1-1
Denver Water Gross Reservoir Storage Rights

Water Right	Appropriation Date	Amount (acre-feet)
Gross Reservoir	May 10, 1945	41,811
Gross Reservoir (conditional)	May 10, 1945	71,267

The existing dam crest elevation is 7,290 feet. At a surface elevation of 7,282 feet (the normal high water line), storage capacity of the reservoir is 41,811 acre-feet (AF). The reservoir lies in a deeply incised valley, and when filled to capacity has a surface area of 418 acres. Drainage area at the dam is 92.8 square miles (MWH 2005). The land surrounding the reservoir is generally forested, with steep slopes (50 percent [%] and greater in places). Much of the reservoir is within the Arapaho & Roosevelt National Forests (ARNF). Normal annual precipitation at Gross Reservoir is 20.5 inches (WRCC 2010a).

Historical Gross Reservoir contents and water elevations over time are depicted in figures contained in Appendix E-1.

For a description of the South Boulder Creek Basin, including hydrographs of the stream located above Gross Reservoir, refer to Section 3.1.5.5.

3.1.1.2 Leyden Gulch Reservoir Site

The proposed Leyden Gulch Reservoir site is located on Leyden Gulch in the upper watershed of Leyden Creek. Leyden Creek originates on the east side of the foothills between Coal Creek to the north and Ralston Creek to the south, and flows east and southeast, joining Ralston Creek, then joining Clear Creek near the Jefferson/Adams

County line. The proposed site is located approximately 2.5 stream miles from the watershed divide and drains an area of 2.5 square miles. Existing grade at the site of the proposed dam crest is at approximately 5,500 feet (MWH 2005). There are no U.S. Geological Survey (USGS) gages on Leyden Gulch or Creek. Based on the National Hydrography Dataset (NHD), a small tributary to Leyden Creek, located in the northwest portion of the site, is considered perennial. The main reach of Leyden Creek through the site is considered intermittent.

The disturbance area associated with the proposed Leyden Gulch Reservoir includes land immediately north of the reservoir and extends into the head of Barbara Gulch, a drainage similarly downcut into the outwash plain of Coal Creek known as Rocky Flats. Barbara Gulch is ungaged.

3.1.2 Conveyance Systems

The water courses that would be crossed by proposed Conduits M and O were identified, along with the nearest stream gage and whether the stream is perennial based on NHD classification. Annual flow at the nearest gage is an indication of the size of the stream. Streams are described as "unnamed" if no name appears on the USGS 1:24000 scale mapping. Refer to Section 3.8 for further discussion on waters of the United States (U.S.), including irrigation canals and ditches.

3.1.2.1 Conduit M

Table 3.1-2 lists the streams crossed by the proposed Conduit M alignment, which links the proposed Advanced Water Treatment Plant (AWTP), just south of the existing Denver Water Recycling Plant site, to the Moffat Collection System delivery point near State Highway (SH) 72. Conduit M crosses the Burlington Ditch and the South Platte River close to the Metro Wastewater Reclamation District Plant (Metro Wastewater Treatment Plant [WWTP]) and Denver Water Recycling Plant. From this crossing on, the pipeline is routed along existing roads. Little Dry Creek is crossed at three places. South of Standley Lake, Conduit M also crosses several ditches that originate at Standley Lake.

Table 3.1-2
Conduit M Stream Crossings

Stream or Ditch	Location	Perennial	Nearest USGS Gage Location	Average Annual Flow at Gage (AF) and Period
South Platte River	Upstream end of Metro WWTP and Denver Water Recycling Plant site	Yes	06714215 South Platte River at West 64th Avenue, Commerce City, 0.75 mile downstream from crossing	174,312 (WY 1983-2005)
Clear Creek	At Broadway crossing, about 2 miles above the confluence with South Platte River mouth	Yes	06720000 Clear Creek at mouth near Derby, Colorado, approximately 2 miles downstream from crossing	65,494 (WY 1928-1982)

Table 3.1-2 (continued)
Conduit M Stream Crossings

Stream or Ditch	Location	Perennial	Nearest USGS Gage Location	Average Annual Flow at Gage (AF) and Period
Little Dry Creek	Just west of Sheridan Boulevard	Yes	Ungaged	N/A
Little Dry Creek	Just south of West 80th Avenue, in Little Dry Creek Park	Yes	Ungaged	N/A
Little Dry Creek	West 80th Avenue crossing of Little Dry Creek 1,400 feet west of Wadsworth Boulevard	Yes	Ungaged	N/A

Notes:
Perennial status based on National Hydrographic Dataset (NHD).
AF = acre-feet
N/A = not applicable
USGS = U.S. Geological Survey
WWTP = Wastewater Treatment Plant

3.1.2.2 Conduit O

Table 3.1-3 lists the streams crossed by the proposed Conduit O alignment, which connects the proposed AWTP near the Worthing Pit with the Moffat Collection System delivery point near SH 72. The alignment is entirely along existing roads. It is joined by the Conduit M alignment about 0.5-mile east of Wadsworth Boulevard on West 80th Avenue. In addition to the streams listed, the alignment crosses the Fulton Ditch near 112th Avenue as well as the Standley Lake ditches mentioned in the section on Conduit M.

Table 3.1-3
Conduit O Stream Crossings

Stream or Ditch	Location	Perennial	Nearest USGS Gage Location	Average Annual Flow at Gage (acre-feet) and Period
South Platte River	At 88th Avenue	Yes	06714215 South Platte River at 64th Avenue, Commerce City; 3 miles upstream from crossing	174,312 (WY 1983-2005)
Tributary to Niver Creek	88th Avenue just west of Interstate 25, and on Huron Street between 88th and 84th avenues	No	Ungaged	N/A
Little Dry Creek	West 80th Avenue crossing of Little Dry Creek 1,400 feet west of Wadsworth Boulevard	Yes	Ungaged	N/A

Notes:
Perennial status based on National Hydrographic Dataset (NHD).
N/A = not applicable
USGS = U.S. Geological Survey

3.1.3 South Platte River Facilities

Gravel Pits

The existing Worthing, North Tower, and South Tower gravel pits are located adjacent to the South Platte River channel. As of 2006, none of these three pits were lined. It is expected that each of the three pits would be lined by the aggregate operator before being integrated into the Moffat Project. The Challenger Pit is on the west side of the South Platte River, approximately 0.5-mile from the channel. As of 2006, this gravel pit is being mined.

The proposed diversion structure for use with these pits is approximately 1.2 stream miles downstream of the USGS gage at Henderson.

For a description of the South Platte River hydrology and water quality, refer to Section 3.1.5.7.

Conveyance

The gravel pit pipeline connects the gravel pits, which are components of Alternatives 8a and 13a. Table 3.1-4 lists the streams crossed by the proposed alignment.

Table 3.1-4
Gravel Pit Pipeline Stream Crossings

Stream or Ditch	Location	Perennial	Nearest USGS Gage Location	Average Annual Flow at Gage (acre-feet) and Period
South Platte River	At SH 7, west of Brighton	Yes	06720500 South Platte River at Henderson, Colorado, 5.7 miles upstream of crossing	392,372 (WY 1976-2005)
Third Creek	At SH 7, west of Brighton	No	Ungaged	N/A
Third Creek	At Brighton Road crossing of Third Creek in NE ¼ of Section 24, T1S, R67W	No	Ungaged	N/A
Second Creek	At Brighton Road crossing of Second Creek, SW ¼ of Section 24, T1S, R67W	Yes	Ungaged	N/A

Notes:
Perennial status based on National Hydrographic Dataset (NHD).
N/A = not applicable
SH = State Highway
USGS = U.S. Geological Survey

3.1.4 Denver Basin Aquifer Facilities

The Denver Basin aquifer storage and recovery (ASR) distribution pipelines connect the injection/recovery well facilities with the proposed AWTP, which are components of Alternative 10a. Table 3.1-5 lists the streams crossed by the proposed alignment.

Table 3.1-5
Denver Basin Aquifer Storage and Recovery Pipeline Stream Crossings

Stream or Ditch	Location	Perennial	Nearest USGS Gage Location	Average Annual Flow at Gage (AF) and Period
Sand Creek	Approximately 1 mile upstream of the Interstate 70 crossing of Sand Creek, within the Stapleton Redevelopment area	Yes	394839104570300 Sand Creek at mouth near Commerce City, approximately 0.6 mile downstream from crossing	40,443 (WY 1993-2005)
Cherry Creek	At the Monaco Parkway crossing of Cherry Creek	Yes	06713300 Cherry Creek at Glendale, approximately 1.5 miles downstream from the crossing	18,413 (WY 1986-2003)
Cherry Creek	At Alamo Placito Park, one block west of the Downing Street crossing Cherry Creek	Yes	06713500 Cherry Creek at Denver, approximately 2.6 miles downstream from the crossing	17,543 (WY 1943-2005)
Cherry Creek	At the 11th Avenue crossing of Cherry Creek	Yes	06713500 Cherry Creek at Denver, approximately 1.2 miles downstream from the crossing	17,543 (WY 1943-2005)
South Platte River	At the south end of Overland Park Golf Course, just north of Evans Avenue crossing of the South Platte River	Yes	06711565 South Platte River at Englewood, approximately 4.9 miles upstream from the crossing	192,650 (WY 1984-2005)
South Platte River	At West 13th Avenue	Yes	06714000 South Platte River at Denver, approximately 1.8 miles downstream from the crossing	258,074 (WY 1976-2005)
Lakewood Gulch	At the railroad crossing approximately 0.25 mile above the confluence with the South Platte River	Yes	Ungaged	N/A

Notes:
Perennial status based on National Hydrographic Dataset (NHD).
AF = acre-feet
N/A = not applicable
USGS = U.S. Geological Survey

3.1.5 River Segments

The geographic scope of this section includes the overall study area for river segments as described in the Chapter 3 Introduction and shown in Figure 3.0-1. With the exception of the Fraser River, all affected river segments are a single continuous segment or a segment with few tributaries. The Fraser River is a highly bifurcated river system with approximately 30 tributaries, which are listed in Table 3.1-6. This large number of affected tributaries explains the relatively high overall affected river segment length of approximately 93 miles.

The affected river segments west of the Continental Divide (Fraser, Williams Fork, Colorado, and Blue rivers) have withdrawals from stream flows that are transported via canals and tunnels to the East Slope drainages (North Fork South Platte River and South Boulder Creek).

The figures referenced in the following Hydrology discussions are included in Appendix E-2 to illustrate the nature of historical flows in the affected river segments including seasonality, peaks, and variability. In general, the figures are presented for the time period 1975 through 2004. The 30-year period is long enough to include a variety of conditions reflecting natural variability (average, wet, and dry years). Furthermore, this 30-year period is relevant because it is representative of existing demands, facilities, and operations, and their effects on flows in Colorado's streams. In a few cases, fewer than 30 years are presented either because data were not available, or because conditions changed dramatically at a discrete time, such that earlier data would not reflect existing conditions.

3.1.5.1 Fraser River

Hydrology

The Fraser River Basin is located in Grand County, about 40 miles west of Denver. The basin boundary is formed by the Vasquez Mountains on the west, which separate it from the Williams Fork River Basin, and by the Continental Divide on the south and east. The river flows northerly from the vicinity of Berthoud Pass for approximately 30 miles, entering the Colorado River near the Town of Granby, Colorado. Major tributaries include Vasquez, St. Louis, Ranch, Crooked, and Strawberry creeks. The USGS reports a drainage area of 297 square miles at the now discontinued gage site "Fraser River at Granby," near the river's mouth (USGS 2005a). Elevations in the basin range from 7,900 to above 13,000 feet.

Annual precipitation ranges from 35.5 inches per year on Berthoud Pass to 20.3 inches per year at the Town of Fraser (WRCC 2010a). Stream hydrology reflects snowmelt, which generates most of the Fraser River's flows.

The uppermost diversion in the Fraser Basin is the Berthoud Canal, a trans-mountain structure that diverted an average of approximately 725 AF per year of water to the east side of the divide for the period from 1975 through 2004 (CDWR 2005). Below the Berthoud Canal, and following the mountainous rim of the basin on its southern and eastern sides is Denver Water's Fraser River Diversion Project, which is a component of the existing Moffat Collection System. Nearly 28 miles of open canals, pipes, and siphons collect flows from numerous contributing drainages and direct it to the Moffat Tunnel, located near the Fraser mainstem above the Town of Winter Park. The system includes Meadow Creek Reservoir and the Englewood-Ranch Collection System, which comprise the upper end of the east side collection system. This portion belongs jointly to the City of Englewood, and Cyprus Climax Metals Company, and is operated by Denver Water. At Vasquez Creek, the system picks up water delivered from the Williams Fork River Basin via the Gumlick and Vasquez tunnels and the Vasquez Creek channel.

Denver Water's 32 primary diversion points in the Fraser River Basin, which contribute flows to the Moffat Tunnel, are shown in Table 3.1-6 and Figure 3.0-2. For the period from 1975 through 2004, the Moffat Tunnel conveyed an average of 55,900 AF per year under the

Continental Divide (CDWR 2009) based on the State's Hydrobase records for station 09022500, Moffat Tunnel at East Portal. The capacity of the Moffat Tunnel is 1,360 cubic feet per second (cfs). The water is delivered to South Boulder Creek on the East Slope, stored in Gross Reservoir, and eventually taken to the Moffat Water Treatment Plant (WTP) in Lakewood.

Table 3.1-6
Moffat Collection System Diversion Points on Fraser River Tributaries

St. Louis – Vasquez Creek Section	Ranch Creek Section
West St. Louis Creek	North Fork Ranch Creek
Short Creek	Dribble Creek
St. Louis Creek	Main Ranch Creek
Iron Creek	Middle Fork Ranch Creek
Byers Creek	South Fork Ranch Creek
East St. Louis Creek	Cub Creek
Fool Creek	Buck Creek
King Creek	Wolverine Creek
West Elk Creek	**Englewood-Ranch Creek Extension**
East Fork Main Elk Creek	Meadow Creek
West Fork Main Elk Creek	South Trail Creek
East Elk Creek	North Trail Creek
Vasquez Creek	Hurd Creek
Little Vasquez Creek	Hamilton Creek
Cooper Creek	Cabin Creek
Fraser River – Jim Creek Section	Little Cabin Creek
Fraser River	
Jim Creek	

Source: Denver Water, 2003h.

Denver Water's direct flow water rights in the Fraser River Basin have been decreed as an aggregate amount divertible at the Moffat Tunnel, with multiple points of diversion at the numerous tributary diversion sites. Denver Water's Fraser River Basin water rights are tabulated in Table 3.1-7. Appropriated in 1921, these rights are junior relative to many of the irrigation rights in the basin. Denver Water's rights are also subject to bypass requirements, shown in Table 3.1-8 and Figure 3.0-5, pursuant to right-of-way (ROW) agreements with the U.S. Forest Service (USFS) under stipulations of the Amendatory Decision dated April 22, 1970. The first ROW stipulation with the USFS originated in 1970 and stipulated minimum bypass flows on the Fraser River, Vasquez Creek, St. Louis Creek, and Ranch Creek. In the Amendatory Decision, Denver Water has the ability to reduce the bypass flows under certain conditions. Under the 1992 Clinton Reservoir Agreement, Denver Water agreed that it would not reduce the bypass flows unless mandatory restrictions were imposed on its customers, provided the reduced bypass flows would not result in mandatory restrictions of indoor use to Grand County water users. However, Denver Water reserved the right to reduce bypass flows whenever mandatory in-house domestic use of water is imposed in the area served by Denver Water. The second ROW stipulation with the USFS originated in 1974 with the City of Englewood and

stipulated minimum flows on North and South Trail creeks, Hurd Creek, Hamilton Creek, Cabin Creek, Little Cabin Creek, and Meadow Creek. These bypass flows do not have provisions which allow for bypass reductions. Any location with a minimum bypass flow requirement has a provision that if the natural flow is less than the bypass flow, Denver Water can bypass the lesser amount. A summary of historical bypass flow reductions is provided in Table 3.1-9. Denver Water reduced bypass flows in the Fraser River Basin in 1975, 1977, 1980, 2002, 2003, and 2004.

Table 3.1-7
Denver Water Fraser River Basin Water Rights at Existing Structures

Water Right	Appropriation Date	Amount
Moffat Tunnel	July 4, 1921	928 cfs
Moffat Tunnel (Conditional)	July 4, 1921	352 cfs
Moffat Tunnel Collection System	August 30, 1963	100 cfs
Cooper Creek	July 4, 1921	10 cfs
Jim Creek	July 4, 1921	75 cfs
Fraser River Intake	July 4, 1921	275 cfs
Little Vasquez Creek	July 4, 1921	75 cfs
Buck Creek	July 4, 1921	75 cfs
North Fork Ranch Creek	July 4, 1921	112 cfs
Ranch Creek	July 4, 1921	112 cfs
Middle Fork Ranch Creek	July 4, 1921	180 cfs
South Fork Ranch Creek	July 4, 1921	280 cfs
St. Louis Creek	July 4, 1921	700 cfs
West St. Louis Creek	July 4, 1921	112 cfs
Vasquez Creek	July 4, 1921	275 cfs
Meadow Creek Reservoir (Absolute)	July 2, 1932	5,100 AF
Meadow Creek Reservoir (Conditional)	May 29, 1923	294 AF
Hamilton-Cabin Ditch	July 2, 1932	70 cfs
Hamilton-Cabin Ditch Extension	July 2, 1932	25 cfs

Source: Boyle, 2005; Denver Water, 2003h.
Notes:
AF = acre-feet
cfs = cubic feet per second

Table 3.1-8
Moffat Collection System Minimum Bypass Requirements

Reach	Flow (cfs)	Period
Fraser River	10.0 4.0	May 15 through September 15 September 16 through May 14
Vasquez Creek	8.0 3.0	May 15 through September 15 September 16 through May 14
St. Louis Creek	10.0 3.0	May 15 through September 15 September 16 through May 14
Ranch Creek	4.0 2.0	May 15 through September 15 September 16 through May 14
Trail Creek (North and South)	0.25	Year-round
Hurd Creek	1.0	Year-round
Hamilton Creek	1.5 1.0	June 15 through April 30 May 1 through June 14
Cabin Creek	2.0	Year-round
Little Cabin Creek	0.25	Year-round
Meadow Creek	3.0 1.5	May 1 through March 31 April 1 through April 30

Source: Denver Water, 2003h.
Note:
cfs = cubic feet per second

Table 3.1-9
Summary of Historical Bypass Flow Reduction in the Fraser River Basin

Days Bypass Reduced	Fraser River Bypass Reduction (cfs)	Vasquez Creek Bypass Reduction (cfs)	St. Louis Creek Bypass Reduction (cfs)	Ranch Creek Bypass Reduction (cfs)
May 15, 1975 to June 22, 1975	5	8	10	4
June 28, 1975 to June 29, 1975	7	8	10	4
June 30, 1975	9	8	10	4
July 3, 1975 to July 5, 1975	5	8	10	4
July 13, 1975 to July 18, 1975	5	8	10	4
July 23, 1975 to August 30, 1975	5	8	10	4
September 1, 1975 to September 6, 1975	8	8	10	4
September 7, 1975	9	8	10	4
September 8, 1975 to September 14, 1975	5	5	10	4
May 15, 1977 to May 22, 1977	9	7.5	9	3.5
May 23, 1977 to May 28, 1977	9	7.5	9	0
May 29, 1977 to June 12, 1977	9.5	7.5	0	0
September 14, 1977	7.5	8	9	0
September 15, 1977	3	8	9	0
September 16, 1977 to September 22, 1977	3	3	3	0
September 23, 1977 to September 26, 1977	3	2	2	0
September 27, 1977 to September 30, 1977	4	2	2	0
October 14, 1977 to October 17, 1977	3	3	3	2
October 20, 1977 to October 31, 1977	3	3	3	2
May 15, 1980 to May 19, 1980	8	8	10	4
September 15, 2001 to May 15, 2002	4	3	3	2
May 15, 2002 to August 12, 2002	10	8	10	4
August 13, 2002 to September 14,2002	4	3	3	2
September 15, 2002 to October 21, 2002	4	3	3	2
October 22, 2002 to May 1, 2003	1	2	1	1
May 1, 2003 to May 15, 2003	4	3	3	2
May 15, 2003 to Sep 15, 2003	10	8	10	4
September 15, 2003 to May 15, 2004	4	3	3	2
May 15, 2004 to June 15, 2004	4	3	3	2
June 15, 2004 to July 2, 2004	7	4	8	3
July 2, 2004 to July 23, 2004	9	4	9	3
July 23, 2004	10	8	10	4

Note:
cfs = cubic feet per second

Flows below Denver Water's Collection System are subsequently diverted for snowmaking, municipal use, and further down the valley, irrigation. Major municipal water users in the basin include the Winter Park Water and Sanitation District, Winter Park West Water and Sanitation District, Winter Park Recreational Association, Town of Fraser, Town of Granby, Grand County Water and Sanitation District, Silver Creek Metro District, Fraser Valley Recreation District, YMCA of the Rockies, and the Fairways at Pole Creek. Major irrigation ditches in the basin include the Vail Ditch system, Walden Hollow Ditch, Klein

Ditch, Hammond Ditch Nos. 1, 2, and 3, Alger and Fowler Ditch, Scybert Ditch, Peavy Ditch No. 2, Gaskil Ditch, and Peterson Ditch No. 1.

The Colorado Water Conservation Board (CWCB) instream flow rights below Denver Water's Collection System are listed in Table 3.1-10 and shown on Figure 3.0-5. These rights are junior to Denver Water's water rights.

Table 3.1-10
Colorado Water Conservation Board Minimum Instream Flow Rights below Moffat Collection System

Reach	Case Number	Flow (cfs)	Period
Vasquez Creek from Denver Water Diversion to Grand County Diversion	5-90CW318	6 3	May 15 through September 15 September 16 through May 14
St. Louis Creek from Denver Water Diversion to East St. Louis Creek	5-90CW304	10 2	May 15 through September 15 September 16 through May 14
St. Louis Creek from East St. Louis Creek to West St. Louis Creek	5-90CW317	10 11 10 3	May 15 through May 31 June 1 through July 31 August 1 through September 15 September 16 through May 14
St. Louis Creek from West St. Louis Creek to King Creek	5-90CW317A	10 11 10 4.5	May 15 through May 31 June 1 through July 31 August 1 through September 15 September 16 through May 14
St. Louis Creek from King Creek to Tyron Ditch	5-90CW316	6 3.5	May 15 through September 15 September 16 through May 14
Ranch Creek from Denver Water Diversion to South Fork Ranch Creek	5-90CW314	3 2	May 15 through September 15 September 16 through May 14
Ranch Creek from South Fork Ranch Creek to Cabin Creek	5-90CW306	4 1.5	May 15 through September 15 September 16 through May 14
Ranch Creek from Cabin Creek to Hurd Creek	5-90CW306A	7 1.5	May 15 through September 15 September 16 through May 14
Ranch Creek from Hurd Creek to Fraser River	5-90CW305	8 5	May 15 through September 15 September 16 through May 14
Meadow Creek from outlet of Meadow Creek Reservoir to Vail Ditch headgate	5-90CW310	3.5 1.5	May 1 through September 30 October 1 through April 30
Meadow Creek from unnamed tributary in NE SE S16 T1N R75W 6PM to Ranch Creek	5-90CW309	1.0	Year-round
Fraser River from Jim Creek to Vasquez Creek	5-90CW302	8 3.5	May 15 through September 15 September 16 through May 14
Fraser River from Vasquez Creek to St. Louis Creek	5-90CW307	11 5	May 15 through September 15 September 16 through May 14
Fraser River from St. Louis Creek to Crooked Creek	5-90CW315	17 11	May 15 through September 15 September 16 through May 14
Fraser River from Crooked Creek to Colorado River	5-90CW308, 5-90CW308B	30 19	May 15 through September 15 September 16 through May 14

Source: Boyle, 2005; Denver Water, 2003h.
Notes:
Case Number included as a reference to Figure 3.0-5, Minimum Instream Flow Rights – Fraser River Basin.
cfs = cubic feet per second

The only significant storage in the Fraser River Basin is Meadow Creek Reservoir, which serves both the Vail Ditch system and the Moffat Collection System. The reservoir has a capacity of 5,370 AF (Denver Water 2003b).

The USGS maintains long-term gages on the Fraser River and the three largest tributaries:

- Fraser River at Winter Park – USGS gage 09024000
- Vasquez Creek at Winter Park – USGS gage 09025000
- St. Louis Creek Near Fraser – USGS gage 09026500
- Ranch Creek Near Fraser – USGS gage 09032000

Graphs of annual flow and average monthly flow over the 30 years from 1975 through 2004 are presented in Appendix E-2.

Average annual stream flow for the Fraser River at Winter Park gage prior to the existing Moffat Collection System was 32,080 acre-feet per year (AF/yr) for the period from 1911 through 1935. For the period from 1936 through 2004 after the existing Moffat Collection System began diverting from the Fraser River Basin, stream flow averaged 12,890 AF/yr at the Winter Park gage. Differences in average annual flows for these two periods are caused primarily by the existing Moffat Collection System diversions, as well as variations in hydrologic conditions (snowpack, precipitation, temperature, and runoff). Comparisons of stream flows pre- and post- the existing Moffat Collection System were not made for the tributary gages listed above since these gages were not in operation prior to 1934.

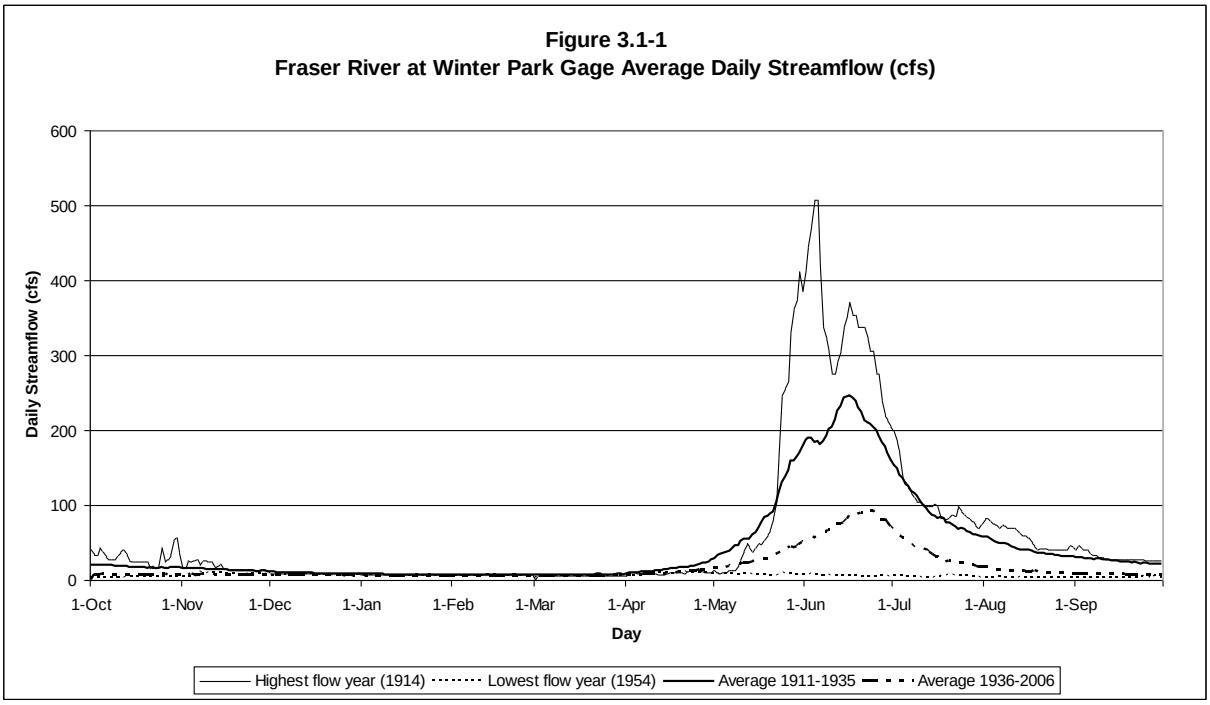
Table 3.1-11 summarizes the effects of historical Moffat Collection System diversions from the Fraser River mainstem and Jim Creek on native flow at the Fraser River at Winter Park gage. Native flows are defined as gaged flows or estimated flows at ungaged points plus adjustments for reservoir releases and filling, diversions, gaged inflows, transbasin imports, and irrigation or other returns to the river. Therefore, the effects of most man-made alterations to the water supply are considered. On average, Denver Water diverted approximately 50% of the average annual native flow available at the Fraser River at Winter Park gage for the 30-year period from 1975 through 2004. Similar tables were not developed for the tributary gages since there are several irrigation and municipal diversions upstream of these gages that affect the calculation of native flows, whereas, there are few diverters other than Denver Water upstream of the Winter Park gage.

Table 3.1-11
Summary of Average Annual Stream Flow and Depletions for the Fraser River Near Winter Park Gage for the Period from 1975 through 2004

	Approximate Average Annual Volume (AF)	Percent of Native Flow Volume Depleted (%)	Percent of Native Flow Volume Remaining (%)	Notes
Fraser River Near Winter Park Native Flow	27,907			Estimated based on gaged flow at Fraser River near Winter Park gage plus upstream depletions
Winter Park Water & Sanitation District Depletions	5	0		Based on existing demands of approximately 130 AF/yr and assumed depletion of 5% (Hydrosphere 2003)
Berthoud Canal	725	2.6		Based on Hydrobase records
Moffat Project Fraser, Jim, Cooper, Cub and Buck Creek Diversions[1]	13,817	49.5		Based on data provided by Denver Water
Fraser River Near Winter Park Gaged Flow	13,360		47.9	USGS records for Fraser River near Winter Park gage (09024000)

Notes:
Averages are based on a water year.
[1]Denver Water maintains a gage that records diversions from Jim Creek and the Fraser River mainstem. Diversions from Cooper, Cub, and Buck creeks, which are also upstream of the Winter Park gage, were estimated since these diversions are not gaged individually.
AF = acre-feet
AF/yr = acre-feet per year
USGS = U.S. Geological Survey

Average daily historical flow at the Fraser River at Winter Park gage is shown in Figure 3.1-1 for the period prior to the Moffat Project (1911 through 1935) and after the existing Moffat Collection System came on-line (1936 through 2006). This figure demonstrates the effects of Denver Water's transbasin diversions and increased water use over time.



Note:
cfs = cubic feet per second

Typical Operations of Denver Water's Moffat Collection System in the Fraser River Basin

The following is a general summary of how Denver Water typically operates the existing Moffat Collection System. Year-to-year operations vary depending on weather, maintenance, and other factors. The collection system is operated year round, therefore, diversions occur throughout the winter months. Typically, the diversion head gates are set in November or December and are not changed until April of the following year. Once the streams and canals freeze, it is impractical to make any further adjustments at many of the collection system facilities.

The existing Moffat Collection System collects water from side slope "sheet flow" and numerous tributary diversion points, which are listed in Table 3.1-6. Typically, Denver Water diverts water that is physically and legally available at each diversion point subject to minimum bypass flows and calls from downstream senior water rights. Most of the water available for diversion occurs during the May through July runoff season. Streams that do not have minimum bypass requirements (and even those with downstream senior rights) are fully diverted at times during the year and no water is bypassed from those diversion structures. As a result, Denver Water, at times, diverts all the stream flow from tributaries in the Fraser River Basin that do not have minimum bypasses. This results in no stream flow for some distance below the diversions. This is how Denver Water has operated in the past and plans to operate in the future.

Diversions from the Moffat Collection System must be replaced when the senior Shoshone or senior Grand Valley call is in effect. Denver Water uses Williams Fork Reservoir, and occasionally Dillon Reservoir, to replace these out-of-priority diversions.

As previously mentioned, operations vary depending on a wide variety of factors. In **dry years** Denver Water diverts the maximum amount of water it legally can from the existing Moffat Collection System. This means that Denver Water diverts all available flows at each diversion point except for flows required to meet senior water rights or minimum bypass flows (Table 3.1-8). At four diversions (Fraser River, Vasquez Creek, Ranch Creek, and St. Louis Creek), Denver Water is allowed to reduce the USFS minimum bypass flows when its customers are on restrictions.

In **wet and average years,** early in the runoff season, Denver Water typically diverts the maximum amount of water physically and legally available at each diversion point. This water is used to fill Gross and Ralston reservoirs and to meet customer demand. Often, Denver Water diverts 100% of the water from streams that do not have minimum bypass flow requirements. Therefore, streams that do not have minimum bypass requirements (even those with downstream senior rights) are fully diverted and dried-up early in runoff season similar to dry years. Once Denver Water anticipates filling Gross and Ralston reservoirs and water demand is being met, Denver Water will begin to reduce diversions and "spill" water from the Moffat Collection System that cannot be used or stored on the East Slope. In general, spills are distributed throughout Denver Water's Collection System with consideration of downstream water users. For example, Denver Water attempts to spill at its diversions points in the St. Louis and Vasquez creek basins simultaneously as opposed to in sequence. As Gross Reservoir begins to be drawn down, typically in midsummer, Denver Water will again divert the maximum amount available to keep Gross Reservoir as full as possible.

Native Flow Diversions

Hydrologic changes have occurred in the Fraser River Basin since 1935 due to past and present operations and diversions of Denver Water's existing Moffat Collection System. As shown in Table 3.1-11, Denver Water historically diverted approximately 50% of the average annual native flow at the Fraser River at Winter Park gage for the 30-year period from 1975 through 2004. Denver Water currently diverts a higher percentage of the native flow in the Fraser River Basin because their average annual demand is higher than it was historically during the period from 1975 through 2004. Tables showing the percentage of native flow diverted by Denver Water under Current Conditions (2006), Full Use of the Existing System, the action alternatives and the No Action Alternative are included in Appendix H-12 (refer to Section 4.6.1 for a description of the model scenarios assessed).

The percentage of native flow diverted by Denver Water depends on the location in the Fraser River Basin. In general, Denver Water diverts the greatest percentage of native flow from small tributaries that do not have bypass flow requirements. The average monthly percentage diverted from these tributaries is often greatest during winter months because flows are typically lower during those months. As described above, several of the Moffat Collection System diversion points are difficult to access in the winter, in which case, the diversion dams are set in late fall to divert all available water at locations where there are no bypass requirements. As a result, Denver Water often diverts 100% of the native flow at these locations during the winter. For example, under Current Conditions, Denver Water diverts 100% of the monthly native flow from Jim Creek in several winter months and 89% of the average annual native flow because there is no bypass requirement on that creek (see Table H-12.2). Similarly Denver Water diverts over 90% of the average monthly native

flow from Little Vasquez Creek in several winter months and 83% of the average annual native flow because the bypass requirement is further downstream on the mainstem of Vasquez Creek (see Table H-12.9).

The percentage of native flow diverted by Denver Water is typically less on tributaries with bypass requirements. Under Current Conditions, Denver Water's diversions from St. Louis Creek range from 1% to 3% of the average monthly native flow from December through March up to 52% in May (see Table H-12.3). Diversions of native flow are considerably less during the winter from September 16 through May 14 because there is a bypass requirement of 3 cfs at Denver Water's St. Louis Creek Diversion during those months. Similarly, Denver Water's diversions from main Ranch Creek range from 0% to 1% of the average monthly native flow from December through March up to 60% in May (see Table H-12.13). Diversions of native flow are less during the winter from September 16 through May 14 because there is a bypass requirement of 2 cfs at their Ranch Creek Diversion during those months. At the Moffat Collection System diversion points, Denver Water's diversions range from 19% of the average annual native flow below the Englewood Ranch Gravity System up to 89% at the Jim Creek Diversion under Current Conditions.

At locations further downstream along the Fraser River mainstem, the percentage of native flow diverted by Denver Water decreases due to tributary inflows. Denver Water would divert about 67% of the average annual native flow at their Fraser River Diversion and approximately 35% of the average annual native flow at the Fraser River at Granby gage under Current Conditions. The percentage of native flow diverted by Denver Water under each of the Moffat Project alternatives and No Action Alternative is discussed in Section 4.6.1.

Floodplains

Portions of the Fraser River floodplain have been mapped by the Federal Emergency Management Agency (FEMA). There is a detailed floodplain study extending from approximately 1,600 feet upstream of the U.S. Highway 40 (US 40) crossing near the Mary Jane entrance to the Winter Park Ski Resort. This region consists of a FEMA-designated Zone A1 floodplain. Zone A1 is defined as an area with a 1% annual chance of flooding based on elevations derived from detailed analysis (FEMA 2009). The 100-year floodplain elevation ranges from a base flood elevation of 9,291 feet at the upstream end of this area down to 8,920 feet at the downstream end based on the Flood Insurance Rate Maps (FIRM) dated 1985. The Fraser River then becomes a Zone D floodplain downstream to a location approximately 500 feet upstream of Beaver Resort area where it again becomes a Zone A1 designated floodplain with a detailed floodplain study extending downstream to just south of the Town of Fraser. Zone D is defined as an area with possible but undetermined flood hazards, where no hazard analysis has been conducted (FEMA 2009). The 100-year floodplain elevation ranges from a base flood elevation of 8,848 feet at the upstream end of this region down to 8,625 feet at the downstream end of this region based on the FIRM dated 1985.

3.1.5.2 Williams Fork River

Hydrology

The Williams Fork River is the next major southside tributary to the Colorado River, below the Fraser River. It flows generally northwest, forming a relatively narrow basin approximately 8 miles wide by 30 miles long. The Vasquez Mountains form the divide between Williams Fork River and the Fraser River to the east, and the Williams Fork Mountains form the western boundary shared by the Blue River Basin. The southern end is delimited by the Continental Divide, which separates the Williams Fork River Basin from Clear Creek. The basin rim includes peaks rising above 13,000 feet, while the confluence with the Colorado River lies at approximately 7,540 feet. The Williams Fork drains approximately 230 square miles at the USGS gage 09038500 Williams Fork below Williams Fork Reservoir. Annual precipitation is estimated to be in excess of 40 inches on the high ridges at the southern end of the basin, but normal annual precipitation at Williams Fork Dam is 14.1 inches (WRCC 2010a).

The Williams Fork River Basin lies almost entirely within the ARNF, and has no population centers. Henderson Mill, owned by Cyprus Climax Metals Company, is located in the Ute Creek Basin, a tributary to Williams Fork River relatively high in the basin. Ore from the Henderson Mine, east of the Continental Divide near Berthoud Pass, is hauled through a 12-mile tunnel to the mill. Water is used and reused in the milling process through an elaborate system of pumping stations, pipelines, reservoirs, tanks, and a single large tailing pond. Historical diversions, taken both from Ute Creek and Williams Fork River, average approximately 2,200 AF and are entirely consumed (Boyle 2000). Lower down, irrigated pasture and hay cropping support livestock production. Generally, these activities represent the only water use within the basin. Major irrigation ditches in the basin include Big Lake Ditch and Lyman Ditch. Water rights associated with these ditches are senior in priority to Denver Water's Williams Fork rights. Denver Water owns a majority of the Big Lake Ditch water rights and as of 2013 the ditch may no longer divert water for irrigation.

In 1963, Denver Water entered into contracts and purchased nearly all of the Big Lake Ditch interests that convey water out of the Williams Fork River Basin. The owners were granted a 40-year lease to continue their operation under the condition that the Big Lake Ditch water rights not call if needed by Denver Water. The 1963 agreement was superseded in a 1998 agreement that waived lease payments owed to Denver Water and provided more detail of the conditions under which Denver Water would need the water, and extended the operation of Denver Water's interests in the ditch for irrigation uses from 2003 to 2013. The 1998 agreement expires November 1, 2013. After 2013 for purposes of EIS analysis, the ditch does not operate across the divide into Reeder Creek. For the EIS, this contract expiration is modeled in the Full Use of the Existing System scenario as described in the introduction to Chapter 4.

Prior to 2013, in dry years, the 1998 agreement specifies the conditions under which Denver Water's interest in the Big Lake Ditch water rights may be used. These conditions were designed to minimize interference with Denver Water's ability to divert water at the existing Williams Fork Collection System or store water in Williams Fork Reservoir under critical supply circumstances. Apart from this, the ditch can divert water, even in dry years.

The non-exercise of Denver Water's interest in the Big Lake Ditch rights during portions of dry years allows Denver Water to divert additional water to storage in Williams Fork Reservoir at times that the reservoir water rights are in-priority. In these years, diversions through the Big Lake Ditch and the corresponding consumptive use of the water for irrigation is reduced, and irrigation return flows to Reeder Creek, a tributary to the Colorado River, are also reduced. This affects the timing of flows in the Colorado River below the confluence with the Williams Fork River. Likewise, after 2013, diversions of Denver Water's interests in the Big Lake Ditch and the corresponding consumptive use of the water for irrigation and irrigation return flows to Reeder Creek could be eliminated. Depending on the type of year, this may increase or decrease the overall gain of water to the Williams Fork River and Colorado River below the confluence with the Williams Fork River. This is reflected in the Full Use of the Existing System scenario.

Over the past several decades, Denver Water has purchased numerous other senior irrigation rights on the West Slope that have been retired and abandoned. At times, especially in dry years, this allows Denver Water to divert water that would have otherwise been "called-out" by these abandoned water rights at its diversion facilities. At other times, because the ditches are no longer diverting and consuming water, this practice creates an increase in flows to the West Slope. This is reflected in the Platte and Colorado Simulation Model (PACSM) simulations used in this EIS.

Denver Water's Collection System in the Williams Fork River headwaters diverts from McQueary, Jones, Bobtail, and Steelman creeks, directing flow to the Gumlick Tunnel (Jones Pass Tunnel) for delivery into Vasquez Creek in the Fraser River Basin above the Moffat Collection System via the Vasquez Tunnel. The diversion locations are shown on Figure 3.0-2. The Williams Fork Collection System intercepts a drainage area of approximately 14.2 square miles (Denver Water 2003c). The decreed capacity of the Gumlick Tunnel is 620 cfs and annual diversions averaged 5,100 AF from 1975 through 2005 (CDWR 2009). Denver Water has also adjudicated a number of conditional water rights for future extension and enlargement of the Williams Fork Collection System, including rights on Darling Creek, Webb Creek, and Middle and South Forks of the Williams Fork. Denver Water's rights associated with existing structures are listed in Table 3.1-12.

Table 3.1-12
Denver Water Williams Fork River Basin Water Rights at Existing Structures

Water Right	Appropriation Date	Amount
Gumlick Tunnel	July 4, 1921	214 cfs
Gumlick Tunnel (conditional)	July 4, 1921	406 cfs
McQueary Creek	July 4, 1921	70 cfs
Jones Creek	July 4, 1921	25 cfs
Bobtail Creek	July 4, 1921	195 cfs
Steelman Creek	July 4, 1921	150 cfs
Williams Fork Reservoir	November 10, 1935	93,637 AF
Williams Fork Reservoir (includes hydropower)	October 9, 1956	93,637 AF
Williams Fork Power Conduit	October 9, 1956	295 cfs
Williams Fork Power Conduit (conditional)	October 9, 1956	105 cfs

Source: Denver Water, 2003h.
Notes:
AF = acre-feet
cfs = cubic feet per second

The CWCB has minimum stream flow rights on the collection system tributaries, but these are junior to Denver Water's Williams Fork water rights. Accordingly, Denver Water has no bypass obligation other than for senior downstream irrigation rights; however, minimum bypasses would be imposed on both existing and future diversions if the collection system is extended, pursuant to a 1979 agreement with CWCB and the Colorado Parks and Wildlife (CPW) (previously called Colorado Division of Wildlife) (Denver Water 2003c). The CWCB rights are listed in Table 3.1-13 and shown on Figure 3.0-6.

Table 3.1-13
Colorado Water Conservation Board Minimum Instream Flow Rights below Williams Fork Collection System

Reach	Case Number	Flow (cfs)	Period
Steelman Creek from Denver Water diversion to a point located at latitude 39 46 43N longitude 105 55 23W	5-79CW166	1.0	May through September
Steelman Creek from a point located at latitude 39 46 43N longitude 105 55 23W to confluence with Williams Fork River	5-79CW167	2.0 1.0	May through September October through April
Bobtail Creek from Denver Water diversion to a point located at latitude 39 46 41N longitude 105 55 16W	5-79CW163	1.0	Year-round
Bobtail Creek from a point located at latitude 39 46 41N longitude 105 55 16W to confluence with McQueary Creek	5-79CW164	2.0 1.0	May through September October through April
Williams Fork from McQueary Creek to Steelman Creek	5-79CW165	2.0 1.0	May through September October through April
Williams Fork from Steelman Creek to a point located at latitude 39 46 33N longitude 105 57 51W	5-79CW168	5.0 2.5	May through September October through April
Williams Fork from a point located at latitude 39 46 33N longitude 105 57 51W to a point located near latitude 39 46 37N long 105 58 48W	5-79CW169	6.0 3.0	May through September October through April
Williams Fork from a point located near latitude 39 46 37N longitude 105 58 48W to Middle Fork Williams Fork	5-79CW170	7.0 3.5	May through September October through April
Williams Fork from Middle Fork Williams Fork to a point located at latitude 39 47 19N longitude 106 01 11W	5-79CW172	9.0 4.5	May through September October through April
Williams Fork from Middle Fork Williams Fork a point located at latitude 39 47 19N longitude 106 01 11W to Darling Creek	5-79CW173	12 6.0	May through September October through April

Table 3.1-13 (continued)
Colorado Water Conservation Board Minimum Instream Flow Rights below Williams Fork Collection System

Reach	Case Number	Flow (cfs)	Period
Williams Fork from Darling Creek to South Fork Williams Fork	5-79CW175	15 8.0	May through September October through April
Williams Fork from South Fork Williams Fork to unnamed tributary at latitude 39 48 58N longitude 106 02 45W	5-79CW180	25 13	May through September October through April
Williams Fork from unnamed tributary at latitude 39 48 58N longitude 106 02 45W to Kinney Creek	5-79CW181	28 14	May through September October through April
Williams Fork from Kinney Creek to Keyser Creek	5-79CW183	32 16	May through September October through April
Williams Fork from Keyser Creek to Williams Fork Reservoir	5-79CW185	19 38	May through September October through April
Williams Fork from Keyser Creek to Williams Fork Reservoir[1]	5-W3739-78	15 39	May through September October through April

Source: Boyle, 2005; Denver Water, 2003h.
Notes:
[1]Earlier appropriation date than listed immediately above.
Case Number included as a reference to Figure 3.0-6 Minimum Instream Flow Rights – Williams Fork River Basin.
cfs = cubic feet per second
CWCB = Colorado Water Conservation Board

Graphs of annual flow and average monthly flow are shown in Appendix E-2 for three USGS gages in the basin:

- Williams Fork River downstream of Steelman Creek, just downstream of the Denver Water Collection System – USGS gage 09035500
- Williams Fork River, just upstream of the Williams Fork Reservoir, near Parshall – USGS gage 09037500
- Williams Fork River, 400 feet downstream of the Williams Fork Reservoir – USGS gage 09038500

Native Flow Diversions

Hydrologic changes have occurred in the Williams Fork River Basin due to past and present operations and diversions of Denver Water's Collection System in the Williams Fork River headwaters, which includes diversions from McQueary, Jones, Bobtail, and Steelman

creeks, and Williams Fork Reservoir. Tables showing the percentage of native flow diverted by Denver Water under Current Conditions, Full Use of the Existing System, the action alternatives and the No Action Alternative are included in Appendix H-12 (refer to Section 4.6.1 for a description of the model scenarios assessed).

The Williams Fork Collection System diversion points are difficult to access in the winter, in which case, the diversion dams are set in late fall to divert all available water through the winter because there are no bypass requirements. As a result, Denver Water often diverts 90% to 100% of the average monthly native flow from McQueary, Jones, Bobtail, and Steelman creeks from October through April under Current Conditions as shown in Tables H-12.16 through H-12.19. During the summer from May through September, the average monthly percentage of native flow diverted by Denver Water varies more and ranges from 24% to 94% under Current Conditions. During those months, Denver Water diverts the greatest percentage of native flow in April, May, August and September when flows are typically lower. In June and July, Denver Water diverts a much lower percentage of the native flow at these locations (24% to 43% on average) because flows are typically much higher during runoff.

At locations further downstream along the Williams Fork River mainstem, the percentage of native flow diverted by Denver Water decreases due to tributary inflows. The percentage of native flow diverted by Denver Water under each of the Moffat Project alternatives and No Action Alternative is discussed in Section 4.6.1.

Floodplains

The Williams Fork River Basin has not been mapped by FEMA; therefore, floodplain information for the affected river reach was not available.

Williams Fork Reservoir

Williams Fork Reservoir, a 96,822 AF reservoir located approximately 3 miles above the Colorado River confluence, is the largest reservoir in the basin. The reservoir was completed in stages, the last of which was finished in 1959 (Denver Water n.d.a). Denver Water's headwater diversions are protected by Williams Fork Reservoir such that when the Denver Water rights are out of priority with respect to senior diverters below Williams Fork Reservoir, the reservoir releases water to satisfy the senior diverters. This type of operation, in which water may be diverted out of priority at one point by replacing a like amount at a downstream point, is called an exchange. Williams Fork Reservoir is operated in part to exchange water to replace out of priority diversions at Denver Water's Moffat Collection System, Roberts Tunnel, and Dillon Reservoir. Refer to the Blue River section below for a discussion of Williams Fork Reservoir substitution operations in relation to Dillon, Green Mountain, and Wolford Mountain reservoirs. Denver Water also has an obligation to provide up to 2,200 AF of replacement water to the Henderson Mill out of Williams Fork Reservoir to protect them from downstream senior calls.

A power plant is located at Williams Fork Reservoir, and as a condition of its Federal Energy Regulatory Commission (FERC) exemption, Denver Water must bypass 15 cfs or inflow, whichever is less, at all times. The overriding function of Williams Fork Reservoir is exchange and substitution. Denver Water also operates a hydroelectric plant at the dam, which was upgraded in 2012. The original 3.2 megawatt (MW) turbine has a hydraulic

range of approximately 60 to 220 cfs, while the new 0.5 MW turbine has a hydraulic range of approximately 15 to 50 cfs. Thus, the effective flow range over which power can be generated is approximately 15 to 270 cfs with a gap between the two units in the 50 cfs to 60 cfs range. The addition of the new 0.5 MW turbine will not affect the timing or magnitude of reservoir releases and Denver Water will have the ability to produce power over a wider range of flow rates. Power releases are made with the objective of filling without spilling, based on seasonal forecasts. Once the reservoir has achieved its maximum storage for the year, it is held at that level until a senior call comes on, and the reservoir begins to exchange. Most of the power generated at Williams Fork Reservoir is delivered to Tri-State Generating and Transmission Association. A portion of the power is used for on-site facility purposes.

3.1.5.3 Colorado River

Hydrology

The section of the Colorado River, from the confluence with the Fraser River downstream to the Kremmling gage, includes approximately 27 river miles beginning at the confluence with the Fraser River—the most upstream point at which Denver Water diversions have an impact on the Colorado River mainstem. It ends at Kremmling, where both the Blue River and Muddy Creek join the Colorado River. Over this reach the river drops from 7,900 feet in elevation to approximately 7,400 feet. Major tributaries in the reach include Troublesome Creek in addition to those mentioned elsewhere in this chapter (Fraser River, Blue River, Williams Fork, and Muddy Creek). The river valley is sparsely populated, with Hot Sulphur Springs, the Grand County seat, being the only municipality other than Kremmling.

Diversions in this reach of the river are primarily to flood-irrigate pasture grass grown in a relatively narrow corridor along the river. Major mainstem irrigation ditches include the Sheriff Ditch, Ute Bill No. 2 Ditch, Farris South Side Ditch, Sophronia Day Ditch, Kinney Barriger Ditch, Thompson Pump No. 2, and McElroy Ditches Nos. 1 and 2. Denver Water's Fraser River and Williams Fork River rights are junior to many of the irrigation rights associated with these ditches. In addition, there are a series of irrigation water rights, termed Meadow Pumpers, that were granted senior status in relation to the Colorado-Big Thompson (C-BT) Project water rights per Senate Document 80. Therefore, although the appropriation dates of these water rights are junior to the C-BT Project, they are administered as senior to the C-BT Project. These water rights are primarily located along the Colorado River mainstem downstream of the confluence with the Williams Fork River and upstream of Kremmling. Several irrigators along the Colorado River are experiencing difficulty in diverting water, particularly in drought years and during late summer fall months due to low flow conditions. This was most evident in 2002 when flows below the confluence with the Williams Fork River were extremely low causing some irrigators to stop diverting. Several irrigators have constructed make-shift cobble dams to raise water levels at their diversion dams to facilitate diversions from the river.

The other major diversion in this reach is the Windy Gap Project, which has a diversion dam just below the confluence with the Fraser River, and a pumping station with a capacity of 600 cfs. The Windy Gap Project is owned and operated by the Municipal Subdistrict of

the Northern Colorado Water Conservancy District. The water diverted at Windy Gap is pumped to Granby Reservoir for eventual delivery to the East Slope via the Adams Tunnel. The historical average annual diversion at Windy Gap is approximately 10,600 AF (1985 through 2004).

Graphs of the annual and average monthly flow in the Colorado River immediately downstream of the Windy Gap diversion dam near Granby and near Kremmling are shown in Appendix E-2. The period of record at Windy Gap reflects conditions only after the Windy Gap diversion began operating in 1985.

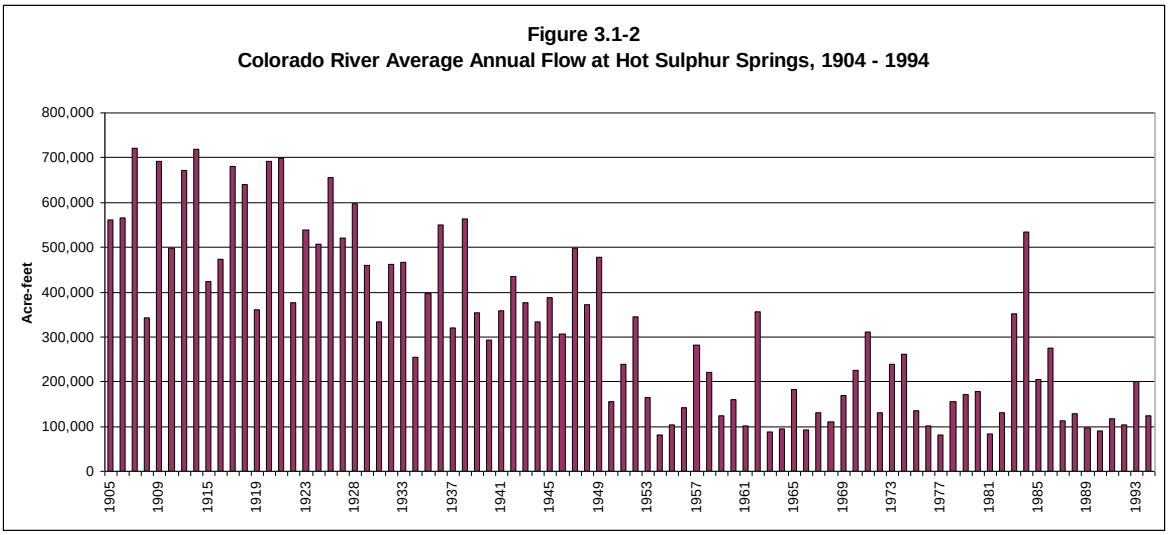
Table 3.1-14 summarizes the effects of historical upstream depletions at the Colorado River at Windy Gap gage (09034250) for the 20-year period from 1985 through 2004. This period was selected because the Windy Gap Project came on-line in 1985; therefore, it includes the effects of all major upstream transbasin diversions (Grand River Ditch, C-BT Project, existing Moffat Collection System, and Windy Gap Project). On average, the Moffat, C-BT, and Windy Gap projects diverted approximately 62% of the average annual native flow at the Windy Gap gage for the period from 1985 through 2004. Figure 3.1-2, which summarizes average annual historical flows at the Colorado River at Hot Sulphur Springs gage from 1905 to 1994, demonstrates the effects of transbasin diversions and increased water used in the basin over time. Average annual stream flow in the Colorado River at Hot Sulphur Springs was 528,730 AF/yr prior to the existing Moffat Collection System (1905 through 1935) and 229,030 AF/yr for the period from 1936 through 1994 after the Moffat, C-BT, and Windy Gap projects began diverting in 1936, 1950, and 1985, respectively. Average daily historical flow at the Colorado River at Hot Sulphur Springs gage is shown in Figure 3.1-3 for the period prior to the existing Moffat Collection System (1911 through 1935) and after the existing Moffat Collection System came on-line (1936 through 1994). This figure also demonstrates the effects of transbasin diversions and increased water use over time. Differences in average annual flows and daily flows for different periods are caused by additional transbasin diversions associated with the Moffat, C-BT and Windy Gap projects; however, there are also differences associated with variations in hydrologic conditions (snowpack, precipitation, temperature, and runoff) and changes in irrigation, municipal, and snowmaking diversions and return flows upstream of these gages.

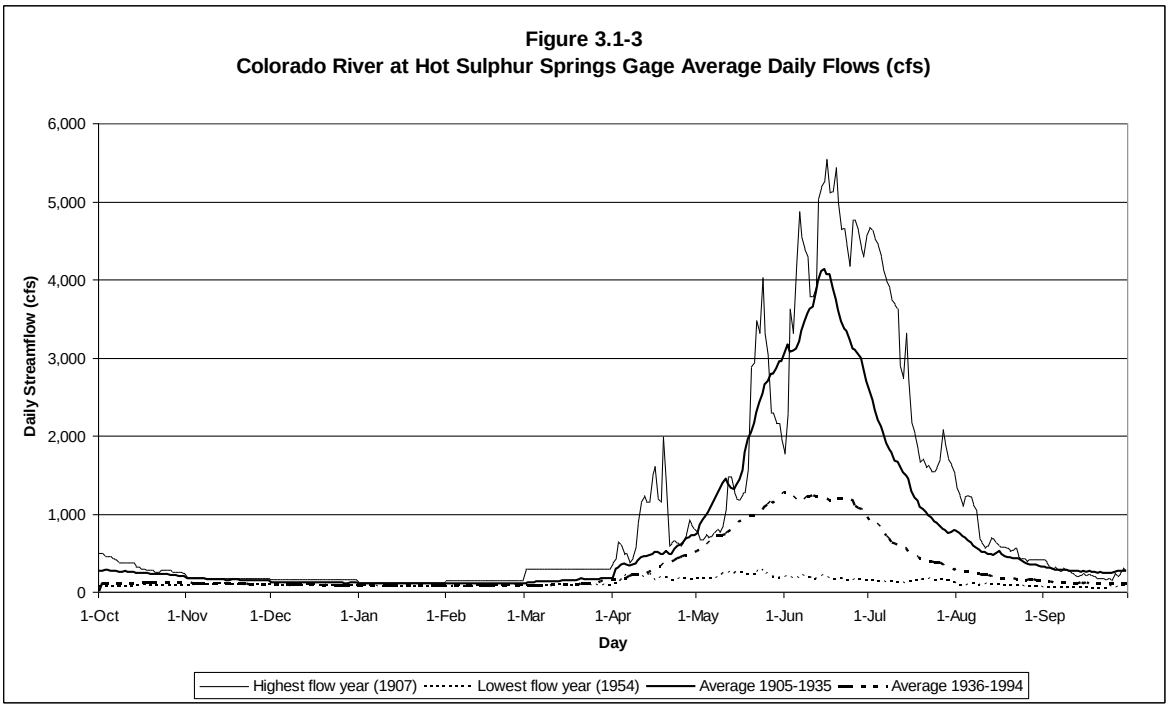
Table 3.1-14
Summary of Average Annual Stream Flow and Depletions for the Colorado River at Windy Gap Gage for the Period from 1985 through 2004

	Approximate Average Annual Volume (AF)	Percent of Native Flow Volume Depleted (%)	Percent of Native Flow Volume Remaining (%)	Notes
Windy Gap Native Flow[1]	476,974			USGS records for Colorado River at Windy Gap Gage (09034250) plus Grand River Ditch, Adams Tunnel, Moffat Tunnel and Windy Gap diversions, C-BT evaporation, and Grand County depletions
Grand River Ditch Diversion	18,506	3.9		Based on Hydrobase records
C-BT Adams Tunnel Diversion	223,013	46.8		Based on Hydrobase and Reclamation records for Adams Tunnel less Windy Gap deliveries
C-BT Evaporation	13,500	2.8		Based on data provided by NCWCD from their planning model and the Reclamation Daily Operations Database for 1995 through 2007
Moffat Tunnel Diversion	49,844	10.4		Based on Hydrobase records less Gumlick Tunnel diversions since diversions from the Williams Fork River through Gumlick Tunnel occur downstream of the Windy Gap gage
Windy Gap Diversions	10,583	2.2		Based on data provided by NCWCD
Grand County Depletion	1,200	0.3		Based on existing demands of approximately 3,100 AF/yr and assumed depletion of 40% (Hydrosphere 2003)
Windy Gap Gaged Flow	160,328		33.6	USGS records for Colorado River at Windy Gap Gage (09034250)

Notes:
Averages are based on a water year.
[1]Native flow at Windy Gap was estimated to be the gaged-flow plus estimated depletions (Grand River Ditch, Adams Tunnel, Moffat Tunnel, and Windy Gap Diversion, C-BT evaporation, and Grand County depletions) upstream of the gage. This estimate does not include the effect of depletions associated with agricultural irrigation upstream of the Windy Gap gage.

AF = acre-feet
C-BT = Colorado-Big Thompson
NCWCD = Northern Colorado Water Conservancy District
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
USGS = U.S. Geological Survey
yr = year





Floodplains

This stretch of the Colorado River, from the confluence with the Fraser River to the Kremmling gage, has not been mapped by FEMA.

3.1.5.4 Blue River

Hydrology

The Blue River rises on the north-facing slopes of the Continental Divide near Hoosier Pass, about 9 miles south of Breckenridge, Colorado. The Continental Divide consists of 13,000- and 14,000-foot peaks and the high ridges between them, and bounds the basin on its southern and southeastern perimeter. The Blue River flows generally northwest, toward Dillon Reservoir, then on toward the Colorado River, forming a long valley between the Williams Fork mountains to the north and east, and the Gore Range to the south and west. It enters the Colorado River near the Town of Kremmling, at an elevation of approximately 7,400 feet. The total drainage area of the basin is 680 square miles (Hydrosphere 1989).

The Blue River above Dillon Reservoir is divided into three major sub-basins. From east to west, they are the Snake River Basin, the upper Blue River Basin, and the Ten Mile Creek Basin. When Dillon Reservoir, which is described below, was filled, it inundated the confluence of these three streams. In the lower Blue River Basin below Dillon Reservoir, tributary streams are shorter and drain less area as they come off the mountain fronts on either side of the basin. The higher Gore Range side produces more water than the Williams Fork Mountain side.

Precipitation varies with elevation across the Blue River Basin, ranging from 15.5 inches at Green Mountain Dam in the lower Blue River, to nearly 24 inches at the Climax Mine near Fremont Pass. Stream flows are highly variable by season across the basin. Most of the annual stream flow results from snowmelt between the months of May and July, but short-lived thunderstorms in July and August can produce spikes in the runoff in the late season.

Water resources development began in the latter half of the 1800s as mining of precious metals drew settlers to the basin. Placer operations of that era produced piles of dredge spoils still visible along the upper Blue River. Hard rock mining was also practiced high on the flanks of the Continental Divide. Mining declined in the early 20th century, and is now almost absent from the basin with the exception of Climax Mine. As mining activities decreased, irrigation of hay and pasture increased, primarily in the lower Blue River where growing conditions were more favorable (Hydrosphere 1989). The Climax Mine is an existing open-pit, molybdenum mine located in the Ten Mile Creek Basin and has been shut down since 1995.

In the last several decades, population in Summit County has increased rapidly, stimulated by easy access from the Front Range and growth of a tourism- and recreation-based economy. During the decade of the 1970s, for instance, Summit County was the fastest growing county in the U.S. The growth has affected primarily the area at and above Dillon Reservoir, where the basin's four population centers (Breckenridge, Dillon, Frisco, and Silverthorne) are located. There are also four major ski areas in this part of the Blue River Basin: Arapahoe Basin, Keystone, Breckenridge, and Copper Mountain. During the summer months, Dillon and Green Mountain reservoirs provide opportunities for boating and fishing, as does the Blue River itself. Transfers of agricultural water rights to municipal use have supported this growth, but because of the high winter population related to skier visitation, Blue River users have developed storage and exchange agreements to

make use of the historical summertime consumptive use. For example, the Summit County Agreement, and later, the Clinton Gulch Agreement established arrangements with Denver Water that allow efficient use of storage and year-round deliveries of water within the basin. Furthermore, Denver allows wintertime withdrawals from the Roberts Tunnel by Snake River users, with repayment made at Dillon Reservoir (Hydrosphere 2003).

Major in-basin water use today is primarily for municipal use, golf course irrigation, and snowmaking at the basin's ski areas. Approximately 35% of the existing in-basin water demands are for water providers in the upper Blue River above Dillon Reservoir (Hydrosphere 2003). These include the Town of Breckenridge (Summit County's largest provider) and Breckenridge Ski Resort. Approximately 20% of existing demand is located in the Snake River and Soda Creek basins, associated with Arapahoe Basin Ski Area, Keystone Resort, Snake River Water District, and East Dillon Water District. Demands in the Tenmile Creek Basin, served by Copper Mountain Incorporated, Copper Mountain Water and Sanitation District, and the Town of Frisco, make up another 20% of the basin's existing water demands. The remaining municipal and commercial use is at or below Dillon Reservoir, and includes Dillon Valley Metropolitan District, the Town of Dillon, the Town of Silverthorne, Buffalo Mountain Metropolitan District, and Mesa Cortina. Major irrigators in the lower Blue River Basin include the Hoagland Canal, Hamilton-Davidson Ditch, Smith Ditch, and Loback Ditch (Hydrosphere 2003).

Blue River water is used far beyond the boundaries of its basin. The 1930s saw the first municipal transbasin diversion, by the City of Colorado Springs. Known both as the Continental-Hoosier Project and the Blue River Project, the system diverts from the headwaters of the Blue River and its tributaries near Hoosier Pass, and conveys water to the upper South Platte Basin via the Hoosier Tunnel. Diversions average approximately 12,000 AF/yr (Denver Water 1995a). The Vidler Tunnel and Boreas Pass Ditch both carry water to East Slope municipalities, from Peru Creek and Indiana Creek, respectively. These diversions generally amount to several hundred AF each in most water years (CDWR 2005). Green Mountain Reservoir, located 13 miles above the confluence with the Colorado River, was completed in 1943 (Denver Water 2003d) as a component of the C-BT Project. The reservoir's primary purpose was to provide replacement water for out of priority diversions in the upper Colorado River Basin by the C-BT Project. It was also authorized in order to supply irrigation and domestic uses junior to the C-BT Project, and to generate power. The reservoir has a capacity of 153,639 AF, of which 52,000 AF is dedicated to the C-BT Project, and the remaining approximately 100,000 AF are for West Slope needs.

By 1964, Denver Water completed the two major components of the Roberts Tunnel Collection System, Roberts Tunnel and Dillon Reservoir. Denver Water's water rights at Roberts Tunnel and Dillon Reservoir are shown in Table 3.1-15. Dillon Reservoir has an active capacity of approximately 254,000 AF. The West Portal of the Roberts Tunnel is located in the Snake River arm of the reservoir. Diversions by Dillon Reservoir are delivered via the Roberts Tunnel to the North Fork South Platte River approximately 23 miles away. The water is delivered to Denver's "southern system" for treatment at either Foothills or Marston WTPs. Annual diversions through the Roberts Tunnel averaged 62,600 AF from 1975 through 2005 (Denver Water 2009b). Dillon Reservoir's operations are described below in the paragraph titled, "Dillon Reservoir."

Table 3.1-15
Denver Water Blue River Basin Water Rights at Existing Structures

Water Right	Appropriation Date	Amount
Dillon Reservoir	June 24, 1946	252,678 AF
Dillon Reservoir Refill[1]	January 1, 1985	175,000 AF
Roberts Tunnel[2]	June 24, 1946	788 cfs

Source: Denver Water, 2003e.
Notes:
[1]13,524 AF decreed absolute.
[2]Decreed in name of Blue River Diversion Project, 520 cfs decreed absolute.
AF = acre-feet
cfs = cubic feet per second

Table 3.1-16 lists CWCB's minimum instream flow rights on the Blue River below Dillon Reservoir. These were decreed in 1987 and are therefore junior to Dillon Reservoir.

Table 3.1-16
Colorado Water Conservation Board Minimum Instream Flow Rights on Blue River below Dillon Reservoir

Reach	Flow (cfs)	Period
Dillon Reservoir outlet to Straight Creek	50	Year-round
Straight Creek to Willow Creek	55 52 50	May through July August through September October through April
Willow Creek to Rock Creek	75 58	April through September October through March
Rock Creek to Boulder Creek	115 90 78 67 90	May through August September October November through March April
Boulder Creek to Slate Creek	125 90 70 78 90	May through August September through October November through February March April
Slate Creek to Green Mountain Reservoir inlet	125 90 85 90	May through September October through November December through February March through April
Green Mountain Reservoir outlet to Colorado River	60 85	May through July 15 July 16 through April

Source: CWCB, 2004, 2012.
Note:
cfs = cubic feet per second

Figures showing the reservoirs' historical end-of-month content and elevation over time are presented in Appendix E-1. Graphs of annual flow and average monthly flow for the following USGS gages are presented in Appendix E-2:

- Blue River downstream of Dillon Reservoir – USGS gage 09050700
- Blue River downstream of Green Mountain Reservoir – USGS gage 0957500

Floodplains

Portions of the Blue River floodplain have been mapped by FEMA. There is a detailed floodplain study extending from just upstream of the Town of Silverthorne down to the confluence with Quaking Creek. This area consists of a Zone A0, Zone A1, and Zone AE designated floodplain. Zone A0 is defined as an area with a 1% annual chance of shallow flooding with depths of 1-3 feet; with average flood depths derived from detailed analyses. Zones AE and A1 are defined as areas with a 1% annual chance of flooding based on elevations derived from detailed analysis (FEMA 2009). The 100-year floodplain elevation ranges from a base flood elevation of 8,773 feet at the upstream end of this region down to 8,446 feet at the downstream end of this region based on the FIRM dated 1980 and 2001.

Dillon Reservoir

Dillon Reservoir was completed in 1963 and is the largest reservoir in Denver Water's Collection System. The reservoir has a storage capacity of 254,036 AF impounded by an earth fill dam 231 feet high. Dillon Reservoir is located at the confluence of the Blue and Snake rivers and Ten Mile Creek.

Pursuant to their ROW agreement with the USFS, Denver Water must bypass 50 cfs or inflow, whichever is less, to the Blue River from Dillon Reservoir, except under certain conditions as documented in the Stipulations of the Bureau of Sport Fisheries and Wildlife, Department of the Interior dated July 5, 1961, and made a part of the Bureau of Land Management ROW Grant No. 018690 dated November 7, 1966 (Denver Water 2003e). The conditions under which Denver Water can reduce bypass flows below Dillon Reservoir include the following:

- During an emergency or temporary periods of time involving maintenance or repairs on the associated water facilities, bypass releases from Dillon Reservoir may be reduced.
- If the combined volume of water in storage in Cheesman, Eleven Mile Canyon, Antero, and Dillon reservoirs is not in excess of Denver Water's estimate of the current one calendar year's use of water through the Denver Water system, then the bypass release from Dillon Reservoir can be reduced in direct proportion to the storage shortage. Bypass releases cannot be reduced below 20 cfs, or the natural inflow if less.
- If the space available for the storage of water in Dillon Reservoir exceeds 100,000 AF, then the bypass release can be reduced proportionately. For each 1,000 AF increase in the space available over 100,000 AF of available space, the release can be decreased by 1%. Bypass releases can not be reduced below 20 cfs, or the natural inflow if less.

- If Denver Water imposes restrictions on the use of water in the area served by Denver Water due to insufficient water supply, the bypass releases may be reduced by Denver Water in accordance with the severity of the restrictions.

The Dillon Power Plant is located at Dillon Reservoir. When possible, releases from Dillon Reservoir to the Blue River are maintained between 50 and 110 cfs, the latter being the flow required for full power generation. Although Dillon Reservoir is not a flood control reservoir, Denver Water voluntarily attempts to keep outflow from Dillon Reservoir to less than 1,800 cfs to minimize possible flooding below the reservoir. The Roberts Tunnel Power Plant generates power from releases from Dillon Reservoir through Roberts Tunnel to the North Fork South Platte River. As with other hydropower facilities owned and operated by Denver Water, power production at Roberts Tunnel is secondary to water supply. When water is needed from Dillon Reservoir for water supply, the outflow of Roberts Tunnel is generally maintained between 65 and 400 cfs (the values are influenced by the amount of water in Dillon Reservoir), if possible, as this is the operating range for the power plant.

Dillon Reservoir and Roberts Tunnel are junior in priority to Green Mountain Reservoir, but situated upstream. In order to increase the opportunity for storage at Dillon Reservoir, an agreement among Denver Water, the U.S. Department of the Interior, Bureau of Reclamation, and Northern Colorado Water Conservancy District permits filling of Dillon Reservoir before Green Mountain Reservoir has filled. To the extent that Green Mountain Reservoir does not fill in a given runoff year, Denver Water has several options for providing replacement water to Green Mountain Reservoir. It can make substitution releases from either Williams Fork or Wolford Mountain reservoirs to fulfill the functions that Green Mountain Reservoir would otherwise serve if it had filled, or it can release the water captured in Dillon Reservoir and deliver it to Green Mountain Reservoir. In a substitution year, Denver Water has the right to release water from a variety of sources including Dillon, Williams Fork, and Wolford Mountain reservoirs (Denver Water 2003f).

Dillon Reservoir is within Water Quality Control Commission (WQCC) Segment 3 of the Blue River and is classified as Aquatic Life Class 1 with High Quality 2 designation. A High Quality 2 designation has been established for this segment because the best available information indicates that the existing quality for dissolved oxygen, pH, fecal coliform, cadmium, copper, iron, lead, manganese, mercury, selenium, silver, and zinc is better than that specified in the Basic Standards and Methodologies for Surface Water, for the protection of Aquatic Life Class 1 and Recreation Class 1 uses (CDPHE 2008a).

3.1.5.5 South Boulder Creek

Hydrology

South Boulder Creek is a tributary of Boulder Creek in the larger St. Vrain Creek Basin and flows into the South Platte River. Most of the South Boulder Creek Basin is located west and a little south of the City of Boulder. The creek drains the east side of the Continental Divide from Rollins Pass to James Peak, elevation 13,300 feet, and joins Boulder Creek on the plains east of Boulder at an elevation of approximately 5,175 feet. The affected section of South Boulder Creek is from the East Portal of the Moffat Tunnel, where Denver Water's diversions from the Fraser and Williams Fork rivers flow into the creek, to the

South Boulder Diversion Dam about 3 miles west of Eldorado Springs. At this diversion dam, Denver Water diverts water to the South Boulder Diversion Canal for delivery to Ralston Reservoir, raw water customers, and the Moffat WTP. The reach includes Gross Reservoir, a 41,811-AF capacity facility belonging to Denver Water (refer to Section 3.1.1.1).

The section through which Denver Water's water is delivered lies mostly in the Roosevelt National Forest. There are no population centers other than the towns of Rollinsville and Pinecliffe. Both are located between the Moffat Tunnel East Portal and Gross Reservoir. There is relatively little water use within this reach; the Colorado State Engineer's Office (SEO) database shows a few small storage and diversion rights, several of which were apparently appropriated originally for ice making (CDWR 2005). However, where the stream leaves the foothills below Eldorado Springs, numerous ditches divert from South Boulder Creek. Major ditches include the Community and South Boulder & Coal Creek Ditch, owned by Farmers Reservoir and Irrigation Company, Howard Ditch, East Boulder, and New Dry Creek Ditch. Generally, the South Boulder Creek ditches were established historically for irrigation but in recent decades, the municipalities of Louisville, Lafayette, and Boulder have purchased some of this agricultural water. Louisville and Lafayette each have pipeline diversions near Eldorado Springs.

Denver Water has water rights on South Boulder Creek, both at Gross Reservoir and the South Boulder Diversion Canal, which are shown in Table 3.1-17.

Table 3.1-17
Denver Water South Boulder Creek Basin Water Rights at Existing Structures

Water Right	Appropriation Date	Amount
Gross Reservoir	May 10, 1945	41,811 AF
Gross Reservoir (conditional)	May 10, 1945	71,267 AF
South Boulder Diversion Conduit	January 1, 1930	461 cfs
South Boulder Diversion Conduit (conditional)	January 1, 1930	789 cfs

Source: Denver Water, 2003h.
Notes:
AF = acre-feet
cfs = cubic feet per second

The capacity of South Boulder Creek above Gross Reservoir is approximately 1,200 cfs at Pinecliffe, including natural flow. During high runoff, Denver Water must limit Moffat Tunnel deliveries in order to meet this constraint. Moffat Tunnel operates throughout the year, but because there is very little storage on the West Slope Collection System, the deliveries mirror natural runoff (i.e., they are highly concentrated during the runoff season and minimal in winter months).

Releases from Gross Reservoir to the South Boulder Diversion Canal do not exceed 500 cfs, the capacity of the canal. Denver Water attempts to fill Ralston Reservoir by December 15, after which it typically shuts the diversion canal down until mid-March. Generally, these deliveries are made at a rate of 75 to 150 cfs. As stated in the Gross Reservoir Hydroelectric Project FERC No. 2035-006 Final Environmental Assessment, Denver Water has agreed "to not divert South Boulder Creek water in the winter such that flows would fall below 7 cfs" (Denver Water 2000a). However, by agreement with the

City of Boulder, Gross Reservoir may release water from November to April in order to maintain a flow of 7 cfs to the Boulder Creek confluence. There is a CWCB minimum instream flow right on South Boulder Creek from the Gross Reservoir outlet to the Eldorado Springs USGS gage, of 15 cfs from May through September, and 6 cfs from October through April. As this right is junior to Denver Water's storage and diversion rights, Gross Reservoir is not obligated to operate to satisfy the CWCB right.

For graphs of Gross Reservoir historical end-of-month content and elevation over time, refer to Section 3.1.1.1 and Appendix E-1.

Native Flow

Native flows on South Boulder Creek from the East Portal of the Moffat Tunnel to Gross Reservoir are affected by Denver Water's transbasin diversions from the Fraser and Williams Fork rivers. Because there is relatively little water use within this reach of South Boulder Creek, hydrologic changes are due primarily to Moffat Tunnel deliveries. Table H-12.20 shows the native flow at the South Boulder Creek at Pinecliffe gage and the Moffat Tunnel delivery under Current Conditions, Full Use of the Existing System, the action alternatives and the No Action Alternative (refer to Section 4.6.1 for a description of the model scenarios assessed). The average annual percentage of native flow added to this segment of South Boulder Creek is approximately 150% of the average annual native flow under Current Conditions. The average monthly percentage of flow added to this river segment is greatest during the fall and winter because native flows are typically lower during those months. In average years, the percentage of flow added to South Boulder Creek at the Pinecliffe gage ranges up to 419% in September. Average monthly flows and Moffat Tunnel deliveries are 18.0 cfs and 75.5 cfs, respectively in September. In wet years, the percentage of flow added to South Boulder Creek ranges up to 615% in September. Average monthly flows and Moffat Tunnel deliveries are 15.9 cfs and 97.6 cfs, respectively in September in a wet year. While, the percentage of flow added to South Boulder Creek from the Moffat Tunnel is significant, the section of South Boulder Creek above Gross Reservoir has been modified to accommodate up to 1,200 cfs at the Pinecliffe gage. Flow increases under each of the Moffat Project alternatives and the No Action Alternative compared to native flows in South Boulder Creek are discussed in Section 4.6.1.

Floodplains

FEMA has not mapped any of the South Boulder Creek floodplain between the East Portal of Moffat Tunnel and the South Boulder Canal Diversion. Extensive channel modifications were done by Denver Water in this reach to ensure a stable channel at a flow rate of 1,200 cfs, and Moffat Tunnel is operated so that the capacity is not exceeded due to the imported water. FEMA has established floodplains for the creek from Eldorado Springs to the confluence with Boulder Creek. The City of Boulder conducted a flood mapping study in the same reach. The flood mapping study was submitted to FEMA in 2008, but has not yet been adopted (Taylor 2008). Boulder's study assumed that Gross Reservoir was full during the design storm, that is, that it provided no attenuation of the peak flows.

3.1.5.6 North Fork South Platte River

Hydrology

The North Fork South Platte River rises along the Continental Divide at the north edge of South Park, near Kenosha Pass. It flows generally southeast as far as the settlement of Estabrook, then follows a winding course through the mountains to its confluence with the South Platte River. In only a few places is the river valley bottom more than a third of a mile wide. The drainage is generally forested with open areas on south-facing slopes and the river bottoms. Elevations range from 12,600 feet down to 6,100 feet. Approximately 12 miles downstream from the Continental Divide is the East Portal of Roberts Tunnel, which delivers water from Dillon Reservoir in the Blue River Basin. Denver Water operates their system in a manner to keep the total flow in the North Fork South Platte River below 680 cfs (daily average) at Grant and below 980 cfs (daily average) above the confluence with the mainstem (Yevdjerick and Simons 1966/1967). Drainage area near the mouth, as reported by the USGS at its discontinued gage 06706000 North Fork South Platte River, is 479 square miles.

There are no exports out of the North Fork South Platte River Basin, and relatively little local use. The SEO's database shows only three active diversion rights for 2.0 cfs or more. Population is dispersed, with only small towns at Shawnee, Bailey, and Pine. There are no CWCB minimum instream flow rights on the North Fork.

Graphs of annual flow and average monthly flow are presented in Appendix E-1 for the USGS gage North Fork South Platte River below Geneva Creek at Grant – 06706000. The gage is located 1.3 miles downstream from the East Portal of Roberts Tunnel.

Native Flow Diversions

Native flows on the North Fork South Platte River downstream of the East Portal of the Robert Tunnel are affected by Denver Water's transbasin diversions from the Blue River. Because there is relatively little water use within this reach of the North Fork South Platte River, hydrologic changes are due primarily to Roberts Tunnel deliveries. Table H-12.21 shows the native flow at the North Fork South Platte River below the Geneva Creek gage and the Roberts Tunnel delivery under Current Conditions, Full Use of the Existing System, the action alternatives, and the No Action Alternative. The average annual percentage of native flow added to this segment of the North Fork South Platte River is approximately 131% of the average annual native flow under Current Conditions. The average monthly percentage of flow added to this river segment is greatest during the fall and winter because native flows are typically lowest during those months. In average years, the percentage of flow added to the North Fork South Platte River at Geneva Creek gage ranges up to 425% in February. Average monthly flows and Roberts Tunnel deliveries are 16.6 cfs and 70.3 cfs, respectively in February. In dry years, the percentage of flow added to the North Fork South Platte River ranges up to 635% in February. Average monthly flows and Roberts Tunnel deliveries are 14.1 cfs and 89.4 cfs, respectively in February in a wet year. While, the percentage of flow added to the North Fork South Platte River from the Roberts Tunnel is significant, the river segment below the Roberts Tunnel outfall has been modified to accommodate up 680 cfs (daily average) at Grant and 980 cfs (daily average) above the confluence with the mainstem. Flow increases under each of the Moffat Project alternatives

and No Action Alternative compared to native flows in the North Fork South Platte River are discussed in Section 4.6.1.

Floodplains

Portions of the North Fork South Platte River floodplain have been mapped by FEMA. The North Fork South Platte River has a Zone A designated floodplain starting downstream of the confluence with Handcart Gulch and extending to just upstream of the confluence with Bone Creek. Zone A is defined as an area with a 1% annual chance of flooding; no detailed analyses have been performed and no base flood elevations are shown (FEMA 2009). There is another stretch of Zone A designated floodplain through the Town of Webster, Colorado at the confluence with Kenosha Gulch. There is a detailed floodplain study extending from the confluence with Homes Gulch downstream to the confluence with the South Platte River. This area consists of a Zone A and Zone AE designated floodplain. Zone AE is defined as an area with a 1% annual chance of flooding based on elevations derived from detailed analyses (FEMA 2009). The 100-year floodplain elevation ranges from a base flood elevation of 6,776 feet just upstream of Crystal Lake down to 6,714 feet near the confluence with Elk Creek based on FIRM dated 2003.

3.1.5.7 South Platte River

Hydrology

The overall study area of this basin extends from Antero Reservoir to Big Dry Creek near the Henderson gage. This river segment contains six mainstem reservoirs: Antero, Spinney Mountain, Eleven Mile Canyon, Cheesman, Strontia Springs, and Chatfield. This basin has been subdivided into an upper segment from Antero Reservoir downstream to the mouth of Waterton Canyon downstream of Strontia Springs Reservoir, and from Waterton Canyon downstream to Henderson.

South Platte River from Antero Reservoir to Waterton Canyon

The headwaters of the South Platte River lie on the east side of the Mosquito Range, among 13,000 and 14,000-foot peaks that form the western perimeter of Colorado's South Park. South Park is a wide, level mountain valley approximately 40 miles from north to south and 25 miles from east to west. Three major streams flow generally southeast across the plain of South Park. From north to south they are Tarryall Creek, Middle Fork South Platte River, and South Fork South Platte River. Three miles east of the Town of Hartsel, the Middle Fork joins the South Fork to form the South Platte River, which exits the mountain valley along its southeast boundary. Tarryall Creek leaves South Park on its eastern edge, following a valley between the Tarryall Mountains and Puma Hills. It joins the South Platte River more than 30 stream miles below the confluence of the Middle and South forks. The upper South Platte River Basin lies generally above 8,800 feet. Although the western peaks receive over 30 inches of precipitation annually, normal precipitation at Antero Reservoir on the valley floor is less than 10 inches. The land and water in South Park were used historically for ranching, but in recent decades, most of the water once used to irrigate hay and pasture grass has been purchased by the City of Aurora and Denver Water.

Antero Reservoir is located on the South Fork South Platte River. This 20,015 AF facility belongs to Denver Water, and provides carryover storage for long droughts. As such, it

does not fluctuate seasonally; once drawn down, it may take more than one season to fill because of limited physical supply, high evaporation rates, and junior water rights. Minimum outflow from Antero Reservoir is generally maintained at the lesser of 5 cfs or inflow (Denver Water 1995b). CWCB holds minimum instream flow rights in the headwater tributaries of the South Platte River, but there are no instream flow rights below Antero Reservoir.

Figures in Appendix E-1 show historical Antero Reservoir end-of-month content and water elevations.

Below the confluence of the South and Middle forks of the South Platte River is Spinney Mountain Reservoir. It has a capacity of 53,651 AF. The City of Aurora stores South Platte River water in Spinney Mountain, as well as transbasin water diverted from the Colorado (Homestake Project) and Arkansas (Frying Pan-Arkansas Project) river basins and delivered via the Otero pumping plant and pipeline. Water is delivered from Spinney Mountain Reservoir to Aurora via the South Platte River channel to Strontia Springs Reservoir, where it is taken into Aurora's Rampart Pipeline System (Denver Water 1995c).

The upper end of Eleven Mile Canyon Reservoir lies about 3.5 miles below Spinney Mountain Reservoir dam, at the eastern edge of South Park. This is Denver Water's largest East Slope reservoir, at 97,779 AF. Its drainage area is 963 square miles, and the dam crest elevation is at 8,600 feet. The reservoir is 6 miles long. Like Antero Reservoir, Eleven Mile Canyon is operated for long-term drought storage and may require multiple seasons to fill after being drawn down. There is no minimum flow requirement below Eleven Mile Canyon, as Aurora's deliveries through Eleven Mile Canyon and bypasses for senior downstream rights are generally adequate to maintain fish flows (Denver Water 1995d). Additionally, in accordance with the A-2 Flow Plan, Denver Water releases a minimum outflow of 32 cfs or the 7-day running average of the computed inflow, whichever is less. There are no CWCB minimum instream flow rights in this section of the river. Figures in Appendix E-1 show historical Eleven Mile Canyon Reservoir end-of-month content and water elevations.

Below Eleven Mile Canyon Reservoir the river begins a much steeper descent through Eleven Mile Canyon, then the South Platte River Canyon and Waterton Canyon, where it emerges onto the eastern plains. Major tributaries in this reach are Tarryall Creek, Goose Creek, and the North Fork South Platte River. The North Fork South Platte River delivers Denver Water's imported Blue River water to the South Platte River, having been brought by the Roberts Tunnel. With the exception of these streams, which enter from the northwest, the South Platte River drainage is a relatively narrow corridor through 8,000 to 9,000-foot mountains in this reach. It is generally forested and sparsely populated, with the small towns of Lake George, just below Eleven Mile Canyon, and Deckers below Cheesman Reservoir. Irrigable terrain is absent due to the narrow canyon and stream gradient, and there is no historical agricultural use along this reach. The river is a prized fly fishing stream and receives heavy recreational use in spring and summer. There are no CWCB minimum instream flow rights from Eleven Mile Canyon Reservoir to and through Waterton Canyon.

Cheesman Reservoir is located at the confluence of Goose Creek and the South Platte River. It was Denver Water's first mountain reservoir, and has a capacity of 79,064 AF. It provides

both seasonal and long-term supply (Denver Water 1995e). Because of its senior rights, it is the most quickly filled of Denver Water's South Platte reservoirs. Figures in Appendix E-1 show historical Cheesman Reservoir end-of-month content and water elevations.

The South Platte Protection Plan (SPPP) established in June 2003 was a locally generated alternative to a USFS recommendation for designation of the South Platte River under the Wild and Scenic Rivers Act. The SPPP includes a Streamflow Management Plan, under which Denver Water commits to the following minimum outflows from Eleven Mile Canyon and Cheesman reservoirs:

- At Eleven Mile Canyon Reservoir, Denver Water commits to release a minimum outflow of 32 cfs or the 7-day running average of computed inflow, whichever is less.
- At Cheesman Reservoir, Denver Water commits to release a minimum of 35 cfs from August through March and 40 cfs from April through July or the 7-day running average of the computed inflow, whichever is less.

All operations under the SPPP are subject to the principle of no loss of existing or future water supply. It is possible that conditions could occur under which Denver Water would reduce bypass flows below Eleven Mile Canyon and Cheesman reservoirs. It is possible that, with or without the proposed Moffat Project, conditions could occur under which Denver Water would reduce bypass flows below Eleven Mile Canyon and Cheesman reservoirs to ensure no loss of yield occurs. However, the Proposed Action would not change the likelihood of these conditions occurring nor would it change Denver Water's commitments made in the SPPP agreement, including minimum reservoir releases. Strontia Springs Reservoir, located at the upper end of Waterton Canyon, is Denver Water's major diversion point from the South Platte River. It was constructed in the early 1980s to create head, presettlement, and regulating capability for the Foothills WTP. The City of Aurora also uses Strontia Springs Reservoir, diverting through a separate intake and conduit. Minimum downstream releases of 60 cfs in the summer and 30 cfs in the winter are required below Strontia Springs (Denver Water 1995f). Three miles downstream from Strontia Springs Reservoir, Denver Water can also divert at the Conduit 20 Diversion, a concrete diversion dam that serves the Marston WTP and Marston Reservoir. At the mouth of Waterton Canyon, at an elevation of approximately 5,525 feet, the South Platte River leaves the foothills.

Graphs of annual flow and average monthly flow are presented in Appendix E-2 for the USGS gage at South Platte River (06707500).

South Platte River from Waterton Canyon to Henderson

The section of the river from the mouth of Waterton Canyon to the USGS gage at Henderson is commonly referred to as the "Metro reach." It extends over 30 miles, dropping to an elevation of 4,999 feet. At the Henderson gage, the river has a drainage area of 4,768 square miles (USGS 2005a). This reach is characterized by large diversions for both municipal and irrigation use, and an urban and suburban setting that includes wastewater return flows at the Littleton-Englewood (Bi-City) WWTP, Metro Wastewater Reclamation District Robert W. Hite Treatment Facility, and the Broomfield WWTP. Major tributaries are Deer Creek, Bear Creek, and Clear Creek from the west, and Cherry Creek from the east.

Minimum fish flows downstream of Strontia Springs Dam are required by the "Water Management Plan for the South Platte River Canyon Below Strontia Springs Dam" (approved May 16, 1979, and incorporated into the August 16, 1978 Amendment to the Grant of an Easement). The minimum flow requirements are 60 cfs from May 15 to September 15 and 30 cfs from September 16 to May 14. Fifteen cfs of the winter minimum flow may be diverted by Denver Water at the Old Last Chance Ditch upstream of Chatfield Reservoir. Easement Amendment No. 4, dated April 15, 2004, allows for reductions in the summer minimum flow requirements as follows:

- During a Stage 1 drought response, as defined by voluntary water restrictions, Denver Water may divert 15 cfs of the 60 cfs minimum flow at the Old Last Chance Ditch Diversion, leaving 45 cfs in the river.
- During a Stage 2 drought response, as defined by mandatory water restrictions, Denver Water may divert 30 cfs of the 60 cfs minimum flow at the Old Last Chance Ditch Diversion, leaving 30 cfs in the river.
- During a Stage 3 drought response, as defined by total constraint of outdoor lawn watering, Denver Water may divert 45 cfs of the 60 cfs minimum flow at the Old Last Chance Ditch Diversion, leaving 15 cfs in the river.

Chatfield Reservoir, a U.S. Army Corps of Engineers facility, is located at the upper end of the reach. Denver Water has 27,428 AF of capacity to manage their supply in Chatfield Reservoir, which it uses primarily to capture minimum releases from Strontia Springs Reservoir and the yield of downstream water rights and return flows that cannot immediately be exchanged to Strontia Springs or other South Platte reservoirs. Denver Water's pool operates within the reservoir's conservation pool, and represents less than 5% of the reservoir's total capacity, which is primarily for flood control. As such, Denver Water's operations occur well within the spatial extent of the flood pool. A State park is located at Chatfield Reservoir and provides a swimming beach, camping, and boating facilities.

Major diverters in the southern half of the Metro reach include the City of Englewood, Centennial Water and Sanitation District, Public Service Company, and Denver Water. Much of this water is used for irrigation of municipal sites and facilities by Englewood and Denver. Xcel Energy takes delivery of relatively small amounts of water at its Arapahoe, Cherokee, and Zuni plants in this reach.

There are three major diversions in the northern half of the reach. Gardener's Ditch and Burlington Ditch are located on opposite sides of the river, above the Metro WWTP outfall. The river can be dried up for a distance of about a mile and a half here. The last diversion is the Fulton Ditch. These three ditches continue to serve irrigation use, although some of the historical irrigation supply has been transferred to municipal/augmentation uses. This section of the river is paralleled by numerous gravel mining operations. Several spent mines have been or will be converted to lined pits used for storage and regulation of South Platte River water by various entities. There are no CWCB minimum instream flow rights on the South Platte River through the Metro reach.

Graphs of annual flow and average monthly flow are presented in Appendix E-2 for USGS gages at Denver (06714000) and at Henderson (06720500).

Floodplains

Detailed floodplain studies have been conducted for several portions of the South Platte River. There is a detailed floodplain study extending approximately 1 mile downstream from the confluence with Lazy Gulch. This area consists of a Zone AE designated floodplain. Zone AE is defined as an area with a 1% annual chance of flooding based on elevations derived from detailed analyses (FEMA 2009). For this area, the 100-year floodplain elevation ranges from a base flood elevation of 6,417 feet down to 6,381 feet based on FIRM dated 2003. The next area for which a detailed study was conducted extends from just upstream of Mineral Avenue downstream to Fairway Lane. This area consists of a Zone AE designated floodplain. For this area, the 100-year floodplain elevation ranges from a base flood elevation of 5,365 feet down to 5,338 feet based on FIRM dated 1995. The next area for which a detailed study was conducted extends from just downstream of West Oxford Avenue downstream to the edge of the City and County of Denver Corporate limits. This area consists of a Zone AE designated floodplain. For this area, the 100-year floodplain elevation ranges from a base flood elevation of 5,272 feet down to 5,134 feet based on FIRM dated 1995 and 2005.

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3.2 WATER QUALITY

3.2.0 Overview

This section describes the affected environment for water quality in the Moffat Collection System Project (Moffat Project or Project) area including existing surface water quality conditions for reservoirs and river segments. Available water quality information is presented, including:

- Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Commission (WQCC) Classification (CDPHE 2011a)
- State of Colorado (State) Section 303(d) and Monitoring and Evaluation List of Impaired Waterbodies, per Regulation 93 (CDPHE 2012a)
- Water quality data for various parameters (multiple sources)
- Location of wastewater treatment facilities and permitted discharge quantity into each basin (EPA 2010a)
- Potable water providers (EPA 2010b) that use surface water in each basin

The WQCC classifies stream segments according to "actual beneficial uses of the water." WQCC classifications are defined as follows (CDPHE 2011a):

- *"Recreation Class E – Existing Primary Contact Use*. These surface waters are used for primary contact recreation or have been used for such activities since November 28, 1975."
- *"Recreation Class P – Potential Primary Contact Use*. These surface waters have the potential to be used for primary contact recreation."
- *"Recreation Class N – Not Primary Contact Use*. These surface waters are not suitable or intended to become suitable for primary contact recreation uses."
- *"Recreation Class U – Undetermined Use*. These are surface waters whose quality is to be protected at the same level as existing primary contact use waters, but for which there has not been a reasonable level of inquiry about existing recreational uses and no recreation use attainability analysis has been completed."
- *"Agriculture*. These surface waters are suitable or intended to become suitable for irrigation of crops usually grown in Colorado and which are not hazardous as drinking water for livestock."
- *"Class 1 – Cold Water Aquatic Life*. These are waters that (1) currently are capable of sustaining a wide variety of cold water biota, including sensitive species, or (2) could sustain such biota but for correctable water quality conditions."
- *"Class 1 – Warm Water Aquatic Life*. These are waters that (1) currently are capable of sustaining a wide variety of warm water biota, including sensitive species, or (2) could sustain such biota but for correctable water quality conditions."

- *"Class 2 – Cold and Warm Water Aquatic Life*. These are waters that are not capable of sustaining a wide variety of cold or warm water biota, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions that result in substantial impairment of the abundance and diversity of species."
- *"Domestic Water Supply*. These surface waters are suitable or intended to become suitable for potable water supplies. After receiving standard treatment (defined as coagulation, flocculation, sedimentation, filtration, and disinfection with chlorine or its equivalent) these waters will meet Colorado drinking water regulations and any revisions, amendments, or supplements thereto."

Stream segments reviewed in the Moffat Project Environmental Impact Statement (EIS) with associated CDPHE regulations are summarized in Table 3.2-1.

Table 3.2-1
Stream Classifications in the Moffat Project Area

Basin	Stream Segment	CDPHE Stream Segment	CDPHE Stream Classification
Fraser River	Mainstem and tributaries	Region 12. Upper Colorado River Segments 10a, 10b, and 10c	Cold Stream, Classes 1 and 2
Williams Fork River	Mainstem and tributaries	Region 12. Upper Colorado River Segment 8	Cold Stream, Class 1
Williams Fork River	Williams Fork Reservoir	Region 12. Upper Colorado River Segment 5	Cold Lake, Class 1
Colorado River	Mainstem from Lake Granby to Roaring Fork	Region 12. Upper Colorado River Segment 3	Cold Stream, Class 2
Colorado River	Grand Lake, Shadow Mountain Reservoir, Lake Granby	Region 12. Upper Colorado River Segment 12	Cold Lake, Class 1
Muddy Creek	Mainstem from Wolford Mountain Reservoir to the Colorado River	Region 12. Upper Colorado River Segment 7b	Cold Stream, Class 1
Muddy Creek	Wolford Mountain Reservoir	Region 12. Upper Colorado River Segment 5	Cold Lake, Class 1
Blue River	Dillon Reservoir	Region 12. Blue River Segment 3	Cold Lake, Class 1
Blue River	Mainstem and tributaries from Dillon Reservoir to Colorado River	Region 12. Blue River Segment 17	Cold Stream, Class 1
South Boulder Creek	Mainstem from source to the outlet of Gross Reservoir	Regions 3 and 4. Boulder Creek Segment 4a	Cold Stream, Class 1
South Boulder Creek	Mainstem from Gross Reservoir to South Boulder Road Reservoir (study area does not extend past Eldorado Springs)	Regions 3 and 4. Boulder Creek Segment 4b	Cold Stream, Class 1
South Boulder Creek	Gross Reservoir	Regions 3 and 4. Boulder Creek Segment 15	Cold Lake, Class 2

Table 3.2-1 (continued)
Stream Classifications in the Moffat Project Area

Basin	Stream Segment	CDPHE Stream Segment	CDPHE Stream Classification
North Fork South Platte River	Mainstem	Regions 3 and 4. Upper South Platte River Segment 4	Cold Stream, Class 1
South Platte River	Mainstem from source to inlet of Cheesman Reservoir	Regions 3 and 4. Upper South Platte River Segments 1a and 2a	Cold Stream, Class 1
South Platte River	Mainstem from the outlet of Cheesman Reservoir to the inlet of Chatfield Reservoir	Regions 3 and 4. Upper South Platte River Segment 6a	Cold Stream, Class 1
South Platte River	Chatfield Reservoir	Regions 3 and 4. Upper South Platte River Segment 6b	Cold Lake, Class 1
South Platte River	Mainstem from the outlet of Chatfield Reservoir to Burlington Ditch	Regions 3 and 4. Upper South Platte River Segment 14	Warm Stream, Class 1
South Platte River	Mainstem from Burlington Ditch to Big Dry Creek (study area does not extend past Henderson)	Regions 3 and 4. Upper South Platte River Segment 15	Warm Stream, Class 2, Use-Protected

Note:
CDPHE = Colorado Department of Public Health and Environment

The purpose of the CDPHE procedures and regulations, specifically Regulation No. 31 and associated regulations (i.e., Regulations 32 through 39), for evaluating surface water quality is to ensure "the suitability of Colorado's waters for beneficial uses including public water supplies, domestic, agricultural, industrial, and recreational uses, and the protection and propagation of terrestrial and aquatic life. It is further intended to be consistent with the 1983 and 1985 goals and objectives of the Federal Act" (from Paragraph 31.2 of Regulation No. 31, CDPHE 2011a). As part of these procedures and regulations, CDPHE designates each stream segment as one of the following:

- *Outstanding Waters* – Waters that have the highest level of water quality protection. These waters have water quality better or equal to that listed in the regulations. These waters also are an outstanding natural resource such as a national park and the waters require protection beyond that provided by a reviewable designation. No stream segments potentially affected by any of the Moffat Project alternatives have this designation.
- *Use-Protected Waters* – Waters that do not warrant the special protection of outstanding waters or the anti-degradation review process. The level of water quality protection ensures that uses are maintained and protected. Use-Protected waters are allowed to degrade to the level of the water quality standards. Stream segments potentially affected by the Moffat Project alternatives that have this designation occur in the South Platte River through the Denver Metropolitan area.

- *Reviewable Waters* – Any water not designated as Outstanding or Use-Protected. This designation is intended to provide protection through a review of potential changes but also allows for changes when justified by economic or social need.

For Reviewable waters, CDPHE has developed criteria for characterizing existing water quality as well as for determining significant impacts to existing water quality. Specifically, existing water quality is defined and/or determined through the following parameters, per CDPHE documents (CDPHE 2001, 2011a):

- CDPHE uses September 30, 2000 as the baseline date for water quality characterization. For purposes of this EIS, existing water quality is based on data within the time period of 2000 to the time of the analysis (ranges from 2007 to 2010 as noted below).
- Ambient water quality conditions are determined using the 85th percentile of representative data unless sufficient low flow data are available. If sufficient low flow data are available, then the 50th percentile of low flow data may be used. Data should be recent, within the last 5 years.
- For data to be considered sufficient, 15 or more samples should be available. Outliers should be handled by use of the 85th percentile and/or geometric mean but professional judgment can also be used.
- The water quality data reported values as less than a numeric value, below detection limit (bdl), and not detected. All of these were converted to "0" for statistical purposes, per CDPHE (CDPHE 2001). When the statistical result was "0," that result is reported herein as "bdl," or below detection limit.
- The stream standard used for comparison to *in situ* water quality data was the chronic standard. The chronic standard is more stringent than the acute standard.
- For specific types of parameters, ambient water quality is determined through the following metrics (subject to availability of low flow data as noted above):
  - Dissolved Metals (85th Percentile)
  - Total or Recoverable Metals (50th Percentile)
  - Fecal Coliform, *Escherichia coli* (*E. Coli*) (Geometric Mean)
  - Dissolved Oxygen (15th Percentile)
  - pH (15th and 85th Percentiles)
  - All Others (85th Percentile)
- *Temperature* – Ambient water quality is determined through the maximum weekly average temperature (MWAT) in a three-year period with the exclusion of values concurrent with maximum daily air temperatures greater than the 90th percentile of historical monthly temperature maxima for chronic standard. The daily maximum (DM) is used for the acute standard again with the exclusion of values concurrent with maximum daily air temperatures greater than the 90th percentile of historic daily temperature.

CDPHE Regulation 93 (CDPHE 2012a) provides the 303(d) List and the Monitoring and Evaluation List. The 303(d) List, Water-Quality-Limited Segments Requiring Total Maximum Daily Load (TMDLs), "fulfills requirements of section 303(d) of the Federal Clean Water Act (CWA) which requires that states submit to the U.S. Environmental Protection Agency (EPA) a list of those waters for which technology-based effluent limitations and other required controls are not stringent enough to implement water quality standards" (CDPHE 2012a). The Monitoring and Evaluation List "identifies water bodies where there is reason to suspect water quality problems, but there is also uncertainty regarding one or more factors, such as the representative nature of the data. Water bodies that are impaired, but it is unclear whether the cause of impairment is attributable to pollutants as opposed to pollution, are also placed on the Monitoring and Evaluation List. This Monitoring and Evaluation List is a State-only document that is not subject to EPA approval" (CDPHE 2012a).

Water quality data were obtained in 2007 through both the U.S. Geological Survey (USGS) and Storage and Retrieval EPA Database (STORET) data searches. Additional data was obtained in 2009 for select locations in the Fraser and Colorado river basins and for select reservoirs. This data was obtained from USGS, the Board of Water Commissioners (Denver Water), and the Grand County Water Information Network (GCWIN). Additional data was obtained in 2010 for specific segments in response to Draft EIS comments. The statistical analyses performed on all three datasets are limited to data from 2000 to the present. CDPHE guidance states that data should be no more than five years old (CDPHE 2001). Data from the year 2000 and newer has been used to be consistent with the original dataset (analysis performed 2005-2007) presented in the Draft EIS as well as to provide sufficient representative data for subsequent analyses presented in the Final EIS. The data were also reviewed for statistical outliers prior to performing any statistical analyses. In cases where the value was recorded as "Non-Detect," meaning below the detection level for that constituent, the data value was changed to a zero value in order to perform the statistical analysis (CDPHE 2001).

Existing water quality was characterized by comparing water quality data from locations throughout the Project area to the stream standards for the same locations. Hardness-based acute and chronic stream standards were calculated using the 15th percentile of hardness. CDPHE protocol for calculating hardness-based stream standards call for use of "the lower 95 percent (%) confidence limit of the mean hardness value at the periodic low flow criteria as determined from a regression analysis of site-specific data," or the "mean hardness" where sufficient paired flow and hardness data do not exist (CDPHE 2011a). Many sampling sites within the Project area do not have flow data concurrent with water quality sampling, preventing use of the lower 95th percentile confidence limit of the mean hardness value at low flow. Additionally, use of the mean hardness may fail to identify sites that may have ambient conditions that are approaching the standard. Therefore, it was determined that use of the 15th percentile of hardness for a given sampling site provides a reasonable estimation of the lower values for hardness (which results in lower standards and conservative estimates). Additionally, use of the 15th percentile provides for consistency throughout the EIS.

An evaluation of the available water quality data was conducted in an attempt to characterize the seasonal fluctuations in existing water quality within the Project area to

support analysis in Chapters 4 and 5 of how these fluctuations would relate to the operation patterns of the Moffat Project alternatives. Based on this evaluation, it was concluded that sufficient water quality data do not exist to appropriately characterize the seasonal fluctuations in existing water quality within the Project area. The absence of representative seasonal water quality data is, in large part, attributable to the fact that water quality sampling tends to occur in focused efforts during specific periods of interest (e.g., low flow periods) rather than on a consistent temporally distributed basis. Therefore, it was determined that this type of analysis would not feasible as part of this EIS.

Wastewater treatment facilities and other long-term discharges with National Pollutant Discharge Elimination System (NPDES) permits are listed below (i.e., temporary construction permits are not listed or evaluated). These were obtained from the EPA's Enforcement and Compliance History Online (ECHO) system (EPA 2010a). Identification of potable water providers that use surface water or groundwater under the influence of surface water in potentially affected stream segments was done through EPA's Safe Drinking Water Information System (EPA 2009).

3.2.1 Reservoirs

3.2.1.1 Gross Reservoir

Gross Reservoir is within WQCC Segment 15 of the Boulder Creek Basin and is classified as Aquatic Life Cold 2, Recreation E, Water Supply, and Agriculture (CDPHE 2011b). Gross Reservoir is listed in Regulation 93 on the Monitoring and Evaluation List for Aquatic Life Use due to mercury in fish tissue (CDPHE 2012a).

Water quality data for Gross Reservoir was obtained from Denver Water with two sample sites—one near the inlet and one near the dam (Denver Water 2009a). The water quality data is summarized in Table 3.2-2, with the State standard shown where applicable. Gross Reservoir meets or exceeds State water quality standards.

Table 3.2-2
Gross Reservoir Water Quality

Parameter	Statistics	Units	Value	Standard (Regulation 38)
Temperature	Maximum	°C	19.4 [101]	21.2
Dissolved Oxygen	15th Percentile	mg/L	9.9 [101]	7.0
pH	15th Percentile	SU	7.3 [101]	6.5
pH	85th Percentile	SU	7.9 [101]	9.0
Chlorophyll *a*	85th Percentile	µg/L	4.85 [6]	N/A
Secchi Depth	15th Percentile	meters	2.4 [6]	N/A

Table 3.2-2 (continued)
Gross Reservoir Water Quality

Parameter	Statistics	Units	Value	Standard (Regulation 38)
Conductivity	85th Percentile	µS/cm	62 [101]	N/A
Turbidity	85th Percentile	NTU	2.0 [88]	N/A

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.

°C = degrees Celsius
µg/L = micrograms per liter
µs/cm = microSiemens per centimeter
mg/L = milligrams per liter
N/A = not applicable
NTU = nephelometric turbidity unit
SU = standard unit

Algae levels are low to moderate (chlorophyll *a* averages 3.6 micrograms per liter [µg/L]). Water clarity, measured by Secchi disk depth, is moderate, averaging 3.4 meters and with a minimum of 2 meters. Based on Vollenweider's 1982 equations relating phosphorus, chlorophyll *a*, and Secchi transparency, an average phosphorus concentration of 4 µg/L should yield an average chlorophyll *a* level of 2.1 µg/L and a maximum of 5.5 µg/L, with water clarity near 6.6 meters (Vollenweider 1982). There may be fine inorganic particles that minimize water clarity without adding to the algal levels, but only one slightly elevated turbidity value (11 nephelometric turbidity unit [NTU]) was observed.

Gross Reservoir contains water of a quality suitable for virtually all uses. There is no evidence of deterioration in the hypolimnion during stratification, and minimum and maximum values for all assessed water quality variables are acceptable for a drinking water supply.

When the reservoir is stratified, inflow waters enter the reservoir and move to the water column depth having a similar density and temperature. An analysis of observed upstream temperatures and continuous outflow temperatures indicates that reservoir outlet water tends to be cooler than inflow water (as measured at Pinecliffe) from roughly June through August/September (Hawley et al. 2013). The data also show that the reservoir tends to release water warmer than inflow water during September and October through early spring. This seasonal pattern reflects the effects of summer stratification and bottom withdrawals.

3.2.1.2 Leyden Gulch Reservoir Site

Leyden Gulch is within WQCC Segment 18b of the Clear Creek Basin and is classified as Aquatic Life Warm 2, Recreation N, Water Supply, and Agriculture. Leyden Gulch is Use-Protected. Leyden Gulch is not listed in Regulation 93 (CDPHE 2012a) on the 303(d) or the Monitoring and Evaluation Lists. There are no existing water quality data in the USGS or STORET databases in close proximity to the Leyden Gulch site.

3.2.1.3 Williams Fork Reservoir

The Williams Fork Reservoir is within Segment 5 of the Colorado River and is classified as Aquatic Life Cold Water Class 1, Recreation E, Water Supply, and Agriculture uses (CDPHE 2008a). The Williams Fork Reservoir is not listed on the 303(d) or Monitoring and Evaluation List as detailed in CDPHE Regulation No. 93 (CDPHE 2012a).

Single monthly samples were taken during May through October of 2000, June through September of 2001, and June through September of 2003 (Denver Water 2004e). The data collection effort focused on the ice-free period because summer stratification is generally the period when water temperatures or dissolved oxygen would have the greatest potential to affect aquatic resources.

The CDPHE DM temperature standard for the Williams Fork Reservoir is 23.8 degrees Celsius (°C) (CDPHE 2011c) April through December. USGS and Denver Water temperature records for the Williams Fork River immediately downstream of the reservoir for the years 1964 through 2003 indicate temperatures never reached 20ºC. Of the 301 measurements taken during this time, the highest temperature recorded was a single occurrence of 19ºC (Denver Water 2004e). Sufficient data is not available to determine the MWAT.

Temperature profiles for 2003 indicate that Williams Fork Reservoir undergoes thermal stratification during the summer. Thermal warming of the surface begins in May, with a well-defined thermocline of about 10 meters gradually developing starting at a depth of 5 to 10 meters below the surface (Denver Water 2004e). By June, water temperatures are generally relatively uniform below 20 or 25 meters. Fall turnover begins in September, and the resulting reservoir destratification is generally complete by October when the water temperatures are relatively uniform throughout the reservoir.

Thermal stratification affects dissolved oxygen levels throughout the reservoir water column during the summer months. June, July, and August dissolved oxygen concentrations measured near the dam were fairly constant at all depths, with readings of 6 to 8 milligrams per liter (mg/L) (Denver Water 2004e). As thermal warming occurs in the summer months, dissolved oxygen levels of the upper layers fall slightly, and dissolved oxygen levels are generally relatively uniform at all depths below the thermocline. The lowest dissolved oxygen levels were recorded late in the season at the greatest depth.

3.2.1.4 Three Lakes (Granby Reservoir, Shadow Mountain Reservoir, and Grand Lake)

The Three Lakes system consists of Granby Reservoir (sometimes referred to as Lake Granby), Shadow Mountain Reservoir, and Grand Lake. These three water bodies are operated together for the Colorado-Big Thompson (C-BT) Project and water can move in either direction through the three lakes. The Windy Gap Project uses the facilities of the C-BT system in conjunction with the operation of Windy Gap Reservoir. Water is pumped from Windy Gap Reservoir through the Three Lakes system, then to the Front Range. Because of the operation of the C-BT system and the fact that the Fraser River discharges into the Colorado River upstream of Windy Gap Reservoir, changes in water quality in the Fraser River have the potential to effect changes in the Three Lakes system. The existing condition of the Three Lakes is described in this section because of potential changes in the Fraser River from the Moffat Project. Key parameters of interest for potential impact by

changes in the Fraser River include clarity, chlorophyll *a*, dissolved oxygen, nitrogen, and phosphorus. These parameters for the Three Lakes are presented in Table 3.2-3.

Table 3.2-3
Selected Water Quality Parameters in the Three Lakes

Parameter	Minimum	Median	Maximum
Grand Lake (Epilimnion Grab Samples at Grand Lake)			
Secchi Disk Depth, m	1.98	3.43	5.74
Chlorophyll *a*, µg/L	1.60	2.70	5.80
Dissolved Oxygen, mg/L	7.30	7.90	8.42
Ammonia, dissolved, µg/L	3.50	7.25	15.00
Nitrate+Nitrite, dissolved, µg/L as N	8.00	15.00	139.00
TKN, µg/L as N	180.00	200.00	220.00
TP, µg/L as P	5.00	9.50	15.00
Orthophosphate, dissolved, µg/L as P	3.00	3.00	4.00
Shadow Mountain Reservoir (Epilimnion Grab Samples)			
Secchi Disk Depth, m	0.97	2.44	3.95
Chlorophyll *a*, µg/L	0.50	3.40	35.40
Dissolved Oxygen, mg/L	6.10	8.00	9.60
Ammonia, dissolved, µg/L	1.00	5.00	24.00
Nitrate+Nitrite, dissolved, µg/L as N	1.50	17.00	114.00
TKN, µg/L as N	76.00	258.00	393.00
TP, µg/L as P	4.00	15.00	27.00
Orthophosphate, dissolved, µg/L as P	0.50	2.00	7.00
Granby Reservoir (Epilimnion Grab Samples Near Lake Reservoir)			
Secchi Disk Depth, m	1.57	3.66	7.95
Chlorophyll *a*, µg/L	1.00	4.40	29.80
Dissolved Oxygen, mg/L	6.10	7.20	14.10
Ammonia, dissolved, µg/L	1.50	7.00	78.00
Nitrate+Nitrite, dissolved, µg/L as N	1.50	8.00	70.00
TKN, µg/L as N	23.00	215.00	480.00
TP, µg/L as P	1.50	11.00	31.00
Orthophosphate, dissolved, µg/L as P	0.50	3.00	7.00

Source: Reclamation, 2008.
Notes:
The number of data points used in the analysis is not available/not contained in the source document.
µg/L = micrograms per liter
m = meter
mg/L = milligrams per liter
N = nitrogen
P = phosphorus
TKN = total Kjeldahl nitrogen
TP = total phosphorus

Although a significant amount of data and literature are available on the Three Lakes system, nutrients are the focus of describing existing conditions in the EIS. This parameter is most likely to impact the Three Lakes system from increased nutrient loading due to a reduction in dilution of point and non-point sources of nitrogen and phosphorus. The potential reduction in dilution is from projected changes in flow, including flow changes associated with Moffat Project.

The Three Lakes are within Segment 12 of the upper Colorado River. All are classified as Aquatic Life Cold 1, Recreation E, Water Supply, and Agriculture (CDPHE 2011a). Shadow Mountain Reservoir is on the 303(d) List for dissolved oxygen. Granby Reservoir is on the 303(d) List for Aquatic Life Use due to findings of mercury in sport fish (CDPHE 2012a).

Grand Lake, the largest and deepest natural lake in Colorado, stratifies in the summer. Average chlorophyll *a* concentrations indicate a mesotrophic trophic state. Orthophosphate and inorganic nitrogen concentrations are low and typical of an oligotrophic trophic state (Reclamation 2008).

Shadow Mountain Reservoir is shallow and typically does not stratify, or stratifies weakly. Average chlorophyll *a* concentrations are indicative of a mesotrophic state. Nitrogen and orthophosphate concentrations are low and typical of an oligotrophic system. Two concerns were noted in the Lake and Reservoir Water Quality Technical Report for the Windy Gap Firming Project: excessive aquatic vegetation growth and the formation of a delta where the North Fork enters the reservoir (Reclamation 2008).

Granby Reservoir has average chlorophyll *a* concentrations that indicate a mesotrophic trophic state. Nitrogen and orthophosphate concentrations are low and typical of an oligotrophic system. Granby Reservoir stratifies (Reclamation 2008).

3.2.1.5 Dillon Reservoir

Limited data on nutrients, temperature, and dissolved oxygen for the years 2000 to 2003 are available from the USGS (USGS 2009a). Data on the Blue River immediately upstream and downstream of the reservoir are available from Denver Water for 1999 through 2005 (Denver Water 2006d). Using the data from the 8 months sampled in both 2004 and 2005, some conclusions of the effect of the reservoir on river water quality can be made. The months having water quality data at the inlet and outlet include: January, March, May, June, July, August, September, and November. Secchi disk depths from the USGS data indicate that the water quality in Dillon Reservoir is generally very good with a minimum measurement of 145 feet and a mean of 200 feet or more, dependent on location.

Temperatures in Dillon Reservoir range from 1.25 to 18.5ºC versus a DM standard of 23.8ºC. Insufficient data are presented to calculate a MWAT. Temperatures in the Blue River were lower at the outlet than at the inlet in 15 of the 16 months sampled (Denver Water 2006d). The temperature range at the outlet was lower throughout the year (1 to 12ºC) than at the inlet (0 to 17ºC). Based on these data, the reservoir tends to release water at cooler and more moderate temperatures than at the inlet of the Blue River.

The USGS data also provides dissolved oxygen concentrations ranging from 0.10 to 10.2 mg/L; the regulatory limit is a minimum of 6.0 mg/L. The very low dissolved oxygen concentrations appear to be in the thermocline as sufficient oxygen is available 5 feet above and below the very low measurements. Dissolved oxygen measurements at the inlet and outlet do show the effect of the reservoir on water quality in the Blue River. The range of dissolved oxygen concentrations in 2004 and 2005 were greater at the inlet (6.1 to 9.4 mg/L) than at the outlet (6.2 to 8.3 mg/L). Outlet dissolved oxygen concentrations were lower than at the inlet in 12 of 15 sampling months, but all measurements were above 6.0 mg/L, the minimum standard for Aquatic Life Class 1. The outlet dissolved oxygen concentrations are

directly affected by the level of the thermocline and the level of water being released at the time of the measurement.

At the inlet, pH levels were in the range of 6.6 to 8.7 standard units, while at the outlet pH levels were 6.7 to 8.5 standard units. Water at the outlet had slightly lower pH in 14 of the 16 months sampled in 2004-2005. All measurements were within the allowed pH range of 6.5 to 9.0 for Class 1 Cold Water Biota (CDPHE 2007a).

Periodic water quality data have been collected for Dillon Reservoir since the 1982 Clean Lake Study of Dillon Reservoir in Summit County, Colorado (Lewis et al. 1983). Phosphorus loading from non-point sources is the principle concern in Dillon Reservoir (NWCCOG 2002). Over the last 10 years, the Summit Water Quality Committee has continued sampling of Dillon Reservoir water. In 2005, the WQCC Division of the CDPHE listed Dillon Reservoir as requiring monitoring, but not as impaired. The listing resulted from the exceedance of the phosphorus standard in 2002 and 2004 caused by extraordinarily low inflows to the reservoir and not by increased point source water pollution (Lewis 2008). During the growing season (July 1 through October 31) of 2007, the mean concentration of total phosphorus in the top 15 meters of the reservoir was 5.4 µg/L versus a regulatory limit of 7.4 µg/L (Lewis 2008).

In the updated Regional Blue River Water Quality Management Plan (NWCCOG 2002), mention was made to the potential effect of changes in hydrologic conditions within the watershed. The plan states: "Changes in the operations of the reservoirs to increase system yields, including reduction in residence times, second fill rights, and routing of new sources of nutrients to Dillon and Green Mountain reservoirs, have the potential to modify future wastewater treatment requirements to maintain the same level of water quality."

3.2.2 Conveyance Systems

Water quality would not be impacted by Conduits M and O, thus the existing water quality conditions for the conveyance systems study area were not described.

3.2.3 South Platte River Facilities

The existing water quality conditions for the South Platte River are described in Section 3.2.5.8.

3.2.4 Denver Basin Aquifer Facilities

Water quality would not be impacted by these alternative components, thus the existing water quality conditions within the Denver Basin Aquifer Facilities study area are not described.

3.2.5 River Segments

3.2.5.1 Fraser River

The Fraser River is Segment 10 of the upper Colorado River and water quality is regulated by CDPHE Regulation 33 (CDPHE 2011c). The classification for the Fraser River mainstem and all its tributaries is Cold Water Aquatic Life Class 1, Recreation E, Water Supply and Agriculture. The Fraser River has three segments, 10a, 10b, and 10c. Portions of the Fraser River are listed in Regulation 93 (CDPHE 2012a) on the Monitoring and Evaluation List or the 303(d) List. The mainstem of the Fraser River upstream of the Rendezvous Bridge and Vasquez Creek are provisionally listed on the 303(d) List for Aquatic Life Use. The mainstem of the Fraser River from Hammond Ditch (just north of the Town of Fraser) to the confluence with the Colorado is listed on the 303(d) for temperature with a State-assigned low priority. The mainstem of the Fraser River from the Town of Fraser to the confluence with the Colorado River is listed on the Monitoring and Evaluation List for copper, and from the Town of Tabernash to the Town of Granby for lead. Additionally, Ranch Creek, a tributary to the Fraser River, is listed on the 303(d) List for temperature with a State-assigned priority of low.

Numerous studies have been conducted in recent decades regarding water quality in the Fraser River Basin. The most recent information is highly preferred in describing the affected environment. Thus, the characterization of existing conditions in the EIS focuses on recent water quality data and the information from the Grand County Stream Management Plan (Grand County 2008, 2010), which includes the Fraser River and its tributaries in its geographic scope. Table 3.2-4 summarizes findings reported in Phase 2 and Phase 3 of the Grand County Stream Management Plan. Phase 2 of the Plan used criterion for temperature that are lower than the standard set by CDPHE in Regulation 33. Phase 3 of the Plan was draft at the time of writing this EIS. Table 3.2-4 is included in the EIS in order to provide information on the most recent study performed on the Fraser River Basin, even though certain procedures and methods used in that study are not in accordance with CDPHE regulations. Also presented in the same table are the results of the temperature analysis performed in accordance with CDPHE regulations and CDPHE software by the U.S. Army Corps of Engineers (Corps).

Table 3.2-4
Summary of Fraser River Water Quality Presented in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)	Water Quality Data Summarized from Tables 3.2-5 and 3.2-6
	Water Temperature Concerns[1]	Water Quality Concerns[1]	Phase 3 Modifications[2]		
F-JC, Jim Creek	No records available. No concerns.	No data located. No concerns reported.	Extensive rock staining suggests high iron content; no testing has been done to confirm.	N/A	N/A
F-RC, Ranch Creek	Near the confluence with the Fraser is the warmest tributary analyzed.	None noted from available data.	N/A	*Ranch Creek below CR8315 (POR 2005 – 2009)* Summer MWAT exceedances: 2005 – None 2006 – 1 2007, 2008, and 2009 – None Summer DM exceedances: 2005 – 7 2006 – 20 2007 – 20 2008 – 4 2009 – 4 *Ranch Creek below Meadow Creek (POR 2007 – 2009)* Summer MWAT exceedances: 2007 – 2 2008 and 2009 – None Summer DM exceedances: 2007 – 11 2008 – 15 2009 – 10	N/A
F-RC1, Ranch Creek (Ranch Creek split into two reaches for Phase 3)	N/A	N/A	Temperature data suggests temperatures well below State standards although reach is listed on 303(d) List.		
F-RC2, Ranch Creek (Ranch Creek split into two reaches for Phase 3)	N/A	N/A	Temperatures generally within MWAT but frequently exceed DM. Reach is listed on 303(d) List. Algae noted in abundance upstream of Devils Thumb lodge.		

Table 3.2-4 (continued)
Summary of Fraser River Water Quality Presented in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)	Water Quality Data Summarized from Tables 3.2-5 and 3.2-6
	Water Temperature Concerns[1]	Water Quality Concerns[1]	Phase 3 Modifications[2]		
F-StL, St. Louis Creek	None noted.	No data available.	N/A	*St. Louis Creek above Fraser River confluence (POR 2007 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: 2007 – 1 2008 and 2009 – None	N/A
F-TC, Tenmile Creek	No data available.	No data available.	N/A	N/A	N/A
F-VC, Vasquez Creek	No concerns noted.	No data available.	Temperature data reviewed in Reach F-VC indicate stream temperatures for Vasquez Creek in this area are well below the MWAT and DM standards.	*Vasquez Creek at Winter Park (POR 2005– 2009)* Summer MWAT exceedances: None Summer DM exceedances: None	85th percentile dissolved copper exceeded standard (calculated with 15th percentile hardness) above the Vasquez Tunnel Outlet[3]
F1, Fraser River, US 40 to Denver Water Diversion	No concerns noted.	Impacts from sanding operations on Berthoud Pass are a concern. A sediment removal project is in place.	N/A	N/A	85th percentile dissolved iron greater than standard

Table 3.2-4 (continued)
Summary of Fraser River Water Quality Presented in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)	Water Quality Data Summarized from Tables 3.2-5 and 3.2-6
	Water Temperature Concerns[1]	Water Quality Concerns[1]	Phase 3 Modifications[2]		
F2, Fraser River, Diversion Canal to Winter Park Water and Sanitation District Wastewater Facility	No concerns noted.	Impacts from sanding operations (see F1). The Moffat Tunnel discharge is a point source with fines and metals.	Monthly monitoring data indicate that there may be exceedances of fine sediment, iron, mercury, copper, and lead.	*Fraser River above WPSD (POR 2007 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None	No exceedances of State standards
F3, Fraser River, Winter Park Water and Sanitation District Wastewater Facility to the Town of Winter Park	No concerns noted.	Impacts from sanding operations (see F1).	N/A	*Fraser River below Winter Park (ski area) (POR 2007 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None	85th percentile dissolved zinc greater than State standard (calculated with 15th percentile hardness)[4]
F4, Fraser River, Town of Winter Park to Town of Fraser	No data available.	Some algae observed. No indication from existing data that constituents are regularly exceeding criteria. Sanding operations could be contributing to sediment and aggradation.	Temperature data indicates temperatures are well below the MWAT and DM.	*Fraser River at Rendezvous Bridge (POR 2008 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None	No exceedances of State standards

Table 3.2-4 (continued)
Summary of Fraser River Water Quality Presented in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)	Water Quality Data Summarized from Tables 3.2-5 and 3.2-6
	Water Temperature Concerns[1]	Water Quality Concerns[1]	Phase 3 Modifications[2]		
F5, Fraser River, Town of Fraser to Fraser Sanitation District Wastewater Treatment Plant	Temperatures occasionally exceed criteria (as set by the Grand County Stream Management Plan).	None noted with completion of Wastewater Treatment Plant in 2004.	Temperature data generally within MWAT and DM with some exceedances, resulting in placement on 303(d) List. On M&E[5] List for copper.[6]	*Fraser River at CR8 HD (POR 2006 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None *Fraser River above FSD (POR 2007 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None	N/A

Table 3.2-4 (continued)
Summary of Fraser River Water Quality Presented in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)	Water Quality Data Summarized from Tables 3.2-5 and 3.2-6
	Water Temperature Concerns[1]	Water Quality Concerns[1]	Phase 3 Modifications[2]		
F6, Fraser River, Fraser Sanitation District Wastewater Treatment Plant to Ranch Creek	Daily maximum frequently exceeds criteria (as set by the Grand County Stream Management Plan).	Phosphorus and pH reading frequently exceed guideline since 1995.	Temperature data generally within MWAT and DM with some exceedances, resulting in placement on 303(d) List. On M&E List for copper.	*Fraser River below FSD at Pietz (POR 8/2005 – 10/2005)* Summer MWAT exceedances: None Summer DM exceedances: None *Fraser River below FSD (POR 2007 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None *Fraser River at Tabernash below bridge on County Road 83 (POR 2005 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: 2005 – 2 2006, 2007, 2008, and 2009 – None	N/A

Table 3.2-4 (continued)
Summary of Fraser River Water Quality Presented in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)	Water Quality Data Summarized from Tables 3.2-5 and 3.2-6
	Water Temperature Concerns[1]	Water Quality Concerns[1]	Phase 3 Modifications[2]		
F7, Fraser River, Ranch Creek to Canyon	Daily maximum frequently exceeds criteria (as set by the Grand County Stream Management Plan).	Phosphorus and pH reading frequently exceed guideline since 1995.	No temperature data; see F6 and F9. On M&E List for copper.	*Fraser River below Crooked Creek (POR 2006)* Summer MWAT exceedances: None Summer DM exceedances: None	85th percentile for pH greater than State standard at Tabernash
F8, Fraser River, Canyon	No data available.	No data available.	No temperature data; see F6 and F9. On M&E List for copper.	N/A	N/A
F9, Fraser River, Canyon to Granby	Warmest reach of the river. MWAT exceeded criteria (as set by the Grand County Stream Management Plan) continuously in summer of 2007.	Phosphorus exceeded guidelines frequently.	Temperature data generally within MWAT and DM with some exceedances, resulting in placement on 303(d) List. On M&E List for copper.	*Fraser River at Highway 40 at Granby (POR 2005 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None	No exceedances of State standards

Table 3.2-4 (continued)
Summary of Fraser River Water Quality Presented in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)	Water Quality Data Summarized from Tables 3.2-5 and 3.2-6
	Water Temperature Concerns[1]	Water Quality Concerns[1]	Phase 3 Modifications[2]		
F10, Fraser River, Granby to Confluence with the Colorado River	See F9.	See F9.	Temperatures generally below MWAT and DM with some exceedances. On the 303(d) List. Available data indicates elevated phosphorus. On M&E List for copper.	*Fraser River above GWSD (POR 2008 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None *Fraser River below GWSD (POR 2008 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None *Fraser River above Colorado River (POR 7/2005 – 11/2005)* Summer MWAT exceedances: None Summer DM exceedances: None	85th percentile dissolved iron exceeds State standard near confluence with Colorado River. 85th percentile dissolved zinc exceeds State standard (using 15th percentile hardness) near confluence with Colorado River[4]

Notes:
[1]Analysis/description as presented by Grand County in the Stream Management Plan, Phase 2.
[2]Analysis/description as presented by Grand County in the Stream Management Plan, Phase 3.
[3]See Table 3.2-6.
[4]Further analyses looking at paired data (zinc and hardness on same date) indicate that stream is within State Water Quality Standards.
[5]Monitoring and Evaluation List per CDPHE Regulation 93 (CDPHE 2012a).
[6]303(d) listing does not start until the Hammond Ditch, downstream of the Town of Fraser.

Corps = U.S. Army Corps of Engineers
CR = Colorado River
DM = daily maximum
FSD = Fraser Sanitation District
GWSD = Granby Water and Sanitation District
HD = Hammond Ditch
M&E = Monitoring and Evaluation
MWAT = maximum weekly average temperature
N/A = not analyzed in GCWIN SMP
POR = Period of Record
US # = U.S. Highway #
WPSD = Winter Park Sanitation District

Phase 3 of the Grand County Stream Management Plan includes recommendations for improving reaches through various management practices. On the Fraser tributaries, only Ranch Creek had recommendations with regards to water quality. For Ranch Creek, the recommendation by Grand County is to increase flushing flows if existing culverts have capacity. On the Fraser River mainstem, recommendations for Reach F1 are overbank Best Management Practices (BMPs). The recommendations for Reach F2 are expected to provide benefit through Reach F5 and include providing enhancement flows at low flow and flushing flows, overbank BMPs, sediment basin, and treatment of Moffat Tunnel discharge. On Reach F6, recommendations include channel bank re-vegetation and channel restoration. On Reach F7, channel bank re-vegetation is suggested. On Reach F9, channel restoration is suggested. On the remaining reaches, there are no suggestions made by Grand County that relate to water quality.

Water quality can also be impacted by point source and non-point source discharges. Point source discharges are regulated by the NPDES. The EPA database, ECHO, was used to identify those entities that currently have an NPDES permit related to sewage treatment. Those entities include, from upstream to downstream:

- Winter Park Water and Sanitation District, 0.45 million gallons per day (mgd), discharge to the Fraser River
- Fraser Sanitation District, 2.0 mgd, discharge to the Fraser River
- Devil's Thumb Ranch, 0.034 mgd, discharge to Ranch Creek
- Young Life Crooked Creek Ranch, 0.033 mgd, discharge to Crooked Creek
- Tabernash Meadows Water and Sanitation District, 0.2 mgd, discharge to the Fraser River
- City of Granby Wastewater Treatment Facility, 0.995 mgd, discharge to the Fraser River

Other NPDES permits in the Fraser River Basin are for Water Treatment Plants (WTPs), construction site runoff, and one industrial permit, the Moffat Tunnel. The Moffat Tunnel discharge permit is for groundwater seepage. The NPDES permit is for 0.5 mgd, with discharge to the Fraser River near the west portal of the tunnel. This permit has two sets of discharge limitations, the first is for discharge prior to April 30, 2013, and the second is for after that date. Interim deadlines were included in the permit for data collection (2009 and 2010), chosen alternative to meet final limitations (April 2011) and compliance with final limitations (April 2013).

There are four water providers that use either surface water and/or groundwater under the influence of surface water in the Fraser River watershed: Town of Granby, Grand County Water Sanitation District #1, Winter Park Water and Sanitation District, and the YMCA Snow Mountain Ranch.

Water quality data was obtained from the USGS and STORET databases and from Denver Water to evaluate Current Conditions for the EIS. Sites used in the assessment of the Fraser River Basin are listed below:

Fraser River Mainstem (EPA 2010c; GCWIN 2010)

1. CDPHE 12166 – located at the mouth of the Fraser River, near US 40 (data taken from 1998 to 2005, Hillegas 2010, 2011)
2. CDPHE 12193 – located at the Town of Fraser (data taken from 1998 to 2002, Hillegas 2010, 2011)
3. CDPHE 12199 – located below Robbers Roost (data from 2000 to 2006, Hillegas 2010, 2011)
4. USGS 09022000 – Fraser River at Upper Station, near Winter Park (data taken from 1994 to 2005, Hillegas 2010, 2011)
5. USGS 09023750 – Fraser River below Buck Creek at Winter Park (data taken from 2000 to 2005, Hillegas 2010, 2011)
6. USGS 09025010 – Fraser River below Vasquez Creek at Winter Park (data taken from 2000 to 2005, Hillegas 2010, 2011)
7. USGS 09027100 Fraser River at Tabernash (data taken from 2000 to 2005, Hillegas 2010, 2011)
8. USGS 09033300 Fraser River below Crooked Creek at Tabernash (data taken from 2001 to 2006, Hillegas 2010, 2011)
9. River Watch 544 Fraser Creek at Granby (data taken from 2002 to 2007, Hillegas 2010, 2011)
10. Northern Colorado Water Conservancy District FR-WGU Fraser River above Colorado River (data taken from 2002 to 2007, Hillegas 2010, 2011)
11. GCWIN Multiple Stations, 2007 and 2008 temperature data (Grand County Information Network [GCWIN 2009])

Fraser River Tributaries

1. USGS 09025000 – Vasquez Creek at Winter Park (data taken from 2000 to 2004) (USGS 2007)
2. USGS 09025010 – Fraser River below Vasquez Creek at Winter Park (data taken from 2000 to 2005) (USGS 2007)
3. USGS 09026500 – St. Louis Creek near Fraser (data taken from 2000 to 2004) (USGS 2007)
4. Denver Water stations at Vasquez Creek above the tunnel and at the Denver Water diversion (data from 2002 through 2007) (Denver Water 2007a)

Water quality data for the Fraser River is shown in Table 3.2-5, followed by a discussion of key parameters.

Of particular interest are temperature and copper, due to the 303(d) and Monitoring and Evaluation listings in CDPHE Regulation 93 (CDPHE 2012a). GCWIN has performed extensive temperature monitoring along the Fraser River beginning in 2005. Data loggers record water temperature at 5- to 30-minute intervals at most stations, generally from mid-summer through mid-October or early November. This comprehensive dataset was

used to establish existing conditions with regards to the chronic temperature standard (MWAT) and the acute temperature standard (DM). Temperature exceedances were identified using an Excel calculator developed by CDPHE (CDPHE 2010a). Results of the analysis for stations in each reach are presented in the rightmost column of Table 3.2-5.

The most frequent exceedances of both MWAT and DM occur on Ranch Creek, which is listed on the 303(d) List with a low priority for temperature. The DM was exceeded twice in July 2005 at the station Fraser River at County Road (CR) 83. This appears to be the only exceedance in the CDPHE-designated Reach 10c, which encompasses Reaches F5 through F10 in the Grand County Stream Management Plan.

Fraser River tributary hourly or half-hourly temperature data were also available from the USFS (Larkin 2011) for 2009 and 2010. The temperature sites were located on Little Vasquez, St. Louis, Cabin, and Hamilton creeks as well as South Fork Ranch Creek, in the general vicinity of Denver Water's diversions. With the exception of St. Louis Creek, the sites are occupied by native cutthroat trout and have been monitored as part of a Forest-wide program for the trout. Additionally, new sites were established in 2009 as part of USFS participation in a climate change study. St. Louis Creek is monitored in cooperation with GCWIN as part of this program.

The USFS data were reviewed and compared with the Cold Stream 1 acute standard (21.2°C averaged over four observations) and chronic standard (17°C over 7 days). In all cases, temperatures were well below the standards. Maximum single temperature observations for twelve station/season time series ranged from 11°C to 17°C. Without calculating running averages, it is clear that standards were not exceeded over the two-year period.

The Fraser River is on the CDPHE Monitoring and Evaluation List for copper (CDPHE 2012a). There have been two exceedances of the acute standard for copper on the Fraser River which occurred on January 25, 2006 and May 5, 2010 at the Water Quality Control Division (WQCD) station 12166 (Hranac 2013). There has also been one exceedance of the acute standard for cadmium on the Fraser River which occurred on May 18, 2008 at River Watch station 544 (Hranac 2013). All other data points are below the acute standard and the 85th percentile for all sites is below the chronic standard for each site.

A number of sites indicate exceedances for iron, 12166, 12199, and FR-WGU. Site 12166 is above all permitted discharges while the remaining two sites are near the mouth. Sites between these two locations are within stream standards for iron. The cause of iron concentrations greater than the stream standard is unknown.

Two sites have an 85th percentile value for pH slightly above the stream standard. Near Tabernash the 85th percentile value is 9.3 and at the mouth the 85th percentile value is 9.2. The cause of pH readings higher than the stream standard is not known. The sites above and below, and the one site between these two sites, are within the stream standard for pH.

Two sites have an 85th percentile value for zinc above the stream standard, at Buck Creek and at the mouth. Further analysis of the data indicates that the paired data of hardness and zinc concentrations indicate that zinc is below the chronic sculpin value for each pair. Thus, the Fraser is within standards set by Regulation 33 for zinc.

Table 3.2-5
Fraser River Water Quality

Parameter	Statistic	Units	Fraser River, WQCD Site 12199		Fraser River, USGS Site 9022000		Fraser River, USGS Site 9023750		Fraser River, USGS Site 9025010		Fraser River, WQCD Site 12193		Fraser River, USGS Site 9027100		Fraser River, USGS Site 9033300		Fraser River, WQCD Site 12166		Fraser River, River Watch Site 544		Fraser River, NCWCD Site FR-WGU		Drinking Water Standards
			Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	
Parameters with Stream Standards																							
Arsenic, total recoverable	50th Percentile	µg/L	bdl [26]	0.02	N/A [0]	0.02	N/A [0]	0.02	N/A [0]	0.02	bdl [8]	0.02	N/A [0]	0.02	N/A [0]	0.02	bdl [28]	0.02	N/A [0]	0.02	bdl [3]	0.02	10
Copper, dissolved	85th Percentile	µg/L	bdl [26]	2.38	N/A [0]	3.06	1.15 [3]	3.02	1.43 [3]	3.02	**3.80** [8]	2.84	2.13 [3]	3.29	N/A [0]	4.44	bdl [28]	4.40	1.30 [44]	5.07	1.59 [28]	3.31	1,300
Dissolved oxygen	15th Percentile	mg/L	8.6 [25]	7.0	8.8 [36]	7.0	8.6 [68]	7.0	8.7 [68]	6.0	7.9 [8]	7.0	8.6 [68]	7.0	8.7 [50]	7.0	8.2 [26]	7.0	7.7 [51]	7.0	7.4 [16]	7.0	N/A
Iron, dissolved	85th Percentile	µg/L	**353** [26]	300	N/A [0]	300	N/A [0]	300	N/A [0]	300	290 [8]	300	N/A [0]	300	N/A [0]	300	**420** [27]	300	270 [44]	300	**303** [27]	300	300
Lead, dissolved	85th Percentile	µg/L	bdl [26]	0.45	N/A [0]	0.63	0.11 [3]	0.61	0.18 [3]	0.61	bdl [8]	0.57	0.15 [3]	0.69	N/A [0]	1.02	bdl [28]	1.01	bdl [43]	1.21	0.20 [4]	0.69	15
Manganese, dissolved	85th Percentile	µg/L	32 [26]	985	N/A [0]	1,086	N/A [0]	1,080	N/A [0]	1,080	19 [8]	1,055	N/A [0]	1,117	N/A [0]	1,255	33 [27]	1,250	32 [44]	1,322	32 [28]	1,119	50
Nitrate and Nitrite	85th Percentile	mg/L	bdl [26]	10.05	0.15 [11]	10.05	0.14 [37]	10.05	0.89 [57]	10.05	bdl [8]	10.05	1.12 [69]	10.05	0.66 [45]	10.05	0.70 [28]	10.05	0.16 [5]	10.05	0.42 [26]	10.05	11
pH	85th Percentile	SU	8.3 [26]	6.5-9.0	8.3 [35]	6.5-9.0	8.4 [67]	6.5-9.0	8.5 [68]	6.5-9.0	8.1 [7]	6.5-9.0	**9.3** [68]	6.5-9.0	8.5 [51]	6.5-9.0	**9.2** [26]	6.5-9.0	8.2 [50]	6.5-9.0	8.8 [20]	6.5-9.0	6.5-8.5
pH	15th Percentile	SU	7.0 [26]	6.5-9.0	7.7 [35]	6.5-9.0	7.6 [67]	6.5-9.0	7.8 [68]	6.5-9.0	7.1 [7]	6.5-9.0	7.9 [68]	6.5-9.0	7.9 [51]	6.5-9.0	7.4 [26]	6.5-9.0	7.6 [50]	6.5-9.0	6.7 [20]	6.5-9.0	6.5-8.5
Silver, dissolved	85th Percentile	µg/L	bdl [26]	0.01	N/A [0]	0.01	N/A [0]	0.01	N/A [0]	0.01	bdl [8]	0.01	N/A [0]	0.01	N/A [0]	0.02	bdl [28]	0.02	N/A [0]	0.02	bdl [12]	0.01	100
Temperature	Daily Maximum	ºC	12.6 [26]	21.2	11.5 [38]	21.2	13.2 [69]	21.2	14.5 [69]	21.2	13.3 [8]	23.8	21.5 [69]	23.8	20 [51]	23.8	22.4 [27]	23.8	22.0 [51]	23.8	N/A [0]	23.8	N/A
Zinc, dissolved	85th Percentile	µg/L	bdl [26]	3.3	1.99 [12]	6.4	**9.83** [3]	6.2	3.52 [3]	6.2	bdl [8]	5.3	5.7 [3]	7.7	N/A [0]	16.8	bdl [27]	16.4	bdl [43]	23.8	**17.4** [12]	7.8	5,000

Table 3.2-5 (continued)
Fraser River Water Quality

Parameter	Statistic	Units	Fraser River, WQCD Site 12199		Fraser River, USGS Site 9022000		Fraser River, USGS Site 9023750		Fraser River, USGS Site 9025010		Fraser River, WQCD Site 12193		Fraser River, USGS Site 9027100		Fraser River, USGS Site 9033300		Fraser River, WQCD Site 12166		Fraser River, River Watch Site 544		Fraser River, NCWCD Site FR-WGU		Drinking Water Standards
			Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	Value	Stream Std	
Parameters without Stream Standards or Drinking Water Standards																							
Hardness as $CaCO_3$	85th Percentile	mg/L	41 [26]	N/A	46 [28]	N/A	51 [41]	N/A	42 [41]	N/A	37 [8]	N/A	47 [41]	N/A	60 [18]	N/A	60 [27]	N/A	69 [50]	N/A	64 [28]	N/A	N/A
Hardness as $CaCO_3$	15th Percentile	mg/L	21 [26]	N/A	29 [28]	N/A	28 [41]	N/A	28 [41]	N/A	26 [8]	N/A	31 [41]	N/A	44 [18]	N/A	44 [27]	N/A	51 [50]	N/A	31 [28]	N/A	N/A

Notes:
Numbers in bold font and gray shading indicate stream standards exceedances.
Numbers inside brackets indicate the number of data points used in the calculation.

°C = degrees Celsius
µg/L = micrograms per liter
bdl = below detection limit
$CaCO_3$ = calcium carbonate
FR = Fraser River
mg/L = milligrams per liter
N/A = not applicable
NCWCD = Northern Colorado Water Conservancy District
Std = standard
SU = standard unit
USGS = U.S. Geological Survey
WGU = Windy Gap Upstream
WQCD = Water Quality Control Division

Water quality data for Vasquez Creek is shown in Table 3.2-6, followed by a discussion of key parameters.

Table 3.2-6
Vasquez Creek Water Quality

Parameter	Statistic	Units	Vasquez Creek		Standard[3]
			Above Tunnel[1]	At Diversion[2]	
Parameters with Stream Standards					
Arsenic, total recoverable	50th Percentile	µg/L	bdl[4] [11]	bdl [11]	0.02
Boron, dissolved	85th Percentile	µg/L	2 [6]	2 [6]	750
Cadmium, dissolved	85th Percentile	µg/L	0.1 [11]	bdl [11]	0.55
Chromium, dissolved[5]	85th Percentile	µg/L	bdl [10]	bdl [10]	11
Copper, dissolved	85th Percentile	µg/L	3 [11]	bdl [11]	1.67
Dissolved oxygen	15th Percentile	mg/L	7.96 [15]	7.83 [15]	7
E. Coli	Geometric Mean	MPN/100 ml	0.59 [15]	2.18 [15]	126
Iron, dissolved	85th Percentile	mg/L	bdl [15]	bdl [15]	0.30
Lead, dissolved	85th Percentile	µg/L	bdl [11]	bdl [11]	0.28
Manganese, dissolved	85th Percentile	µg/L	5.4 [16]	5.4 [16]	857
Mercury, dissolved	85th Percentile	µg/L	bdl [12]	bdl [12]	0.01
Nickel, dissolved	85th Percentile	µg/L	0.45 [11]	bdl [11]	9.9
pH	15th Percentile	SU	7.57 [12]	7.7 [12]	6.5-9.0
pH	85th Percentile	SU	8.1 [12]	8.14 [12]	6.5-9.0
Selenium, dissolved	85th Percentile	mg/L	bdl [11]	bdl [11]	4.60
Silver, dissolved	85th Percentile	µg/L	bdl [12]	bdl [12]	0.002
Temperature	Daily Maximum	°C	10 [12]	11 [12]	21.2
Zinc, dissolved	85th Percentile	µg/L	7.05 [12]	5.7 [12]	22

Table 3.2-6 (continued)
Vasquez Creek Water Quality

Parameter	Statistic	Units	Vasquez Creek		Standard[3]
			Above Tunnel[1]	At Diversion[2]	
Parameters with Drinking Water Standards[6]					
Aluminum, dissolved	85th Percentile	µg/L	43 [12]	44 [12]	50-200
Antimony, dissolved	85th Percentile	µg/L	bdl [11]	bdl [11]	6
Barium, dissolved	85th Percentile	µg/L	6.5 [10]	9.0 [10]	2,000
Beryllium, dissolved	85th Percentile	µg/L	bdl [10]	bdl [10]	4
Sodium, dissolved	85th Percentile	mg/L	2.1 [11]	3.0 [11]	20
Thallium, dissolved	85th Percentile	µg/L	bdl [11]	bdl [11]	2
Total coliform	Geometric Mean	MPN/100 ml	9.4 [12]	20 [12]	TT[7]
Turbidity	85th Percentile	NTU	1.07 [12]	1.04 [12]	TT[7]
Uranium, dissolved	85th Percentile	µg/L	1.3 [11]	1.4 [11]	30
Parameters with No Standards					
Alkalinity, total as $CaCO_3$	85th Percentile	mg/L	23 [12]	23 [12]	N/A
Calcium, dissolved	85th Percentile	mg/L	8 [10]	7.8 [10]	N/A
Cobalt, dissolved	85th Percentile	µg/L	1 [10]	0.5 [10]	N/A
Hardness as $CaCO_3$	85th Percentile	mg/L	22 [15]	23 [15]	N/A
Hardness as $CaCO_3$	15th Percentile	mg/L	14 [15]	13 [15]	N/A
Magnesium, dissolved	85th Percentile	mg/L	0.9 [11]	1.4 [11]	N/A
Molybdenum, dissolved	85th Percentile	µg/L	3 [11]	bdl [11]	N/A
Phosphorus, total as P	85th Percentile	mg/L	0.02 [9]	0.03 [9]	N/A
Potassium, dissolved	85th Percentile	mg/L	bdl [11]	0.4 [11]	N/A
Silicon, dissolved	85th Percentile	mg/L	3.6 [7]	4.4 [7]	N/A

Table 3.2-6 (continued)
Vasquez Creek Water Quality

Parameter	Statistic	Units	Vasquez Creek		Standard[3]
			Above Tunnel[1]	At Diversion[2]	
Specific conductance	85th Percentile	µmhos/cm	40 [12]	50 [12]	N/A
Total Suspended Solids	85th Percentile	mg/L	2 [12]	1.2 [12]	N/A
Vanadium, dissolved	85th Percentile	µg/L	bdl [11]	bdl [11]	N/A

Source: Denver Water, 2007a.
Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
[1] Denver Water sample site "Vasquez Creek above Vasquez Tunnel."
[2] Denver Water sample site "Vasquez Creek at diversion structure."
[3] Stream standard is per Regulation No. 33. Where the standard is "TVS," a hardness of 14 mg/L (the 15th percentile) was used in the TVS formula. Some parameters also have Drinking Water Standards set by CDPHE/EPA. Only Stream Standard is listed in this table.
[4] Per the methodology, bdl was reported when statistic results in value of "0," per CDPHE procedures.
[5] Stream Standard is for Chromium VI, while data are for total dissolved Chromium.
[6] Per EPA website. Standards listed include primary, secondary, and advisory limits.
[7] TTs, per EPA's website.

°C = degrees Celsius
µg/L = micrograms per liter
µmhos/cm = micromhos per centimeter
bdl = below detection limit
$CaCO_3$ = calcium carbonate
CDPHE = Colorado Department of Public Health and Environment
EPA = U.S. Environmental Protection Agency
mg/L = milligrams per liter
ml = milliliters
MPN = most probable number
N/A = not applicable
NTU = nephelometric turbidity unit
SU = standard unit
TT = Treatment Technique
TVS = table value standard

Most parameters listed for those with stream standards in Vasquez Creek are well within stream standards. Of note is cadmium. Above the Vasquez Tunnel, the data indicates an 85th percentile value of 0.1 µg/L. Below the tunnel, the 85th percentile is below detection limit. However, the detection limit in the method used is 0.1 µg/L. Per CDPHE procedures, those samples with values below detection limits were changed to "0" for statistical purposes. Thus, the actual change above and below the tunnel is likely very small due to most data points being below detection limits, with one or two samples being slightly above detection limits at the location above the tunnel. The stream standard is 0.55 µg/L, and thus both locations above and below the tunnel are well within stream standards.

Also of note for Vasquez Creek is copper. Above the tunnel the 85th percentile value is 3.0 µg/L, well above the stream standard of 1.67 µg/L. Similar to cadmium, the detection limit is equivalent to the calculated 85th percentile, 3 µg/L. The 85th percentile below the tunnel is 0 µg/L. However, similar to cadmium, these changes are likely due to all values being near the detection limit. The stream standard for copper is 1.67 µg/L, which is less than the detection limit of the method used. Copper is likely to be near the calculated standard at locations both above and below the tunnel. However, there is no way of knowing since the calculated standard is below the detection limit of the laboratory method.

Escherichia coli (*E. Coli*) shows an increase downstream of the tunnel discharge. The value in the tunnel is 0.75 most probable number (MPN)/100 milliliters (ml), very similar to the value above the tunnel discharge. *E. Coli* concentrations are affected by many parameters, including the presence of wildlife. The stream standard for *E. Coli* is 126 MPN/100 ml. All three locations indicate water of pristine water quality.

Dissolved nickel shows a decrease downstream of the tunnel discharge. However, the detection limit for the various samples ranges from 0.8 to 2.0 µg/L. Thus, the decrease is likely a result of testing limits and the statistical methods used. The stream standard is 9.9 µg/L, well above any changes noted in the water quality data above and below the tunnel.

All parameters that have drinking water standards are less than drinking water standards with the exception of total coliform and turbidity. Turbidity is an indication of sediment/silt in the water and cannot be expected to approach zero, except after treatment. All drinking WTPs and the drinking water regulations focus on removal of turbidity with the understanding that natural waters would have varying degrees of turbidity. Coliform are a type of bacteria that occur naturally with fecal coliform coming specifically from human and livestock waste. Coliform are measured in treated drinking water as an indicator of the presence of potentially harmful microscopic organisms. Again, all drinking WTPs and the drinking water regulations focus on removal of coliform and other pathogens with the understanding that natural waters would have some degree of biological activity such as coliform. The values for coliform and turbidity indicate high-quality water sources.

St. Louis Creek water quality is presented in Table 3.2-7. Little data is available for this water body. As shown in the table, temperature is within stream standards and specific conductance indicates water of high quality. Note that GCWIN data had one exceedance of the DM for a nearby sample station.

Table 3.2-7
St. Louis Creek Water Quality

Parameter	Statistic	Units	USGS Site 9026500, St. Louis Creek Near Fraser, Colorado		Drinking Water Standards
			Value	Stream Std[1]	
Parameters with Stream Standards					
Temperature	Daily Maximum	ºC	15 [29]	21.2	N/A
Parameters without Stream Standards or Drinking Water Standards					
Specific conductance	85th Percentile	µmhos/cm	96 [28]	N/A	N/A

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
[1]CDPHE Regulation 33.
°C = degrees Celsius
µmhos/cm = micromhos per centimeter
N/A = not applicable
Std = standard
USGS = U.S. Geological Survey

3.2.5.2 Williams Fork River

The Surface Water Classification for the Williams Fork River and all its tributaries is Cold Water Aquatic Life Class 1, Recreation E, Water Supply and Agriculture (CDPHE 2008a). The Williams Fork River is within WQCC Segment 8 of the upper Colorado River. The Williams Fork River is not listed on the 303(d) or Monitoring and Evaluation Lists in CDPHE Regulation No. 93 (CDPHE 2012a).

The Grand County Stream Management Plan (Grand County 2008, 2010) included a portion of the Williams Fork River, from below the reservoir to the confluence with the Colorado River. The Phase 2 report noted that flows below the reservoir are controlled releases and tend to be cool, rarely exceeding 10°C. The Phase 2 report also noted low dissolved oxygen with 16 of 92 samples below 6.0 mg/L. The Draft Phase 3 report had the same information, adding that low dissolved oxygen may be due to reservoir releases from the bottom and required further investigation.

Water quality in the Williams Fork River is shown in Tables 3.2-8 and 3.2-9. The selected Denver Water sampling sites used to determine current water quality conditions include:

- Denver Water WS-WF-002 – Williams Fork River below Kinney Creek confluence at Leal gage (data taken from 2002-2007)
- Denver Water WS-WF-004 – Williams Fork above bridge at Sugarloaf Campground
- Denver Water WS-WF-005 – Steelman Creek at bridge above diversion dam (data taken from 2002-2007)
- Denver Water WS-WF-006 – McQueary Creek above diversion dam (data taken from 2002-2007)
- Denver Water WS-WF-009 – Williams Fork River above Williams Fork Reservoir (data taken from 2002-2007)
- Denver Water WS-WF-008 – Bobtail Creek above diversion dam downstream of gauging station (data taken from 2002-2007)

Data from the following USGS stations were also reviewed (USGS 2007):

- Station 09035500 – Williams Fork below Steelman Creek (data taken from 2000-2003)
- Station 09035700 – Williams Fork above Darling Creek, near Leal (data taken from 2000-2003)
- Station 09037500 – Williams Fork near Parshall (data taken from 1998-2003)
- Station 09038500 – Williams Fork River downstream of Williams Fork Reservoir (data taken from 2000-2004)
- Station 09249750 – Williams Fork at Mouth, near Hamilton (data taken from 2000-2002)

As presented in Table 3.2-8, one parameter, dissolved oxygen, does not meet stream standards downstream of the confluence of headwater tributaries at two sampling stations: above the bridge at Sugarloaf Campground and below Kinney Creek. Further evaluation of the limited data (sample count = 10), indicates that low dissolved oxygen occurs in June and July, outside spawning season. Fall data indicates dissolved oxygen levels above spawning regulatory levels. No data is available in spring spawning months for those two sampling sites. The reason for depressed dissolved oxygen is unknown. Due to the presence of organic matter, temperature, rate of mixing, and other factors, dissolved oxygen changes throughout a stream's length. Note that the 15th percentile dissolved oxygen level for the Denver Water sampling site on the Williams Fork River above Williams Fork Reservoir (WS-WF-001) is 7.3 mg/L. Additionally, as shown in Table 3.2-8, dissolved oxygen levels upstream of Sugarloaf Campground are within regulatory guidelines, indicating that low dissolved oxygen levels appear to be a localized issue near the campground. Upstream of the reservoir, the spawning season 15th percentile for dissolved oxygen is 8.0 mg/L.

The available USGS data was primarily temperature and specific conductance as summarized in Table 3.2-9.

Table 3.2-8
Water Quality Data from Denver Water Sampling Stations for the Williams Fork River

Parameter	Statistic	Units	Steelman Creek[1]		Bobtail Creek[2]		McQueary Creek[3]		Williams Fork above Sugarloaf Campground[4]		Williams Fork at Kinney Creek below Leal Gage[5]		Drinking Water Standards[6]
			Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	
Parameters with Stream Standards													
Arsenic, total recoverable	50th Percentile	µg/L	bdl[8] [4]	.02	bdl [4]	0.02	bdl [4]	0.02	bdl [4]	0.02	bdl[8] [4]	0.02	10
Boron, dissolved	85th Percentile	µg/L	1.0 [4]	750	1.0 [4]	750	1.3 [4]	750	2.0 [4]	750	2.0 [4]	750	N/A
Cadmium, dissolved	85th Percentile	µg/L	0.1 [4]	0.9	0.1 [4]	0.66	0.15 [4]	0.38	0.2 [4]	0.75	0.2 [4]	0.75	5
Chromium, dissolved[9]	85th Percentile	µg/L	bdl [4]	11	bdl [4]	11	bdl [4]	11	bdl [4]	11	bdl [4]	61	100
Copper, dissolved	85th Percentile	µg/L	bdl [4]	3.2	bdl [4]	2.2	bdl [4]	1.1	1.5 [4]	2.6	bdl [4]	2.5	1,300
Dissolved oxygen	15th Percentile	mg/L	7.3 [40]	>7.0	7.5 [40]	>7.0	7.4 [40]	>7.0	5.3 [40]	>7.0	5.9 [40]	>7.0	N/A
E. Coli	Geomean	MPN/ 100 ml	15 [1]	126	2.7 [1]	126	5.2 [1]	126	40 [1]	126	27 [1]	126	N/A
Iron, dissolved	85th Percentile	mg/L	0.06 [4]	0.3	0.03 [4]	0.3	bdl [4]	0.3	0.1 [4]	0.3	0.13 [4]	0.3	0.3
Lead, dissolved	85th Percentile	µg/L	bdl [4]	0.6	bdl [4]	0.4	bdl [4]	0.2	bdl [4]	0.5	bdl [4]	0.49	15
Manganese, dissolved	85th Percentile	µg/L	7.5 [4]	1,098	3.5 [4]	950	bdl [4]	740	15.0 [4]	1,011	12 [4]	1,007	50

Table 3.2-8 (continued)
Water Quality Data from Denver Water Sampling Stations for the Williams Fork River

Parameter	Statistic	Units	Steelman Creek[1]		Bobtail Creek[2]		McQueary Creek[3]		Williams Fork above Sugarloaf Campground[4]		Williams Fork at Kinney Creek below Leal Gage[5]		Drinking Water Standards[6]
			Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	
Mercury, dissolved	85th Percentile	µg/L	bdl [4]	0.01	bdl [4]	0.01	bdl [4]	0.01	bdl [4]	0.01	bdl [4]	0.01	2
Nickel, dissolved	85th Percentile	µg/L	bdl [4]	19	bdl [4]	13	bdl [4]	6.8	1.0 [4]	15	1.3 [4]	15	N/A
pH	85th Percentile	SU	8.1 [5]	6.5-9.0	8.0 [5]	6.5-9.0	8.3 [5]	6.5-9.0	8.1 [5]	6.5-9.0	8.0 [5]	6.5-9.0	6.5-8.5
pH	15th Percentile	SU	7.4 [5]	6.5-9.0	7.4 [5]	6.5-9.0	7.1 [5]	6.5-9.0	7.5 [5]	6.5-9.0	7.5 [5]	6.5-9.0	6.5-8.5
Selenium, dissolved	85th Percentile	µg/L	bdl [4]	4.6	bdl [4]	4.6	bdl [4]	4.6	bdl [4]	4.6	bdl [4]	4.6	50
Silver, dissolved	85th Percentile	mg/L	bdl [4]	0.04	bdl [4]	0.02	bdl [4]	0.005	bdl [4]	0.03	bdl [4]	0.03	0.10
Temperature	Daily Maximum	ºC	14.0 [2]	21.2	12.0 [2]	21.2	11.0 [2]	21.2	15.0 [2]	21.2	9.5 [2]	21.2	N/A
Uranium, dissolved	85th Percentile	µg/L	1.4 [4]	391	0.4 [4]	241	1.4 [4]	106	0.65 [4]	297	0.65 [4]	293	30
Zinc, dissolved	85th Percentile	µg/L	bdl [4]	9	5.5 [4]	3	4.5 [4]	1	8.0 [4]	5	9.0 [4]	5	5,000

Table 3.2-8 (continued)
Water Quality Data from Denver Water Sampling Stations for the Williams Fork River

Parameter	Statistic	Units	Steelman Creek[1]		Bobtail Creek[2]		McQueary Creek[3]		Williams Fork above Sugarloaf Campground[4]		Williams Fork at Kinney Creek below Leal Gage[5]		Drinking Water Standards[6]
			Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	
Parameters with Drinking Water Standards													
Aluminum, dissolved	85th Percentile	mg/L	bdl[8] [1]	N/A	0.03 [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	0.05-0.2
Antimony, dissolved	85th Percentile	µg/L	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	6
Barium, dissolved	85th Percentile	µg/L	14 [1]	N/A	23 [1]	N/A	bdl [1]	N/A	13 [1]	N/A	14 [1]	N/A	2,000
Beryllium, dissolved	85th Percentile	µg/L	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	4
Sodium, dissolved	85th Percentile	mg/L	1.9 [1]	N/A	1.2 [1]	N/A	1.7 [1]	N/A	2.1 [1]	N/A	2.2 [1]	N/A	20
Thallium, dissolved	85th Percentile	µg/L	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	2
Total coliform	Geomean	MPN/ 100 ml	94 [1]	N/A	51 [1]	N/A	54 [1]	N/A	95 [1]	N/A	145 [1]	N/A	TT[10]
Turbidity	85th Percentile	NTU	0.6 [3]	N/A	1.0 [3]	N/A	0.9 [3]	N/A	0.9 [3]	N/A	1.0 [3]	N/A	TT[10]

Table 3.2-8 (continued)
Water Quality Data from Denver Water Sampling Stations for the Williams Fork River

Parameter	Statistic	Units	Steelman Creek[1]		Bobtail Creek[2]		McQueary Creek[3]		Williams Fork above Sugarloaf Campground[4]		Williams Fork at Kinney Creek below Leal Gage[5]		Drinking Water Standards[6]
			Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	
Parameters without Stream Standards or Drinking Water Standards													
Alkalinity, total as $CaCO_3$	85th Percentile	mg/L	26 [2]	N/A	19 [2]	N/A	10 [2]	N/A	21 [2]	N/A	28 [2]	N/A	N/A
Calcium, dissolved	85th Percentile	mg/L	12 [1]	N/A	10 [1]	N/A	5.0 [1]	N/A	8.8 [1]	N/A	11 [1]	N/A	N/A
Cobalt, dissolved	85th Percentile	µg/L	bdl[7] [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl[2] [1]	N/A	N/A
Hardness as $CaCO_3$	85th Percentile	mg/L	48 [2]	N/A	34 [2]	N/A	16 [2]	N/A	30 [2]	N/A	39 [2]	N/A	N/A
Hardness as $CaCO_3$	15th Percentile	mg/L	30 [2]	N/A	19 [2]	N/A	9.0 [2]	N/A	23 [2]	N/A	23 [2]	N/A	N/A
Magnesium, dissolved	85th Percentile	mg/L	2.1 [1]	N/A	1.9 [1]	N/A	0.8 [1]	N/A	2.1 [1]	N/A	2.4 [1]	N/A	N/A
Molybdenum, dissolved	85th Percentile	µg/L	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	N/A
Phosphorus, total as P	85th Percentile	mg/L	0.02 [2]	N/A	0.02 [2]	N/A	0.02 [2]	N/A	0.02 [2]	N/A	0.02 [2]	N/A	N/A
Potassium, dissolved	85th Percentile	mg/L	0.4 [1]	N/A	0.5 [1]	N/A	0.5 [1]	N/A	0.8 [1]	N/A	1.0 [1]	N/A	N/A
Silicon, dissolved	85th Percentile	mg/L	2.8 [1]	N/A	2.0 [1]	N/A	2.6 [1]	N/A	3.9 [1]	N/A	4.0 [1]	N/A	N/A

Table 3.2-8 (continued)
Water Quality Data from Denver Water Sampling Stations for the Williams Fork River

Parameter	Statistic	Units	Steelman Creek[1]		Bobtail Creek[2]		McQueary Creek[3]		Williams Fork above Sugarloaf Campground[4]		Williams Fork at Kinney Creek below Leal Gage[5]		Drinking Water Standards[6]
			Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	Value	Stream Std[7]	
Specific conductance	85th Percentile	µmhos/cm	60 [3]	N/A	60 [3]	N/A	35 [3]	N/A	66 [3]	N/A	75 [3]	N/A	N/A
Total Suspended Solids	85th Percentile	mg/L	bdl [3]	N/A	bdl [3]	N/A	bdl [3]	N/A	2 [3]	N/A	bdl [3]	N/A	N/A
Vanadium, dissolved	85th Percentile	µg/L	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	bdl [1]	N/A	N/A

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
[1]Denver Water sample site WS-WF-005. Denver Water WS-WF-005 – Steelman Creek at bridge above diversion dam (data from 2002-2007).
[2]Denver Water sample site WS-WF-008. Denver Water WS-WF-008 – Bobtail Creek above diversion dam downstream of gauging station (data from 2002-2007).
[3]Denver Water sample site WS-WF-006. Denver Water WS-WF-006 – McQueary Creek above diversion dam (data from 2002-2007).
[4]Denver Water sample site WS-WF-004. Denver Water WS-WF-004 – Williams Fork above bridge at Sugarloaf Campground (data from 2002-2007).
[5]Denver Water sample site WS-WF-002. Williams Fork River below Kinney Creek confluence at Leal gage (data from 2002-2007).
[6]Drinking water standards per EPA website. Standards listed include primary, secondary, and advisory limits.
[7]Stream standard is per Regulation No. 33. Where the standard is "TVS," a hardness of the 15th Percentile was used in the TVS formula (Steelman=29.5, Bobtail=19.05, McQueary=9.0, and Williams Fork=23.0). Some parameters also have Drinking Water Standards set by CDPHE/EPA. Only Stream Standard is listed in this table.
[8]Per the methodology, bdl was reported when statistic results in value of "0."
[9]Stream Standard is for Chromium VI, while data are for total dissolved Chromium.
[10]TTs, per EPA's website.

°C = degrees Celsius
> = greater than
µg/L = micrograms per liter
µmhos/cm = micromhos per centimeter
bdl = below detection limit
$CaCO_3$ = calcium carbonate
EPA = U.S. Environmental Protection Agency
mg/L = milligrams per liter
ml = milliliters
MPN = most probable number
N/A = not applicable
NTU = nephelometric turbidity units
Std = standard
SU = standard unit
TT = Treatment Technique
TVS = table value standard

Table 3.2-9
USGS Data on the Williams Fork River

Site	Temperature (°C) 85th Percentile	Specific Conductance (µmhos/cm) 85th Percentile	Dissolved Oxygen (Minimum)
09035500 – Below Steelman Creek	9.9	N/A	N/A
09035700 – Above Darling Creek, Near Leal	8.9	72	N/A
09037500 – Near Parshall	13	129	N/A
09038500 – Below Williams Fork Reservoir	10	132	6.1
09249750 – Williams Fork at mouth, Near Hamilton	20.4	688	6.9

Notes:
°C = degrees Celsius
µmhos/cm = micromhos per centimeter
N/A = not available – no data for that parameter is available at specific sites

The limited USGS data indicates the Williams Fork River is within regulatory standards.

Dissolved oxygen may be below regulatory standards downstream of the dam. Two datasets were available to provide further information. The first is Denver Water's Sampling Site on the Williams Fork River below Williams Fork Reservoir (WS-WF-009) and the second is River Watch data (Bailey 2010). Both were provided by the same source (Bailey 2010) and used in the GCWIN Stream Management Report (GCWIN 2009). Table 3.2-10 summarizes the information on dissolved oxygen below Williams Fork Dam.

Table 3.2-10
Dissolved Oxygen (mg/L) below Williams Fork Reservoir

Condition	15th Percentile	Median	85th Percentile	Count of Sampling Points	Count of Sampling Points below Regulatory Standard	Regulatory Standard (applied to 15th Percentile)
Overall Dataset	6.3	9.0	11.0	92	12	6.0
Spring and Fall Spawning Seasons	6.9	9.0	10.3	38	6	7.0
Spring Spawning Only	7.0	9.0	9.7	18	1	7.0
Fall Spawning Only	5.5	9.0	10.5	20	5	7.0

Source: Bailey, 2010.

The Williams Fork River appears to be below dissolved oxygen regulatory standards during the fall spawning season (brown trout). The cause is not known but may be related to fall reservoir turnover combined with reservoir releases. Denver Water is currently constructing improvements to the Williams Fork outlet works which will allow for releases from different levels in the reservoir. This may improve the dissolved oxygen levels in the releases during fall months. The data in Tables 3.2-9 and 3.2-10 do not include information for nitrite and nitrate. Two values have been recorded at Station 09038500. In August of 2002, the recorded combined nitrite plus nitrate value was 0.126 mg/L. In September of 2002, the recorded value was 0.046 mg/L. The regulatory standard for nitrite is 0.05 mg/L and for nitrate is 10 mg/L (CDPHE Regulation No. 33, 2011b). No data is available for

nitrite and nitrate separately although nitrite is readily converted in natural systems to nitrate and from the two sample sites; the stream is very likely to be within regulatory standards.

There is one discharge permit in the Williams Fork watershed for the Henderson Mill (Permit No. CO0000230). The permit is for a 30-day average flow of 0.10 mgd. The wastewater facilities at the Mill are intended to be zero discharge (Freeport-McMoRan 2010).

3.2.5.3 Colorado River

The Surface Water Classification for the Colorado River mainstem from the confluence of the Fraser River downstream to the Town of Kremmling is Cold Water Aquatic Life Class 1, Recreation E, Water Supply and Agriculture (CDPHE 2008a). This section of the Colorado River is Segment 3 of the upper Colorado River. The Colorado River from the outlet of Windy Gap Reservoir to the 578 Road Bridge is on the Monitoring and Evaluation List for Aquatic Life Use (CDPHE 2012a). The Colorado River from the 578 Road Bridge to just above the confluence with the Blue River is on the 303(d) List for temperature and manganese with a State-determined high priority.

NPDES permits indicating point source discharges have been issued for the following wastewater treatment facilities:

- Town of Hot Sulphur Springs, 0.09 mgd
- Kremmling Sanitation District, 0.3 mgd (Muddy Creek discharge)
- Ouray Ranch Homeowners Association, 0.016 mgd
- Windy Gap Reservoir Viewing Area, 0.0004 mgd

Drinking water providers that use the Colorado River from the confluence with the Fraser River to the confluence with the Blue River are:

- Hot Sulphur Springs
- Kremmling

The most recent study on this portion of the Colorado is the Grand County Stream Management Plan (Grand County 2008, 2010). Table 3.2-11 summarizes findings reported in Phase 2 and Phase 3 of the Plan.

The Windy Gap Project diverts water from the Colorado River just downstream of the Fraser River confluence to multiple water users in Colorado's Front Range via C-BT Project facilities. Water is pumped from Windy Gap Reservoir to Granby Reservoir, then Shadow Mountain Reservoir/Grand Lake and then by gravity through the Adams Tunnel to Colorado's East Slope.

GCWIN has performed extensive temperature monitoring on the Colorado River below Windy Gap beginning in 2005. Water temperature is recorded by data loggers at 5- to 30-minute intervals at most stations, generally from mid-summer through mid-October or early November. This comprehensive dataset (GCWIN 2010) was used in the 2010 Draft EIS analysis to establish existing conditions with regards to the chronic temperature standard (MWAT) and the acute temperature standard (DM). The regulatory standard from

Windy Gap to Kremmling (and further downstream) is Cold Stream Tier II, with a summer DM of 23.8ºC and a summer MWAT of 18.2ºC. Exceedances were identified using an Excel calculator developed by CDPHE (CDPHE 2010a). Results of the analysis for stations in each reach are presented in Table 3.2-11.

Summary observations from Table 3.2-11 include the following:

- The MWAT has been exceeded one time in five years at the station below Windy Gap, indicating attainment of the temperature standard. According to Regulation 31 (CDPHE 2011a), the standard is considered "attained" if exceedance occurs no more often than once in three years.
- From the vicinity of Hot Sulphur Springs to the Williams Fork confluence, two stations exhibited exceedances of the MWAT and/or DM in 2006 and 2007; while a third station exhibited no exceedances.
- Below Williams Fork, three of five stations exhibited no exceedances. The MWAT standard was exceeded at CR3 in 2007 and 2008, and at the Highway 9 Bridge, in 2007 and 2010; there were no exceedances of the DM standard below Williams Fork.
- DM temperatures that exceed the acute standard have occurred only at Hot Sulphur Springs.

The following discussion is based on these sampling stations:

- CDPHE Station 12105, Colorado River at US 34 (EPA 2010c), data taken from 2001 to 2008.
- USGS Station 09034250, Colorado River At Windy Gap, Near Granby, Colorado (USGS 2010a), data taken from 2000 to 2010.
- USGS 09058000 Colorado River Near Kremmling, Colorado (USGS 2010a), data taken from 2000 to 2010.

Table 3.2-11
Summary of Colorado River Water Quality in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)*	Water Quality Data Summarized from Table 3.2-12
	Water Temperature Concerns	Water Quality Concerns	Phase 3 Additions		
CR2, Shadow Mountain Reservoir to Granby Reservoir	Temperature data not collected.	The Three Lakes are in a mesotrophic state and water quality of the lakes is similar due to operations of the C-BT system.	No changes.	Not analyzed.	N/A
CR3, Granby Reservoir to Windy Gap	None noted.	Increased pumping from Windy Gap would result in an increase in nutrient loading to Granby Reservoir. Not clear if this would affect the river below. No other water quality concerns noted.	Temperatures well below the DM and the MWAT.	Not analyzed.	N/A

Table 3.2-11 (continued)
Summary of Colorado River Water Quality in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)*	Water Quality Data Summarized from Table 3.2-12
	Water Temperature Concerns	Water Quality Concerns	Phase 3 Additions		
CR4, Windy Gap to Williams Fork	Windy Gap temperatures tend to parallel those of the Fraser. The Lone Buck gage may be influenced by the hot springs at Hot Sulphur Springs. Above Windy Gap, the DM was exceeded nine times in 2007. Below Windy Gap, the guideline (18.2°C) was exceeded every day from July 29 to August 27, 2009. The seven day rolling average exceeded the guideline (18.2°C) for four consecutive days. Possible influences are configuration of Windy Gap (wide and shallow) in combination with irrigation return flows.	None noted.	Temperatures typically exceed the MWAT in late July and August. Portion is listed on 303(d) List. Algae are abundant upstream of Hot Sulphur Springs. pH has occasionally exceeded 9.	*Colorado River below Windy Gap (POR 2005 – 2009)* Summer MWAT exceedances: 2005 – None 2006 – 1 2007, 2008, and 2009 – None Summer DM exceedances: None *Colorado River above Hot Sulphur Springs (POR 2006 – 2009)* Summer MWAT exceedances: 2006 – 3 2007 – 3 2008 and 2009 – None	No exceedances of State water quality standards

Table 3.2-11 (continued)
Summary of Colorado River Water Quality in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)*	Water Quality Data Summarized from Table 3.2-12
	Water Temperature Concerns	Water Quality Concerns	Phase 3 Additions		
				Colorado River above Hot Sulphur Springs (POR 2006 – 2009) (continued) Summer DM exceedances: 2006 – 2 2007 – 4 2008 and 2009 – None *Colorado River below Byers Canyon (POR 2008 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None *Colorado River at Lonebuck (POR 2006 – 2008)* Summer MWAT exceedances: 2006 – 3 2007 – 4 2008 – None Summer DM exceedances: None	

Table 3.2-11 (continued)
Summary of Colorado River Water Quality in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)*	Water Quality Data Summarized from Table 3.2-12
	Water Temperature Concerns	Water Quality Concerns	Phase 3 Additions		
CR5, Williams Fork to the KB Ditch	A number of days in late July and early August exceeded guideline of 18.2°C. The seven-day rolling average exceeded 18.2°C every day from July 25 to August 26, 2007. Temperatures cool downstream of Williams Fork due to the cooler temperatures of the Williams Fork.	None noted.	Stream temperatures are generally within the DM and MWAT. Some exceedances have occurred. Reach has been included on the 303(d) List.	*Colorado River above Kid Pond (POR 2005 – 2008)* Summer MWAT exceedances: None Summer DM exceedances: None *Colorado River at County Road 3 (POR 2007 – 2009)* Summer MWAT exceedances: 2007 – 5 2008 – 1 2009 – None Summer DM exceedances: None *Colorado River at Con Ritschard Ranch (POR 9/2006 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None	N/A

Table 3.2-11 (continued)
Summary of Colorado River Water Quality in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)*	Water Quality Data Summarized from Table 3.2-12
	Water Temperature Concerns	Water Quality Concerns	Phase 3 Additions		
CR6, Below KB Ditch to Blue River Confluence	None noted.	None noted.	Stream temperatures are generally within the DM and MWAT. Some exceedances have occurred. Reach has been included on the 303(d) List. Algae are a constant nuisance for pumping operations and affect aesthetics.	*Colorado River at County Road 39 Bridge and KB Ditch (POR 2007 – 2009)* Summer MWAT exceedances: None Summer DM exceedances: None	No exceedances of State water quality standards
CR7, Below Gore Canyon to Grand-Eagle County Line	Overall regime appears to fall within the recommendations of the USFWS and supports the target species and life stages.	None noted.	Stream temperatures are generally below the MWAT and DM. The MWAT near Kremmling was exceeded for several days in August 2007.	*Colorado River at Highway 9 Bridge (POR 2006 – 2010)* Summer MWAT exceedances: 2006 – None 2007 – 3 2008 and 2009 – None 2010 – 4 Summer DM exceedances: None	N/A Outside of study area

Notes:
*Not presented in Grand County Stream Management Plan. Analytical procedures performed by the Corps per CDPHE Regulation 93 (CDPHE 2012a) and using macro developed by CDPHE (CDPHE 2010c).

°C = degrees Celsius
C-BT = Colorado-Big Thompson
CDPHE = Colorado Department of Public Health and Environment
Corps = U.S. Army Corps of Engineers
CR = Colorado River
DM = daily maximum
MWAT = maximum weekly average temperature
N/A = not applicable
POR = Period of Record
USFWS = U.S. Fish and Wildlife Service

The CDPHE and USGS data is shown in Table 3.2-12.

Table 3.2-12
Water Quality Data for the Colorado River from Granby to Kremmling

Parameter	Statistic	Units	CDPHE Station 12105		USGS 09034250		USGS 09058000	
			Value	Standard[1,2]	Value	Standard[1,2]	Value	Standard[1,2]
Parameters with Stream Standards								
Ammonia	85th Percentile	mg/L	0.04 [44]	2.8	0.05 [42]	2.8	0.01 [56]	2.8
Arsenic, total recoverable	50th Percentile	µg/L	bdl[3] [23]	0.02	bdl [19]	0.02	0.7 [27]	0.02
Cadmium, dissolved	85th Percentile	µg/L	bdl [32]	0.14	0.01 [42]	0.14	0.07 [50]	0.14
Copper, dissolved	85th Percentile	µg/L	bdl [32]	2.5	2.5 [42]	3.6	2.2 [53]	7.2
Dissolved oxygen	15th Percentile	mg/L	8.3 [29]	>7.0	8.8 [45]	>7.0	7.1 [60]	>7.0
E. Coli	Geometric Mean	MPN/ 100 ml	bdl [22]	126	4.8 [12]	126	5.0 [20]	126
Iron, dissolved	85th Percentile	µg/L	91 [32]	300	109 [42]	300	128 [54]	300
Lead, dissolved	85th Percentile	µg/L	bdl [32]	0.49	0.12 [42]	0.49	0.13 [54]	0.49
Manganese, dissolved	85th Percentile	µg/L	24 [32]	1,011	58 [42]	1,011	85 [54]	1,011
Mercury, dissolved	85th Percentile	µg/L	bdl [22]	0.01	bdl [12]	0.01	N/A [0]	0.01
Nitrate + Nitrite	85th Percentile	mg/L	bdl [32]	10.05	0.15 [42]	10.05	0.14 [56]	10.05
pH	85th Percentile	SU	8.7 [29]	6.5-9.0	8.9 [45]	6.5-9.0	8.3 [60]	6.5-9.0
pH	15th Percentile	SU	7.8 [29]	6.5-9.0	8.1 [45]	6.5-9.0	8.0 [60]	6.5-9.0
Selenium, dissolved	85th Percentile	mg/L	bdl [32]	4.6	0.14 [42]	4.6	0.4 [28]	4.6
Silver, dissolved	85th Percentile	µg/L	bdl [32]	0.006	bdl [41]	0.006	N/A [0]	0.006
Temperature	Daily Maximum	°C	19.9 [30]	23.8	21 [78]	23.8	19 [63]	23.8
Zinc, dissolved	85th Percentile	µg/L	bdl [32]	3.7	5.2 [42]	11	5.3 [51]	67
Parameters with Drinking Water Standards								
Aluminum, dissolved	85th Percentile	µg/L	86 [27]	50-200	18 [7]	50-200	5.2 [17]	50-200
Sulfate, total	85th Percentile	mg/L	4 [31]	250	6.8 [43]	250	51 [54]	250
Fecal coliform	Geometric Mean	MPN/ 100 ml	0 [6]	TT	N/A [0]	TT	N/A [0]	TT

Table 3.2-12 (continued)
Water Quality Data for the Colorado River from Granby to Kremmling

Parameter	Statistic	Units	CDPHE Station 12105		USGS 09034250		USGS 09058000	
			Value	Standard[1,2]	Value	Standard[1,2]	Value	Standard[1,2]
Manganese, dissolved	85th Percentile	µg/L	24 [32]	50	58 [42]	50	85 [54]	50
Total dissolved solid	85th Percentile	mg/L	60 [22]	500	101 [3]	500	210 [29]	500
Uranium, dissolved	85th Percentile	µg/L	bdl [8]	30	N/A [0]	30	N/A [0]	30
Parameters without Standards								
Alkalinity, total as $CaCO_3$	85th Percentile	mg/L	36 [14]	N/A	61 [15]	N/A	75 [16]	N/A
Hardness as $CaCO_3$	85th Percentile	mg/L	28 [32]	N/A	61 [43]	N/A	119 [55]	N/A
Hardness as $CaCO_3$	15th Percentile	mg/L	23 [32]	N/A	36 [43]	N/A	82 [55]	N/A
Total Kjeldahl Nitrogen	85th Percentile	mg/L	0.16 [32]	N/A	N/A [0]	N/A	N/A [0]	N/A
Phosphates, total as P	85th Percentile	mg/L	0.04 [32]	N/A	0.04 [23]	N/A	0.01 [41]	N/A
Specific conductance	85th Percentile	µmhos/cm	80 [29]	N/A	154 [78]	N/A	285 [63]	N/A
Total Suspended Solids	85th Percentile	mg/L	bdl [22]	N/A	13 [42]	N/A	24 [28]	N/A

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
[1]Stream standard is per Regulation No. 33. Where the standard is "TVS," a hardness of the 15th Percentile for Station 12105 was used in the TVS formula resulting in the most stringent standard for these sites. If multiple standards are shown, the 15th Percentile for each station was used. Some parameters also have Drinking Water Standards set by CDPHE/EPA. Only Stream Standard is listed in this table. Many of the stream standards change dependent on hardness and are thus, different for each sampling site. Only where 85th percentile values approach or exceed the minimum standard for the three sites are multiple standards listed.
[2]Drinking water standards per EPA website. Standards listed include primary, secondary, and advisory limits.
[3]Per the methodology, bdl was reported when statistic results in value of "0."

°C = degrees Celsius
> = greater than
µg/L = micrograms per liter
µmhos/cm = micromhos per centimeter
bdl = below detection limit
$CaCO_3$ = Calcium Carbonate
CDPHE = Colorado Department of Public Health and Environment
EPA = U.S. Environmental Protection Agency
mg/L = milligrams per liter
ml = milliliters
MPN = most probable number
N/A = not applicable
SU = standard unit
TT = Treatment Technique
TVS = table value standard
USGS = U.S. Geological Survey

Values listed in Table 3.2-12 indicate that the Colorado River water quality is generally within stream standards at the stations shown. The exception is dissolved arsenic at the Kremmling station. The source of the arsenic is unknown.

3.2.5.4 Muddy Creek

Muddy Creek, below Wolford Mountain Reservoir, is within WQCC Segment 7b of the upper Colorado River Basin and is classified as Aquatic Life Cold 1, Recreation E, Water Supply, and Agriculture (CDPHE 2012a).

Muddy Creek between the outlet of Wolford Mountain dam and Cow Gulch is on CDPHE's Monitoring and Evaluation List for temperature. Muddy Creek between Cow Gulch and the confluence with the Colorado River is on the 303(d) List (CDPHE 2012a). No TMDLs have been developed for any portion of Muddy Creek for temperature.

There is one NPDES discharge, the Town of Kremmling, with 0.3 mgd permitted discharge to Muddy Creek.

The Grand County Stream Management Plan, Phases 2 and 3, provide information on Muddy Creek as shown in Table 3.2-13. This table includes only the stream reach below Wolford Mountain Reservoir. Reaches above the reservoir will not be affected by the proposed Project.

Table 3.2-13
Summary of Muddy Creek Water Quality in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)	Water Quality Data Summarized from Table 3.2-14
	Water Temperature Concerns	Water Quality Concerns	Phase 3 Additions		
MC2, Muddy Creek – Wolford Mountain Reservoir to the Colorado River	Water temperature not a concern. Close to Kremmling, several temperature exceedances occurred between 1995 and 2003.	Exceedances in pH in the early 2000s. No other concerns noted.	Temperatures exceed both the MWAT and DM standard in late July/early August. On M&E List for temperature.	*Muddy Creek below KSD (POR 2008)* Summer MWAT exceedances: 2008 – 2 Summer DM exceedances: 2008 – 6	85th percentile for sulfate exceeds State standard. State water quality standard is set to secondary drinking water standard. 50th percentile for total arsenic exceeds State chronic water quality standard.

Notes:
Corps = U.S. Army Corps of Engineers
DM = daily maximum
KSD = Kremmling Sanitation District
M&E = Monitoring and Evaluation
MWAT = maximum weekly average temperature
POR = Period of Record

One sampling site in the area of interest is available near Kremmling (USGS 09041400) with data from 2003 to 2010, as shown in Table 3.2-14 (USGS 2010a).

Table 3.2-14
Muddy Creek Water Quality Data

Parameter	Statistic	Units	USGS 09041400 Muddy Creek below Wolford Mountain Reservation Near Kremmling		
			Value	Stream Std[1]	Drinking Water Standards[2]
Ammonia, dissolved	85th Percentile	mg/L	0.05 [94]	0.70	N/A
Arsenic, total	50th Percentile	µg/L	**0.69** [15]	0.02 (total recoverable)	10
Cadmium, dissolved	85th Percentile	µg/L	0.03 [15]	0.86	5
Copper, dissolved	85th Percentile	µg/L	2.02 [15]	20.03	1,300
Dissolved oxygen	15th Percentile	mg/L	8 [94]	>7	N/A
E. Coli	Geomean	MPN/ 100 ml	bdl[3] [30]	126	N/A
Iron, dissolved	85th Percentile	µg/L	15 [91]	300	300
Lead, dissolved	85th Percentile	µg/L	0.06 [14]	6.90	15
Manganese, dissolved	85th Percentile	µg/L	66 [92]	2,258	50
Nitrate and Nitrite	85th Percentile	mg/L	0.24 [94]	10.05	11
pH	85th Percentile	SU	8.5 [94]	6.5-9.0	6.5-8.5
pH	15th Percentile	SU	8.1 [94]	6.5-9.0	6.5-8.5
Selenium, dissolved	85th Percentile	µg/L	2.7 [15]	4.6	50
Silver, dissolved	85th Percentile	µg/L	bdl [15]	0.4	100
Temperature	Daily Maximum	ºC	20.3 [94]	21.2	N/A
Zinc, dissolved	85th Percentile	µg/L	2.0 [14]	277.5	5,000
Parameters with Drinking Water Standards					
Sulfate	85th Percentile	mg/L	**293** [92]	250	250
Total Dissolved Solid	85th Percentile	mg/L	589 [92]	N/A	500

Table 3.2-14 (continued)
Muddy Creek Water Quality Data

Parameter	Statistic	Units	USGS 09041400 Muddy Creek below Wolford Mountain Reservation Near Kremmling		
			Value	Stream Std[1]	Drinking Water Standards[2]
Parameters without Stream Standards or Drinking Water Standards					
Hardness as $CaCO_3$	85th Percentile	mg/L	367 [92]	N/A	N/A
Hardness as $CaCO_3$	15th Percentile	mg/L	257 [92]	N/A	N/A
Specific conductance	85th Percentile	µmhos/cm	831 [94]	N/A	N/A

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
Numbers in bold font and gray shading indicate stream standard exceedances.
[1]Stream standard is per Regulation No. 33. Where the standard is "TVS," a hardness of the 15th Percentile for Station 12105 was used in the TVS formula resulting in the most stringent standard for these sites. If multiple standards are shown, the 15th Percentile for each station was used. Some parameters also have Drinking Water Standards set by CDPHE/EPA. Only Stream Standard is listed in this table. Many of the stream standards change dependent on hardness and are thus, different for each sampling site. Only where 85th percentile values approach or exceed the minimum standard for the three sites are multiple standards listed.
[2]Drinking water standards per EPA website. Standards listed include primary, secondary, and advisory limits.
[3]Per the methodology, below detection limit (bdl) was reported when statistic results in value of "0."

°C	=	degrees Celsius	ml	=	milliliters
>	=	greater than	MPN	=	most probable number
µg/L	=	micrograms per liter	N/A	=	not applicable
µmhos/cm	=	micromhos per centimeter	Std	=	standard
bdl	=	below detection limit	SU	=	standard unit
$CaCO_3$	=	Calcium Carbonate	TVS	=	table value standard
mg/L	=	milligrams per liter	USGS	=	U.S. Geological Survey

From Table 3.2-14, all parameters are within stream standards except for arsenic and sulfate. The 50th percentile for total recoverable arsenic is 0.69 µg/L versus a chronic standard of 0.02 µg/L. The USGS evaluated water quality in Muddy Creek before and after the construction of Wolford Mountain Reservoir. From these evaluations, the source of arsenic appears to be Alkali Slough, which now discharges into an arm of Wolford Mountain Reservoir. The reservoir appears to mitigate higher and lower concentrations through mixing with similar changes between upstream and downstream as before construction of the reservoir (Stevens and Sprague 2001).

The 85th percentile for sulfate is 293 mg/L versus the standard of 250 mg/L. The standard is set for drinking water. The secondary (not enforceable) standard is 250 mg/L. There is not a primary drinking water standard for sulfate.

3.2.5.5 Blue River

The Surface Water Classification for the mainstem of the Blue River from the source to the confluence with the Colorado River is Cold Water Aquatic Life Class 1, Recreation E, Water Supply and Agriculture (CDPHE 2008a). Denver Water does not divert above Dillon Reservoir and does not impact the Blue River or tributaries upstream of Dillon Reservoir. The Blue River from the outlet of Dillon Reservoir to the confluence with North

Rock Creek is listed for Aquatic Life Use on the Monitoring and Evaluation List detailed in Regulation 93 (CDPHE 2012a). The Blue River from the confluence of North Rock Creek to the confluence with the Colorado River is not listed on the 303(d) or Monitoring and Evaluation Lists. Upstream of Dillon Reservoir, the Blue River is on the Monitoring and Evaluation List for cadmium and zinc. Also upstream of Dillon Reservoir, Illinois Gulch is on the 303(d) List for cadmium, and Spruce Creek is on the Monitoring and Evaluation List for iron.

Wastewater treatment facilities upstream and downstream of Dillon Reservoir are operated by the following entities under NPDES permits presented in Table 3.2-15.

Table 3.2-15
Wastewater Treatment Facilities on the Blue River

Treatment Facility	Facility Owner	Discharge Stream	Permitted Discharge (mgd)
Iowa Hill	Breckenridge Sanitation District	Blue River	1.5
Farmers Korner	Breckenridge Sanitation District	Diversion channel from the Blue River to Dillon Reservoir	3.0
Copper Mountain	Copper Mountain Consolidated Metro District	Tenmile Creek	1.1
Frisco	Frisco Sanitation District	Miners Creek and wetlands created by Dillon Reservoir	1.7
Arapahoe Basin	Dundee Realty	North Fork Snake River	0.035
Snake River	Summit County	Snake River/Snake River arm of Dillon Reservoir	2.6
Blue River	Silverthorne/Dillon Joint Sewer Authority	Blue River	4.0

Source: EPA, 2010b.
Note:
mgd = million gallons per day

Entities that discharge directly to or to tributaries of Dillon Reservoir are governed by CDPHE Regulation 71, Dillon Reservoir Control Regulation, which limits phosphorus in discharges.

The Grand County Stream Management Plan, Phases 2 and 3, provide information on the Blue River as shown in Table 3.2-16. No frequent water temperature measurements are available from GCWIN for the Blue River, so additional temperature analysis was not conducted for the EIS for this river segment.

Table 3.2-16
Summary of Blue River Water Quality in the Grand County Stream Management Plan

Grand County Stream Management Plan Reach Description	Grand County Stream Management Plan, Phases 2 and 3, Reach Summaries			Temperature Analysis per State Regulations (Performed by the Corps)
	Water Temperature Concerns	Water Quality Concerns	Phase 3 Additions	
BR, Blue River (county line approximately 3 miles downstream of Green Mountain Reservoir)	Exceeded 17°C several times and 18.2°C once.	Exceedances in pH in the early 2000s. No other concerns noted.	MWAT is 17°C and DM is 21.2°C.	N/A

Notes:
°C = degrees Celsius
Corps = U.S. Army Corps of Engineers
DM = daily maximum
MWAT = maximum weekly average temperature
N/A = not applicable

Water quality data for the following stations was obtained from:

- CDPHE Station 12300, Blue River at City Road 1 (EPA 2010c, data taken from November 2000 to May 2004)
- CDPHE Station 12302, Blue River downstream from Green Mountain Reservoir (EPA 2010c, data taken from November 2000 to August 2003)
- CDPHE Station 12304, Blue River downstream from Dillon Reservoir and Straight Creek (EPA 2010c, data taken from November 2000 to August 2002)

This data is summarized in Table 3.2-17.

The Blue River is within regulatory standards and drinking water standards based on the available data.

Table 3.2-17
Water Quality in the Blue River Downstream of Dillon Reservoir

Parameter	Statistic	Units	12304, Blue River D/S Dillon Reservoir and Straight Creek		12302, Blue River D/S Green Mountain Reservoir		12300, Blue River at City Road 1		Drinking Water Standards[2]
			Value	Stream Std[1]	Value	Stream Std[1]	Value	Stream Std[1]	
Parameters with Stream Standards									
Arsenic, dissolved	50th Percentile	µg/L	bdl [18]	0.02 (total recoverable)	bdl [19]	0.02 (total recoverable)	bdl [21]	0.02 (total recoverable)	10
Cadmium, dissolved	85th Percentile	µg/L	bdl [18]	0.42	bdl [19]	0.37	bdl [21]	0.39	N/A
Copper, dissolved	85th Percentile	µg/L	bdl [18]	8.84	1.2 [19]	7.67	bdl [21]	8.11	1,300
Dissolved oxygen	15th Percentile	mg/L	7.9 [16]	>6	7.2 [17]	>6	8.4 [21]	>6	N/A
E. Coli	Geomean	MPN/100 ml	0.06 [16]	126	0.02 [14]	126	1.82 [16]	126	N/A
Iron, dissolved	85th Percentile	µg/L	bdl [36]	300	17.9 [38]	300	50 [43]	300	300
Lead, dissolved	85th Percentile	µg/L	bdl [18]	2.48	bdl [19]	2.06	bdl [21]	2.22	15
Manganese, dissolved	85th Percentile	µg/L	20.15 [18]	1,641.58	0.6 [19]	1,552.80	48 [21]	1,586.78	50
Nitrate and Nitrite	85th Percentile	mg/L	bdl [18]	10.05	0.013 [19]	10.05	bdl [22]	10.05	11
pH	85th Percentile	SU	7.6 [16]	6.5-9.0	7.552 [17]	6.5-9.0	7.6 [21]	6.5-9.0	6.5-8.5
pH	15th Percentile	SU	8.045 [16]	6.5-9.0	8.312 [17]	6.5-9.0	8.37 [21]	6.5-9.0	6.5-8.5

Table 3.2-17 (continued)
Water Quality in the Blue River Downstream of Dillon Reservoir

Parameter	Statistic	Units	12304, Blue River D/S Dillon Reservoir and Straight Creek		12302, Blue River D/S Green Mountain Reservoir		12300, Blue River at City Road 1		Drinking Water Standards[2]
			Value	Stream Std[1]	Value	Stream Std[1]	Value	Stream Std[1]	
Selenium, dissolved	85th Percentile	µg/L	bdl [18]	4.6	bdl [19]	4.6	bdl [21]	4.6	N/A
Silver, dissolved	85th Percentile	µg/L	bdl [18]	0.07	bdl [19]	0.05	bdl [21]	0.06	100
Temperature	Daily Maximum	ºC	12.1 [16]	21.2	16.4 [17]	21.2	18.5 [20]	21.2	N/A
Zinc, dissolved	85th Percentile	µg/L	18.9 [18]	101.4	3.6 [19]	69.9	15.45 [20]	80.8	5,000
Parameters with Drinking Water Standards									
Aluminum, dissolved	85th Percentile	µg/L	bdl [18]	N/A	bdl [19]	N/A	bdl [21]	N/A	50-200
Sulfate	85th Percentile	mg/L	99 [18]	250	46 [19]	250	46 [22]	250	250
Fecal Coliform	Geomean	MPN/100 ml	bdl [1]	N/A	bdl [2]	N/A	0.12 [3]	N/A	TT
Total Dissolved Solid	85th Percentile	mg/L	220 [18]	N/A	153 [19]	N/A	180 [22]	N/A	500

Table 3.2-17 (continued)
Water Quality in the Blue River Downstream of Dillon Reservoir

Parameter	Statistic	Units	12304, Blue River D/S Dillon Reservoir and Straight Creek		12302, Blue River D/S Green Mountain Reservoir		12300, Blue River at City Road 1		Drinking Water Standards[2]
			Value	Stream Std[1]	Value	Stream Std[1]	Value	Stream Std[1]	
Parameters without Stream Standards or Drinking Water Standards									
Alkalinity, total as $CaCO_3$	85th Percentile	mg/L	41.4 [12]	N/A	66 [11]	N/A	93 [13]	N/A	N/A
Hardness as $CaCO_3$	85th Percentile	mg/L	130 [18]	N/A	95.6 [19]	N/A	130 [21]	N/A	N/A
Hardness as $CaCO_3$	15th Percentile	mg/L	98.55 [18]	N/A	83.4 [19]	N/A	89 [21]	N/A	N/A
Total Kjeldahl Nitrogen	85th Percentile	mg/L	bdl [18]	N/A	0.232 [19]	N/A	0.23 [22]	N/A	N/A
Phosphorus, total as P	85th Percentile	mg/L	0.0045 [18]	N/A	0.02 [19]	N/A	0.02 [22]	N/A	N/A
Specific conductance	85th Percentile	µmhos/cm	320.25 [16]	N/A	241.6 [17]	N/A	295 [21]	N/A	N/A
Total Suspended Solids	85th Percentile	mg/L	bdl [18]	N/A	bdl [19]	N/A	bdl [22]	N/A	N/A

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
[1]CDPHE Regulation 38
[2]EPA Safe Drinking Water Act Standards

°C = degrees Celsius
> = greater than
µg/L = micrograms per liter
µmhos/cm = micromhos per centimeter
bdl = below detection limit
$CaCO_3$ = Calcium Carbonate
D/S = downstream
mg/L = milligrams per liter
ml = milliliters
MPN = most probable number
Std = standard
SU = standard unit
TT = Treatment Technique

3.2.5.6 South Boulder Creek

The Surface Water Classification for the mainstem of South Boulder Creek including all tributaries lakes, reservoirs, and wetlands from the source to South Boulder Road is Cold Water Aquatic Life Cold 1, Recreation E, Water Supply and Agriculture (CDPHE 2011b). The mainstem of South Boulder Creek is designated WQCC Segments 4a, 4b, and 5 of the Boulder Creek Basin (CDPHE 2011b). Downstream of South Boulder Road, the designation changes to Aquatic Life Warm 1. No sections of the mainstem of South Boulder Creek are listed in Regulation 93 (CDPHE 2012a) on the 303(d) or Monitoring and Evaluation Lists.

Water suppliers that use South Boulder Creek include:

- Denver Water, including contract customers (via Gross Reservoir)
- Town of Erie (via South Boulder Canon Ditch)
- City of Lafayette
- City of Louisville (at Eldorado Springs)
- San Souci Mobile Home Park (groundwater under the influence of surface water)
- Superior
- Eldora Mountain Resort

Of these water suppliers, only Eldora Mountain Resort diverts upstream of Gross Reservoir.

Wastewater dischargers to the mainstem of South Boulder Creek include:

- Union Pacific Railroad (UPRR) at the East Portal of the Moffat Tunnel, CO0047554, permitted discharge of 0.5 mgd
- Eldorado Springs Wastewater Treatment Facility, CO047651, permitted discharge of 0.032 mgd
- San Souci Mobile Home Park, COG588101, permitted discharge of 0.018 mgd

Denver Water maintains sampling sites above and below the Moffat Tunnel discharge. Data from these stations were used herein because the upper site provides unaltered stream information and the downstream site provides information for the stretch of South Boulder Creek most likely to be potentially affected by the Moffat Project. The data from these sites is shown in Table 3.2-18. Note that the downstream site reflects both Denver Water deliveries through the Moffat Tunnel and UPRR permitted discharges from the Moffat Tunnel.

Table 3.2-18
Water Quality Data for South Boulder Creek Near Moffat Tunnel

Parameter	Statistic	Units	Above Moffat Tunnel[1]	Below Moffat Tunnel[2]	Standard[3]
Parameters with Stream Standards					
Arsenic, dissolved	85th Percentile	µg/L	bdl[4] [9]	bdl [9]	0.02 (total recoverable)
Boron, dissolved	85th Percentile	µg/L	2.0 [9]	2.0 [9]	750
Cadmium, dissolved	85th Percentile	µg/L	0.18 [9]	0.10 [9]	0.11
Chromium, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	11[5]
Copper, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	2
Dissolved oxygen	15th Percentile	mg/L	7.2 [9]	7.6 [9]	>7
E. Coli	Geometric Mean	MPN/100 ml	0.8 [9]	2.1 [9]	126
Iron, dissolved	85th Percentile	mg/L	bdl [9]	0.05 [9]	0.3
Lead, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	0.36
Manganese, dissolved	85th Percentile	µg/L	1.6 [9]	6.4 [9]	925
Mercury, total	50th Percentile	µg/L	bdl [9]	bdl [9]	0.01
Nickel, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	12
pH	85th Percentile	SU	8.1 [9]	8.3 [9]	6.5-9.0
pH	15th Percentile	SU	7.4 [9]	7.3 [9]	6.5-9.0
Selenium, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	4.6
Silver, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	0.02
Temperature	Daily Maximum	ºC	12 [9]	11 [9]	21.2
Zinc, dissolved	85th Percentile	µg/L	4.0 [9]	4.0 [9]	25

Table 3.2-18 (continued)
Water Quality Data for South Boulder Creek Near Moffat Tunnel

Parameter	Statistic	Units	Above Moffat Tunnel[1]	Below Moffat Tunnel[2]	Standard[3]
Parameters with Drinking Water Standards					
Aluminum, dissolved	85th Percentile	mg/L	0.03 [9]	0.10 [9]	0.05-0.2[4]
Antimony, dissolved	85th Percentile	mg/L	bdl[5] [9]	bdl [9]	0.006
Barium, dissolved	85th Percentile	µg/L	20 [9]	19 [9]	2,000
Beryllium, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	4
Mercury, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	2
Sodium, dissolved	85th Percentile	mg/L	1.8 [9]	3 [9]	20[6]
Thallium, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	2
Fecal coliform	Geometric Mean	MPN/100 ml	27.9 [9]	29.5 [9]	TT[6]
Turbidity	85th Percentile	NTU	1.9 [9]	1.6 [9]	TT[6]
Uranium, dissolved	85th Percentile	µg/L	0.4 [9]	3.3 [9]	30
Parameters without Standards					
Alkalinity, total as $CaCO_3$	85th Percentile	mg/L	22 [9]	27 [9]	N/A
Antimony, total	50th Percentile	µg/L	bdl[3] [9]	bdl [9]	N/A
Barium, total	50th Percentile	µg/L	17 [9]	16 [9]	N/A
Boron, total	50th Percentile	µg/L	2 [9]	2 [9]	N/A
Calcium, dissolved	85th Percentile	mg/L	7 [9]	8 [9]	N/A
Cobalt, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	N/A
Hardness as $CaCO_3$	85th Percentile	mg/L	30 [9]	28 [9]	N/A
Magnesium, dissolved	85th Percentile	mg/L	3.0 [9]	2.4 [9]	N/A
Molybdenum, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	N/A

Table 3.2-18 (continued)
Water Quality Data for South Boulder Creek Near Moffat Tunnel

Parameter	Statistic	Units	Above Moffat Tunnel[1]	Below Moffat Tunnel[2]	Standard[3]
Phosphorus, total as P	85th Percentile	mg/L	0.02 [9]	0.02 [9]	N/A
Potassium, dissolved	85th Percentile	mg/L	0.4 [9]	0.7 [9]	N/A
Silicon, dissolved	85th Percentile	mg/L	2.6 [9]	4.4 [9]	N/A
Specific conductance	85th Percentile	µmhos/cm	60 [9]	69 [9]	N/A
Total Suspended Solids	85th Percentile	mg/L	bdl [9]	bdl [9]	N/A
Vanadium, dissolved	85th Percentile	µg/L	bdl [9]	bdl [9]	N/A

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
[1]Denver Water sample site WS-RL-018. Data from 2005 to 2007.
[2]Denver Water sample site WS-RL-019. Data from 2005 to 2007.
[3]Stream standard is per Regulation No. 38. Where the standard is "TVS," a hardness of 17.6 mg/L (the 15th Percentile) was used in the TVS formula. Some parameters also have Drinking Water Standards set by CDPHE/EPA. Only Stream Standard is listed in this table. Drinking Water Standard as listed on the EPA's website and includes primary, secondary and advisory standards.
[4]Per the methodology, bdl was reported when statistic results in value of "0," per CDPHE website.
[5]Stream Standard is for Chromium VI, while data are for total dissolved Chromium.
[6]TT related to drinking water standards for testing, percent removal, and specific treatment methods.

°C = degrees Celsius
µg/L = micrograms per liter
µmhos/cm = micromhos per centimeter
bdl = below detection limit
$CaCO_3$ = Calcium Carbonate
CDPHE = Colorado Department of Public Health and Environment
EPA = U.S. Environmental Protection Agency
mg/L = milligrams per liter
ml = milliliters
MPN = most probable number
N/A = not applicable
NTU = nephelometric turbidity unit
SU = standard unit
TT = Treatment Technique
TVS = table value standard

South Boulder Creek is within stream standards as well as drinking water standards with few differences upstream and downstream of the tunnel. Historically, the average Moffat Tunnel releases contribute between 46% to 78% of the total stream flow at the State Highway (SH) 72 bridge (sampling site No. 124), which is downstream of the Moffat Tunnel discharge. Additionally, by supplementing native flows, the Moffat Tunnel water imports are providing dilution for the UPRR discharge.

3.2.5.7 North Fork South Platte River

North Fork South Platte River is within WQCC Segment 4 of the upper South Platte River Basin and is classified as Aquatic Life Cold 1, Recreation E, Water Supply, and Agriculture (CDPHE 2011b).

A segment of the North Fork South Platte River, Hall Valley area to Geneva Creek, is listed on the 303(d) List in Regulation No. 93 (CDPHE 2012a) for pH with a State-assigned priority of high. No segments are listed on the Monitoring and Evaluation List

(CDPHE 2012a). Abandoned mines in the watershed contribute cadmium, copper, lead, silver, and zinc to the North Fork South Platte River water. Two TMDLs are listed for the North Fork South Platte River: Hall Valley for copper (April 2008) and pH (draft, May 2010). The copper TMDL (CDPHE 2012b) concluded that the abandoned Missouri Mine in Handcart Gulch is the primary source of copper. The pH TMDL was issued as an addendum to the copper TMDL. The pH TMDL noted that the Coalition for the upper South Platte was awarded a grant in 2010 to identify sources of low pH and provide for remediation planning. Low pH is anticipated to be ameliorated to some extent with copper loading reductions but acid rock drainage in Handcart Gulch is not from anthropogenic sources and is not associated with remediable sources.

There are no NPDES discharges into the North Fork South Platte River. A number of water suppliers use the South Platte River, including Denver Water and the City of Aurora. The discussion below is based on the water quality data immediately upstream and downstream of the Roberts Tunnel discharge. The summary of this data is shown in Table 3.2-19.

- Station WS-NF-004 – North Fork South Platte River upstream of Roberts Tunnel at the Grant Caretakers Facility Entrance (Denver Water 2007b) (data taken from 2005-2007).
- Station WS-NF-005 – North Fork South Platte River downstream of Roberts Tunnel, upstream of Geneva Creek inflow (Denver Water 2007b) (data taken from 2005-2007).

Table 3.2-19
Water Quality Data for North Fork South Platte River Near Roberts Tunnel

Parameter	Statistic	Units	Upstream of Roberts Tunnel[1]	Downstream of Roberts Tunnel[2]	Standard[3]
Parameter with Stream Standards					
Arsenic, dissolved	85th Percentile	µg/L	bdl[4] [21]	bdl [19]	0.02 (total recoverable)
Boron, dissolved	85th Percentile	µg/L	4.0 [21]	7.3 [19]	750
Cadmium, dissolved	85th Percentile	µg/L	**0.30** [21]	**0.30** [19]	0.17
Copper, dissolved	85th Percentile	µg/L	**27** [21]	**5.60** [19]	3.1
Chromium, dissolved	50th Percentile	µg/L	bdl [21]	bdl [19]	11[5]
Dissolved oxygen	15th Percentile	µg/L	7.6 [21]	7.7 [19]	>7.0
E. Coli	Geometric Mean	MPN/100 ml	0.9 [22]	0.7 [20]	126
Iron, dissolved	85th Percentile	mg/L	0.23 [21]	0.08 [19]	0.3
Lead, dissolved	85th Percentile	µg/L	bdl [21]	bdl [19]	0.65
Manganese, dissolved	85th Percentile	µg/L	130 [21]	88 [19]	1,096

Table 3.2-19 (continued)
Water Quality Data for North Fork South Platte River Near Roberts Tunnel

Parameter	Statistic	Units	Upstream of Roberts Tunnel[1]	Downstream of Roberts Tunnel[2]	Standard[3]
Mercury, dissolved	85th Percentile	µg/L	bdl [21]	bdl [19]	0.01
Nickel, dissolved	85th Percentile	µg/L	12 [21]	6.3 [19]	18.4
pH	15th Percentile	SU	7.1 [22]	7.5 [20]	6.5-9.0
pH	85th Percentile	SU	8.0 [22]	8.0 [20]	6.5-9.0
Selenium, dissolved	85th Percentile	µg/L	bdl [21]	bdl [19]	4.6
Silver, dissolved	85th Percentile	µg/L	bdl [21]	bdl [19]	0.038
Temperature	Daily Maximum	ºC	15 [22]	15 [20]	21.2
Zinc, dissolved	85th Percentile	µg/L	33 [21]	32 [19]	40
Parameters with Drinking Water Standards					
Aluminum, dissolved	85th Percentile	mg/L	0.7 [21]	0.11 [19]	0.05-0.2
Antimony, dissolved	85th Percentile	µg/L	bdl[4] [21]	bdl [19]	6
Barium, dissolved	85th Percentile	µg/L	33 [21]	43 [19]	2,000
Beryllium, dissolved	85th Percentile	µg/L	bdl [21]	bdl [19]	4
Cadmium, dissolved	85th Percentile	µg/L	0.3 [21]	0.3 [19]	5
Sodium, dissolved	85th Percentile	mg/L	8.0 [21]	9.3 [19]	20[6]
Thallium, dissolved	85th Percentile	µg/L	bdl [21]	bdl [19]	2
Fecal coliform	Geometric Mean	MPN/100 ml	38 [22]	21 [20]	TT
Turbidity	85th Percentile	NTU	10 [22]	7.8 [20]	TT[7]
Uranium, dissolved	85th Percentile	µg/L	0.6 [21]	1.4 [19]	30

Table 3.2-19 (continued)
Water Quality Data for North Fork South Platte River Near Roberts Tunnel

Parameter	Statistic	Units	Upstream of Roberts Tunnel[1]	Downstream of Roberts Tunnel[2]	Standard[3]
Parameters without Standards					
Alkalinity, total as $CaCO_3$	85th Percentile	mg/L	3.0 [22]	11 [20]	N/A
Calcium, dissolved	85th Percentile	mg/L	13 [21]	42 [19]	N/A
Cobalt, dissolved	85th Percentile	µg/L	5.0 [21]	2.3 [19]	N/A
Hardness as $CaCO_3$	85th Percentile	mg/L	45 [22]	122 [20]	N/A
Hardness as $CaCO_3$	15th Percentile	mg/L	29 [22]	50 [20]	N/A
Magnesium, dissolved	85th Percentile	mg/L	4.8 [21]	5.7 [19]	N/A
Molybdenum, total	50th Percentile	µg/L	bdl[3] [21]	83 [19]	N/A
Phosphorus, total as P	85th Percentile	mg/L	0.04 [22]	0.02 [20]	N/A
Potassium, dissolved	85th Percentile	mg/L	1.2 [21]	3.4 [19]	N/A
Silicon, dissolved	85th Percentile	mg/L	8.4 [21]	6.7 [19]	N/A
Specific conductance	85th Percentile	µmhos/cm	140 [22]	315 [20]	N/A
Total Suspended Solids	85th Percentile	mg/L	13 [22]	9.5 [20]	N/A
Vanadium	85th Percentile	µg/L	bdl [21]	bdl [19]	N/A

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
Numbers in bold font and gray shading indicate stream standards exceedances.
[1]Denver Water sample site WS-NF-004. Data from 2005 to 2007.
[2]Denver Water sample site WS-NF-005. Data from 2005 to 2007.
[3]Stream standard is per Regulation No. 38. Where the standard is "TVS," a hardness of 50.1 mg/L (the 15th Percentile) was used in the TVS formula. Some parameters also have Drinking Water Standards set by CDPHE/EPA. Only Stream Standard is listed in this table. Drinking Water Standard as listed on the EPA's website. Standard listed is primary unless otherwise noted.
[4]Per the methodology, bdl was reported when statistic results in value of "0," per CDPHE results.
[5]Stream Standard is for Chromium VI, while data are for *total* dissolved Chromium.
[6]Advisory level, not a primary or secondary standard.
[7]TT related to drinking water standards for testing, percent removal, and specific treatment methods.

°C = degrees Celsius
> = greater than
µg/L = micrograms per liter
µmhos = micromhos
µmhos/cm = micromhos per centimeter
bdl = below detection limit
$CaCO_3$ = calcium carbonate
CDPHE = Colorado Department of Public Health and Environment
mg/L = milligrams per liter
ml = milliliters
MPN = most probable number
N/A = not applicable
NTU = nephelometric turbidity units
SU = standard unit
TT = Treatment Technique
TVS = table value standard

Copper and pH are known issues in this portion of the North Fork South Platte River. The data shown in Table 3.2-19 indicates copper is above stream standards. This data however, indicates pH values within regulatory standards. Note that the minimum pH measurement upstream of Roberts Tunnel has a value of 5.0. CDPHE defines ambient conditions as the 15th percentile.

There is no stream standard for phosphorus on the North Fork South Platte River. Downstream of the confluence of the North Fork South Platte River with the South Platte River, phosphorus is regulated in Chatfield Reservoir. Thus, phosphorus is of interest in the North Fork South Platte River, particularly any phosphorus added to the watershed. Upstream of Roberts Tunnel had a maximum value of 0.05 mg/L, while downstream of Roberts tunnel had a maximum value of 0.03 mg/L.

Also of note is that many constituents have changes upstream and downstream of the tunnel suggesting that imports from Dillon Reservoir may be modifying the water quality in the North Fork South Platte River. This is not unexpected given that imports can comprise from 2% to over 75% of stream flow downstream of the tunnel on a monthly basis.

3.2.5.8 South Platte River

The South Platte River segment in the Project area extends from Antero Reservoir to the Henderson gage. The first part of this segment, to the Chatfield Reservoir, includes the Agate Creek, Fourmile Creek, Middle Fork, Tarryall Creek, Long Branch, North Fork, and Plum Creek tributaries. The next part of the segment from Chatfield Reservoir to the Henderson gage below the Metro Wastewater Reclamation District Plant (Metro Wastewater Treatment Plant [WWTP]) includes the Clear Creek, Deer Creek, Cherry Creek, and Bear Creek tributaries. The Surface Water Classification for the South Platte River from the source to the outlet of Chatfield Reservoir, including all mainstem reservoirs is Cold Water Aquatic Life Class 1, Recreation E, Water Supply and Agriculture (CDPHE 2011b).

From Chatfield Reservoir to the Burlington Ditch Diversion, the classification is changed to Warm Water Aquatic Life Class 1. From the Burlington Ditch Diversion to a point just below Big Dry Creek, the classification is changed to Warm Water Aquatic Life Class 2 and it is Use-Protected.

Segments of the South Platte River from the source to Henderson that are on the 303(d) or Monitoring and Evaluation List include (CDPHE 2012a):

- South Fork South Platte River, below Antero Reservoir – Monitoring and Evaluation List for Aquatic Life Use
- South Platte River, confluence with North Fork South Platte River to Strontia Springs Reservoir – Monitoring and Evaluation List for sediment
- South Platte River, Cheesman Reservoir to Fourmile Creek – Monitoring and Evaluation List for Aquatic Life Use
- South Platte River, Bowles Avenue to the Burlington Ditch – 303(d) for Arsenic with high priority

- South Platte River, Burlington Ditch to Big Dry Creek – 303(d) for *E. Coli* with high priority
- Barr Lake – Monitoring and Evaluation List for dissolved oxygen
- Barr Lake and Milton Reservoir – 303(d) for pH and ammonia with medium and low priority, respectively
- Milton Reservoir – 303(d) List for dissolved oxygen with low priority

Segments of the South Platte River that have had TMDLs completed include (CDPHE 2012b):

- South Platte River, Eleven Mile Dam to Cheesman Reservoir, Sediment – The sediment TMDL is dated June 2002. Identified sediment loading was primarily non-paved roads. Methods of reduction for identified sediment loading included improved management practices and closing of roads.
- South Platte River, Bowles Avenue to the Burlington Ditch, Nitrate – The nitrate TMDL is dated April 2004. Municipal wastewater treatment providers are the primary point source for nitrate. Non-point sources are not thought to contribute significantly.
- South Platte River, Bowles Avenue to the Burlington Ditch, *E. Coli* – The *E. Coli* TMDL focuses on non-point sources and implementation of BMPs for stormwater discharges, particularly dry weather discharges.
- South Platte River, Burlington Ditch to Clear Creek, Cadmium – The cadmium TMDL was revised in April 2010. The TMDL identifies groundwater seepage as the only source that requires load reduction to bring the segment in compliance with stream standards. The source of cadmium in the groundwater is from the Globeville American Smelting and Refining Company Facility and the Argo site.
- South Platte River, Burlington Ditch to Big Dry Creek, Dissolved Oxygen – The Dissolved Oxygen TMDL is dated February 2000. Municipal wastewater treatment providers are the primary source of ammonia and organic matter to this segment. The natural conversion of ammonia to nitrate consumes oxygen as does the decomposition of organic matter. Control of wastewater treatment provider discharges in combination with construction of physical re-aeration structures are the proposed methods for increasing oxygen in this segment.

Potable water providers that use the South Platte River include Denver Water, the City of Aurora, the City of Englewood, and the City of Thornton.

There are no NPDES permits for domestic wastewater treatment providers to discharge into the South Platte River upstream of Chatfield Reservoir. WWTPs that discharge into the South Platte River between Chatfield and Henderson include:

- Centennial Water and Sanitation District, Colorado – 8.48 mgd to Marcy Gulch (near the South Platte River)
- Littleton-Englewood (Bi-City) Wastewater Treatment Plant – 50 mgd
- Metro Wastewater Reclamation District Plant – 220 mgd

- South Adams County Water and Sanitation District – 7.0 mgd

South Platte River from Antero Reservoir to North Fork South Platte River

The data from CDPHE Station 5952, the South Platte River below Spinney Reservoir (EPA 2007a) is summarized in Table 3.2-20.

The values in Table 3.2-20 indicate the segment of the South Platte River below Spinney Reservoir is within stream standards with the possible exception of temperature. The chronic standard (MWAT) is 18.2 ºC (CDPHE 2011b). There is no acute temperature standard for the South Platte River in these segments; there are insufficient data to calculate a MWAT for these stations. It is unknown if the MWAT has been exceeded.

There is no stream standard for phosphorus in Colorado excepting certain reservoirs (CDPHE 2011b). Downstream, phosphorus is regulated in Chatfield Reservoir. Thus, phosphorus is of interest, particularly any phosphorus added to the watershed. The minimum and maximum values along the South Platte River ranged from a low of below detection limit at all stations to a high of 0.08 mg/L, recorded at South Platte (25).

Table 3.2-20
Water Quality in the South Platte River below Spinney Reservoir
(CDPHE Station 5952)

Parameter	Statistic	Units	Value[1]	Stream Standard[2]
Arsenic, dissolved	85th Percentile	µg/L	bdl[3] [13]	0.02 (total recoverable)
Cadmium, dissolved	85th Percentile	µg/L	bdl [13]	1.08
Copper, dissolved	85th Percentile	µg/L	bdl [13]	9.45
Dissolved oxygen	15th Percentile	mg/L	8.2 [10]	>7.0
E. Coli	Geometric Mean	#/100 ml	5 [9]	126
Iron, dissolved	85th Percentile	µg/L	bdl [22]	300
Lead, dissolved	85th Percentile	µg/L	bdl [12]	2.7
Mercury, dissolved	85th Percentile	µg/L	bdl [12]	0.01
Ammonia	85th Percentile	mg/L	0.004 [12]	1.34
Nitrite and Nitrate	85th Percentile	mg/L	0.05 [12]	10.05
pH	15th Percentile	SU	8.3 [12]	6.5-9.0
pH	85th Percentile	SU	8.7 [12]	6.5-9.0

Table 3.2-20 (continued)
Water Quality in the South Platte River below Spinney Reservoir
(CDPHE Station 5952)

Parameter	Statistic	Units	Value[1]	Stream Standard[2]
Selenium, dissolved	85th Percentile	µg/L	bdl [13]	4.6
Silver, dissolved	85th Percentile	µg/L	bdl [13]	0.36
Sulfate	85th Percentile	mg/L	50 [12]	250
Temperature	Daily Maximum	ºC	19.8 [12]	21.2[4]
Zinc, dissolved	85th Percentile	µg/L	18 [13]	128

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
[1]Data from Site 5952 was taken in 2001-2003.
[2]Stream standard is per Regulation No. 38. Where the standard is "TVS," a hardness of 106.5 mg/L (the 15th percentile) was used in the TVS formula. Some parameters also have Drinking Water Standards set by CDPHE/EPA. Only Stream Standard is listed in this table.
[3]Per the methodology, bdl was reported when statistic results in value of "0" per CDPHE.
[4]The temperature standard is the daily maximum.

ºC	= degrees Celsius	CDPHE	= Colorado Department of Public Health and Environment
>	= greater than	EPA	= U.S. Environmental Protection Agency
µg/L	= micrograms per liter	mg/L	= milligrams per liter
#	= number	SU	= standard unit
bdl	= below detection limit	TVS	= table value standard

South Platte River from North Fork South Platte River to Chatfield Reservoir

The water quality in this section of the South Platte River is primarily influenced by the following:

- Water quality from upstream of the confluence with the North Fork South Platte River
- Water quality of the tributary North Fork South Platte River
- Water quality in Strontia Springs Reservoir

Water quality downstream of the North Fork is shown in Table 3.2-21.

All parameters shown in Table 3.2-21 indicate that the stream is within regulatory stream standards.

Table 3.2-21
Water Quality in the South Platte River at WS-UP-008[1]

Parameter	Statistic	Units	Value	Stream Standard[2]
Ammonia	85th Percentile	mg/L	bdl[3] [108]	2.8
Arsenic, dissolved	85th Percentile	µg/L	bdl [95]	0.02 (total recoverable)
Boron, dissolved	85th Percentile	µg/L	14 [58]	750
Cadmium, dissolved[4]	85th Percentile	µg/L	0.2 [96]	0.33
Chloride	85th Percentile	mg/L	21 [107]	250
Chromium, dissolved[4]	85th Percentile	µg/L	bdl [92]	114
Copper, dissolved	85th Percentile	µg/L	bdl [95]	6.8
Dissolved Oxygen	15th Percentile	mg/L	7.3 [111]	>7.0
E. Coli	Geometric Mean	MPN/100 ml	6.3 [106]	126
Iron, dissolved	85th Percentile	µg/L	100 [108]	300
Lead, dissolved	85th Percentile	µg/L	bdl [95]	1.8
Manganese, dissolved	85th Percentile	µg/L	32 [110]	50
Mercury, dissolved	85th Percentile	µg/L	bdl [95]	0.01
Nickel, dissolved	85th Percentile	µg/L	1.4 [91]	39
Nitrate and Nitrite	85th Percentile	mg/L	0.21 [60]	10.05
pH	15th Percentile	SU	7.8 [124]	6.5-9.0
pH	85th Percentile	SU	8.4 [124]	6.5-9.0
Selenium, dissolved	85th Percentile	µg/L	bdl [95]	4.6
Silver, dissolved	85th Percentile	µg/L	bdl [96]	0.04
Sulfate	85th Percentile	mg/L	58 [107]	250
Temperature	Daily Maximum	°C	20 [123]	21.2

Table 3.2-21 (continued)
Water Quality in the South Platte River at WS-UP-008[1]

Parameter	Statistic	Units	Value	Stream Standard[2]
Uranium, dissolved	85th Percentile	µg/L	1.8 [96]	1,313
Zinc, dissolved	85th Percentile	µg/L	8.8 [96]	90

Source: Denver Water, 2007a.
Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
[1]Denver Water sample site WS-UP-008, South Platte River, approximately 1.3 miles below the confluence with the North Fork South Platte River. Data is from 2002 to 2007.
[2]Stream Standard is per Regulation No. 38, where the standard is "TVS" a hardness of 72 mg/L (15th percentile) was used in the TVS formula. Some parameters also have drinking water standards set by CDPHE/EPA. Only Stream Standard is listed in this table.
[3]Per the methodology, bdl is reported when statistic results in a value of "0," per CDPHE results.
[4]Stream standard is for Chromium VI while data are for total dissolved chromium.

ºC = degrees Celsius
> = greater than
µg/L = micrograms per liter
bdl = below detection limit
CDPHE = Colorado Department of Public Health and Environment
EPA = U.S. Environmental Protection Agency
mg/L = milligrams per liter
ml = milliliter
MPN = most probable number
SU = standard unit
TVS = table value standard

South Platte River from Chatfield Reservoir to the Denver Gage

The flow in the South Platte River downstream of Chatfield Reservoir is highly regulated, with numerous withdrawals. Additionally, there are two major municipal wastewater treatment discharges, Centennial Water and Sanitation District and the Bi-City WWTP.

Water quality is shown in Table 3.2-22. The water quality in the South Platte River below Chatfield Reservoir to the Denver gage is primarily influenced by the following factors:

- Water quality in Chatfield Reservoir (particularly influenced via Plum Creek)
- WWTP discharge from the Centennial Water and Sanitation District
- WWTP discharge from the Bi-City WWTP
- Influent from tributaries, namely Bear Creek
- Groundwater flow

Table 3.2-22
South Platte River Water Quality at Mineral Avenue Upstream of the Littleton-Englewood Wastewater Treatment Plant

Parameter	Statistic	Units	At Mineral Avenue[1]	Standard Upstream of Bowles Avenue[2]	Upstream of the Littleton-Englewood Wastewater Treatment Plant[3]	Standard Downstream of Bowles Avenue[2]
Parameters with Stream Standards						
Arsenic, total	50th Percentile	µg/L	bdl [129]	0.02 (total recoverable)	N/A	0.02 (total recoverable)
Cadmium, dissolved	85th Percentile	µg/L	bdl [129]	0.5	0.001 [120]	0.7
Chloride, total	85th Percentile	µg/L	84 [20]	250	109 [24]	250
Copper, dissolved	85th Percentile	µg/L	5.4 [200]	12	3.4 [116]	41
Chromium, dissolved	50th Percentile	µg/L	bdl [20]	11[4]	4.7 [71]	11[4]
Dissolved Oxygen	15th Percentile	mg/L	6.9 [136]	>5.0	6.4 [120]	>5.0
Lead, dissolved	85th Percentile	µg/L	bdl[5] [129]	3.5	0.2 [119]	4.7
Manganese	85th Percentile	µg/L	85 [128]	190	163 [120]	190
Mercury, total	50th Percentile	µg/L	bdl [127]	0.01	bdl [104]	0.01
Nickel, total	50th Percentile	µg/L	2.9 [20]	67	5.6 [111]	85
pH	15th Percentile	SU	7.7 [146]	6.5-9.0	7.1 [120]	6.5-9.0
pH	85th Percentile	SU	8.4 [146]	6.5-9.0	8.3 [120]	6.5-9.0
Ammonia	85th Percentile	mg/L	0.3 [131]	2.5	0.52 [112]	4.7
Nitrate	85th Percentile	mg/L	5.1 [19]	10	2.0 [110]	10
Selenium, dissolved	85th Percentile	µg/L	bdl [129]	4.6	**5.5** [120]	4.6
Silver, dissolved	85th Percentile	µg/L	bdl [129]	0.5	bdl [120]	0.9
Sulfate	85th Percentile	µg/L	100 [127]	250	185 [93]	250
Temperature	DM[6]	°C	29 [147]	29	20.6 [109]	29

Table 3.2-22 (continued)
South Platte River Water Quality at Mineral Avenue Upstream of the Littleton-Englewood Wastewater Treatment Plant

Parameter	Statistic	Units	At Mineral Avenue[1]	Standard Upstream of Bowles Avenue[2]	Upstream of the Littleton-Englewood Wastewater Treatment Plant[3]	Standard Downstream of Bowles Avenue[2]
Parameters with Drinking Water Standards[7]						
Aluminum, dissolved	85th Percentile	mg/L	0.1 [129]	0.05-0.2	0.1 [15]	0.05-0.2
Antimony, total	50th Percentile	mg/L	bdl[4] [20]	0.006	0.001 [15]	0.006
Total Organic Carbon	85th Percentile	mg/L	6.4 [168]	TT[8]	6.7 [116]	TT[8]
Fluorides[9], total	85th Percentile	mg/L	0.9 [20]	2.0	0.8 [24]	2.0
Sodium, total	85th Percentile	mg/L	83 [20]	20	33 [24]	20
Total Dissolved Solid	85th Percentile	mg/L	518 [127]	500	687 [71]	500
Fecal coliform	Geometric Mean	MPN/ 100 ml	19 [119]	TT	260 [111]	TT
Turbidity	85th Percentile	NTU	12 [85]	TT[8]	15 [99]	TT[8]
Zinc, dissolved	85th Percentile	mg/L	0.15 [128]	5.0	0.19 [112]	5.0
Parameters without Standards						
Alkalinity, total as $CaCO_3$	85th Percentile	mg/L	156 [144]	N/A	215 [119]	N/A
Biological Oxygen Demand	85th Percentile	mg/L	3.8 [20]	N/A	3.0 [119]	N/A
Dissolved Organic Carbon	85th Percentile	mg/L	6.1 [23]	N/A	5.9 [103]	N/A
Hardness as $CaCO_3$	85th Percentile	mg/L	212 [132]	N/A	323 [119]	N/A
Molybdenum, total	50th Percentile	µg/L	13 [20]	N/A	11 [120]	N/A
Phosphorus, total as P	85th Percentile	mg/L	0.54 [126]	N/A	0.70 [111]	N/A

Table 3.2-22 (continued)
South Platte River Water Quality at Mineral Avenue Upstream of the Littleton-Englewood Wastewater Treatment Plant

Parameter	Statistic	Units	At Mineral Avenue[1]	Standard Upstream of Bowles Avenue[2]	Upstream of the Littleton-Englewood Wastewater Treatment Plant[3]	Standard Downstream of Bowles Avenue[2]
Specific Conductance	85th Percentile	µmhos/ cm	809 [109]	N/A	1,052 [119]	N/A
Total Suspended Solids	85th Percentile	mg/L	26 [148]	N/A	373 [151]	N/A

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
Numbers in bold font and gray shading indicate stream standard exceedances.
[1]Centennial Water and Sanitation District site L04. Data from 2000 to 2007.
[2]Stream standard is per Regulation No. 38. Where the standard is "TVS," a hardness of 136 mg/L (the 15th Percentile) was used in the TVS formula. Some parameters also have Drinking Water Standards set by CDPHE/EPA. Only Stream Standard is listed in this table.
[3]Littleton-Englewood Wastewater Treatment Plant site UP. Data from 2000 to 2007.
[4]Stream Standard is for Chromium VI, while data are for total dissolved Chromium.
[5]Per the methodology, bdl was reported when statistic results in value of "0," per CDPHE website.
[6]The temperature standard is the daily maximum.
[7]Drinking Water Standard as listed on EPA's website. Standard listed is primary, secondary, or advisory.
[8]TT related to drinking water standards for testing, percent removal, and specific treatment methods.
[9]Primary Standard is 4.0 mg/L. Secondary standard is 2.0 mg/L.

ºC = degrees Celsius
> = greater than
µg/L = micrograms per liter
µmhos/cm = micromhos per centimeter
bdl = below detection limit
$CaCO_3$ = calcium carbonate
CDPHE = Colorado Department of Public Health and Environment
DM = daily maximum
EPA = U.S. Environmental Protection Agency
mg/L = milligrams per liter
ml = milliliters
MPN = most probable number
N/A = not applicable
NTU = nephelometric turbidity units
SU = standard unit
TT = Treatment Technique
TVS = table value standard
WWTP = Wastewater Treatment Plant

Standards for some parameters are different due to different values for hardness and pH, for those parameters whose standards are TVS.

Selenium is greater than the stream standard at the second sampling site. The cause is not known and could be due to non-point sources as this segment of the river has highly industrialized areas along the banks.

Sodium levels are greater than the EPA's advisory level at both sampling sites. The advisory level was set to 20 mg/L. However, sodium is on the contaminant candidate list in part because EPA believes this guidance level needs updating and is probably low (EPA 2010d). Thus, although sodium exceeds the current advisory level, there is likely no health concern with the levels found at both sampling sites.

Total dissolved solid (TDS) levels are greater than the EPA's secondary limit at both sampling sites. Consumption of water with TDS levels greater than the advisory level is considered safe but the water may have aesthetic concerns. Aesthetic concerns for water with high TDS include corrosion and taste issues.

South Platte River from Bowles Avenue to the Henderson Gage

The flow in the South Platte River from Bowles Avenue to the Henderson gage (Stations SP-64, SP-78, SP-124, 156, 06710247, and 06720500) is highly regulated with numerous withdrawals. Additionally, there is significant wastewater influence with both upstream dischargers noted above and the discharges from the Metro WWTP and the South Adams County Water and Sanitation District. The land use along this stretch of river is highly urbanized and industrialized.

Water quality is shown in Table 3.2-23. The water quality in the South Platte River from Bowles Avenue to Henderson (between 64th and 78th Avenue) is primarily influenced by the following factors:

- Water quality upstream
- WWTP discharge from the Metro WWTP
- WWTP discharge from South Adams County Water and Sanitation District (at downstream end of reach)
- Influent from tributaries, namely Clear Creek
- Groundwater flow
- Water withdrawals, including the Burlington Ditch

Table 3.2-23
South Platte River Water Quality Upstream and Downstream of the Metro Wastewater Treatment Plant Discharge

Parameter	Statistic	Units	South Platte River Near 64th Avenue[1]		South Platte River Near 78th Avenue[1]	
			Value	Stream Std[2]	Value	Stream Std[2]
Ammonia	85th Percentile	mg/L	bdl[3] [48]	1.7	0.03 [46]	2.9
Arsenic, total	85th Percentile	µg/L	bdl [59]	0.02 (total recoverable)	bdl [59]	0.02 (total recoverable)
Cadmium, dissolved	85th Percentile	µg/L	**18** [119]	0.85	**1.13** [119]	0.66
Chloride	85th Percentile	mg/L	201 [21]	250	124 [21]	250
Copper, dissolved	85th Percentile	µg/L	9 [238]	20	7 [238]	15
Chromium, dissolved	85th Percentile	µg/L	bdl [119]	114[4]	bdl [119]	114[4]
Cyanide	85th Percentile	mg/L	bdl [26]	0.005	bdl [26]	0.005
Dissolved Oxygen	15th Percentile	mg/L	6.7 [234]	>5	5.2 [232	>5
E. Coli	Geometric Mean	MPN/ 100 ml	**323** [119]	126	**213** [119]	12

Table 3.2-23 (continued)
South Platte River Water Quality Upstream and Downstream of the Metro Wastewater Treatment Plant Discharge

Parameter	Statistic	Units	South Platte River Near 64th Avenue[1]		South Platte River Near 78th Avenue[1]	
			Value	Stream Std[2]	Value	Stream Std[2]
Iron, dissolved	85th Percentile	mg/L	0.1 [95]	0.3	0.2 [95]	0.3
Lead, dissolved	85th Percentile	µg/L	bdl [189]	6.7	bdl [189]	4.7
Manganese, dissolved	85th Percentile	µg/L	290 [119]	400	180 [119]	400
Mercury, dissolved	85th Percentile	µg/L	bdl [69]	0.01	bdl [69]	0.01
Nickel, dissolved	85th Percentile	µg/L	bdl [119]	113	bdl [119]	86
Nitrate	85th Percentile	mg/L	10.8 (as NO_3) [131]	10 (as N)	5.13 (as NO_3) [131]	10 (as N)
Nitrite	85th Percentile	mg/L	0.17 [217]	1	0.46 [217]	1
pH	15th Percentile	SU	7.3 [241]	6.5-9.0	6.9 [239]	6.5-9.0
pH	85th Percentile	SU	8 [241]	6.5-9.0	7.5 [239]	6.5-9.0
Selenium, dissolved	85th Percentile	µg/L	3 [202]	4.6	2 [201]	4.6
Silver, dissolved	85th Percentile	µg/L	bdl [70]	1.55	bdl [70]	0.9
Sulfate	85th Percentile	mg/L	**537** [28]	250	192 [27]	250
Temperature	Daily Maximum	°C	24.1 [241]	29[4]	20.8 [239]	29[5]
Zinc, dissolved	85th Percentile	mg/L	0.04 [119]	0.26	0.04 [119]	0.20
Parameters with Drinking Water Standards						
Sodium, dissolved	85th Percentile	mg/L	**150** [21]	20[7]	**74** [21]	20[7]
Fecal Coliform	Geometric Mean	MPN/ 100 ml	434 [163]	TT[6]	323 [159]	TT[6]
Turbidity	85th Percentile	NTU	24 [115]	TT[6]	23 [115]	TT[6]

Table 3.2-23 (continued)
South Platte River Water Quality Upstream and Downstream of the Metro Wastewater Treatment Plant Discharge

Parameter	Statistic	Units	South Platte River Near 64th Avenue[1]		South Platte River Near 78th Avenue[1]	
			Value	Stream Std[2]	Value	Stream Std[2]
Parameters without Standards						
Alkalinity, total as $CaCO_3$	85th Percentile	mg/L	182 [217]	N/A	189 [217]	N/A
BOD	85th Percentile	mg/L	4 [157]	N/A	18 [157]	N/A
BOD, carbonaceous	85th Percentile	mg/L	3 [164]	N/A	6 [164]	N/A
Calcium, dissolved	85th Percentile	mg/L	189 [21]	N/A	119 [21]	N/A
Hardness as $CaCO_3$	85th Percentile	mg/L	555 [96]	N/A	286 [96]	N/A

Notes:
Numbers inside brackets indicate the number of data points used in the calculation.
Numbers in bold font and gray shading indicate stream standards exceedances.
[1]Metro Wastewater Treatment Plant sample sites. Data from 2000 to 2007.
[2]Stream standard is per Regulation No. 38. Where the standard is "TVS," a hardness of 250 mg/L (the 15th Percentile) was used in the TVS formula. Some parameters also have Drinking Water Standards set by CDPHE/EPA. Only Stream Standard is listed in this table. Drinking water standard per EPA's website.
[3]Per the methodology, bdl was reported when statistic results in value of "0."
[4]Stream Standard is for Chromium VI, while data are for total dissolved chromium.
[5]The temperature standard is the daily maximum.
[6]TT related to drinking water standards for testing, percent removal, and specific treatment methods.
[7]Advisory level.

°C	= degrees Celsius	ml	= milliliter
>	= greater than	MPN	= most probable number
µg/L	= micrograms per liter	N	= nitrogen
µS/cm	= microSiemens/centimeter	NO_3	= nitrate
bdl	= below detection limit	NTU	= nephelometric turbidity units
BOD	= biological oxygen demand	Std	= standard
$CaCO_3$	= calcium carbonate	SU	= standard unit
mg/L	= milligrams per liter	TT	= Treatment Technique

Ammonia concentrations exceed the stream standard downstream of the Metro WWTP discharge. Ammonia concentrations in the Metro WWTP discharge are regulated by CDPHE in the NPDES permit.

Cadmium concentrations exceed the stream standard upstream of the Metro WWTP discharge. CDPHE has issued a TMDL for cadmium, as noted above.

E. Coli and fecal coliform are both biological parameters that are indicators of wastewater. Nitrate is also indicative of treated wastewater. This segment of the South Platte River is highly influenced by treated wastewater due to the discharges of Centennial Water and Sanitation District, the Bi-City WWTP, and the Metro WWTP. All dischargers are regulated by the CDPHE with limits on the noted parameters. *E. Coli* and fecal coliform can also be influenced by stormwater runoff. There is a TMDL for *E. Coli* and one for nitrate for this segment.

Sulfate exceeds the stream standard upstream of the Metro WWTP discharge. The stream standard is set for drinking water purposes. There are no drinking water withdrawals between 64th Avenue and the Metro WWTP discharge.

Sodium levels are greater than the EPA's advisory level at both sampling sites. The advisory level was set to 20 mg/L. However, sodium is on the contaminant candidate list in part because EPA believes this guidance level needs updating and is probably low (EPA 2010d). Thus, although sodium exceeds the current advisory level, there is likely no health concern with the levels found at both sampling sites.

Stream Segments Outside the Project Area

Portions of the Colorado River, South Platte River, and Boulder Creek that are downstream of the Project area are listed in CDPHE Regulation 93 (CDPHE 2012a) on the 303(d) List and/or Monitoring and Evaluation List. Additionally, there are stream segments downstream of the Project area that have had TMDLs developed. As water quality changes can occur due to associated changes in water supply withdrawals, these stream segments are evaluated in Section 4.2 and Section 5.2, with regards to the Moffat Project potentially causing or contributing to the these segments being listed in Regulation 93 or having TMDLs developed. These segments are listed in Table 3.2-24 and potential impacts are discussed in Section 4.6.2 and Section 5.2.

Table 3.2-24
Stream Segments Outside the Project Area

Stream Segment ID	Stream Segment Description	M&E List	Section 303(d) List	TMDL
Colorado River				
COLCLC01	Roaring Fork to Rifle Creek	Sediment	None	None
COLCLC02a	Rifle Creek to Rapid Creek	Sediment	None	None
COLCLC02b	Rapid Creek to Gunnison River	Sediment	See Below	None
COLCLC02b	Rapid Creek to Gunnison River (Humphrey Backwater Area only)	See Above	Se	None
COUCUC12	Shadow Mountain Lake	None	DO	None
COUCUC12	Lake Granby	None	Aquatic Life Use (Hg Fish Tissue)	None
South Platte River				
COSPLS01	Weld/Morgan County Line to State Line	Aquatic Life Use	Se, Mn	None
COSPMS01a	Big Dry Creek to St. Vrain Creek	None	*E. Coli*	None
COSPMS01b	St. Vrain Creek to Weld/Morgan County Line	None	Se	None
COSPUS15	Burlington Ditch to Big Dry Creek	None	*E. Coli*	DO, Cd

Table 3.2-24 (continued)
Stream Segments Outside the Project Area

Stream Segment ID	Stream Segment Description	M&E List	Section 303(d) List	TMDL
Boulder Creek				
COSPBO09	South Boulder Creek to Coal Creek	Aquatic Life, Cd, As	See Below	Ammonia (archived)
COSPBO09	South Boulder Creek to Coal Creek (107th Street to Coal Creek)	See Above	Aquatic Life (Provisional)	See Above
COSPBO10	Boulder Creek From Coal Creek to St. Vrain Creek	Aquatic Life, Cd	*E. Coli*	Ammonia (archived)

Source: CDPHE, 2012a.
Notes:
As = arsenic
Cd = cadmium
DO = dissolved oxygen
E. Coli = *Escherichia coli*
FCA = Food Consumption Advisory
Hg = mercury
ID = identification
M&E = Monitoring and Evaluation
Mn = manganese
Se = selenium
TMDL = total maximum daily load

In addition to the stream segments listed in Table 3.2-24, there are off-stream reservoirs in each basin that are also listed. As these reservoirs are supplied by the mainstem and the mainstem is also listed for parameters of interest, these off-stream reservoirs are not evaluated separately in the EIS.

3.3 CHANNEL MORPHOLOGY

3.3.0 Overview

The existing conditions of streams within the Moffat Collection System Project (Moffat Project or Project) area that may be affected by implementation of a Project alternative are described in this section. The characterization of existing conditions provides the basis from which responses to potential flow alterations are compared in Section 4.6.3 and Section 5.3.

This channel morphology assessment considers a stream's ability to transport flows and sediment. Stream systems naturally adjust to achieve a balance between flow, sediment transport capacity, and sediment supply—a process known as channel dynamics. A stream experiences changes in the bed elevation and bank alignment on a continual basis. Natural streams include areas where both aggradation and degradation occur. Aggradation is most common in lower gradient areas and areas where flow velocity is reduced. Examples typically include inside bends, behind larger flow obstructions such as logs and boulders, on bars and upstream of any flow restrictions. Degradation including bank erosion is a natural process that typically occurs along outside bends and in locations where bed and bank material are smaller, hence more prone to erosion. Stream channel dynamics may be affected by many factors including land usage changes and increases or decreases in stream flow or sediment production.

Stream flows within the Project area have been altered historically as a result of water depletion and augmentation practices. Existing conditions were evaluated to define whether streams are currently stable or whether they are undergoing changes in response to flow variations. A stable stream system is one that conveys water and sediment while maintaining its general shape (width and planform) over time without long-term trends of aggrading or degrading. Signs of an unstable stream subjected to flow reductions would typically be channel narrowing and bed aggradation that persist over an extended number of years, causing a long-term change in the overall stream morphology. Unstable streams that experience flow increases would typically show signs of excessive bed and bank erosion leading to channel widening and downcutting.

Existing channel conditions are described based on detailed field assessment at Representative sites, evaluation of existing data at Reconnaissance sites and precursory field assessments at selected sites of special interest, including locations downstream of the Board of Water Commissioners' (Denver Water's) diversion points.

3.3.1 Reservoirs

3.3.1.1 Gross Reservoir

Channel morphology would not be impacted by this alternative component, thus the existing geomorphology conditions within the Gross Reservoir study area was not described.

3.3.1.2 Leyden Gulch Reservoir Site

Channel morphology would not be impacted by this alternative component, thus the existing geomorphology conditions within the Leyden Gulch Reservoir study area was not described.

3.3.2 Conveyance Systems

Channel morphology would not be impacted by Conduits M and O, thus the existing geomorphology conditions within the conveyance systems study area was not described.

3.3.3 South Platte River Facilities

Channel morphology changes are not anticipated from these alternative components, thus the existing geomorphology conditions within the South Platte River Facilities study area was not described.

3.3.4 Denver Basin Aquifer Facilities

Channel morphology would not be impacted by these alternative components, thus the existing geomorphology conditions within the Denver Basin Aquifer Facilities study area were not described.

3.3.5 River Segments

The Project area encompasses several river basins; therefore it was impractical to collect detailed data on every potentially affected river reach. Instead, detailed data were collected at 16 Representative sites. Representative sites were selected based on a preliminary level assessment of stream types, accessibility, stream flow data availability, site investigations and diversion practices in the basins. The sites were selected to obtain specific information to represent similar stream types present in an affected drainage basin. Data obtained from 16 Representative sites were also compared to existing information gathered at 32 Reconnaissance sites to evaluate whether data obtained from the 16 Representative sites were typical of the basins evaluated. Locations of Representative and Reconnaissance sites are presented in Figures E-3.1 through E-3.6 in Appendix E-3.

In order to select Representative stream sites, a desktop study was completed to determine the Level I Rosgen stream type of all affected stream segments that would experience average annual flow changes greater than 10 percent (%) due to the Moffat Project using 7.5 minute digital topographic maps. These stream segments were selected to focus the selection of Representative stream sites and field work in areas that would experience the greatest flow change. Table 3.3-1 provides an overview of characteristics of the affected stream reaches, including approximate lengths measured from 7.5 minute digital topographic maps. The Rosgen stream classification system is a widely used technique that defines nine Level I stream types on the basis of geomorphic characteristics including channel slope, sinuosity, valley type, width/depth ratio, and entrenchment. Level I stream types are identified by letters, such as A, B, and C, as shown below. The classification system integrates geomorphic pattern with predominate bed material to define 42 Level II

stream types, identified by letters and numbers, such as B3, C3, and C4 (Rosgen and Silvey 1998). Numbers 1 through 6 are used to sequentially describe bedrock, boulders, cobble, gravel, sand, and silt and clay as the predominate bed material. It should be noted that the Level I stream classifications completed for this assessment were defined based on desktop analysis of large regions where stream slope and sinuosity were determined. Entrenchment and width/depth ratios were not determined from this analysis thereby limiting the detail of results. Stream types presented in Table 3.3-1 were therefore defined based primarily on slope. Detailed investigations completed for evaluation of Representative sites occasionally revealed slightly different stream types than described in topographic mapping.

Table 3.3-1
Stream Channel Characteristics of Affected River Segments

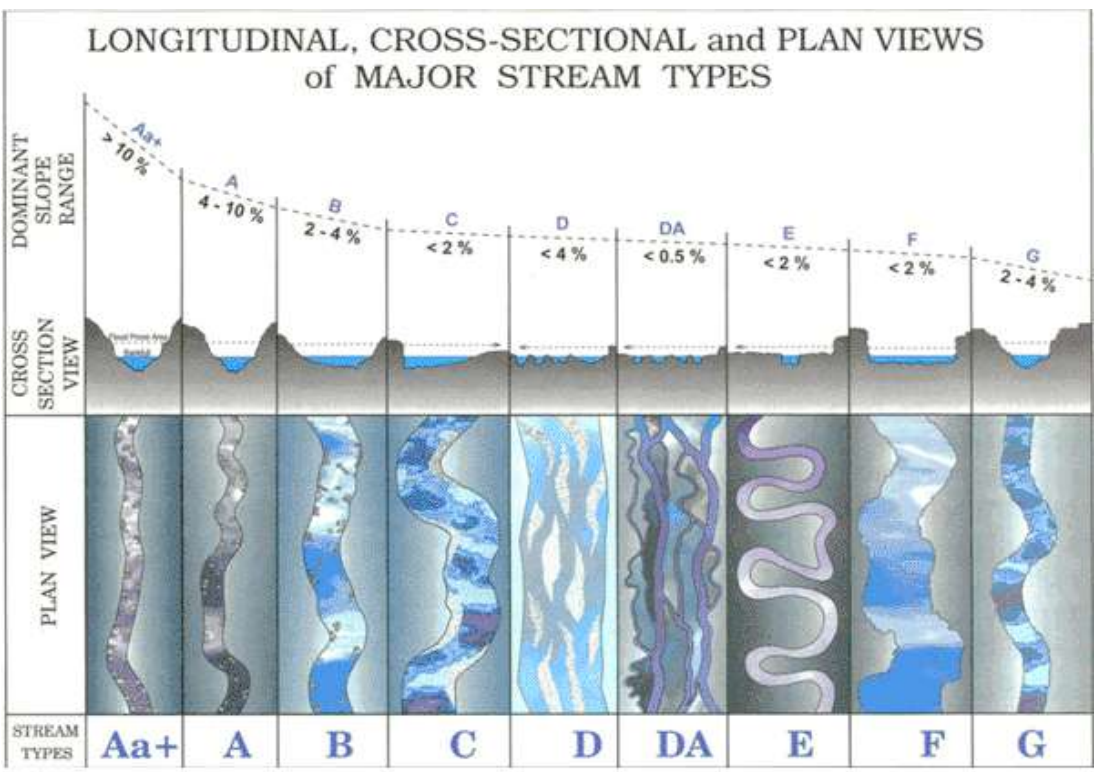
Stream	Description	Affected Length (mile)	Slope (feet per foot)	Rosgen Level I Stream Type
FRASER RIVER WATERSHED				
Fraser River Upstream Tributaries and Mainstem				
Jim Creek	From Denver Water diversion points to confluence with Fraser River	0.9	0.037	B
Buck Creek		0.6	0.091	A
Cub Creek		0.5	0.16	Aa+
Cooper Creek		0.6	0.12	Aa+
Fraser River	From Moffat Tunnel to Colorado River	27.7	0.0045-0.020	B (16%) C (84%)
St. Louis Creek				
Short Creek	From Denver Water diversion points to confluence with West St. Louis Creek	0.2	0.19	Aa+
West St. Louis Creek	From Denver Water diversion points to confluence with St. Louis Creek mainstem	2.4	0.039-0.065	A (39%) B (61%)
Iron Creek		0.2	0.087	A
Byers Creek		0.2	0.24	Aa+
East St. Louis Creek		0.5	0.062	A
Fool Creek		0.9	0.087	A
King Creek		1.4	0.066	A
St. Louis Creek	From Range Creek to Fraser River	9.7	0.015-0.023	B (52%) C (48%)
Elk/Vasquez Creek				
West Elk Creek	From Denver Water diversion points to confluence with main Elk Creek	2.0	0.076	A
East Elk Creek		0.1	0.10	A
West Fork main Elk Creek (East Elk Creek)	From Denver Water diversion points to confluence of main Elk Creek (East Elk Creek)	0.1	0.083	A
East Fork main Elk Creek (East Elk Creek)		0.3	0.13	Aa+
Main Elk Creek	From confluence of West and East forks of Elk Creek to Fraser River	4.7	0.018-0.021	B (65%) C (35%)

Table 3.3-1 (continued)
Stream Channel Characteristics of Affected River Segments

Stream	Description	Affected Length (mile)	Slope (feet per foot)	Rosgen Level I Stream Type
Little Vasquez Creek	From Denver Water diversion points to confluence with Vasquez Creek	1.3	0.061	A
Vasquez Creek	From Denver Water diversion points to confluence with Fraser River	3.0	0.033	B
Ranch Creek				
Trail Creek	From Denver Water diversion points to confluence with Hurd Creek	3.5	0.070	A
Hamilton Creek		3.0	0.065	A
Hurd Creek	From Denver Water diversion points to confluence with main Ranch Creek	4.1	0.013-0.082	A (71%) C (29%)
Meadow Creek		5.8	0.0030-0.045	A (85%) C (15%)
North Fork Ranch Creek		0.8	0.11	Aa+
Dribble Creek		0.5	0.13	Aa+
Middle Fork Ranch Creek		2.0	0.070	A
South Fork Ranch Creek		2.7	0.066	A
Little Cabin Creek		2.1	0.050	A
Cabin Creek		2.7	0.043-0.082	A
Main Ranch Creek	From Denver Water diversion points to confluence with Fraser River	10.6	0.0080-0.083	A (17%) C (83%)
WILLIAMS FORK WATERSHED				
Steelman Creek	From Denver Water diversion points to confluence with Williams Fork	1.9	0.060	A
Bobtail Creek		1.6	0.060	A
McQueary Creek		0.4	0.25	Aa+
Jones Creek	From Denver Water diversion points to confluence with Bobtail Creek	0.2	0.16	Aa+
Williams Fork	From confluence with Steelman Creek to confluence with South Fork of Williams Fork	8.1	0.015-0.033	B (49%) C (51%)
COLORADO RIVER WATERSHED				
Colorado River	From confluence with Fraser River to confluence with Williams Fork River	15.5	0.0025-0.0075	C
BLUE RIVER WATERSHED				
Blue River	From Dillon Reservoir to Green Mountain Reservoir	21.1	0.0070	C

Table 3.3-1 (continued)
Stream Channel Characteristics of Affected River Segments

Stream	Description	Affected Length (mile)	Slope (feet per foot)	Rosgen Level I Stream Type
SOUTH BOULDER CREEK WATERSHED				
South Boulder Creek above Gross Reservoir	From Moffat Tunnel outlet to Eldorado Springs	16.1	0.013-0.052	A (14%) B (12%) C (74%)
South Boulder Creek below Gross Reservoir		8.0	0.091	A
NORTH FORK SOUTH PLATTE RIVER WATERSHED				
North Fork South Platte River	From Roberts Tunnel outlet to confluence with South Platte River	39.7	0.0057-0.018	C
SOUTH PLATTE RIVER WATERSHED				
South Platte River	From Antero Reservoir to Henderson gage	120.1	0.0019-0.011	C



Rosgen, David L. "A classification of natural rivers." Catena 22 (1994): 179. www.wildlandhydrology.com

Using the Rosgen Level I classification, characteristics to be represented by sampling sites were determined. Representative sites were then selected on the basis of field observations, natural quality of the site (similarities with other areas), hydraulic modeling potential, and accessibility as a means to obtain specific information for most of the stream types present in an affected drainage basin. The Representative sites described in each basin are as follows:

- Fraser River
  - Fraser River above Winter Park Gage (FR1)
  - Fraser River near Tabernash (FR2)
  - St. Louis Creek below West St. Louis Creek (FR3)
  - Ranch Creek below South Fork (FR4)
  - Fraser River below Denver Water's Diversion (FR5)
  - Jim Creek below Denver Water's Diversion (FR6)
  - Vasquez Creek above Denver Water's Diversion (FR7)
- Williams Fork River
  - Williams Fork River near Sugarloaf Campground (WF1)
  - Williams Fork River below Steelman Creek (WF2)
- Colorado River
  - Colorado River above Parshall (CR1)
  - Colorado River at Kemp-Breeze SWA (CR2)
- Blue River
  - Blue River below confluence with Boulder Creek (BR1)
- South Boulder Creek
  - South Boulder Creek above Gross Reservoir (SBC1)
  - South Boulder Creek below Gross Reservoir (SBC3)
- North Fork South Platte River
  - North Fork South Platte River near Shawnee (NF1)
  - North Fork South Platte River near Pine (NF2)

No Representative sites were selected in the South Platte River Basin due to results obtained from other sites and the relatively low flow changes predicted on the South Platte River.

Hydraulic data collected at each sampling site include stream discharge, velocity, channel geometry, and water surface elevations. The channel bankfull width and depth were calculated from survey data. A Hydrologic Engineering Centers-River Analysis System (HEC-RAS) hydraulic model was developed for each sampling site. The HEC-RAS hydraulic models were used to generate water surface profiles and other hydraulic output as a function of discharge for each site.

Surface sediment samples were collected using a variation of the Wolman pebble count method. A sediment sampling frame, which has been shown to reduce sampling bias, was utilized with selected material measured using a gravelometer following procedures

outlined in Sampling Surface and Subsurface Particle-Size Distributions in Wadable Gravel- and Cobble-Bed Streams for Analysis in Sediment Transport, Hydraulics, and Streambed Monitoring (Bunte and Abt 2001). The surface sediment samples were used to develop particle size distributions for each site, which are presented in the Sediment Gradations Curves for Representative Reaches section of Appendix E-3. Photographs and descriptions of conditions at each location are presented in the Photographs of Representative Reaches, Existing Conditions section of Appendix E-3.

3.3.5.1 Fraser River Basin

Seven Representative sites were selected for surface sediment sampling and surveying in the Fraser River Basin. A Type C channel reach on the Fraser River at Idlewild Campground near the Winter Park gage (FR1), a Type C channel reach on the Fraser River near Tabernash (FR2), a Type C channel reach on St. Louis Creek (FR3), a Type A channel reach on Ranch Creek (FR4), a Type C channel reach on the Fraser River immediately downstream of Denver Water's diversion (FR5), a Type A channel reach on Jim Creek immediately downstream of Denver Water's diversion (FR6) and a Type C channel reach on Vasquez Creek upstream of Denver Water's diversion (FR7) were selected. Descriptions of each site are presented in the following sections.

FR1 – Fraser River above Winter Park Gage – FR1 is located on the Fraser River at the Idlewild Campground in Winter Park. This site was 539 feet long with an average slope of 0.0168 feet per foot (ft/ft) and a sinuosity of 1.06 over the length of the reach evaluated. Average bankfull width and depth at the FR1 site were 27.4 and 1.28 feet, respectively. Maximum bankfull depth was 2.21 feet. The bed material was predominately cobble. Moderate to large amounts of sand were stored along the banks and on the bed between cobbles. The quantity of sand observed appears to be an indicator of potential temporary aggradation in the channel, but signs of long-term aggradation or build up of the channel bed were not observed. Based on visual observation of the reach and predominate bed material, FR1 was characteristic of a Rosgen C3 stream type.

The FR1 reach was uniform in water flow pattern, with the entire reach exhibiting riffle-type flows through cobbles. Small to moderate amounts of woody debris were observed in the channel in the form of one isolated debris jam causing split flow. The banks throughout the reach were predominately gently sloping to vertical, and were composed of cobbles and woody root masses. Banks were vegetated by herbaceous species as well as willows and coniferous trees, and appeared generally stable. Occasional instances of overhanging and unstable banks were observed, but appear isolated and not a sign of overall channel instability. Photographs from the FR1 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at eight cross sections at the FR1 site. All particles collected at the eight cross sections were combined into one sample for the site. As the reach was essentially uniform in water flow pattern, cross sections were selected at evenly spaced intervals throughout the reach. A total of 274 particles were collected and the median grain size was determined to be approximately 64 millimeters (mm) (very coarse gravel) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

FR2 – Fraser River Near Tabernash – FR2 was located on the Fraser River in a moderately broad U-shaped valley approximately 1 mile downstream of Tabernash. This site was 872 feet long with an average slope of 0.0048 ft/ft and a sinuosity of 1.03 over the length of the reach evaluated. Average bankfull width and depth at the FR2 site were 58.4 and 1.49 feet, respectively. The maximum bankfull depth was 2.26 feet. The bed material was predominately cobble and gravel, with exposed cobble bars on the inside of some bends. Very little sand and fine material was observed in the bed and along the banks. Considerable amounts of organic matter were observed on streambed sediments, particularly along the banks. No signs of aggradation or degradation were consistently observed throughout the reach, although localized areas with sand storage and bank instability were noted as would be expected in a natural system. Based on visual observation of the reach and predominate bed material, FR2 was characteristic of a Rosgen C3 stream type.

Approximately two-thirds of the FR2 reach was described as glide-type flow, and the remaining one third as riffle-type flow. No woody debris was observed in the channel. The banks throughout the reach were predominately gently sloping to vertical, were composed of cobbles, and were heavily vegetated with moss and grasses. Willows were prevalent along the banks as well. Coniferous trees were present at the site, but were not observed to grow along the banks. Throughout the reach, the banks were considered stable. Photographs from the FR2 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at three cross sections at the FR2 site. All particles collected at the three cross sections were combined into one sample for the site. As approximately one-third of the reach was comprised of riffles, and the remaining two-thirds of glides, one riffle cross section and two glide cross sections were selected. A total of 406 particles were collected and the median grain size was determined to be approximately 83 mm (small cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

FR3 – St. Louis Creek below West St. Louis Creek – FR3 was located on St. Louis Creek approximately 4.5 miles southwest of the Town of Fraser. This site was 335 feet long with an average slope of 0.020 ft/ft and a sinuosity of 1.08 over the length of the reach evaluated. Average bankfull width and depth at the FR3 site were 34.9 and 1.41 feet, respectively. The maximum bankfull depth was 2.34 feet. The bed material was predominately cobble and gravel, with considerable amounts of moss and organic material attached to surface sediments. Sand deposits were occasionally observed on the downstream sides of streambed cobbles. Moderate amounts of coarse sand to medium sized gravel were deposited behind large cobbles on point bars along stream banks, and were considered a potential sign of localized aggradation. Sand deposits were located in areas where fine material typically deposits and there was no evidence of sustained sediment deposition pervasive to the system. Based on visual observation of the reach and predominate bed material, FR3 was characteristic of a Rosgen C3 stream type with a relatively wide flood-prone width.

Beaver dams with recent activity were observed on the up- and downstream boundaries of the FR3 reach. The dam at the downstream end created a backwater condition, submerging small pine trees and grasses along the bank. Approximately half of the FR3 reach was

described as glide-type flow, and the other half as riffle-type flow. Considerable amounts of woody debris were observed in the channel. The banks throughout the reach were vertical to overhanging, and were composed of cobbles, woody debris, mosses and woody vegetation, or were gently sloping with herbaceous vegetation above point bars. Willows and coniferous trees were prevalent along the banks as well. Throughout the reach, the banks were considered stable. Photographs from the FR3 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at nine cross sections at the FR3 site. All particles collected at the nine cross sections were combined into one sample for the site. As the reach consists of half glide-type and half riffle-type flow patterns, cross sections were selected at evenly spaced intervals throughout the reach. A total of 261 particles were collected and the median grain size was determined to be approximately 73 mm (small cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

FR4 – Ranch Creek below South Fork – FR4 was located on Ranch Creek just below the confluence of the North Fork of Ranch Creek. This site was 571 feet long with an average slope of 0.0748 ft/ft and a sinuosity of 1.0 over the length of the reach evaluated. Average bankfull width and depth at the FR4 site were 22.1 and 1.38 feet, respectively. The maximum bankfull depth was 2.4 feet. The bed material was predominately cobble with boulders frequently interspersed throughout the reach. Moderate amounts of coarse sand were observed on the downstream sides of boulders and in overbank areas, indicating potential localized aggradation in locations where flow velocities were lowest. Based on visual observations of the reach and predominate bed material, FR4 was characteristic of a Rosgen A2 to A3 stream type.

The entire FR4 reach was described as a step-pool channel with equal areas of fast and slow flowing water. Considerable amounts of woody debris were observed in the channel. The banks throughout the reach were predominately vertical and are composed of large cobbles, woody root masses, and mosses. Willows and coniferous trees were prevalent along the banks as well. Throughout the reach, the banks were considered stable. Photographs from the FR4 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at 10 cross sections at the FR4 site. All particles collected at the 10 cross sections were combined into one sample for the site. As the reach is essentially uniform in water flow pattern, cross sections were selected at evenly spaced intervals throughout the reach. A total of 218 particles were collected and the median grain size was determined to be approximately 110 mm (small cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

FR5 – Fraser River below Denver Water's Diversion – FR5 was located on the Fraser River approximately 0.1 mile downstream of Denver Water's diversion. This site was 628 feet long with an average slope of 0.0155 ft/ft and a sinuosity of 1.27 over the length of the reach evaluated. Average bankfull width and depth at the FR5 site were 20.6 and 2.3 feet, respectively. The maximum bankfull depth was 3.2 feet. The bed material was predominately cobble and gravel. Sand and silt deposits were present in deeper pools and

in localized eddies as is typical of these low velocity locations. Point bars existed on the inside of most bends; bar material consisted mostly of cobble to sand sized material. There was some deposition of sand above the bankfull elevation. Based on visual observation of the reach and predominate bed material, FR5 was characteristic of a Rosgen C3 stream type with a relatively wide flood prone width. A beaver dam was observed just beyond the upstream boundary of the FR5 reach. Approximately 40% of the FR5 reach was described as faster riffle type flow and 60% as slower pools and glides. Woody debris was present in the channel throughout much of the site. The banks throughout the reach consisted of vertical to overhanging banks, and were composed of cobbles and woody vegetation. Overhanging banks appeared stable with thick grasses and willows. In the vicinity of point bars, banks were gently sloping with herbaceous vegetation. Throughout the reach, the banks were considered stable. Photographs from the FR5 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at 12 cross sections at the FR5 site. All particles collected at the 12 cross sections were combined into one sample for the site. Sediment was collected at 10 cross sections within the reach plus the cross section immediately upstream and downstream to provide a representative sediment distribution. A total of 212 particles were collected and the median grain size was determined to be approximately 43 mm (very coarse gravel) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

FR6 – Jim Creek below Denver Water's Diversion – FR6 was located on Jim Creek approximately 6.0 miles southeast of the Town of Fraser and 0.5 mile east of U.S. Highway 40 (US 40). This site was 390 feet long with an average slope of 0.0465 ft/ft and a sinuosity of 1.11 over the length of the reach evaluated. Average bankfull width and depth at the FR6 site were 14.1 and 1.60 feet, respectively. The maximum bankfull depth was 2.7 feet. The FR6 site was generally steep with step/pool morphology. At the time of the survey no flows were bypassing the Denver Water diversion structure. The bed material consisted primarily of large cobble with some boulders, gravel and sand. The finer material was generally only observed near the banks and behind rocks or debris where flow velocities would be lowest. Material up to cobble size was observed that has accumulated upstream of larger drops in the vicinity of woody debris. Only minor cobble bars were observed throughout the site. Based on visual observation of the reach and predominate bed material, FR6 was characteristic of a Rosgen A3 stream type with a relatively narrow flood prone width. While significant amounts of woody debris were present in the channel there were no signs of beaver activity. Due to the lack of flows in the channel, a ratio of fast to slow moving water could not be determined. Stream banks through the FR6 site were stable due to good vegetation and the presence of large material. The banks were very well vegetated with willows and alders. Vegetation had grown over the channel in many areas and may have been encroaching on the bankfull elevation in some areas. Photographs from the FR6 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at 14 cross sections at the FR6 site. All particles collected at the 14 cross sections were combined into one sample for the site. Sediment was collected at 10 cross sections within the reach plus the two cross sections immediately upstream and downstream to provide a representative sediment distribution. A total of

211 particles were collected and the median grain size was determined to be approximately 82 mm (small cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

FR7 – Vasquez Creek above Denver Water's Diversion – FR7 was located on Vasquez Creek approximately 5.5 miles south of the Town of Fraser and directly west of the Winter Park ski area. The site was located upstream of Denver Water's Vasquez Creek Diversion. This site was 612 feet long with an average slope of 0.0124 ft/ft and a sinuosity of 1.24 over the length of the reach evaluated. Average bankfull width and depth at the FR7 site were 22.8 and 2.4 feet, respectively. The maximum bankfull depth was 3.1 feet. The channel bed material was dominated by cobble and sand with some boulders. Point bars were generally located in tighter bends throughout the reach. Point bar material consisted of cobble, gravel, sand, and some fines. Some deposits of sand and fines were observed in the active channel. These deposits typically occurred along the banks and behind larger material where flow velocities are lowest but were occasionally mixed in with larger material. No sediment deposits were observed above bankfull elevation. Based on visual observation of the reach and predominate bed material, FR7 was characteristic of a Rosgen C3 stream type with a relatively wide flood prone width. Although there was woody debris in the channel there were no obvious signs of beaver activity in the immediate area. Approximately 70% of the FR7 reach can be described as faster moving riffle type flow; the remaining 30% was comprised of slower moving pools and glides. The FR7 reach was situated with a large flood prone meadow to the west and a hillside to the east. The banks throughout the reach appeared very stable and well vegetated with willows and grasses. Undercut banks were common throughout the reach but also appeared to be stable. Spruce trees were sporadic on the west side of the channel and common on the east side of the channel. Photographs from the FR7 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at 10 cross sections at the FR7 site. All particles collected at the 10 cross sections were combined into one sample for the site. Sampling was conducted at 10 of the 14 total cross sections. The four cross sections that were not sampled were excluded due to water depth. A total of 270 particles were collected and the median grain size was determined to be approximately 70 mm (small cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

Observed and measured characteristics from Representative sites in the Fraser River Basin are summarized in Table 3.3-2.

Table 3.3-2
Attributes of Representative Sampling Sites in the Fraser River Basin

Representative Sampling Site	Attributes							Entrenchment Ratio	Median Grain Size-d50 (mm)	Observations of Erosion
	Rosgen Stream Type	Reach Length (feet)	Reach Slope (feet per foot)	Sinuosity	Bankfull Width (feet)	Average Bankfull Depth (feet)	Maximum Bankfull Depth (feet)			
Fraser River above Winter Park Gage (FR1)	C3	539	0.0168	1.06	27.4	1.3	2.2	2.1	64	Moderate to large amounts of sand stored in the stream bed and on downstream side of larger cobbles/boulders; possible sign of aggradation.
Fraser River near Tabernash (FR2)	C3	872	0.0048	1.03	58.4	1.5	2.3	3.4	83	Very little sand stored; no signs of aggradation. Banks are generally vertical to overhanging and stable.
St. Louis Creek below West St. Louis Creek (FR3)	C3	335	0.0200	1.08	34.9	1.4	2.3	2.8	73	Moderate amounts of medium to coarse sand observed behind large cobbles on point bars; possible sign of aggradation. Banks are stable.
Ranch Creek below South Fork (FR4)	A2 to A3	571	0.0748	1.0	22.1	1.4	2.4	3.4	110	Moderate amounts of sand observed behind boulders and in overbank; possible signs of aggradation. Banks are stable.
Fraser River below Denver Water's Diversion (FR5)	C3	628	0.0155	1.27	20.6	2.3	3.2	5.9	43	Sand and silt observed in local eddies, pools and on point bars; possible sign of aggradation. Banks are generally stable with some local erosion noted.
Jim Creek below Denver Water's Diversion (FR6)	A3	390	0.0465	1.11	14.1	1.6	2.7	3.0	82	Only minimal amounts of sands or fines observed. Dense vegetation along stable banks; possible vegetative encroachment.
Vasquez Creek above Denver Water's Diversion (FR7)	C3	612	0.0124	1.24	22.8	2.4	3.1	5.9	70	Sand and silt observed in local eddies, pools and on point bars; possible sign of aggradation. Banks are generally stable with some local erosion noted.

Notes:
Sinuosity calculated over the Representative reach length only and may understate overall sinuosity.
mm = millimeter

The following general observations were recorded at the Representative sites in the Fraser River Basin:

Channel Stability

- The greatest amount of sand, a potential sign of aggradation, was observed at site FR1 which is located downstream of Denver Water's diversion and upstream of the Town of Winter Park. The amount of observed sand, however, did not indicate long-term aggradation had caused an increase in bed levels.

- Little to no sand or fines were observed at the Jim Creek site (FR6); no sediment aggradation was likely, but vegetative encroachment was possible.
- Little to no sand or fines were observed at the Fraser River site near Tabernash (FR2), the furthest downstream site on the Fraser River.
- Moderate amounts of sand were noted at all other sites, including Vasquez Creek above Denver Water's diversion (FR7) and the Fraser River immediately downstream of Denver Water's diversion (FR5). As one of these locations is below Denver Water's diversion point and another is above, these sand levels are believed to be typical of the natural stream system and do not appear to be influenced by past diversions.
- Banks in higher gradient channels were generally very stable. Banks in lower gradient segments were also stable with more localized bank erosion observed as is typical in a natural, stable stream system.

Median Grain Size

- The largest median grain sizes were observed in Ranch Creek (FR4), Jim Creek (FR6) and the Fraser River near Tabernash (FR2). Median grain sizes at these locations were all between 82 mm and 110 mm, which are categorized as cobbles.
- The smallest median grain size was observed on the Fraser River downstream of Denver Water's diversion (FR5). The median grain size at this location was 43 mm, which classifies as very coarse gravel.
- Median grain sizes ranged from 64 mm to 73 mm at all other Representative sites, which classifies as very coarse gravel to small cobbles.

3.3.5.2 Williams Fork River Basin

Two Representative sites were selected on the Williams Fork River for surface sediment sampling and surveying: A Type C channel reach near the Sugarloaf Campground (WF1) and a Type B channel reach below Steelman Creek (WF2).

WF1 – Williams Fork River Near Sugarloaf Campground – WF1 was located on the Williams Fork River near the Sugarloaf Campground. This site was 1,157 feet long with an average slope of 0.0136 ft/ft and a sinuosity of 1.12 over the length of the reach evaluated. Average bankfull width and depth at the WF1 site were 45.8 and 1.56 feet, respectively. Maximum bankfull depth was 2.78 feet. The bed material was predominately cobble and gravel, with large sand bars located on the inside of bends. Sand was also stored in the stream bed on the downstream side of larger cobbles and boulders, which were interspersed throughout the reach. The large sand bars and sand stored in the streambed was considered an indicator of potential aggradation at the site, although all observed aggradation appeared temporary in nature with no signs of long-term depositional trends. Based on visual observation of the reach and predominate bed material, WF1 was characteristic of a Rosgen C3 stream type.

The WF1 reach contained approximately equal areas of riffles with faster flowing water and glides with moderately paced flowing water. Moderate amounts of large woody debris were located throughout the reach, creating isolated areas of faster or slower flowing water. The banks throughout the reach were predominately overhanging, vegetated, and composed

of cobble and appeared stable. Vegetation along the banks was both woody and herbaceous. Areas of localized bank instability were observed, as well as limited amounts of braiding and exposed cobble bars in the channel. Both observations are consistent with natural channel variability and are not believed to be an indication of an unstable channel condition. Photographs from the WF1 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at three cross sections at the WF1 site. All particles collected at the three cross sections were combined into one sample for the site. The reach contained approximately equal areas of riffles and glides, and significant cobble and sand bars; cross sections were selected accordingly. The first sampling cross section was located in glide-type water with a cobble bar on the left bank. The second cross section was located in riffle-type flow, with a large exposed cobble bar in the middle of the channel. The third cross section was located in a wide portion of the stream, with riffle-type flow on the left bank and slower glide-type flow towards the right bank. A total of 255 particles were collected and the median grain size was determined to be approximately 53 mm (very coarse gravel) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

WF2 – Williams Fork River below Steelman Creek – WF2 was located on the Williams Fork River below the confluence with Steelman Creek, a first order tributary to the Williams Fork. This site was 590 feet long with an average slope of 0.0244 ft/ft and a sinuosity of 1.08 over the length of the reach evaluated. Average bankfull width and depth at the WF2 site were 27 and 1.57 feet, respectively. Maximum bankfull depth was 2.59 feet. The bed material was predominately cobble and small boulders. Small to moderate amounts of sand were stored along the banks and on the downstream side of larger cobbles and small boulders. No consistent signs of aggradation or degradation were apparent throughout the reach. Based on visual observation of the reach and predominate bed material, WF2 was characteristic of a Rosgen B2 to B3 stream type.

The WF2 reach was uniform in water flow pattern, with the entire reach exhibiting low flow conditions through cobble and small boulders at the time of the site visit. Minimal amounts of woody debris were observed in the channel. The banks throughout the reach were predominately vertical to overhanging, and were composed of cobbles, woody root masses, and woody debris. Vegetation along the banks included mosses, grasses, willows, and coniferous trees. Throughout the WF2 reach, banks appeared stable with only isolated areas of bank instability. Photographs from the WF2 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at four cross sections at the WF2 site. All particles collected at the four cross sections were combined into one sample for the site. As the reach is essentially uniform in water flow pattern, cross sections were selected at evenly spaced intervals throughout the reach. A total of 219 particles were collected and the median grain size was determined to be approximately 64 mm (very coarse cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

Observed and measured characteristics from Representative sites in the Williams Fork River Basin are summarized in Table 3.3-3.

Table 3.3-3
Attributes of Representative Sampling Sites in the Williams Fork River Basin

Representative Sampling Site	Attributes							Entrenchment Ratio	Median Grain Size-d50 (mm)	Observations of Erosion
	Rosgen Stream Type	Reach Length (feet)	Reach Slope (feet per foot)	Sinuosity	Bankfull Width (feet)	Average Bankfull Depth (feet)	Maximum Bankfull Depth (feet)			
Williams Fork River near Sugarloaf Campground (WF1)	C3	1,157	0.0136	1.12	45.8	1.6	2.8	3.5	53	Moderate to large amounts of sand stored in the stream bed and on downstream side of larger cobbles/ boulders; possible signs of aggradation. Some local bank instability.
Williams Fork River below Steelman Creek (WF2)	B2 to B3	590	0.0244	1.08	27	1.6	2.6	2.4	64	Small to moderate amounts of sand stored; no signs of aggradation. Banks are generally vertical to overhanging and stable.

Notes:
Sinuosity calculated over the Representative reach length only and may understate overall sinuosity.
mm = millimeter

The following general observations were made regarding the Representative sites in the Williams Fork River Basin:

Channel Stability

- The greatest amount of sand, a potential sign of aggradation, was observed at site WF1 which is a lower gradient stream section (1.4% slope) located near Sugarloaf Campground. There were not, however, signs of long-term aggradation.
- Small to moderate amounts of sand or fines were observed at the Williams Fork below Steelman Creek site (WF2).
- Banks in higher gradient channels were generally very stable. Banks in lower gradient segments were also stable with more localized bank erosion observed.

Median Grain Size

- The median grain size was larger (64 mm) at the steeper upstream site below Steelman Creek (WF2) than at the lower gradient site near Sugarloaf Campground (WF1) where it was 53 mm. Both classify as very coarse gravel.

3.3.5.3 Colorado River Basin

Two Type F channel reaches on the Colorado River were selected for sediment sampling and surveying.

CR1 – Colorado River above Parshall – The sampling site, CR1, was located on the Colorado River approximately 1 mile upstream of Parshall in the Hot Sulphur Springs State Wildlife Area (SWA). This site was 953 feet long with an average slope of 0.00255 ft/ft and a sinuosity of 1.00 over the length of the reach evaluated. Average bankfull width and

depth at the CR1 site were 140.3 and 1.60 feet, respectively. The maximum bankfull depth was 2.64 feet. The bed material was predominately cobble with some gravel. A large cobble bar was exposed in the middle of the reach due to the low flow level at the time of sampling, and was not considered to be a sign of aggradation. Throughout the reach, no consistent signs of long-term aggradation or degradation were observed. Small to moderate amounts of sand were stored in the bed and on the cobble bar. Above the current water level, small to moderate amounts of fine gravel, sand, and silt were observed. Small to moderate amounts of organic matter were observed on streambed sediments, particularly along the banks. CR1 was characteristic of a Rosgen F3 stream type.

The CR1 reach was equally characterized by fast riffle-type flow and slower glide-type flow. No woody debris was observed in the channel. The banks throughout the reach were predominately gently sloping to vertical and were heavily vegetated with herbaceous and woody vegetation. Throughout the reach, the banks were observed to be stable. Photographs from the CR1 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at two cross sections at the CR1 site. All particles collected at the two cross sections were combined into one sample for the site. As the reach is approximately equally represented by riffles and glides, one riffle cross section and one glide cross section was selected. A total of 284 particles were collected and the median grain size was determined to be approximately 80 mm (small cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

CR2 – Colorado River at Kemp-Breeze SWA – CR2 was located on the Colorado River approximately 1 mile downstream of Parshall in the Kemp-Breeze SWA. This site was 1,113 feet long with an average slope of 0.0044 ft/ft and a sinuosity of 1.01 over the length of the reach evaluated. Average bankfull width and depth at the CR2 site were 142.2 and 3.7 feet, respectively. The maximum bankfull depth was 5.1 feet. The bed material was predominately cobble with some gravel and sand. Although they were generally submerged under less than 6 inches of water at the time of the site visit, significant cobble bars were present in the CR2 reach. These bars generally consisted of cobble to sand sized material. No consistent signs of long-term aggradation or degradation were observed at the CR2 site. The banks consisted of very stable mild slopes and were comprised of smaller cobble, gravel and sand. Significant organic matter was observed on streambed sediments throughout the width of the channel. CR2 was characteristic of a Rosgen F3 stream type. The CR2 reach was equally characterized by fast riffle- type flow and slower glide- type flow. No woody debris was observed in the channel itself, however, large fallen cottonwood branches were common on the banks. The banks throughout the reach were predominately gently sloping and were well vegetated with herbaceous and woody vegetation. Thick grasses were present on both banks while willows tended to dominate the north bank and cottonwood trees tended to dominate the south bank. Photographs from the CR2 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at four cross sections at the CR2 site. All particles collected at the four cross sections were combined into one sample for the site. As the reach is approximately equally represented by riffles and glides, two riffle cross sections

and two glide cross sections were selected. A total of 270 particles were collected and the median grain size was determined to be approximately 46 mm (very coarse gravel) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

Observed and measured characteristics from Representative sites in the Colorado River Basin are summarized in Table 3.3-4.

Table 3.3-4
Attributes of Representative Sampling Sites in the Colorado River Basin

Representative Sampling Site	Attributes							Entrenchment Ratio	Median Grain Size-d50 (mm)	Observations of Erosion
	Rosgen Stream Type	Reach Length (feet)	Reach Slope (feet per foot)	Sinuosity	Bankfull Width (feet)	Average Bankfull Depth (feet)	Maximum Bankfull Depth (feet)			
Colorado River above Parshall (CR1)	F3	953	0.0026	1.00	140.3	1.6	2.6	1.4	80	Small to moderate amounts of sand and silt stored; no signs of aggradation. Banks are gently sloping to vertical, heavily vegetated and stable.
Colorado River at Kemp-Breeze SWA (CR2)	F3	1,113	0.0044	1.01	142.2	3.7	5.1	1.5	46	Small to moderate amounts of sand and silt stored; no signs of aggradation. Banks are generally gently sloping, heavily vegetated and stable.

Notes:
Sinuosity calculated over the Representative reach length only and may understate overall sinuosity.
mm = millimeter
SWA = State Wildlife Area

The following general observations were recorded at the Representative sites along the Colorado River:

Channel Stability

- Small to moderate amounts of sand or fines were observed at both sites.
- Banks were observed to be well vegetated and stable.
- Signs of on-going aggradation were not noted at either location.

Median Grain Size

- The median grain size was larger (80 mm, small cobble) at the site on the Colorado River upstream of the Williams Fork River (CR1) than it was at the site on the Colorado River downstream of the Williams Fork (CR2), where the median grain size was 46 mm (very coarse gravel).

3.3.5.4 Blue River Basin

One Representative Type F channel reach on the Blue River was selected for sediment sampling and surveying.

BR1 – Blue River below Confluence with Boulder Creek – BR1 was located on the Blue River approximately 10 miles north of Dillon and 10 miles south of Green Mountain Reservoir. This site was 876 feet long with an average slope of 0.0121 ft/ft and a sinuosity of 1.02 over the length of the reach evaluated. Average bankfull width and depth at the BR1 site were 100.7 and 4.8 feet, respectively. The maximum bankfull depth was 5.4 feet. The bed material consisted predominantly of boulder and cobble material. Narrow point bars were present in the reach. The bars consisted of cobble to boulder sized material similar to the channel material but with a higher proportion of cobble. BR1 was characteristic of a Rosgen Type F3 channel with drops and riffle/pool morphology. Approximately 80% of the reach was comprised of drops and riffles while 20% was slower moving pools and glides. No woody debris was present in the channel. There were no consistent signs of aggradation or degradation at the BR1 site. Although the channel was locally deeply incised with a narrow flood prone area, banks in the immediate vicinity of the channel were observed to be shallow and very stable. The BR1 banks were well vegetated with willows and spruce. Some grasses were also present. Photographs from the BR1 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at three cross sections at the BR1 site. All particles collected at the three cross sections were combined into one sample for the site. The three cross sections were taken in areas that were predominately low gradient riffle. A total of 303 particles were collected and the median grain size was determined to be approximately 81 mm (small cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

Observed and measured characteristics from Representative site in the Blue River Basin are summarized in Table 3.3-5.

Table 3.3-5
Attributes of Representative Sampling Site in the Blue River Basin

Representative Sampling Site	Attributes							Entrenchment Ratio	Median Grain Size-d50 (mm)	Observations of Erosion
	Rosgen Stream Type	Reach Length (feet)	Reach Slope (feet per foot)	Sinuosity	Bankfull Width (feet)	Average Bankfull Depth (feet)	Maximum Bankfull Depth (feet)			
Blue River below confluence with Boulder Creek (BR1)	F3	876	0.0121	1.02	100.7	4.8	5.4	1.5	81	Small amounts of sand were observed. Channel and banks were observed to be stable. Banks are well vegetated. No signs of aggradation or degradation. Locally the site is incised.

Notes:
Sinuosity calculated over the Representative reach length only and may understate overall sinuosity.
mm = millimeter

The following general observations were recorded at the Representative site on the Blue River:

Channel Stability

- Limited amounts of sand or fines were observed at the site.
- Banks were observed to be well vegetated and stable.
- Signs of aggradation were not noted at the site.

Median Grain Size

- The median grain size for BR1 was 81 mm (small cobble).

3.3.5.5 South Boulder Creek Basin

Two Representative sites were selected on South Boulder Creek for surface sediment sampling and surveying: A Type F channel reach above Rollinsville (SBC1) and a Type B reach below Gross Reservoir (SBC3).

SBC1 – South Boulder Creek above Gross Reservoir – SBC1 was located on South Boulder Creek above Gross Reservoir approximately 2 miles upstream of Rollinsville. This site was 599 feet long with an average slope of 0.0180 ft/ft and a sinuosity of 1.00 over the length of the reach evaluated. Average bankfull width and depth at the SBC1 site were 42.4 and 2.28 feet, respectively. The maximum bankfull depth was 3.66 feet. The bed material was predominately cobble and boulders. Minimal amounts of sand were stored in the bed and small quantities were stored along the banks where velocities were lowest. Moderate to considerable amounts of organic matter were observed on streambed sediments, particularly along the banks. Based on visual observations of the reach and predominate bed material, SBC1 was characteristic of a Rosgen F3 to F2 stream type.

The entire SBC1 reach was characterized by fast riffle-type flow. No woody debris was observed in the channel. The banks throughout the reach were predominately vertical or very steeply sloped and were composed of cobbles, and in some places bare soil. Banks were mostly vegetated by herbaceous species as well as willows and some coniferous trees. Throughout the reach, the banks were observed to be stable, with some localized instabilities. The reach was confined between the Moffat Tunnel Road and the UPRR tracks, with high terraces on both sides of the channel. This condition existed for the entire reach and it is suspected that stream banks were stabilized in the past. Banks appeared stable and were vegetated. Photographs from the SBC1 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at four cross sections at the SBC1 site. All particles collected at the four cross sections were combined into one sample for the site. As the reach is essentially uniform in water flow pattern, cross sections were selected at evenly spaced intervals throughout the reach. A total of 217 particles were collected and the median grain size was determined to be approximately 170 mm (large cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

SBC3 – South Boulder Creek below Gross Reservoir – SBC3 was located on South Boulder Creek approximately 1 mile below Gross Reservoir. This site was 446 feet long

with an average slope of 0.0258 ft/ft and a sinuosity of 1.08 over the length of the reach evaluated. Average bankfull width and depth at the SBC3 site were 61.8 and 1.95 feet, respectively. The maximum bankfull depth was 3.25 feet. The bed material was predominately cobble and boulders with large areas of bedrock outcrops. Substantial amounts of coarse sand and fine gravel were present in the stream bed. No signs of long-term aggradation or degradation were consistently observed throughout the reach. Based on visual observations of the reach and predominate bed material, SBC3 was characteristic of a Rosgen B2 to B1 stream type in the upstream portion, and a B2 to B3 stream type in the downstream portion.

The upstream half of the SBC3 reach was characterized by low gradient steps in bedrock punctuated by riffle flow, and the downstream half of the reach was characterized by a narrower low flow area through cobbles. Moderate amounts of woody debris were observed in the channel at the upstream extent of the reach. The right bank throughout the reach was predominately grassy, gradually sloped, and adjacent to a riparian area. The left bank was generally steep below a hillslope vegetated by ponderosa pine trees. Throughout the reach, the banks were observed to be stable, with some localized instabilities consistent with an overall stable channel. Photographs from the SBC3 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at three cross sections at the SBC3 site. All particles collected at the three cross sections were combined into one sample for the site. Cross sections were selected according to reach characteristics, representing flow through bedrock and cobbles. A total of 197 particles were collected and the median grain size was determined to be approximately 110 mm (small cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

Observed and measured characteristics from Representative sites in the South Boulder Creek Basin are summarized in Table 3.3-6.

Table 3.3-6
Attributes of Representative Sampling Sites in the South Boulder Creek Basin

Representative Sampling Site	Attributes							Entrenchment Ratio	Median Grain Size-d50 (mm)	Observations of Erosion
	Rosgen Stream Type	Reach Length (feet)	Reach Slope (feet per foot)	Sinuosity	Bankfull Width (feet)	Average Bankfull Depth (feet)	Maximum Bankfull Depth (feet)			
South Boulder Creek above Gross Reservoir (SBC1)	F3 to F2	599	0.0180	1.00	42.4	2.3	3.7	1.4	170	Minimal sand stored in bed with moderate amounts in banks. Banks are steeply sloped to vertical. Banks are generally stable with local sloughing observed.
South Boulder Creek below Gross Reservoir (SBC3)	B1 to B3	446	0.0258	1.08	61.8	2.0	3.3	2.3	110	Substantial coarse sand to fine gravel stored in the bed, but aggradation not likely. Banks are generally stable with local sloughing observed.

Notes:
Sinuosity calculated over the Representative reach length only and may understate overall sinuosity.
mm = millimeter

The following general observations were recorded at the Representative sites in the South Boulder Creek Basin:

Channel Stability

- Minimal amounts of fines were observed.
- Coarse sand to fine gravel was stored in the bed below Gross Reservoir (SBC3).
- Banks were generally stable with localized sloughing observed.

Median Grain Size

- The median grain size was larger (170 mm, large cobble) at the site above Rollinsville (SBC1) than downstream of Gross Reservoir (110 mm, small cobble).

3.3.5.6 North Fork South Platte River Basin

Two Representative sites on the North Fork South Platte River were selected for surface sediment sampling and surveying: A Type C channel reach near Shawnee (NF1) and another Type C reach near Pine (NF2).

NF1 – North Fork South Platte River Near Shawnee – NF1 was located on the North Fork South Platte River near Shawnee. This site was 300 feet long with an average slope of 0.0080 ft/ft and a sinuosity of 1.04 over the length of the reach evaluated. Average bankfull width and depth at the NF1 site were 51.2 and 1.73 feet, respectively. The maximum bankfull depth was 2.96 feet. The bed material was predominately cobble and gravel. Minimal amounts of coarse sand were stored along the banks and on the bed between cobbles. Based on visual observations of the reach and predominate bed material, NF1 was characteristic of a Rosgen C3 stream type.

The NF1 reach was characterized primarily by riffle-type flow, interspersed with areas of slower water. Braiding was observed both up- and downstream of the reach. Small to moderate amounts of woody debris were observed in the channel in the form of one isolated debris jam causing the formation of a cobble bar. Bedrock bank control was observed at the upstream end of the reach. The banks throughout the reach were predominately overhanging to vertical, and were composed of cobbles and woody root masses. Banks were vegetated by herbaceous species as well as willows and coniferous trees. An area of past bank stabilization, in the form of a 30-foot long stacked rock and riprap wall was observed on the right bank on an outside bend in the upstream extent of the reach, suggesting past degradation. Just upstream of the reach, an exposed vertical bank approximately 10 feet tall was noted, indicating potential degradation. Photographs from the NF1 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at four cross sections at the NF1 site. All particles collected at the four cross sections were combined into one sample for the site. As the reach exhibited pool-riffle-glide sequences with braiding and a large cobble bar, cross sections were selected accordingly. Three of the four cross sections were asymmetrical, with the majority of the flow on one side of the channel, and shallow, slower water in the other portion of the channel. One cross section was on a large cobble bar upstream of observed bedrock control and a debris jam. A total of 244 particles were collected and the

median grain size was determined to be approximately 75 mm (small cobble) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

NF2 – North Fork South Platte River Near Pine – NF2 was located on the North Fork South Platte River just upstream of Pine, within Jefferson County's Pine Junction open space park. This site was located in a wide valley with a well-defined floodplain. The reach length of NF2 was 778 feet long with an average slope of 0.0065 ft/ft and a sinuosity of 1.03 over the length of reach evaluated. Average bankfull width and depth at the NF2 site were 70.9 and 3.53 feet, respectively. The maximum bankfull depth was 5.51 feet. The bed material was predominately large gravel with cobble. Moderate amounts of sand were stored along the banks and on the bed between cobbles but were not considered signs of on-going aggradation. Based on visual observation of the reach and predominate bed material, NF2 was characteristic of a Rosgen C3 stream type.

The NF2 reach was characterized by riffle and glide sequences, with a well-defined thalweg. Approximately one-third of the reach was described as riffle-type flow and two-thirds as glide-type flow. No woody debris was observed in the channel. The banks throughout the reach were predominately vertical and are composed of fine sandy soils. Banks were vegetated by herbaceous species and willows. Small isolated islands of willows, which had likely eroded from the bank, were observed in the channel near the water's edge in a small portion of the reach, suggesting localized bank instability. Three areas of bank stabilization, in the form of stacked angular rock were observed throughout the reach, indicating potential past degradation. A concrete wall and headgate structure were observed at the downstream end of the reach. Photographs from the NF2 site are provided in the Photographs of Representative Reaches, Existing Conditions section in Appendix E-3.

Sediment sampling was conducted at three cross sections at the NF2 site. It should be noted that sediments were sampled upstream of the surveyed reach, as cross sections in this area were judged to be more representative of overall channel characteristics. All particles collected at the three cross sections were combined into one sample for the site. As approximately one-third of the reach was comprised of riffles and the remaining two-thirds of glides, one riffle cross section and two glide cross sections were selected. A total of 226 particles were collected and the median grain size was determined to be approximately 45 mm (very coarse gravel) from the particle size distribution shown in the Sediment Gradation Curves for Representative Reaches section of Appendix E-3.

Observed and measured characteristics from Representative sites in the North Fork of South Platte River Basin are summarized in Table 3.3-7.

Table 3.3-7
Attributes of Representative Sampling Sites in the North Fork South Platte River Basin

Representative Sampling Site	Attributes							Entrenchment Ratio	Median Grain Size-d50 (mm)	Observations of Erosion
	Rosgen Stream Type	Reach Length (feet)	Reach Slope (feet per foot)	Sinuosity	Bankfull Width (feet)	Average Bankfull Depth (feet)	Maximum Bankfull Depth (feet)			
North Fork South Platte River near Shawnee (NF1)	C3	300	0.0080	1.04	51.2	1.7	3.0	2.0	75	Minimal coarse sand stored along banks and in bed. Minor braiding observed. Banks overhanging to vertical and generally stable. A 30 foot section of rock and riprap was observed suggesting localized past bank erosion.
North Fork South Platte River near Pine (NF2)	C3	778	0.0065	1.03	70.9	3.5	5.5	3.3	45	Moderate amounts of sand stored along banks and in bed. Banks are predominately vertical. Local areas of bank stabilization were noted indicating localized past bank erosion.

Notes:
Sinuosity calculated over the representative reach length only and may understate overall sinuosity.
mm = millimeter

The following general observations were made at the Representative sites in the North Fork South Platte River Basin:

Channel Stability

- Channel banks were generally stable in part due to past stabilization efforts
- Minimal to moderate amounts of fines were observed.

Median Grain Size

- The median grain size was larger (75 mm, small cobble) at the site near Shawnee (NF1) than the site downstream near Pine (45 mm, very coarse gravel).

3.3.5.7 South Platte River Basin

The overall study area on the South Platte River extends from the Antero Reservoir outlet to the Henderson gage. No Representative sites were selected in the South Platte River Basin due to results obtained from other sites and the relatively low flow changes predicted on the South Platte River.

3.3.6 Reconnaissance River Segments

Reconnaissance river segments were evaluated to supplement detailed information gained from the Representative reaches and to evaluate whether it is generally appropriate to extrapolate detailed results from Representative sites to other streams in the surrounding basins. A total of 32 Reconnaissance sites were included in the analysis for the Moffat Project Environmental Impact Statement (EIS). Data for the Reconnaissance sites were

collected and evaluated in the 1980s as part of the assessment of existing channel conditions for the Metropolitan Denver Water Supply EIS, also referred to as Two Forks (Corps 1988). These sites were selected by the U.S. Forest Service (USFS) as part of the Two Forks project assessment as being representative of channel types found throughout the basin (Simons and Associates 1986). Some of the Reconnaissance sites are at or very near Representative sites evaluated as part of the Moffat Project EIS while others are in the surrounding basins. No quantitative field sampling was done at the Reconnaissance sites for the Moffat Project EIS and no quantitative results derived for this study are based on data from the Reconnaissance sites. Rather, Reconnaissance sites were used to determine if observations of stream channel characteristics including stability, sediment size and potential aggradation/degradation made at Representative sites were consistent with the larger sample size that Reconnaissance sites offered.

The Reconnaissance river segments evaluated in each basin are as follows:

- Fraser River Basin
  - Vasquez Creek (FR-Recon 1)
  - Upper St. Louis Creek above Diversion (FR-Recon 2)
  - Upper St. Louis Creek below Diversion (FR-Recon 3)
  - Fraser River at Berthoud Pass (FR-Recon 4)
  - Upper Vasquez Creek above Tunnel (FR-Recon 5)
  - Upper Vasquez Creek below Tunnel (FR-Recon 6)
  - Fraser River near Idlewild (FR-Recon 7)
  - South Fork Ranch Creek above Diversion (FR-Recon 8)
  - South Fork Ranch Creek below Diversion (FR-Recon 9)
  - Middle Fork Ranch Creek above Diversion (FR-Recon 10)
  - Middle Fork Ranch Creek below Diversion (FR-Recon 11)
- Williams Fork River Basin
  - Bobtail Creek (WF-Recon 1)
  - Kinney Creek near Leal (WF-Recon 2)
  - Lower South Fork Williams Fork near Leal (WF-Recon 3)
  - Williams Fork below Steelman (WF-Recon 4)
  - Williams Fork near Leal (WF-Recon 5)
  - Upper South Fork of Williams Fork (WF-Recon 6)
  - Williams Fork near Sugarloaf Campground (WF-Recon 7)
  - Steelman Creek above Diversion (WF-Recon 8)
  - Steelman Creek below Diversion (WF-Recon 9)

  - Bobtail Creek above Diversion (WF-Recon 10)
  - Bobtail Creek below Diversion (WF-Recon 11)
  - Middle Fork Williams Fork near Diversion (WF-Recon 12)
  - Middle Fork Williams Fork near Mouth (WF-Recon 13)
  - Darling Creek (WF-Recon 14)
- Blue River Basin
  - Blue River below Dillon Reservoir (BR-Recon 1)
  - Blue River below Green Mountain Reservoir (BR-Recon 2)
  - Blue River at Blue River Campground (BR-Recon 3)
- North Fork South Platte River Basin
  - North Fork South Platte River at Shawnee (NF-Recon 1)
  - North Fork South Platte River at Crossons (NF-Recon 2)
  - North Fork South Platte River at Buffalo (NF-Recon 3)
- South Boulder Creek Basin
  - South Boulder Creek below Pinecliffe (SBC-Recon 1)

Channel slopes, bankfull channel widths, sediment sizes and stability observations from the Reconnaissance sites were compared to the Representative sites to aid in extrapolation of results. A summary of recorded physical conditions at these sites is presented in Tables 3.3-8 through 3.3-12. Locations of all Representative and Reconnaissance reaches are presented in Figures E-3.1 through E-3.6 of Appendix E-3.

3.3.6.1 Fraser River Basin Reconnaissance Sites

Eleven Reconnaissance sites from the Fraser River Basin were included in the EIS evaluation including: two locations on the main stem of the Fraser River, three sites on Vasquez Creek, two sites on St. Louis Creek, and four sites in the Ranch Creek Basin. Sites included three areas where data was collected both above and below a Denver Water diversion. Data is summarized in Table 3.3-8.

Table 3.3-8
Attributes of Reconnaissance Sites in the Fraser River Basin

Site Location	Fraser River Basin				
	Site ID	Slope (feet per foot)	Bankfull Width (feet)	Median Grain Size-d50 (mm)	Stability Observations
Vasquez Creek	FR-Recon 1	0.0072	22	90	Channel bed is stable, not meandering or migrating but bank erosion has occurred.
Upper St. Louis above Diversion	FR-Recon 2	0.012	15	75	N/A
Upper St. Louis below Diversion	FR-Recon 3	0.030	23	63	Bed material is coarse and resistant to erosion up to very high flows. No channel aggradation.
Fraser River at Berthoud Pass	FR-Recon 4	0.051	15	65	N/A
Upper Vasquez Creek above Tunnel	FR-Recon 5	0.018	16	118	N/A
Upper Vasquez Creek below Tunnel	FR-Recon 6	0.034	16	85	Channel bed is stable, not meandering or migrating but bank erosion has occurred.
Fraser River Near Idlewild	FR-Recon 7	0.010	31	55	Bed is coarse and stable. Minor vegetative encroachment.
South Fork Ranch Creek above Diversion	FR-Recon 8	0.117	12	58	N/A
South Fork Ranch Creek below Diversion	FR-Recon 9	0.072	11	55	Bed material is coarse and resistant to erosion up to very high flows. No channel aggradation.
Middle Fork Ranch Creek above Diversion	FR-Recon 10	0.053	13	60	N/A
Middle Fork Ranch Creek below Diversion	FR-Recon 11	0.039	19	95	Bed material is coarse and resistant to erosion up to very high flows. No channel aggradation.

Notes:
ID = identification
mm = millimeter
N/A = not applicable

The following general observations were recorded at the Reconnaissance sites in the Fraser River Basin:

Channel Stability

- All sites with descriptions of channel stability were observed to be generally stable.
- Minor vegetative encroachment was possible at the Fraser River near Idlewild (FR-Recon 7).
- Some bank erosion was observed along Vasquez Creek, but the channel is not migrating laterally.

Median Grain Size

- Median grain sizes in Vasquez Creek and in the Middle Fork Ranch Creek below Denver Water's diversion classified as small cobbles and ranged from 90 mm to 118 mm.
- Median grain sizes ranged from 55 mm to 75 mm at all other Reconnaissance sites, which classify as very coarse gravel to small cobble.
- Median grain sizes decreased by approximately 10 mm from above to below Denver Water's diversion on St. Louis Creek. Median grain sizes increased by approximately 25 mm from above to below the diversion on the Middle Fork Ranch Creek and remained basically unchanged from above to below the diversion on the South Fork of Ranch Creek.

Overall observations made at the Reconnaissance sites were generally similar with observations made at the Representative sites. The Representative site observed to have the most sand stored (FR1) corresponded to the Reconnaissance site that showed signs of potential vegetative encroachment (FR-Recon 7), both signs of potential aggradation. Stream beds and banks were noted to be stable throughout and median grain sizes for all sites varied within a reasonably small range of 43 mm (very coarse sand) to 118 mm (small cobble). The median grain size of all Representative and Reconnaissance sites with slopes greater than 4% was 81 mm (small cobble). The median grain size of all Representative and Reconnaissance sites with slopes between 2% and 4% and less than 2% were 61 mm (very coarse gravel) and 72 mm (small cobble), respectively.

3.3.6.2 Williams Fork River Basin Reconnaissance Sites

Fourteen Reconnaissance sites from the Williams Fork River Basin were included in the EIS evaluation including: three locations on the main stem of the Williams Fork River, two on the South Fork Williams Fork River, two on the Middle Fork Williams Fork River, three sites on Bobtail Creek, one site on Kinney Creek, two sites on Steelman Creek, and one site on Darling Creek. Sites included two areas where data was collected both above and below a Denver Water diversion. Data is summarized in Table 3.3-9.

Table 3.3-9
Attributes of Reconnaissance Sites in the Williams Fork River Basin

Site Location	Williams Fork River Basin				
	Site ID	Slope (feet per foot)	Bankfull Width (feet)	Median Grain Size-d50 (mm)	Stability Observations
Bobtail Creek	WF-Recon 1	0.033	27	75	N/A
Kinney Creek near Leal	WF-Recon 2	0.020	27	58	N/A
Lower South Fork Williams Fork near Leal	WF-Recon 3	0.016	31	65	Some bank erosion on-going.
Williams Fork below Steelman Creek	WF-Recon 4	0.020	33	78	Evidence of minor bank erosion, but in general banks are stable.
Williams Fork near Leal	WF-Recon 5	0.0058	57	28	Evidence of some bank cutting and undercutting of vegetation.
Upper South Fork of Williams Fork	WF-Recon 6	0.0096	38	22	Evidence of minor bank erosion, but in general banks are stable.
Williams Fork near Sugarloaf Campground	WF-Recon 7	0.004	30	30	Channel stable with respect to channel degradation due to coarse bed material. Minor bank instabilities can be found but channel is well vegetated and stable.
Steelman Creek above Diversion	WF-Recon 8	0.073	24	52*	N/A
Steelman Creek below Diversion	WF-Recon 9	0.025	10	38	Bed material is coarse and resistant to erosion up to very high flows. No channel aggradation. Minor bank instabilities can be found but channel is well vegetated and stable.
Bobtail Creek above Diversion	WF-Recon 10	0.026	22	82*	N/A
Bobtail Creek below Diversion	WF-Recon 11	0.080	14	112*	Bed material is coarse and resistant to erosion up to very high flows. No channel aggradation. Minor bank instabilities can be found but channel is well vegetated and stable.
Middle Fork Williams Fork near Diversion	WF-Recon 12	0.087	16	50	Minor bank instabilities can be found but channel is well vegetated and stable.
Middle Fork Williams Fork near Mouth	WF-Recon 13	0.039	13	65	Some evidence of bank cutting and sloughing, but in general river banks are stable.

Table 3.3-9 (continued)
Attributes of Reconnaissance Sites in the Williams Fork River Basin

Site Location	Williams Fork River Basin				
	Site ID	Slope (feet per foot)	Bankfull Width (feet)	Median Grain Size-d50 (mm)	Stability Observations
Darling Creek	WF-Recon 14	0.065	14	53	Bed material is coarse and resistant to erosion up to very high flows. No channel aggradation. Minor bank instabilities can be found but channel is well vegetated and stable.

Notes:
*Denotes average median grain size taken from multiple sections at this location.
ID = identification
mm = millimeter
N/A = not applicable

The following general observations were recorded at the Reconnaissance sites in the Williams Fork River Basin:

Channel Stability

- All sites with descriptions of channel stability were observed to be generally stable.
- Coarser materials in the banks along steeper channels make them very resistant to erosion.
- Bank erosion was most prevalent in lower gradient reaches (generally less than 1%).

Median Grain Size

- Median grain sizes in the steepest channels with slopes greater than 4% ranged from 52 mm (very coarse gravel) to 112 mm (small cobbles). The mean of the four sites was 67 mm.
- Median grain sizes in channels with slopes between 2% and 4% ranged from 38 mm (very coarse gravel) to 75 mm (small cobbles). The mean of the four sites was 65 mm.
- Median grain sizes in channels with slopes between 1% and 2% ranged from 58 mm (very coarse gravel) to 78 mm (small cobbles). The mean of the three sites was 67 mm.
- Median grain sizes in channels with slopes less than 1% ranged from 22 mm to 30 mm, with all materials classifying as coarse gravel. The mean of the three sites was 27 mm.
- Grain sizes in channels with slopes greater than 1% were found to be generally similar and larger than median grain sizes in channels with slopes less than 1%.
- Median grain sizes decreased by 14 mm from above to below Denver Water's diversion on Steelman Creek. Median sizes increased by 20 mm from above to below the diversion on Bobtail Creek.

Overall observations made at the Reconnaissance sites were generally similar with observations made at the Representative sites. The Representative site observed to have the

most sand stored (WF1) was found to have localized bank instabilities at the Representative site and the nearby Reconnaissance site (WF-Recon 7). Stream beds and banks were noted to be stable throughout. Median grain sizes for all Representative sites and all Reconnaissance sites with slopes greater than 1% ranged within a relatively small window of 50 mm (very coarse sand) to 112 mm (small cobble). The median grain size of all Representative and Reconnaissance sites with slopes greater than 4% was 67 mm (small cobble). The median grain size of all Representative and Reconnaissance sites with slopes between 2% and 4% was 65 mm (small cobble). Median grain sizes for channels with slopes between 1% and 2% and less than 1% were 64 mm (very coarse gravel) and 27 mm (coarse gravel), respectively.

3.3.6.3 Colorado River Basin Reconnaissance Sites

No sites on the Colorado River were evaluated for the Two Forks study therefore no Reconnaissance sites were included in the Moffat Project EIS.

3.3.6.4 Blue River Basin Reconnaissance Sites

Three Reconnaissance sites in the Blue River Basin were included in the EIS evaluation including: two sites below Dillon and Green Mountain Reservoirs and a site located between the two reservoirs. Data is summarized in Table 3.3-10.

Table 3.3-10
Attributes of Reconnaissance Sites in the Blue River Basin

Site Location	Blue River Basin				
	Site ID	Slope (feet per foot)	Bankfull Width (feet)	Median Grain Size-d50 (mm)	Stability Observations
Blue River below Dillon Reservoir	BR-Recon 1	N/A	98	115	No evidence of significant bank cutting and sloughing and in general the river banks are stable.
Blue River below Green Mountain Reservoir	BR-Recon 2	N/A	114	65	Some evidence of bank cutting and sloughing, but in general river banks are stable.
Blue River at Blue River Campground	BR-Recon 3	0.0032	152	150	Some evidence of bank cutting and sloughing, but in general, river banks are stable.

Notes:
ID = identification
mm = millimeter
N/A = not applicable

The following general observations were recorded at the Reconnaissance sites on the Blue River:

Channel Stability

- Some bank sloughing was observed at all sites.
- Overall stream banks were found to be stable.

Median Grain Size

- Median grain sizes in the three areas ranged from 65 mm (small cobble) to 150 mm (large cobble).
- Median grain sizes were smaller at the two sites located downstream from reservoirs (BR-Recon 1 and BR-Recon 2) than at the site not immediately downstream from a reservoir.
- The average of median grain sizes observed at these sites is 110 mm (small cobble).

In general, channel banks were stable at all Representative and Reconnaissance sites; however localized bank erosion was noted at the Reconnaissance sites. Recorded observations made at the Reconnaissance sites focused on bank stability; no mention of aggradation was made at any of these sites so bed stability at these stations could not be directly compared to the Representative sites. The median grain size at BR-Recon 3 classifies at large cobble. Median grain sizes at the other three sites range from 65 mm to 115 mm and classify as small cobble. The median grain size at the Representative site was 81 mm and classifies as small cobble.

3.3.6.5 South Boulder Creek Basin Reconnaissance Sites

One Reconnaissance site on South Boulder Creek below Pinecliffe was included in the EIS evaluation. Data is summarized in Table 3.3-11.

Table 3.3-11
Attributes of Reconnaissance Site in the South Boulder Creek Basin

Site Location	South Boulder Creek Basin				
	Site ID	Slope (feet per foot)	Bankfull Width (feet)	Median Grain Size-d50 (mm)	Stability Observations
South Boulder Creek below Pinecliffe	SBC-Recon 1	0.0246	N/A	N/A	Channel generally stable due to coarse bed material, vegetated banks and past channel stabilization work.

Notes:
ID = identification
mm = millimeter
N/A = not applicable

The following general observations were recorded at the Reconnaissance site on South Boulder Creek:

Channel Stability

- Channel was generally stable in part due to past stabilization efforts
- Banks were vegetated and channel and bed material is large.

Median Grain Size

- Grain size data were not available

Channel banks were noted to be generally stable in all Representative sites and the Reconnaissance sites; however localized bank erosion was noted. Coarse sand and fine gravel were observed to be stored in the bed at the Representative site below Gross Reservoir, but aggradation was not noted at this or other Representative or Reconnaissance locations. Bank stabilization efforts have occurred at some locations and have helped to stabilize banks on South Boulder Creek.

3.3.6.6 North Fork South Platte River Basin Reconnaissance Sites

Three Reconnaissance sites along the North Fork South Platte River were included in the EIS evaluation. Stations near Shawnee, Crossons and Buffalo provide data from upstream to downstream on the North Fork South Platte River. Data is summarized in Table 3.3-12.

Table 3.3-12
Attributes of Reconnaissance Sites in the North Fork South Platte River Basin

Site Location	North Fork South Platte River Basin				
	Site ID	Slope (feet per foot)	Bankfull Width (feet)	Median Grain Size-d50 (mm)	Stability Observations
North Fork South Platte River at Shawnee	NFSP-Recon 1	0.0069	57	88	Channel generally stable due to coarse bed material, vegetated banks and past channel stabilization work.
North Fork South Platte River at Crossons	NFSP-Recon 2	0.0055	67	83	Channel generally stable due to coarse bed material, vegetated banks and past channel stabilization work.
North Fork South Platte River at Buffalo	NFSP-Recon 3	0.0107	57	55	Channel generally stable due to coarse bed material, vegetated banks and past channel stabilization work.

Notes:
ID = identification
mm = millimeter
N/A = not applicable

The following general observations were recorded at the Reconnaissance sites on the North Fork South Platte River:

Channel Stability

- Channel was generally stable in part due to past stabilization efforts

Median Grain Size

- Median grain sizes ranged from 55 mm (very coarse gravel) to 88 mm (small cobble).
- The smallest grain size was observed at the steepest channel segment.

Channel banks were noted to be generally stable in all Representative and Reconnaissance sites; however localized bank erosion was noted and past bank stabilization was observed in all areas. Minimal to moderate amounts of sand and fine grain material were observed.

3.3.7 Sites of Special Interest

Additional site characterization was completed at specific areas of interest that were believed to be important for the evaluation of channel morphology in the study areas. The additional sites were photographed and general observations were recorded. Additional sites included areas downstream of Denver Water's diversion points with no bypass flows, locations on the Fraser River upstream of Denver Water's diversion that accumulate traction sand and a location on the South Platte River that has increased sediment loads as a result of the 2002 Hayman Fire and subsequent flooding. Photographs and descriptions of these sites of special interest are presented in the Photographs of Additional Sites section of Appendix E-3.

3.3.7.1 Fraser River Downstream of Diversions

Two of Denver Water's diversions in the Fraser River Basin with no bypass flow requirements were evaluated. These diversion points are located on East St. Louis Creek and Fool Creek, both tributaries to St. Louis Creek in the Fraser River Basin. At both locations the diversion was constructed to collect all typical flows. Overflows exist to allow flows from extreme flood events to pass downstream to the natural drainage. Photos of the diversions and stream segments upstream and downstream of the diversion are provided in the Photographs of Additional Sites section of Appendix E-3. At the time of the field observations, all water in both streams was being diverted with no water bypassed downstream.

At both locations, fine sediment was observed in the channel upstream of the diversion. Little to no fine sediment was observed downstream of the diversion. Smaller sediment appeared to be settling at the diversion due to the localized decrease in flow velocity that results from the diversion. No signs of sediment deposition were noted downstream.

More woody debris was observed in the channel downstream of the diversion than in the channel upstream of the diversion at both locations. This likely is an indication that wood and other larger material that is transported in larger flow events is not transported below the diversion points as frequently as it is above the diversion.

Both channels were relatively steep, small streams with mature riparian vegetation including trees immediately adjacent to the channel. Grasses were observed within the cobble channel bottom in areas downstream of the diversions. Observed vegetation was limited to grasses and smaller vegetation; mature woody vegetation was not observed within the channel. The cobble channel bottoms upstream of the diversions were generally free of any grasses or other vegetation. The presence of vegetation downstream of the diversion coupled with the absence of vegetation upstream is an indication that vegetative encroachment is likely occurring downstream of these diversion points.

Observations at these locations were similar to observations made at Representative site FR6 which is located downstream of Denver Water's diversion on Jim Creek. Based on

this information it is believed that streams downstream of diversions are likely experiencing vegetative encroachment.

3.3.7.2 Fraser River Upstream of Diversion

Traction sanding operations on US 40 in the winter months lead to an additional input of sediment into the Fraser River. Areas upstream of Denver Water's diversion on the main stem of the Fraser River near the base of Berthoud Pass were evaluated to provide an understanding of existing sediment management and its impacts above the diversion point. Locations evaluated included a segment of the Fraser River between the base of Berthoud Pass and Denver Water's diversion point and at the diversion structure itself. Photographs of these three areas are provided in the Photographs of Additional Sites section of Appendix E-3.

Sand was stored in the bars and above the bankfull elevation in the stretch of the Fraser River between the base of Berthoud Pass and Denver Water's diversion point. Sand was also observed in the channel bed in slower moving areas such as pools and local eddies. Sand storage was generally observed to be limited to these locations and the active channel was dominated by gravel and cobble sized materials. Areas between the base of Berthoud Pass and the diversion appeared to have more sand stored than areas downstream of the diversion, suggesting that the diversion itself does not appear to be causing fine sediment accumulation downstream.

Significant amounts of sand were observed immediately upstream of the diversion structure. Flow velocities decrease immediately upstream of the diversion allowing material to settle out at this location. Deposited sands and gravels on the order of several feet deep were noted at this location. The diversion itself appeared to remove a significant portion of the sediment load from the river and likely greatly decreases impacts upstream of sanding operations on the Fraser River downstream of this point, particularly during low flow periods. Layout of the diversion structure suggests that sediment accumulated upstream of the diversion could be transported downstream and add to the total downstream sediment load during high flow events.

In 2011, Denver Water, the Colorado Department of Transportation (CDOT), Grand County, and the Town of Winter Park entered into an Intergovernmental Agreement to construct a sediment control basin within Denver Water's diversion facility. The sediment control basin was completed in 2012. Sediment that accumulates within the basin will be removed by CDOT and is expected to help reduce the amount of sand-sized sediment that is transported to lower segments of the Fraser River.

3.3.7.3 South Platte River Downstream of Hayman Fire

The Hayman Fire of 2002 and subsequent flooding events in Pike National Forest added a significant sediment load to the South Platte River and its tributaries. Over time the sediment has traveled downstream with a significant portion of the sediment reaching Strontia Springs Reservoir while significant excess sediment still exists within the stream and is transported further downstream each year. This sediment load consisted primarily of sand and smaller gravel sized material. Photos showing the local sediment deposition that exists are given in the Photographs of Additional Sites section of Appendix E-3.

3.4 GROUNDWATER

3.4.0 Overview

Groundwater is a key component of the hydrologic cycle, which is a conceptual model of the circulation and physical interrelationships of water in the Earth's crust, atmosphere, oceans, lakes, and streams. Porous subterranean sediment or rock formations that are saturated with groundwater and have sufficient permeability to yield water to a well or spring in a useable quantity are called aquifers. These hydrogeologic units transmit water from recharge areas to discharge areas, and store groundwater. Aquifers in the mountainous portions of the Moffat Collection System Project (Moffat Project or Project) area are generally in fractured, crystalline rock. Along streams and in the lower parts of the valleys, shallower aquifers composed of alluvial sediments overlie the crystalline bedrock.

Water flowing in a stream can originate from precipitation or from groundwater that seeps from the streambed. The proportion of the stream flow attributable to groundwater is termed base flow, which sustains stream flow during the periods of the year when there is no precipitation or snowmelt runoff. Groundwater aquifers are recharged by infiltration of precipitation or seepage from surface water bodies. Depletion of groundwater in storage increases the costs of extraction and may induce water quality degradation, land subsidence, and eventually loss of the resource.

Groundwater protection occurs at the Federal, State, and local government levels through various environmental, agricultural, and natural resources agencies and through laws, regulations, and policies.

The following text provides a brief description of the Project components and a summary of the affected environment as it relates to groundwater resources. Surface water, geology, and climate of the area are also briefly discussed where necessary to identify interrelationships with the groundwater resources of an area.

3.4.1 Reservoirs

Reservoirs serve as temporary storage locations for the diverted water. Surface water storage sites may influence the hydrologic environment and alter the natural groundwater quality (i.e., the chemistry of the water). The addition of a reservoir to a watershed will increase recharge to the groundwater system throughout the year, thereby raising water levels in the underlying aquifer.

3.4.1.1 Gross Reservoir

Bedrock in the Gross Reservoir study area is Precambrian rock (Boulder Creek Granodiorite) that has been uplifted as part of the formation of the Front Range Mountains. Stream sediments comprise the Quaternary alluvium located mainly in the South Boulder Creek valley. The reservoir discharges to a localized aquifer in the surface soils, alluvium, and bedrock. The bedrock does not transmit water except where fractures are present; however, the alluvium along the stream channel has a higher hydraulic conductivity and transmits groundwater more readily (Denver Water 1998b).

Based on a review of well records from the State Engineer's Office (SEO), there are at least 50 water wells located approximately 0.3 mile north of Gross Reservoir near Retallack Gulch. A majority of the wells near Gross Reservoir, however, are located about 1.5 miles south of the reservoir near the towns of Wondervu and Crescent Village. These latter wells are located upgradient (i.e., at a higher elevation) from Gross Reservoir.

3.4.1.2 Leyden Gulch Reservoir Site

Geology in the area of the proposed reservoir site consists of alluvium underlain by the sedimentary sequence of the Arapahoe, Laramie, Fox Hills, and Pierre formations. The area consists of a valley that is a maximum of about 4,000 feet wide tapering to about 1,000 feet wide at the southeastern end of the proposed reservoir. The Laramie Formation hogback and a remnant alluvial fan bound the end of the valley to the east and south, respectively (URS 1999).

There are two principal aquifers in the Leyden Gulch study area, coarse-grained alluvial sediment and the Laramie-Fox Hills aquifer. Claystones and siltstones of the Laramie and Arapahoe formations form an aquitard up to 800 feet thick. The alluvial aquifer can be up to 100 feet thick and the water table is generally about 10 feet below ground surface (bgs). These aquifers are recharged by infiltration of precipitation and surface water. Water levels in the Laramie-Fox Hills aquifer are generally greater than 100 feet bgs (ERO and Shapins 2004).

A background groundwater chemistry study was conducted for areas near the Rocky Flats Plant, which is located approximately 2 miles to the northeast of the proposed Leyden Gulch Reservoir location (EG&G 1993). Based on that study, the upper flow system (alluvial and colluvial materials) is predominantly a calcium-bicarbonate-type water.

The average annual precipitation at the nearby Ralston Reservoir is 18.70 inches (WRCC 2010a), only a very small portion of which becomes groundwater recharge. Evaporation from the proposed Leyden Gulch Reservoir would be approximately 38 inches per year (USGS 1995). Based on the minimum and maximum design, evaporation from the reservoir would range between about 800 and 1,700 acre-feet per year (AF/yr).

Based on a review of water well records from the SEO, there are water wells located around the proposed location for the Leyden Gulch Reservoir. Specifically, wells are located on the west side of the Ralston Buttes (approximately 1 mile west of the site), near the clay pits about 0.5 mile south west of the site, between Ralston Reservoir and the site, and east of the geologic ridge that parallels Foothills Road near the landfill (approximately 0.5 mile east of the site). Additionally, there are many wells located at and near the Rocky Flats Plant, about 2 miles northeast of the proposed reservoir. Several springs are mapped on the U.S. Geological Survey (USGS) quadrangle maps of the area, including one approximately 2,500 feet west of the proposed site.

3.4.2 Conveyance Systems

Conduits M and O would be constructed in shallow surficial aquifers overlying the Denver Basin bedrock aquifers. The Denver Basin is described in more detail in Section 3.4.4. Groundwater levels in the shallow aquifers vary along the pipeline corridor, and are likely

to be encountered at stream crossings. These shallow surficial aquifers are generally used for irrigation, stock, and domestic water supplies.

3.4.3 South Platte River Facilities

The groundwater in the South Platte River valley is described in Section 3.4.5.6. The alluvium along the river serves as a local aquifer. Water levels in the alluvium are near the surface, thus water quality is influenced by surrounding and upstream land uses and surface water quality in the river. Most wells are utilized for agricultural purposes and rural residential water supply.

3.4.4 Denver Basin Aquifer Facilities

The Denver Basin bedrock aquifer is a structural sedimentary basin that underlies the Denver Metropolitan area. The layered, multi-aquifer system consists of four bedrock aquifers: Dawson, Denver, Arapahoe, and Laramie-Fox Hills, and covers approximately 6,700 square miles. The Denver Basin extends north-south from Greeley to Colorado Springs, and west-east from the Front Range of the Rocky Mountains to Limon. The aquifers serve as both primary and supplemental sources of water for the growing population in the Denver Metropolitan area. In some portions of the Denver Basin, the aquifer system is hydrogeologically connected to the alluvial aquifer under the South Platte River (Topper 2004).

The Dawson and Denver aquifers are in the southwestern and central portions of the basin. Both aquifers vary in thickness up to about 1,000 feet and consist of sandstones interbedded with claystones. The Arapahoe aquifer consists of interbedded conglomerate, sandstone, siltstone, and shale units. It is approximately 2,200 feet deep in the center of the basin and ranges from 400 to 700 feet thick. The Arapahoe aquifer is the most prolific water-producing aquifer in the system, and has been used extensively for municipal water supply. The upper portion of the Laramie Formation is mainly shale; this shale unit separates the Arapahoe aquifer from the sandstone aquifer of the lower Laramie and Fox Hills formations (termed the Laramie-Fox Hills aquifer). The Laramie-Fox Hills aquifer is up to 350 feet thick and is found throughout the entire Denver Basin. The essentially impermeable Pierre Shale unit, which may be up to 7,000 feet thick, underlies the Laramie-Fox Hills aquifer (Topper 2004).

The Denver Basin has a semi-arid climate. In Denver, the mean annual precipitation is approximately 12.6 inches per year (WRCC 2010b). Most of the water derived from precipitation within the Denver Basin is lost through evaporation, transpiration, and runoff. On average, less than 1 percent (%) of precipitation recharges the bedrock aquifers (Robson 1987). Most of the recharge for the Denver Basin aquifers occurs in the highland areas between stream channels in the southern portion of the basin, where the formations outcrop and precipitation is greater than average (USGS 1995).

Groundwater from the Denver Basin aquifers generally meets drinking water regulations established by the U.S. Environmental Protection Agency (EPA) for public water supplies. However, the natural water quality degrades towards the margins of the aquifers where the direct recharge to the aquifer is influenced by land use. Groundwater samples collected from the Arapahoe and Laramie-Fox Hills aquifers indicate that, in some areas, water

originating from these formations could have total dissolved solid concentrations above the secondary Maximum Contaminant Limit (MCL) of 500 milligrams per liter (mg/L). Additionally, iron and fluoride concentrations detected in the Laramie-Fox Hills aquifer water are, on average, greater than the secondary MCL of 0.3 and 2 mg/L, respectively (Boyle 2003a). Water in both the Arapahoe and Laramie-Fox Hills aquifers is generally classified as a sodium-bicarbonate or sodium-sulfate-type (Robson 1987; USGS 1995).

Depth to groundwater in the Denver Basin generally ranges from 0 to 250 feet bgs, and the depth to groundwater is greater in the southern portion of the basin (USGS 1995). Water in these aquifers generally moves northward from the recharge areas toward the discharge areas in the northern part of the Denver Basin or toward the depressions in the groundwater levels caused by pumping of existing wells in the Denver Metropolitan area (USGS 1995). Water levels in the Arapahoe aquifer have declined since 1995 at a rate up to 30 feet per year resulting in decreasing water levels up to 300 feet. During the same period, the Laramie-Fox Hills aquifer has also shown substantial decreases in water levels, up to approximately 125 feet of decline. Approximately 33,700 wells of record are completed into the various aquifers in the Denver Basin (Topper 2004). The Arapahoe aquifer could transition from a confined to an unconfined aquifer during the next couple of decades, which would decrease production from wells completed in the aquifer and additional water supply sources would need to be secured (Raynolds 2004).

Groundwater discharge from the Denver Basin aquifers is principally by well withdrawals and, in some areas, into the alluvial aquifers (USGS 1995). Most groundwater wells are less than 2,500 feet deep because of the higher costs associated with deeper wells (CGS 2003).

Near the Denver Metropolitan area, the transmissivity of the Arapahoe and Laramie-Fox Hills aquifers have been estimated to be between 300 and 500 square feet per day and 10 and 1,000 square feet per day, respectively. Storage coefficients for these aquifers have also been estimated and range from 2E-4 to 6E-4 for both aquifers (Robson 1987).

3.4.5 River Segments

The hydrologic system of a watershed gains water through precipitation, inflow of surface water, underflow of groundwater from other basins, and, in some cases, diversions of surface water via conveyance structures to other adjacent watersheds (i.e., trans-mountain diversions). Losses of water from the hydrologic system are attributable to outflow of surface water from the watershed, underflow of groundwater out of the basin, consumptive use of water (generally through irrigation), and surface water diversions out of the watershed. For the mountain watersheds potentially affected by this Project, the available hydrogeologic data have been evaluated to develop a conceptual model of the groundwater flow system, which is described in the following paragraphs.

Groundwater Levels and Flow

Groundwater levels in these mountain watersheds are closely related to the land surface elevation and topography. Groundwater levels are higher in the higher elevation areas, where precipitation and snowmelt water enter the subsurface and cause groundwater recharge. Hydraulic gradients control groundwater flow directions, which are also closely related to the land surface elevation. Groundwater moves through subsurface pathways

from upland recharge areas and toward lowland discharge areas along stream drainages and valleys. Where the groundwater level is higher than the adjacent surface water level, groundwater discharges as springs or flows into a lake or into a stream bed. Groundwater flow rates are also controlled by the physical and hydraulic properties of soil and rock units.

Groundwater recharges and flows within fractured and weathered bedrock as well as shallow unconsolidated materials including alluvium, colluvium, weathered bedrock, and glacial sediment. Thickness of the unconsolidated sediments varies significantly within the watersheds. In upland areas, the unconsolidated sediments are thin or absent because of the steeper topographic relief. Alluvial deposits are thickest beneath the surface water drainages in the lower elevations. Higher infiltration rates occur where permeable coarse-grained soils or open fractures exist at or near the ground surface. Within the bedrock, groundwater flows primarily through secondary porosity features (e.g., fractures and bedding plane partings). Fracture dimensions, orientation, and spacing are extremely variable in the bedrock formations.

Groundwater Recharge

A portion of the total annual precipitation falling on a watershed infiltrates the land surface to become groundwater recharge. Compared to semi-arid areas, recharge is relatively high because these mountain watersheds have a temperate alpine to sub-alpine climate, and relatively high snowfall. Large portions of these watersheds are underlain by permeable rock and soil, which cause higher recharge rates. Groundwater recharge occurs throughout the watershed except where upward hydraulic gradient exist at the ground level. Higher recharge rates occur in the upper elevations where substantial snowpack accumulates in winter, and spring snowmelt percolates directly into fractured bedrock or glacial sediments. Relatively high recharge rates also occur in areas with less vegetation cover where permeable materials exist on gently-sloping ground surfaces. Somewhat lower recharge rates occur where the land surface is steeply sloped or where relatively unfractured rock and fine-grained glacial till cause the land surface to have lower permeability.

Groundwater Discharge

Groundwater leaves the watersheds by (1) evaporation from the ground surface at seeps, springs, streams and lakes; (2) transpiration from phreatophyte vegetation; and (3) groundwater discharging into streams or lakes. Groundwater discharges in the lowlands along the streams contribute to stream flows.

During the peak runoff period in early summer, stream flows are dominated by snowmelt. Because groundwater recharge is relatively high due to snowmelt, groundwater levels are also high during that period. After the peak snowmelt runoff, the perennial streams are characterized by relatively steady surface water flows that slowly recede during the late summer and fall to base flow conditions. Base flow in the streams is sustained primarily by groundwater discharge. Wetland vegetation along streams (e.g., fens) is also supported by discharge from the groundwater flow system.

3.4.5.1 Fraser River

The Fraser River flows approximately 30 miles from the headwaters at the Continental Divide to the Colorado River in Grand County. A majority of the precipitation received in the basin is in the form of snowfall. Snowmelt during April to July is the primary source of

surface water runoff, stream flow, and groundwater recharge. A USGS Report (Apodaca and Bails 1999) provides a description of the groundwater system in the Fraser River Valley, which is summarized in the following paragraphs. Additional groundwater data were also collected in the Fraser Valley and evaluated for this Final Environmental Impact Statement (EIS) to address comments on the Draft EIS expressing concerns about insufficient data and interactions between streams, wetlands, and groundwater. The following paragraphs describe the currently available groundwater information, which provides the basis for impacts analysis in Section 4.6.4 and Section 5.4.

Glacial deposits and alluvial gravels underlie large portions of the Fraser River watershed. Fractured crystalline rocks are also exposed in higher elevation areas of the basin. Precipitation and snowmelt infiltrate though permeable soils and fractured rocks in upland areas of the basin to become groundwater recharge. As is typical for mountain watersheds, groundwater flows generally from upland recharge areas toward the lowlands along the stream valleys.

Groundwater recharge occurs throughout the watershed, yet recharge rates are generally higher in the uplands because there is more water available from snowmelt to infiltrate the ground in the upland areas. The depth to groundwater ranges from about 5 to 250 feet bgs. Seasonal fluctuations in recharge and discharge typically cause groundwater levels to vary as much as 10 feet between May and October each year, depending on location (Apodaca and Bails 1999). The water table in the immediate vicinity of the river is within a few feet of the surface (NWCCOG 2002). Residential and municipal water users in the Fraser River Basin generally withdraw water supplies from sedimentary rocks of Tertiary and Quaternary age. Precambrian formations also yield small quantities of water to wells and springs; however, these formations are generally only utilized for domestic or livestock water supply purposes.

Overlying the Precambrian bedrock in some areas of the basin, the Tertiary-aged Troublesome Formation may be up to 1,000 feet thick and consists of siltstones interbedded with sandstones and conglomerates. In many parts of the basin, particularly along the larger stream valleys, Quaternary alluvium directly overlies these older bedrock formations. Alluvial deposits average as much as 200 feet thick and are comprised of unconsolidated sands and gravels with older glacial drift materials. Age dating of groundwater in the Fraser River Basin indicates that the interval between groundwater recharge at the land surface and when it is withdrawn from wells is between 20 and 40 years. Therefore, influences of land use changes on the water quality of the basin may not be detected in the water supply aquifers for up to 40 years (Apodaca et al. 2000).

A review of the water well database maintained by the SEO indicates that most of the water wells in the Fraser River watershed are located within 1 mile from the river near towns (e.g., Granby, Tabernash, Fraser, and Winter Park). Additionally, small communities along various creeks (e.g., Trail, Hurd, Meadow, Ranch, Spring Branch, and St. Louis) are supplied by water wells. There are very few wells located in the headwaters portion of the watershed.

Based on a study of the central and lower portions of the Fraser River, the USGS classified the groundwater as mainly calcium-bicarbonate-type water (Bauch and Bails 2004). No widespread groundwater quality issues were identified in the basin, with one notable exception—elevated radon-222. Groundwater samples from a few wells have detected

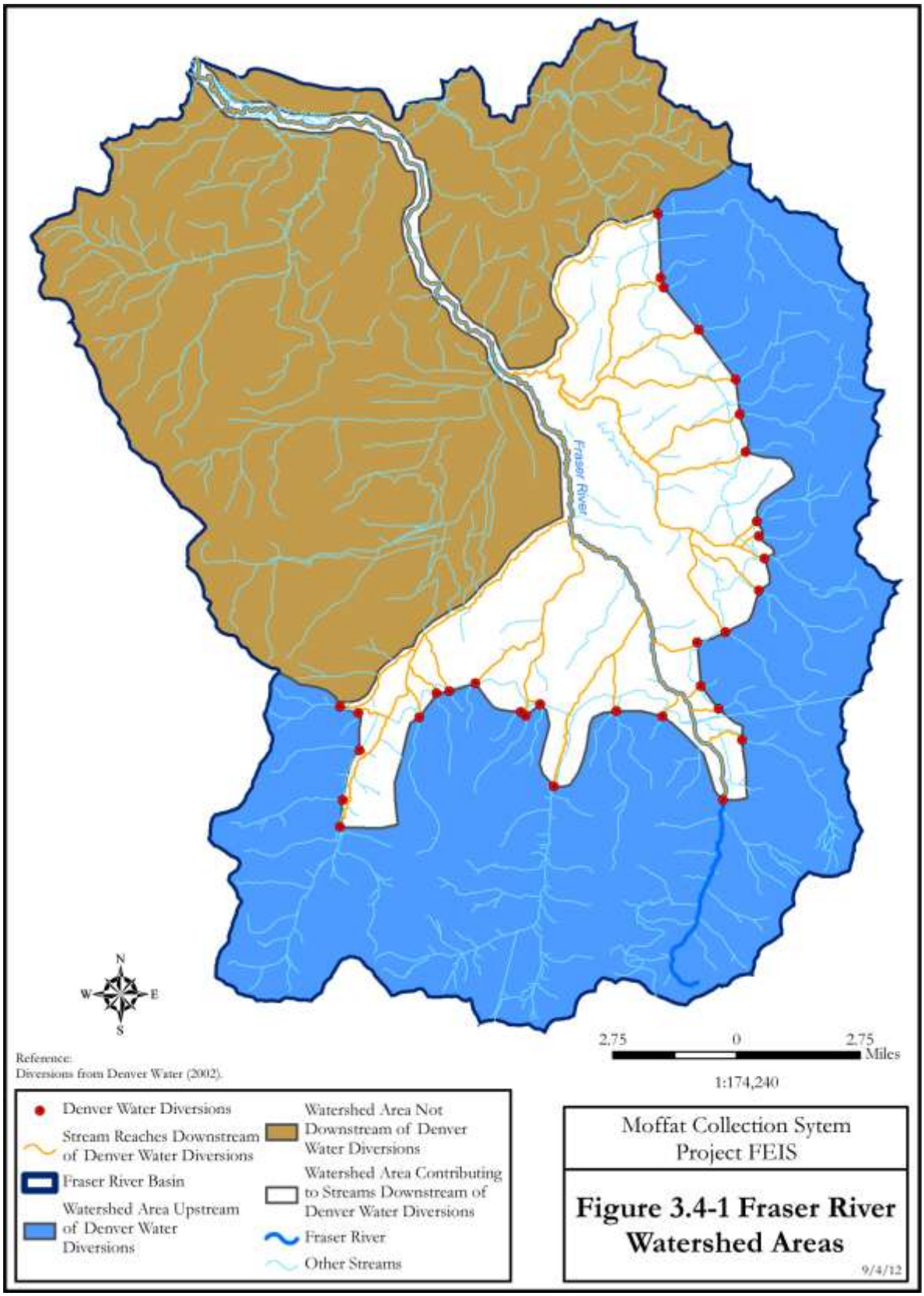
naturally occurring radon-222 at levels up to 6,380 picoCuries per liter (pCi/L), and concentrations for every well sample exceeded 300 pCi/L. These radon-222 concentrations are similar to those detected in groundwater samples from wells in other areas of the upper Colorado River Basin. Groundwater in the Fraser River watershed is considered a suitable source of water supply (i.e., domestic, municipal, industrial, and irrigation purposes). Chloride, magnesium, and sulfate concentrations are higher in the alluvial aquifer than the Troublesome Formation aquifer, as well as in urbanized areas and locations with septic systems (Bauch and Bails 2004).

On Figure 3.4-1, the watershed is subdivided to facilitate description of the areas potentially affected by the Moffat Project and those that would remain unaffected. The Moffat Project would not make any changes to the locations or the physical features of any of the existing Board of Water Commissioners (Denver Water) diversion structures, which are shown as red dots on Figure 3.4-1. All of the blue area of this map is upstream of the Denver Water stream diversion points. This area constitutes a large percentage of the whole watershed and it includes the highest land surface elevations, precipitation rates, and snowpack amounts. Throughout this blue area, groundwater recharge rates will also remain the same as those under Current Conditions, both in the upland areas and in areas adjacent to the stream channels throughout that area.

Similarly, the brown area of Figure 3.4-1 is not downstream of any of the Denver Water stream diversion points. Consistent with fundamental hydrogeologic concepts, substantial groundwater recharge occurs throughout the blue and brown areas on Figure 3.4-1. The generalized map of groundwater levels in the valley provided in the USGS report (Apodaca and Bails 1999) shows hydraulic gradients and groundwater flow directions diverge from the upland areas and converge toward the streams in the portion of the Fraser River Basin downstream of the Denver Water diversion points. Thus, the available groundwater level data demonstrate that recharge occurs in higher elevation areas, upland of the streams. Where the water table contours show groundwater flow converges toward streams, this indicates the streams are receiving groundwater discharge.

Stream segments within the blue and brown areas on Figure 3.4-1, are depicted with light blue lines. Those stream segments are upstream of the diversion points, and thus would not be affected by the Proposed Action. Areas outside of the banks of stream channels within the white area of this map would also not be affected by the Proposed Action because those areas are not downstream of any of the diversions.

On the other hand, the Proposed Action does have the potential to affect groundwater in the Fraser River watershed that lies immediately adjacent to the streams, downstream of the Denver Water diversion structures. Along the golden-brown stream segments shown on Figure 3.4-1, withdrawing more stream flow at the diversion points could affect groundwater levels directly beneath and immediately beside the stream. Withdrawing stream flow at the diversion points could potentially reduce seasonal groundwater recharge rates directly beneath and immediately beside reaches of stream channels if the proposed withdrawals reduce the extent of overbank flooding areas during high runoff periods, and if the stream level is higher than the groundwater level.


Fraser River
N
W
E
S
2.75
0
2.75
Miles
1:174,240
Reference:
Diversions from Denver Water (2002).
Denver Water Diversions
Stream Reaches Downstream of Denver Water Diversions
Fraser River Basin
Watershed Area Upstream of Denver Water Diversions
Watershed Area Not Downstream of Denver Water Diversions
Watershed Area Contributing to Streams Downstream of Denver Water Diversions
Fraser River
Other Streams
Moffat Collection Sytem Project FEIS
Figure 3.4-1 Fraser River Watershed Areas
9/4/12

To address these and other issues raised by comments on the Draft EIS regarding the potential effects of the proposed diversions on groundwater, additional groundwater data were collected in October 2010 along several potentially-affected stream segments. Figure 3.4-2 indicates the locations of these groundwater study sites on a USGS topographic map, which also shows the groundwater level contours and well locations reported by the USGS (Apodaca and Bails 1999). At three of these study sites, a total of nine monitor wells were installed for measurements of groundwater levels adjacent to the streams. Elevations of the wells, the adjacent stream water level and nearby wetlands (if present) were accurately surveyed to allow determination of the hydraulic heads (water level elevations) and flow relationships. Land surface surveying was also conducted at a fourth site in the Fraser Valley near Winter Park (southeastern portion of Figure 3.4-2), to determine the groundwater level elevations using monitoring data reported by Grand Environmental Services for the Winter Park Shops Expansion Project (Grand Environmental Services 2009).

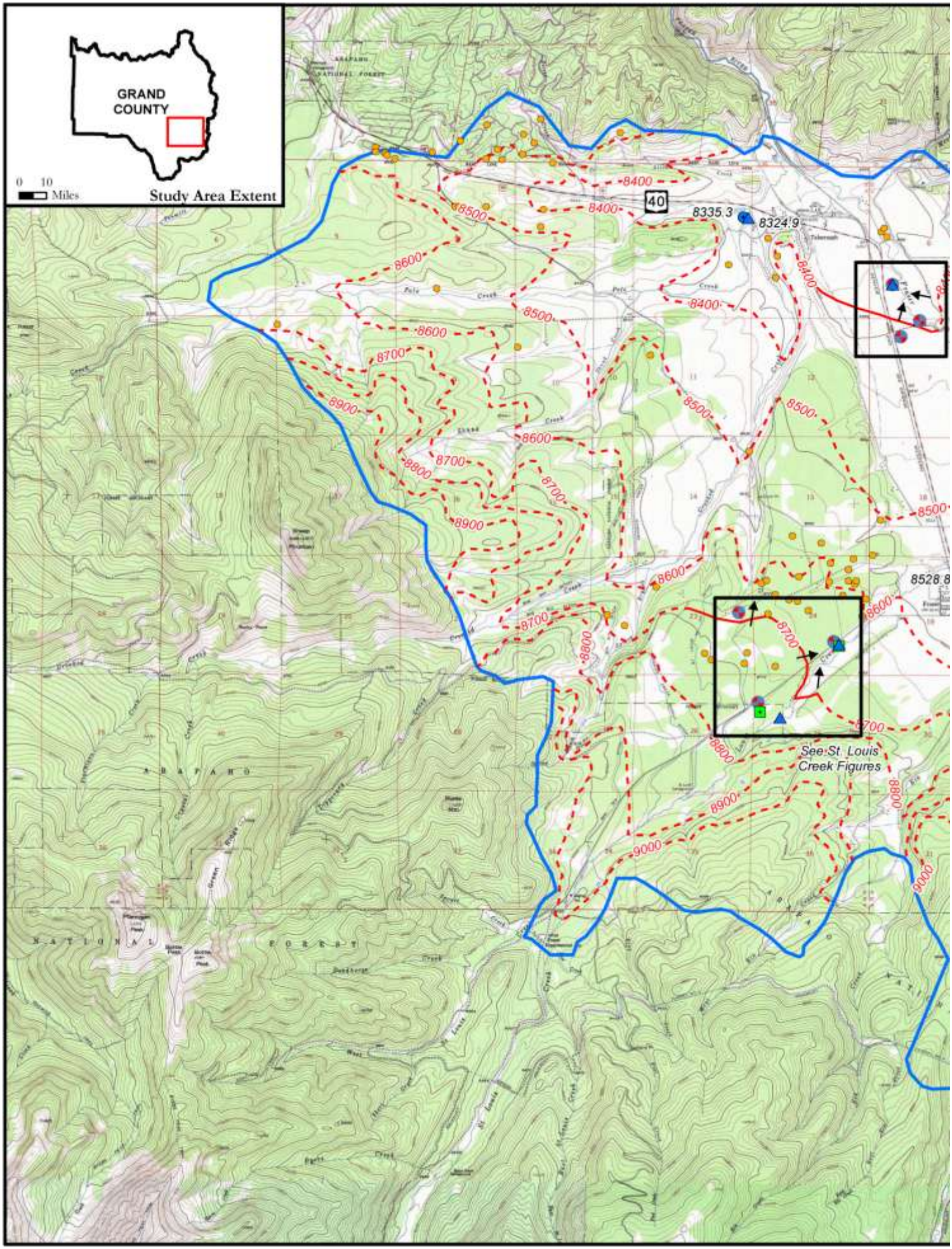
The purpose of collecting these additional data was to better define the elevation of groundwater levels and adjacent stream levels to augment the groundwater level information provided in Apodaca and Bails (1999). This new dataset further establishes the hydraulic head relationships between the groundwater and streams in the valley, which allows more a more detailed description of current groundwater conditions and a more definitive basis for assessing the potential effects of the Moffat Project on groundwater.

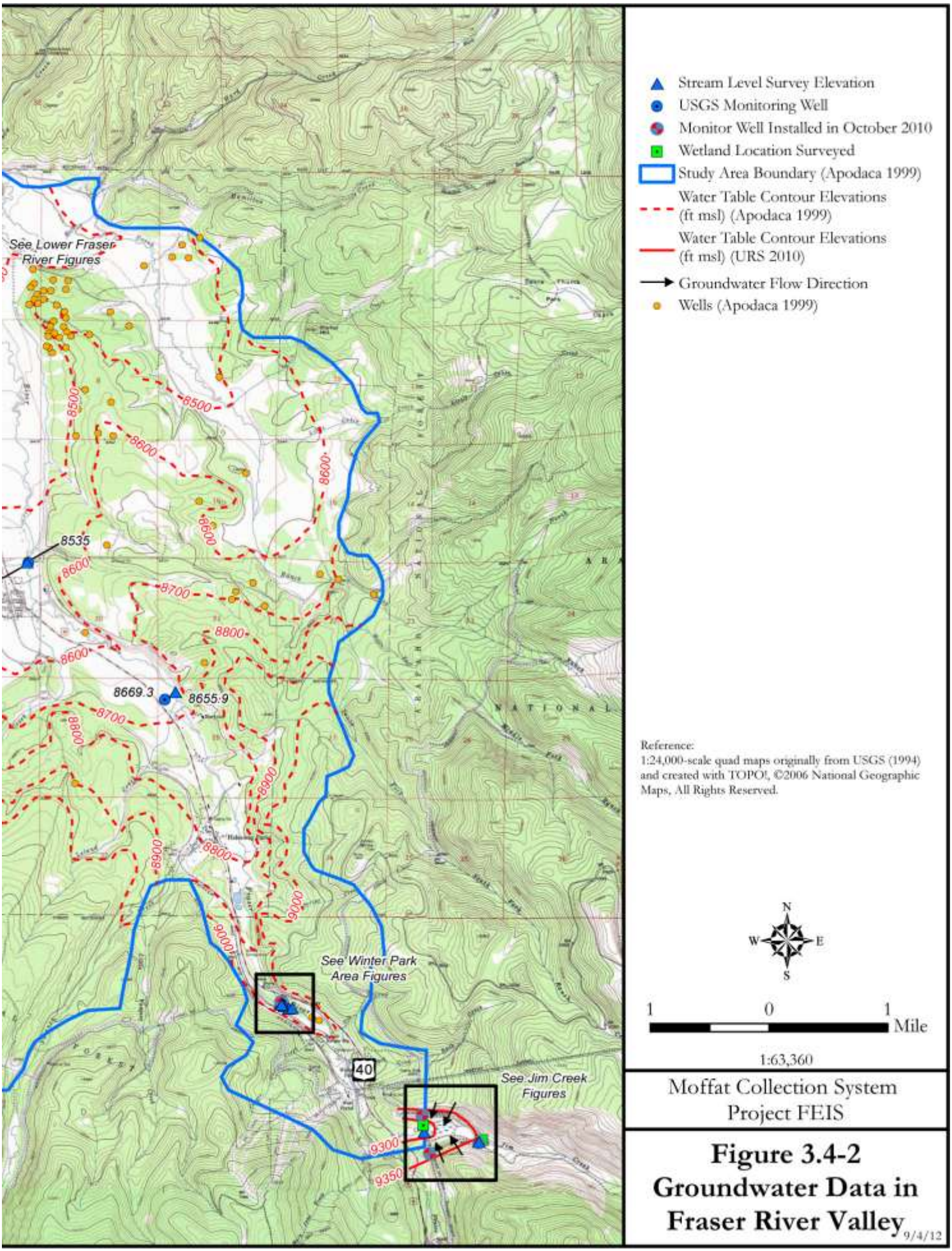
The available groundwater elevation data show a strong relationship between ground surface elevations and groundwater level elevation. Figure 3.4-3 is a linear regression plot of groundwater elevation vs. topographic elevation based on the data collected from the monitor wells. The relationship has an R-square value of 0.99, which is a strong correlation, and indicates that hydraulic heads and hydraulic gradients are influenced primarily by the elevation of the ground surface. In addition, this correlation provides a means of using topographic elevations for estimating the water table elevations between and beyond the locations of groundwater level measurement points. These new data provide confirmation of the groundwater level contour patterns reported by the USGS (Apodaca and Bails 1999) as illustrated on Figure 3.4-2. These data also provide more definition of the groundwater, wetlands and stream relationships.

On Figure 3.4-2, the USGS groundwater level contours are shown as red dashed lines for comparison with the new groundwater level data collected in 2010. These data also give better definition of the groundwater, wetlands and streams relationships. Evaluations of the hydrologic relationships based on the data in each of the study areas are provided below.

Jim Creek

Just downstream of the Denver Water diversion structure on Jim Creek, the groundwater levels in the three monitoring wells show the hydraulic gradients are oriented down slope and converge toward the stream and wetland area. Figure 3.4-4 shows the well locations, the measured groundwater levels and stream level elevations. The map also shows the groundwater level contours and flow directions relative to the stream and the wetland area that lies downstream of the diversion structure. Groundwater levels, flow directions, and head relationships between the groundwater, stream, and wetland are depicted vertically on Figure 3.4-5, a north-south hydrologic cross section through the west side of this study site.

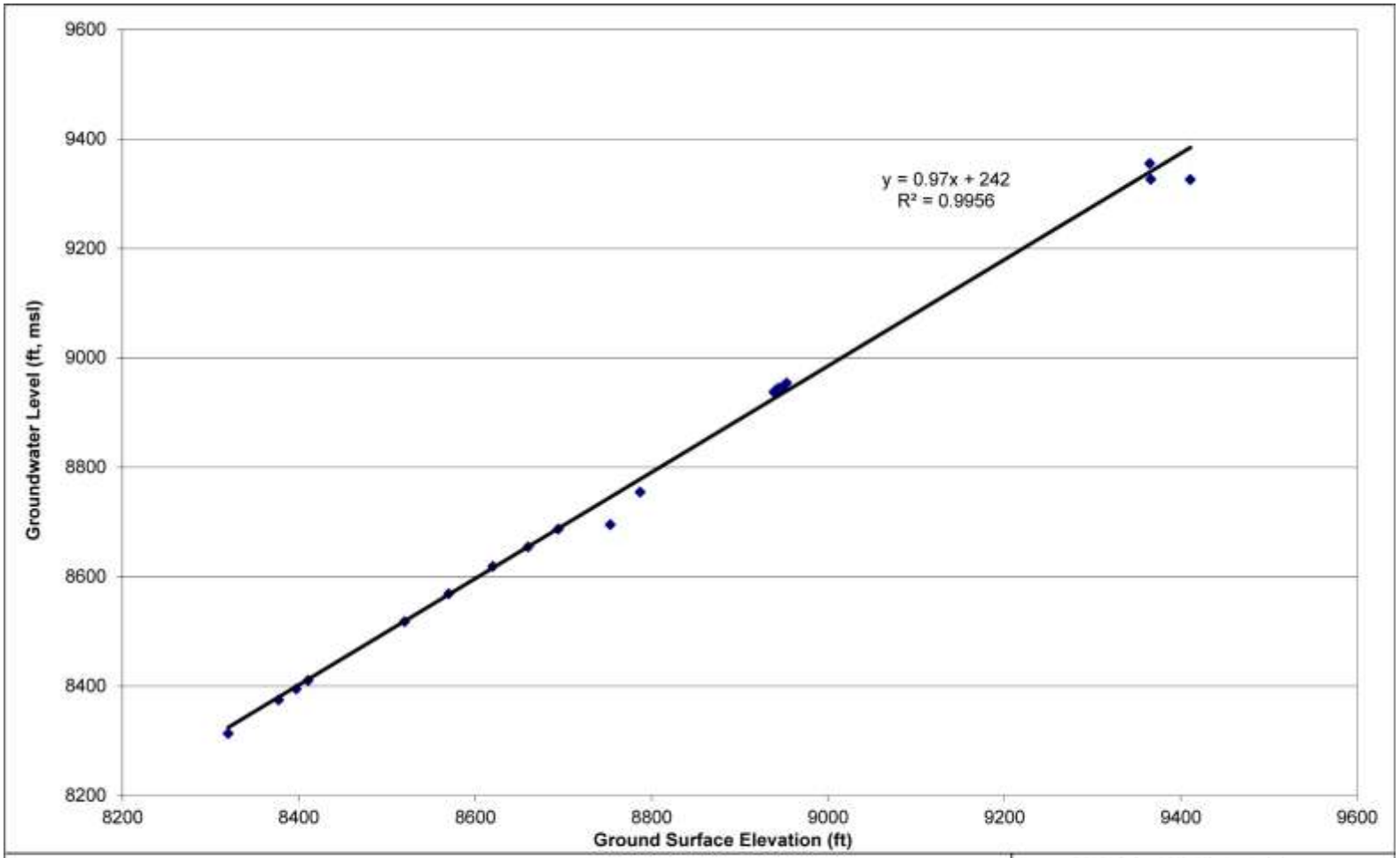

GRAND COUNTY
0 10
Miles
Study Area Extent
40
8335.3
8324.9
8528.8
See St. Louis Creek Figures
8400
8500
8600
8700
8800
8900
9000



Moffat Collection System Project FEIS

Figure 3.4-2 Groundwater Data in Fraser River Valley

9/4/12



Moffat Collection System Project FEIS

Figure 3.4-3
Groundwater and Topographic Elevations

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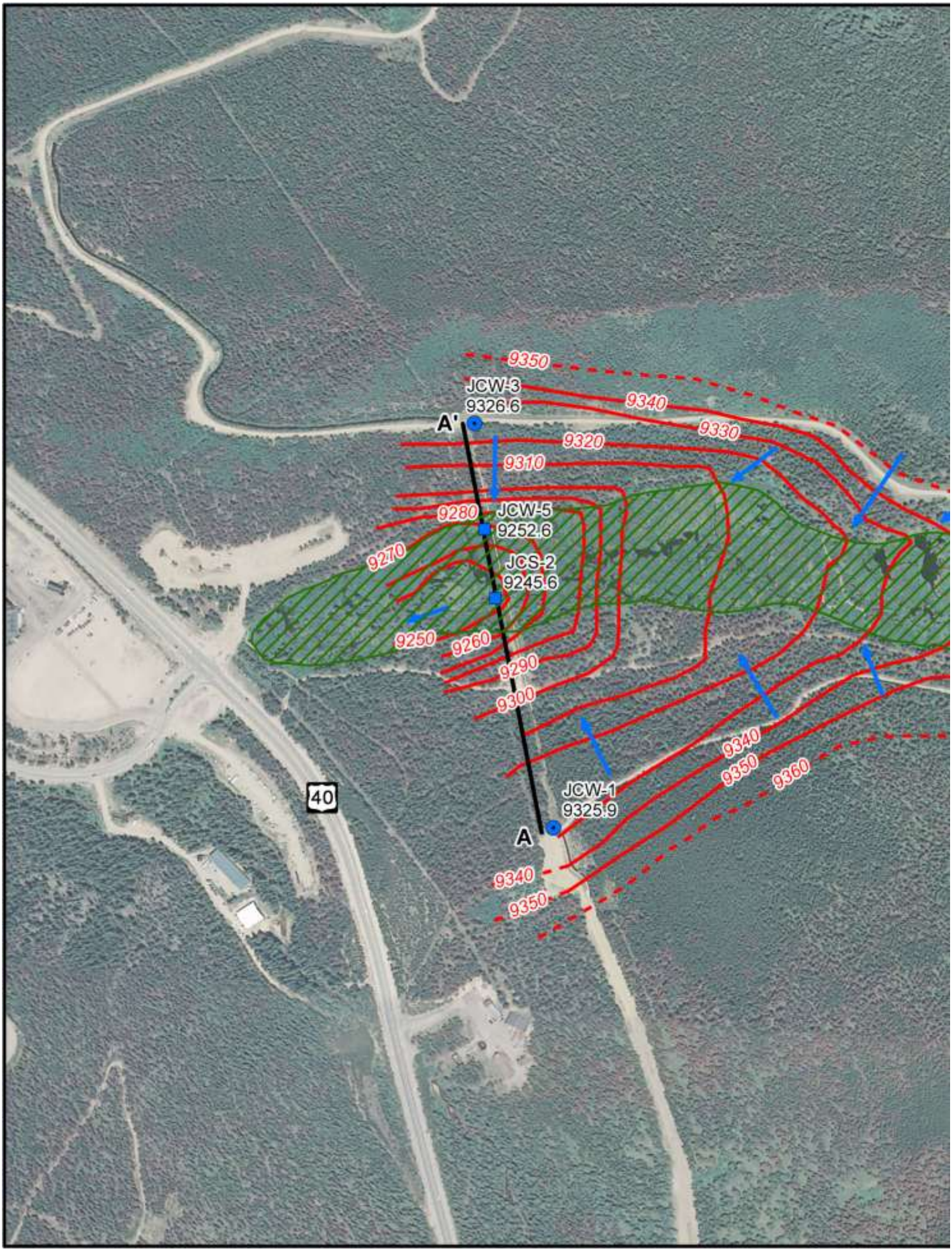

9350
JCW-3
9326.6
9340
A'
9330
9320
9310
9280
JCW-5
9252.6
9270
JCS-2
9245.6
9250
9260
9290
9300
9340
9350
9360
JCW-1
9325.9
40
A
9340
9350

Stream Level Survey Elevation
Well Location
Water Table Contour Elevations (ft msl) (URS 2010)
Inferred Water Table Contour Elevations (ft msl) (URS 2010)
Groundwater Flow Directions
Approximate Area of Wetland
Hydrologic Cross-Section (Figure 3.4-5)
Diversion

References:
Aerial photography from USDA (2009).

Diversions from Denver Water (2002).

N
W E
S

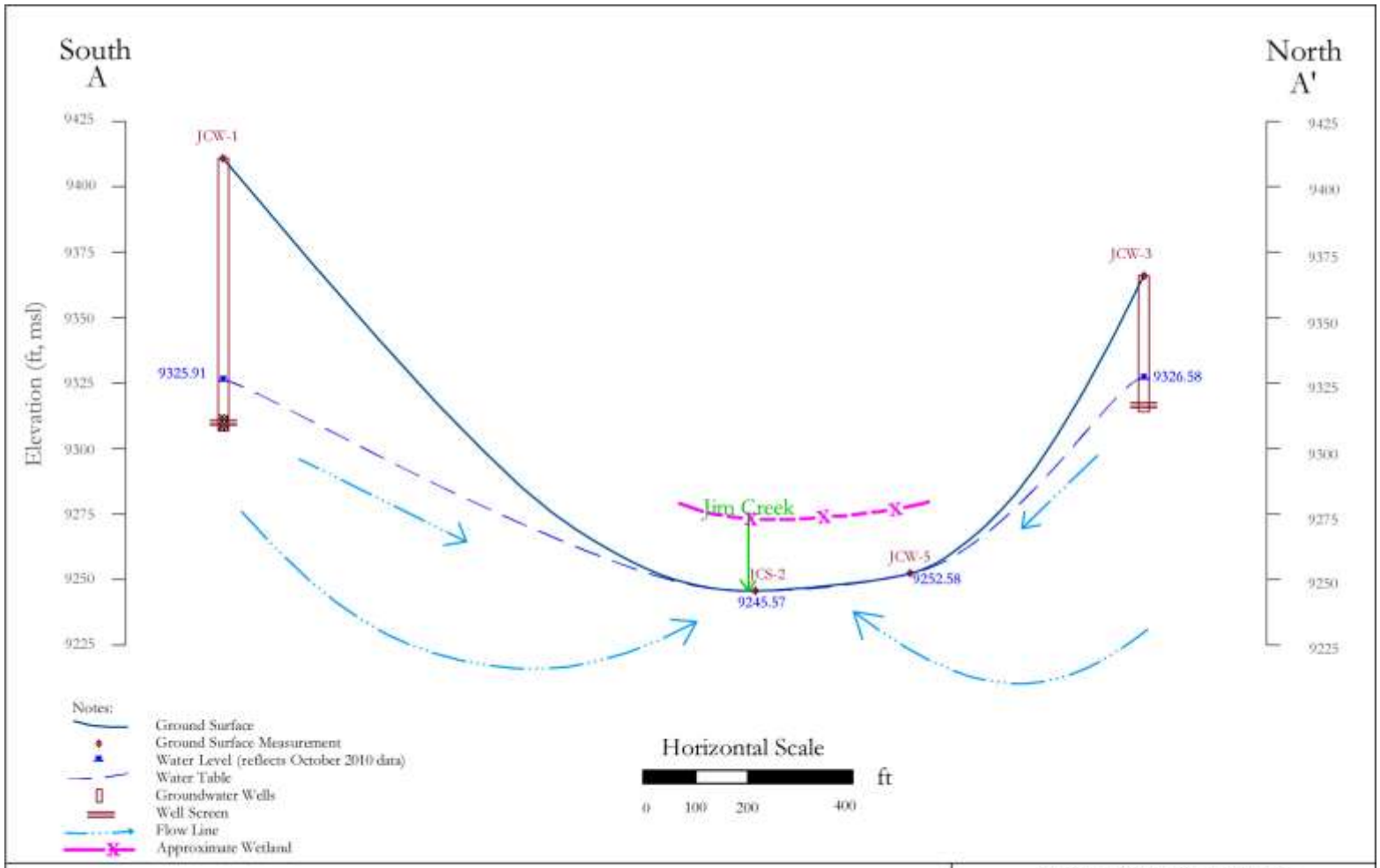
500 0 500 Feet

1:6,000

Moffat Collection System Project FEIS

Figure 3.4-4
Water Levels, Jim Creek Area

9/4/12



Moffat Collection System Project FEIS

Figure 3.4-5
Hydrologic Cross-Section A-A', Jim Creek

9/4/12

These data show groundwater levels are substantially higher than the creek level, and groundwater levels are higher than the wetland along the stream below the Denver Water diversion. This indicates groundwater flows toward and discharges into the creek and wetland.

Winter Park

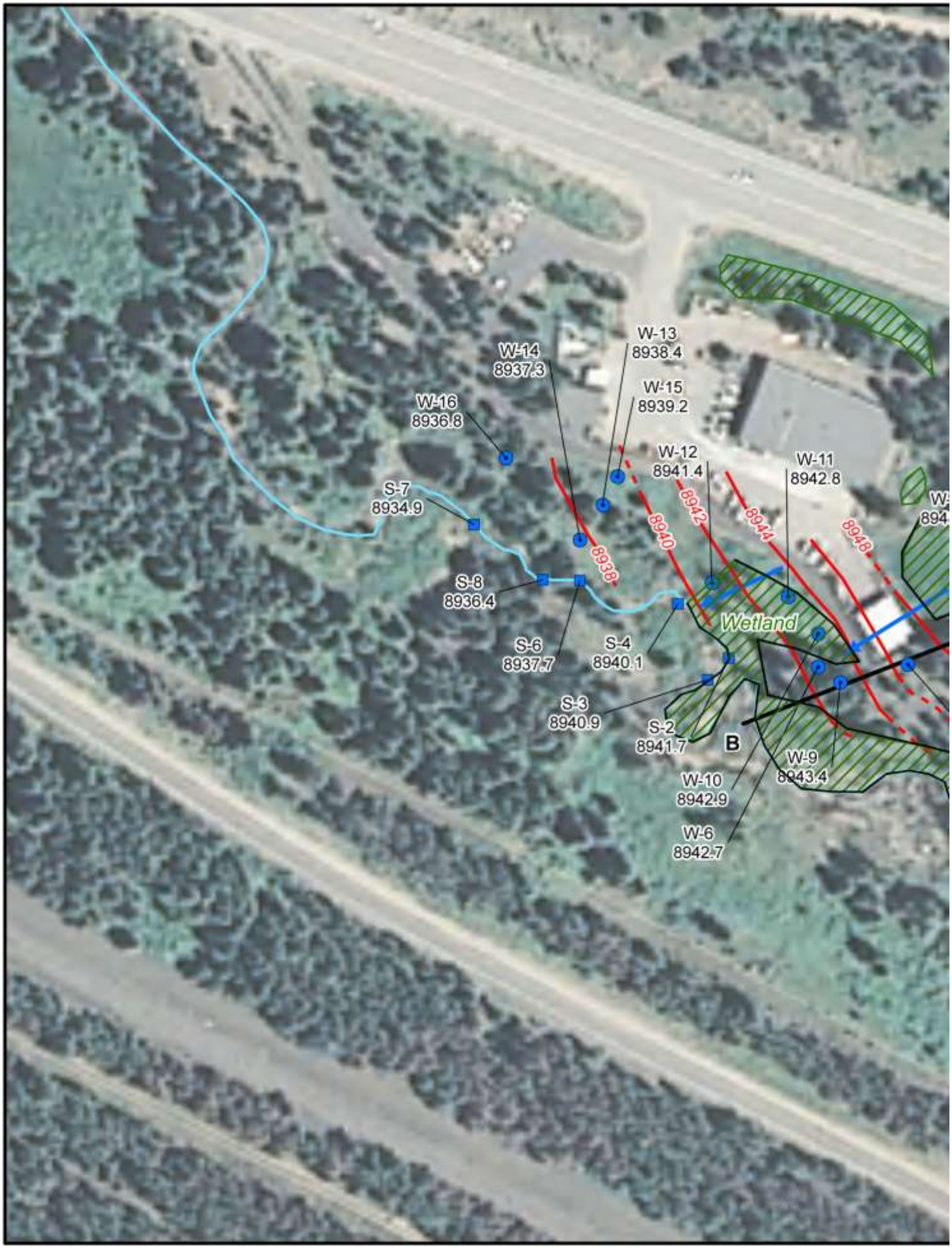
Useful data were obtained from another site near Winter Park, located downstream of the Denver Water diversion structure on the upper Fraser River (Figure 3.4-6). A groundwater contour map was prepared using water level measurements from another recent report (Grand Environmental Services 2009), after accurate land survey data was collected to determine the well locations and measurement point elevations. Figure 3.4-7 shows hydrographs of groundwater level elevations in the wells, which were measured during the snowmelt period (May – July 2009). Slightly higher groundwater levels in several wells coincide with the high stream level caused by snowmelt runoff.

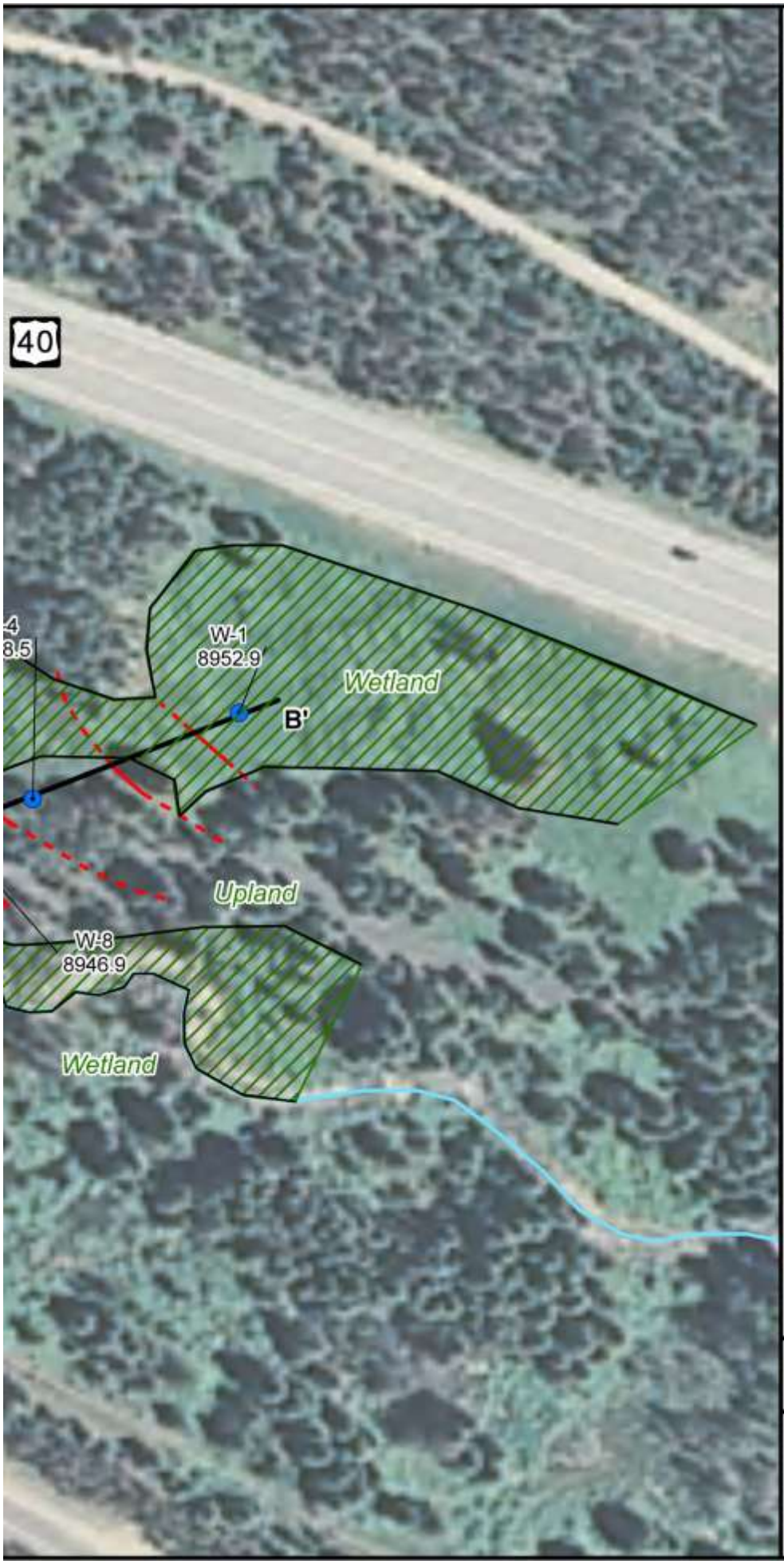
As shown on Figure 3.4-7, the groundwater level rise caused by seasonal snowmelt is most evident in wells immediately adjacent to the Fraser River. The largest groundwater level rise in any well is approximately 2 feet. Fluctuations in the groundwater levels decrease in wells located further from the river. The well furthest away from the river, Well W-1, shows minimal groundwater level change. This well is located within a wetland that is about 10 feet in vertical distance from the river. Groundwater levels in the elevated wetland area are approximately the same as the ground surface during the high-runoff period; even during the low-flow season, the groundwater level in this wetland area remains close to the ground surface based on observations by URS Corporation (URS) hydrogeologists in September 2010.

Hydrologic relationships between the groundwater, stream, and wetland in the Winter Park area are shown on Figure 3.4-8. This hydrologic cross section is aligned southwest – northeast, along the southern side of this study site, just north of the Fraser River. The spatial distribution of hydraulic heads demonstrates that groundwater flows from the topographically elevated areas along the valley margins toward the Fraser River. Groundwater levels approach stream levels along the stream bank where the groundwater and surface water flow mix. The larger groundwater level rise in wells near the river is attributable to the combination of two snowmelt effects: (1) runoff causes the stream level to be higher, and (2) direct infiltration of the snowmelt recharges groundwater in areas upslope from the river. These data demonstrate that wetland areas more than a few feet above the Fraser River banks are supported by groundwater and not by stream flow.

Lower Fraser Valley

Hydrologic interactions between the groundwater, wetlands, and the stream have also been studied at another site located further downstream in the Fraser River Valley, just north of Tabernash. Figure 3.4-9 shows the three new monitoring well locations, the measured groundwater levels, and stream level elevations during low flow conditions (October 2010). It also shows the groundwater level contours and flow directions relative to the stream and the wetland area. Figure 3.4-10 is a hydrologic cross-section to illustrate the groundwater-stream-wetlands relationships during low flow conditions. These data indicate that groundwater flows toward and into the Fraser River, and that groundwater discharging as seepage at the ground surface supports the wetland area between Wells FRW-2 and FRW-3, which lies substantially higher in elevation than the river.


W-13
8938.4
W-14
8937.3
W-15
8939.2
W-16
8936.8
W-12
8941.4
W-11
8942.8
S-7
8934.9
8938
8940
8942
8944
8948
S-8
8936.4
Wetland
S-6
8937.7
S-4
8940.1
S-3
8940.9
S-2
8941.7
B
W-9
8943.4
W-10
8942.9
W-6
8942.7



Stream Measurement Location
Well Location
Water Table Contour Elevations (ft msl) (URS 2010)
Inferred Water Table Contour Elevations (ft msl) (URS 2010)
Groundwater Flow Directions
Fraser River
Approximate Area of Wetland
Approximate Edge of Wetland
Hydrologic Cross-Section (Figure 3.4-8)

References:
Aerial photography from USDA (2009).

Water level measurements (6/29/09) from Grand Environmental Services (2009).

N
W E
S

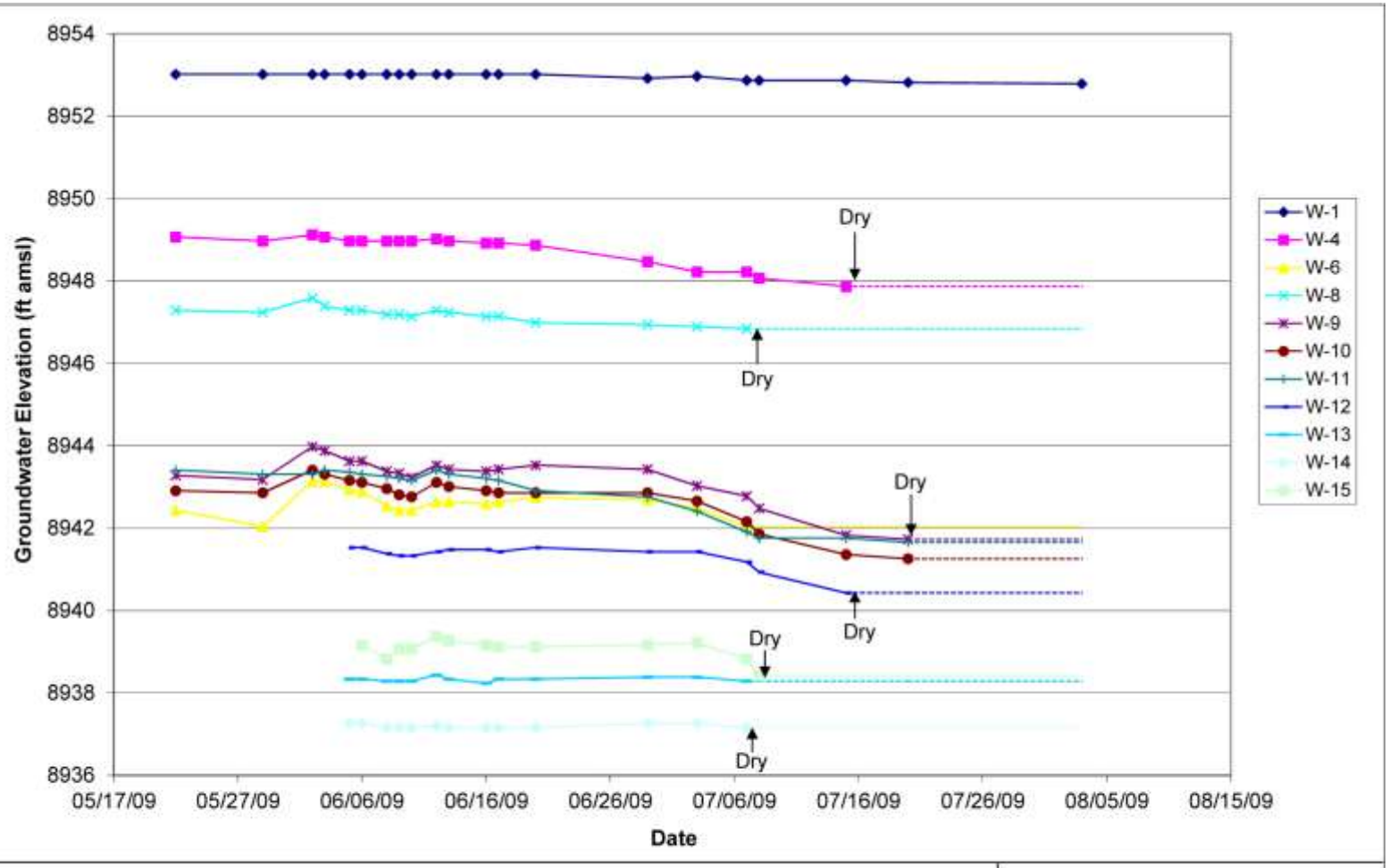
100 0 100 Feet

1:1,200

Moffat Collection System Project FEIS

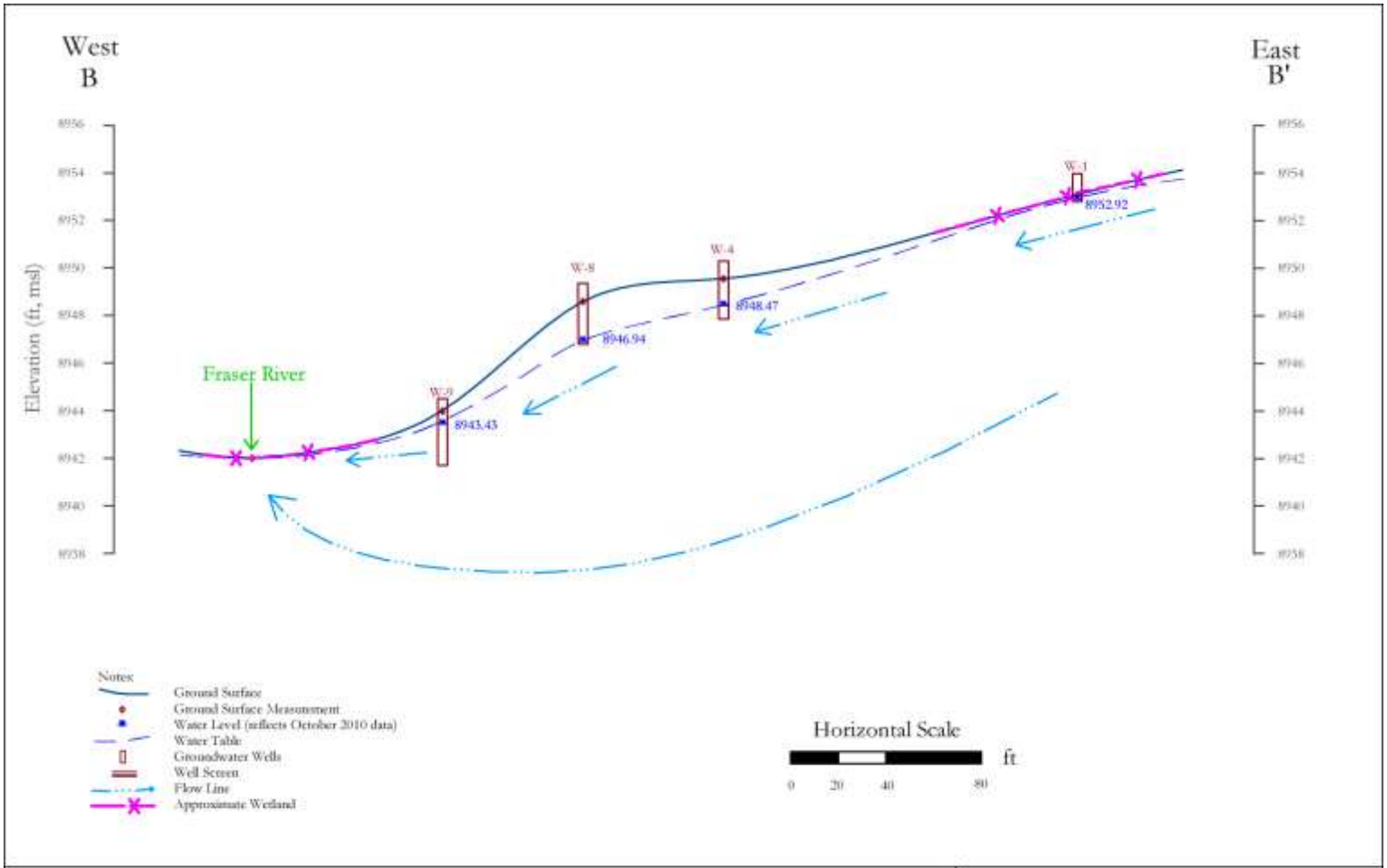
Figure 3.4-6
Water Levels, Winter Park Area

9/4/12



Moffat Collection System Project FEIS

Figure 3.4-7
Hydrographs of Winter Park Wells

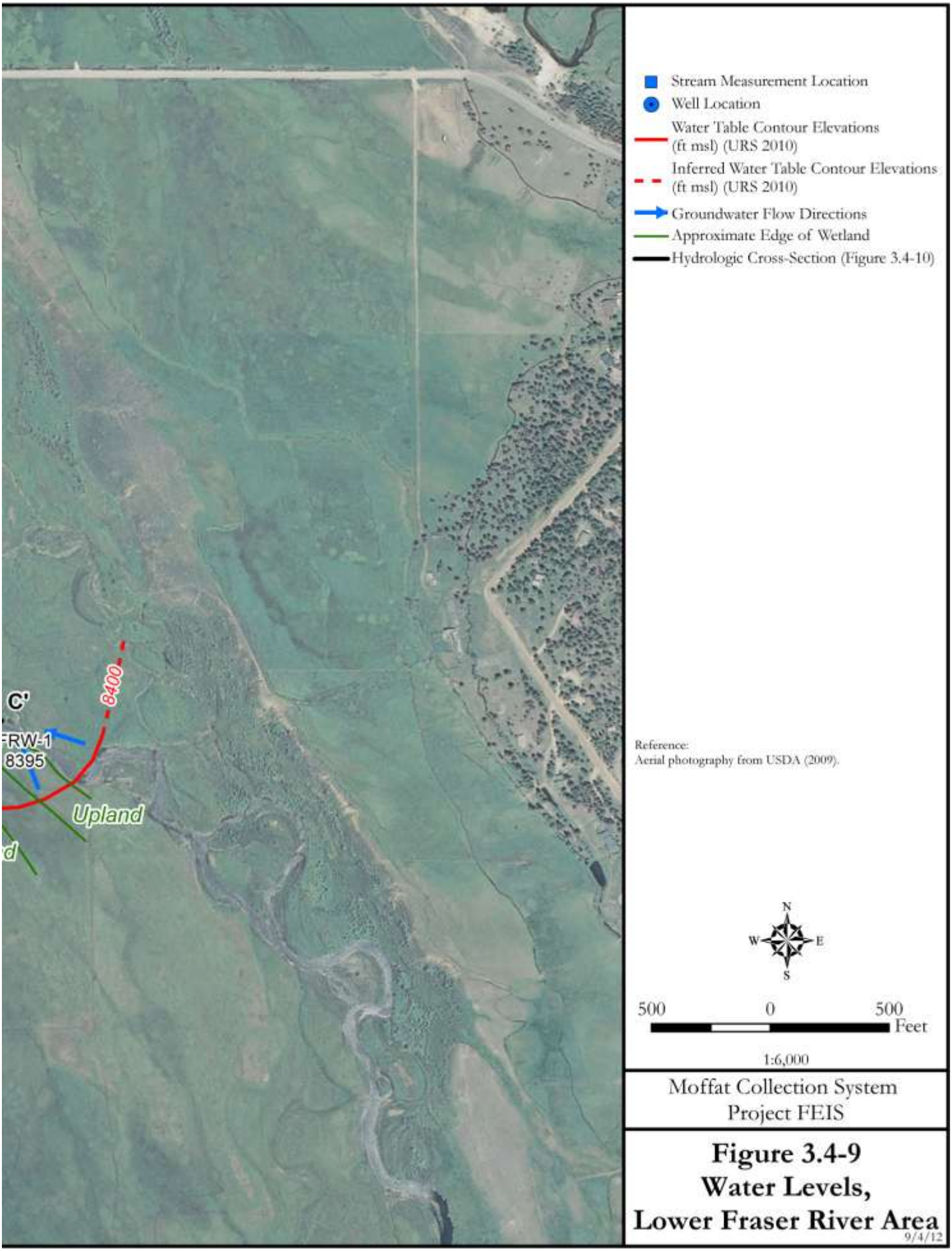


Moffat Collection System Project FEIS

Figure 3.4-8
Hydrologic Cross-Section B-B', Winter Park Area

9/4/12

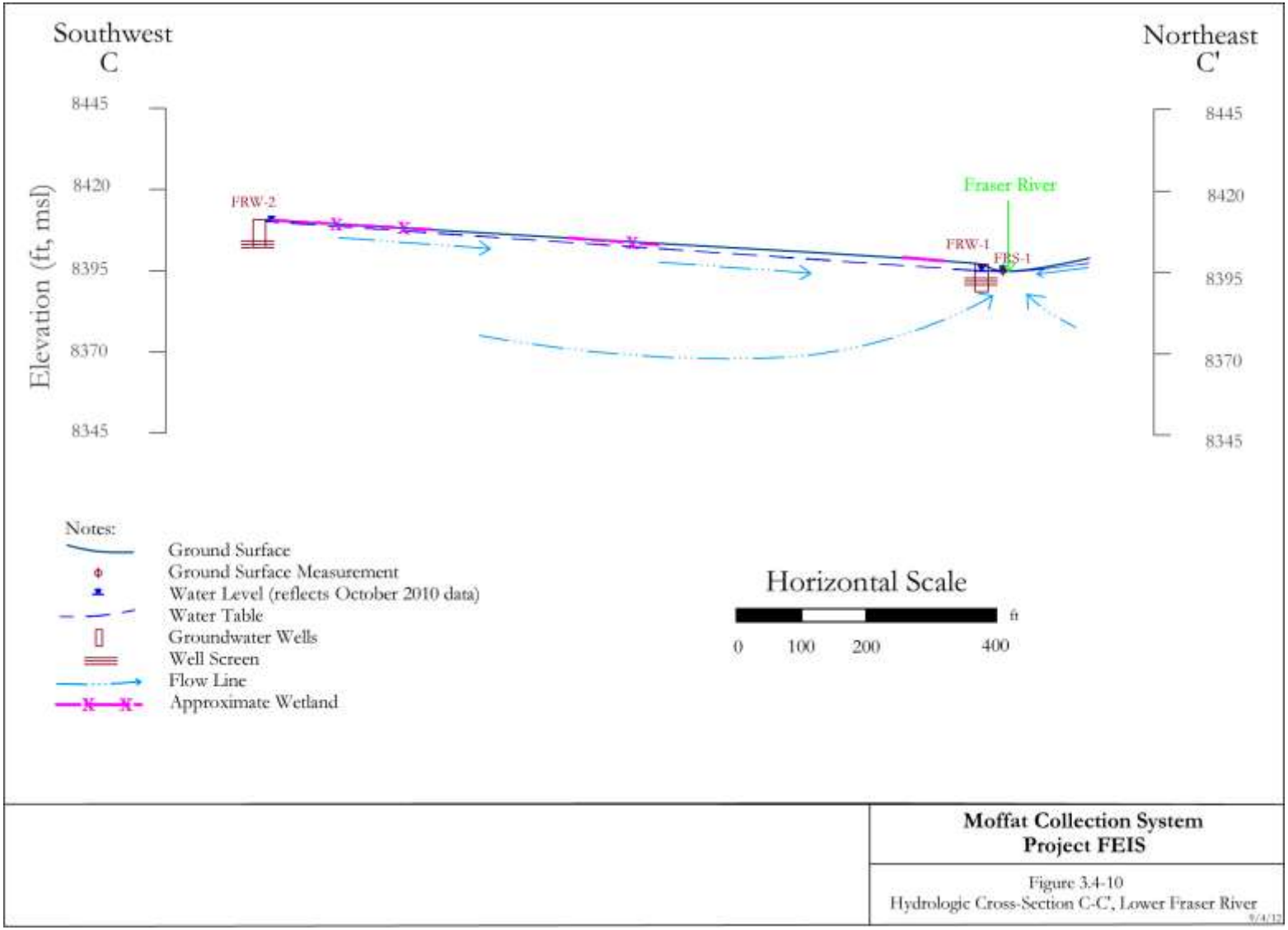
FRW-3 FRS-2
8374.9 8374.9
8380
8390
40
Wetland
FRS-1
8394.9
Wetlan
8410
Upland
C
FRW-2
8410.2



Moffat Collection System
Project FEIS

Figure 3.4-9
Water Levels,
Lower Fraser River Area

9/4/12


Southwest
C
Northeast
C'
Elevation (ft, msl)
8445
8420
8395
8370
8345
FRW-2
Fraser River
FRW-1
FES-1
Notes:
Ground Surface
Ground Surface Measurement
Water Level (reflects October 2010 data)
Water Table
Groundwater Wells
Well Screen
Flow Line
Approximate Wetland
Horizontal Scale
ft
0
100
200
400
Moffat Collection System
Project FEIS
Figure 3.4-10
Hydrologic Cross-Section C-C', Lower Fraser River

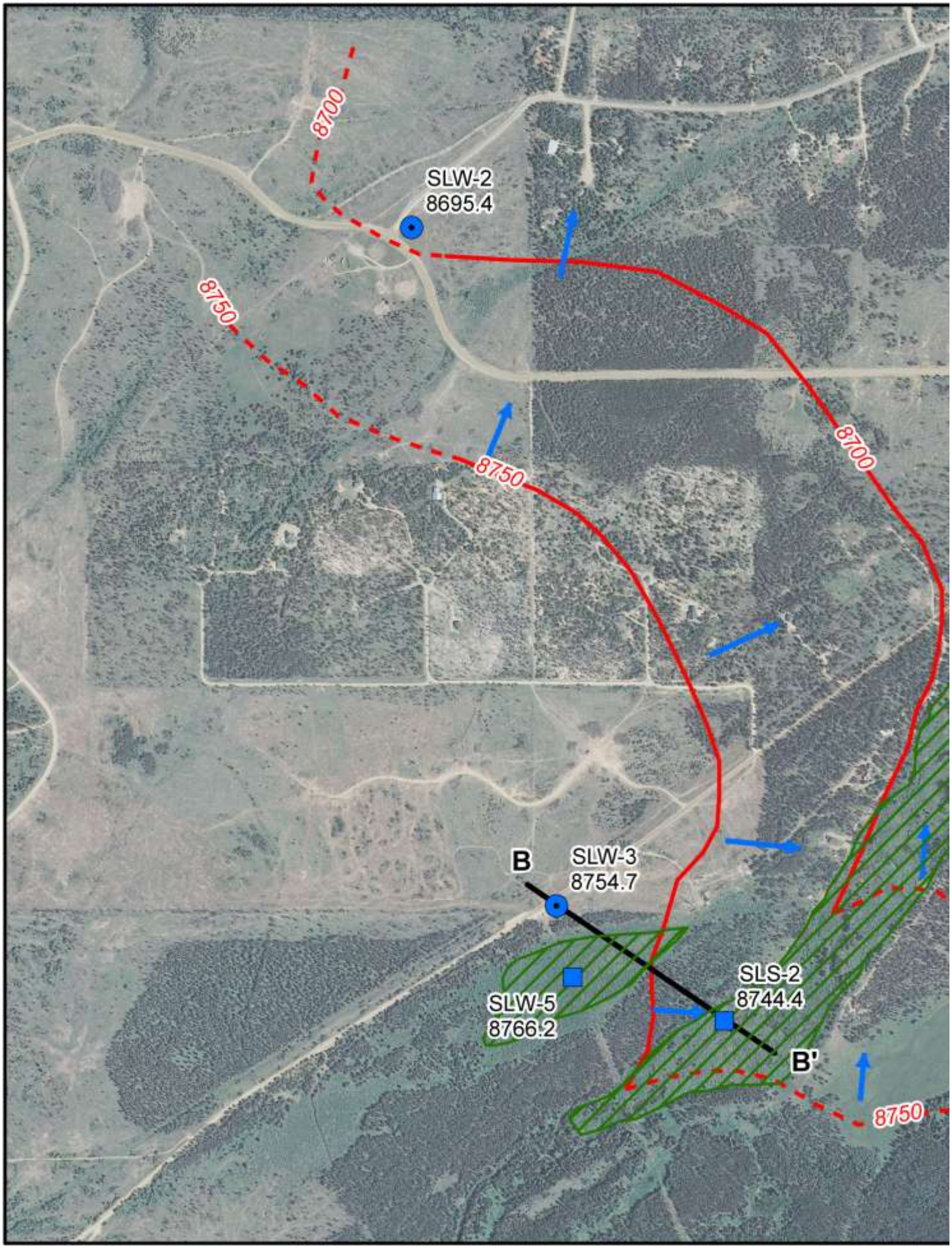
St. Louis Creek

New monitoring wells have also been installed near a potentially affected segment of St. Louis Creek to evaluate the groundwater relationships with the wetlands and the creek. Figure 3.4-11 shows the three new monitoring well locations, the measured groundwater levels, and the nearby stream level elevations. Groundwater level contours and flow directions are also shown on Figure 3.4-11. These well locations were constrained by property ownership and drilling rig access, which resulted in these data points being widely spaced. Therefore, two hydrologic cross sections were prepared to illustrate the hydraulic head relationships between the groundwater, stream, and the wetlands for low flow conditions in October 2010 (Figure 3.4-12 and Figure 3.4-13).

The spatial distribution of these hydraulic head data show that groundwater flows toward St. Louis Creek. Groundwater levels exist near the ground surface in the area just south of well SLW-3, which supports a large wetland containing phreatophyte vegetation (e.g., willow) surrounding point SL-5. The ground surface in this wetland is several feet higher than the high water level of the creek immediately to the north.

Evaluation of High-Flow Monitoring Data

As requested by EPA (a Cooperating Agency on the Moffat Project), weekly measurements of groundwater levels were conducted in the new monitoring wells and the adjacent stream levels throughout the high runoff period in June-July 2011. Table 3.4-1 provides these weekly monitoring data, as well as the measurements taken in October 2010 for comparison purposes. Field observations are also noted on the table. Hydrographs of the water level elevations in the wells and adjacent streams for the three study sites are presented in Figure 3.4-14, Figure 3.4-15, and Figure 3.4-16.


8700
SLW-2
8695.4
8750
8750
8700
B
SLW-3
8754.7
SLW-5
8766.2
SLS-2
8744.4
B'
8750

Stream Measurement Location
Well Location
Water Table Contour Elevations (ft msl) (URS 2010)
Inferred Water Table Contour Elevations (ft msl) (URS 2010)
Groundwater Flow Directions
Approximate Area of Wetland
Hydrologic Cross-Section (Figures 3.4-12 and 3.4-13)

Reference:
Aerial photography from USDA (2009).

N
W E
S

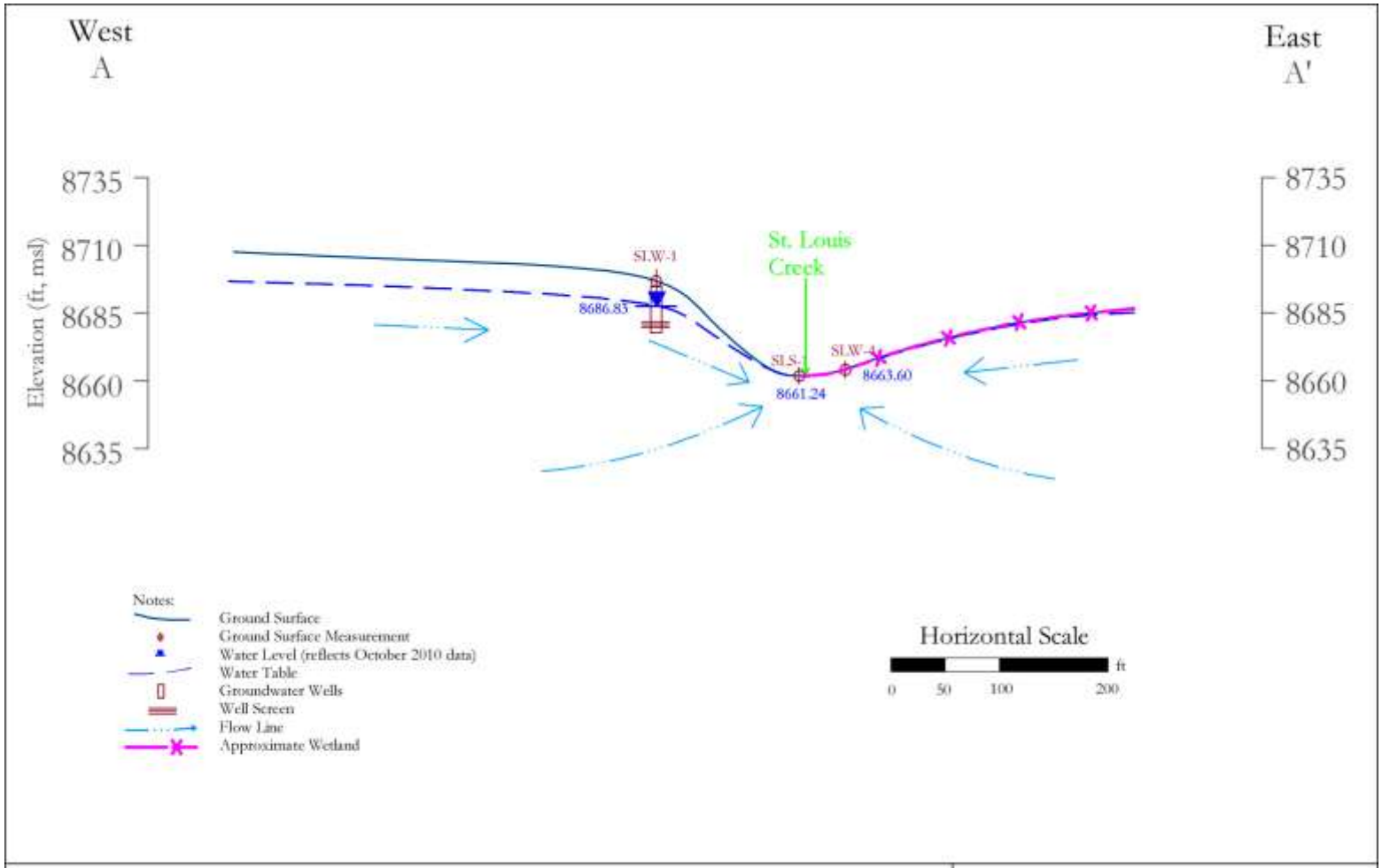
700 0 700 Feet

1:8,400

Moffat Collection System Project FEIS

Figure 3.4-11
Water Levels,
St. Louis Creek Area

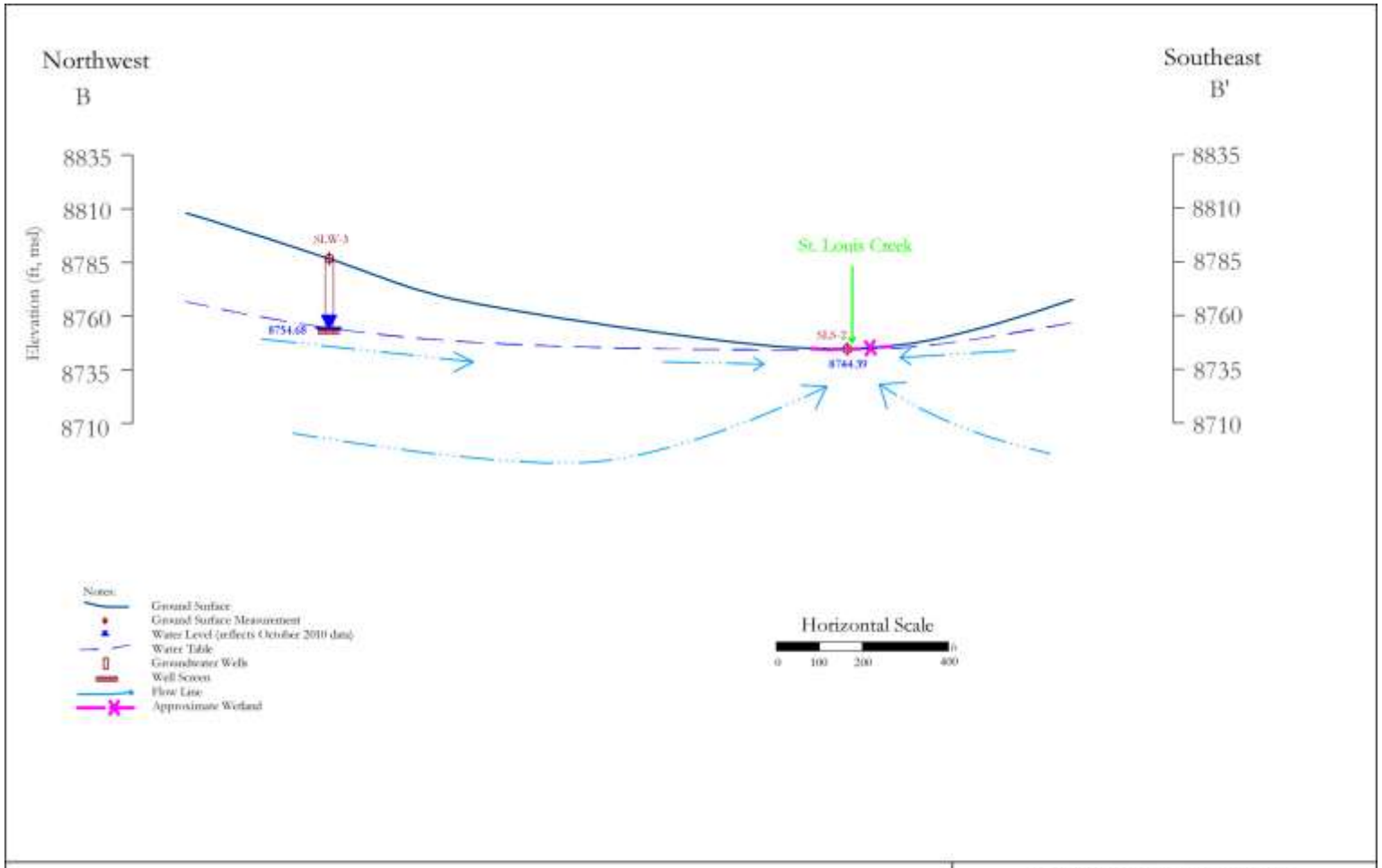
9/4/12



Moffat Collection System Project FEIS

Figure 3.4-12
Hydrologic Cross-Section A-A', St. Louis Creek

9/4/12



Moffat Collection System Project FEIS

Figure 3.4-13
Hydrologic Cross-Section B-B', St. Louis Creek
9/4/12

Table 3.4-1
Summary of Stream and Groundwater Levels

Location Information				Measurement Information				
Location ID	Ground Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)[1]	Measuring Point Reference[1]	Measurement Date	Measurement (feet)	Water Elevation (ft msl)	Change from Previous (feet)[2]	Comments/Observations
JCW-1	9410.86	9410.99	Well - Depth to Water from Top of Casing	10/15/2010	85.08	9,325.91	N/A	
				6/16/2011	81.99	9,329.00	3.09	Snowmelt recharge
				6/23/2011	81.27	9,329.72	0.72	
				6/30/2011	82.31	9,328.68	-1.04	
				7/7/2011	83.52	9,327.47	-1.21	
				7/13/2011	84.35	9,326.64	-0.83	
				7/20/2011	84.62	9,326.37	-0.27	
				7/28/2011	84.96	9,326.03	-0.34	
				8/18/2011	84.89	9,326.10	0.07	
JCW-2	9364.84	9367.37	Well - Depth to Water from Top of Casing	10/15/2010	12.24	9,355.13	N/A	
				6/16/2011	2.10	9,365.27	10.14	Snowmelt recharge (0.42 ft above groundsurface)
				6/23/2011	3.43	9,363.94	-1.33	
				6/30/2011	5.52	9,361.85	-2.09	
				7/7/2011	6.95	9,360.42	-1.43	
				7/13/2011	7.55	9,359.82	-0.60	
				7/20/2011	8.00	9,359.37	-0.45	
				7/28/2011	9.17	9,358.20	-1.17	
				8/18/2011	11.09	9,356.28	-1.92	
JCW-3	9365.96	9365.93	Well - Depth to Water from Top of Casing	10/15/2010	39.35	9,326.58	N/A	
				6/16/2011	39.12	9,326.81	0.23	Snowmelt recharge (south facing slope)
				6/23/2011	39.16	9,326.77	-0.04	
				6/30/2011	39.22	9,326.71	-0.06	
				7/7/2011	39.27	9,326.66	-0.05	
				7/13/2011	39.30	9,326.63	-0.03	
				7/20/2011	39.31	9,326.62	-0.01	
				7/28/2011	39.32	9,326.61	-0.01	
				8/18/2011	39.37	9,326.56	-0.05	
JCS-1	9354.74	9355.52	Stream - Water Depth from Stream Bottom	10/15/2010	N/A	9,354.74	N/A	
				6/16/2011	0.33	9,355.85	1.11	Stream up ~1 ft since October – gate closed = diverting
				6/23/2011	1.50	9,357.02	1.17	Stream up ~1 ft since last week – gate closed = diverting
				6/30/2011	1.92	9,357.44	0.42	Gate open, not diverting
				7/7/2011	1.46	9,356.98	-0.46	Gate open, not diverting
				7/13/2011	1.50	9,357.02	0.04	Gate open, not diverting
				7/20/2011	1.08	9,356.60	-0.42	Gate open, not diverting
				7/28/2011	0.54	9,356.06	-0.54	Gate partially closed, diverting
				8/18/2011	0.17	9,355.69	-0.38	Gate partially closed, diverting

Table 3.4-1 (continued)
Summary of Stream and Groundwater Levels

Location Information				Measurement Information				
Location ID	Ground Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)[1]	Measuring Point Reference[1]	Measurement Date	Measurement (feet)	Water Elevation (ft msl)	Change from Previous (feet)[2]	Comments/Observations
JCS-2	9245.57	9246.15	Stream - Height Above or Below Bottom of Stake	10/15/2010	N/A	9,245.57	N/A	
				6/16/2011	0.00	9,246.15	0.58	Gate closed = diverting
				6/23/2011	0.50	9,246.65	0.50	Gate closed = diverting
				6/30/2011	0.75	9,246.90	0.25	Gate open, not diverting
				7/7/2011	0.65	9,246.80	-0.10	Gate open, not diverting
				7/13/2011	0.54	9,246.69	-0.10	Gate open, not diverting
				7/20/2011	0.25	9,246.40	-0.29	Gate open, not diverting
				7/28/2011	0.00	9,246.15	-0.25	Gate partially closed, diverting
				8/18/2011	-0.17	9,245.98	-0.17	Gate partially closed, diverting
SLW-1	8694.15	8696.47	Well - Depth to Water from Top of Casing	10/15/2010	9.64	8,686.83	N/A	
				6/16/2011	3.72	8,692.75	5.92	Snowmelt recharge
				6/23/2011	3.84	8,692.63	-0.12	
				6/30/2011	4.35	8,692.12	-0.51	
				7/7/2011	4.84	8,691.63	-0.49	
				7/13/2011	5.07	8,691.40	-0.23	
				7/20/2011	5.36	8,691.11	-0.29	
				7/28/2011	5.89	8,690.58	-0.53	
				8/18/2011	6.97	8,689.50	-1.08	
SLW-2	8753.23	8756.12	Well - Depth to Water from Top of Casing	10/15/2010	60.76	8,695.36	N/A	
				6/16/2011	52.09	8,704.03	8.67	Snowmelt recharge
				6/23/2011	52.78	8,703.34	-0.69	
				6/30/2011	53.24	8,702.88	-0.46	
				7/7/2011	53.78	8,702.34	-0.54	
				7/13/2011	54.12	8,702.00	-0.34	
				7/20/2011	54.49	8,701.63	-0.37	
				7/28/2011	54.94	8,701.18	-0.45	
				8/18/2011	56.05	8,700.07	-1.11	
SLW-3	8786.99	8789.42	Well - Depth to Water from Top of Casing	10/15/2010	34.74	8,754.68	N/A	
				6/16/2011	26.35	8,763.07	8.39	Snowmelt recharge
				6/23/2011	27.28	8,762.14	-0.93	
				6/30/2011	28.09	8,761.33	-0.81	
				7/7/2011	28.91	8,760.51	-0.82	
				7/13/2011	29.44	8,759.98	-0.53	
				7/20/2011	30.10	8,759.32	-0.66	
				7/28/2011	30.72	8,758.70	-0.62	
				8/18/2011	31.75	8,757.67	-1.03	

Table 3.4-1 (continued)
Summary of Stream and Groundwater Levels

Location Information				Measurement Information				
Location ID	Ground Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)[1]	Measuring Point Reference[1]	Measurement Date	Measurement (feet)	Water Elevation (ft msl)	Change from Previous (feet)[2]	Comments/Observations
SLS-1	8661.24	8662.91	Stream - Height Above or Below Bottom of Stake	10/15/2010	N/A	8,661.24	N/A	
				6/16/2011	-0.58	8,662.32	1.08	Stream up ~1.1 ft since October
				6/23/2011	-0.50	8,662.41	0.08	
				6/30/2011	-0.17	8,662.74	0.33	
				7/7/2011	0.27	8,663.18	0.44	
				7/13/2011	0.40	8,663.30	0.13	
				7/20/2011	0.25	8,663.16	-0.15	
				7/28/2011	-0.25	8,662.66	-0.50	
				8/18/2011	-0.44	8,662.47	-0.19	
SLS-2	8744.39	8745.39	Stream - Height Above or Below Bottom of Stake	10/15/2010	N/A	8,744.39	N/A	
				6/16/2011	-0.17	8,745.22	0.83	
				6/23/2011	0.00	8,745.39	0.17	
				6/30/2011	0.38	8,745.77	0.38	
				7/7/2011	0.48	8,745.87	0.10	
				7/13/2011	0.50	8,745.89	0.02	
				7/20/2011	0.27	8,745.66	-0.23	
				7/28/2011	-0.19	8,745.20	-0.46	
				8/18/2011	-1.00	8,744.39	-0.81	
FRW-1	8397.03	8399.58	Well - Depth to Water from Top of Casing	10/15/2010	4.60	8,394.98	N/A	
				6/16/2011	3.52	8,396.06	1.08	About 1.1 ft higher than October (0.29 ft > stream level)
				6/23/2011	3.26	8,396.32	0.26	
				6/30/2011	3.02	8,396.56	0.24	
				7/7/2011	3.02	8,396.56	0.00	
				7/13/2011	3.07	8,396.51	-0.05	
				7/20/2011	3.22	8,396.36	-0.15	
				7/28/2011	3.62	8,395.96	-0.40	
				8/18/2011	4.29	8,395.29	-0.67	
FRW-2	8410.66	8413.10	Well - Depth to Water from Top of Casing	10/15/2010	2.93	8,410.17	N/A	
				6/16/2011	3.06	8,410.04	-0.13	Down ~0.1 ft since October
				6/23/2011	2.31	8,410.79	0.75	0.13 ft above groundsurface
				6/30/2011	2.22	8,410.88	0.09	0.22 ft above groundsurface
				7/7/2011	2.15	8,410.95	0.07	0.28 ft above groundsurface
				7/13/2011	2.09	8,411.01	0.06	0.34 ft above groundsurface
				7/20/2011	2.17	8,410.93	-0.08	0.26 ft above groundsurface
				7/28/2011	2.61	8,410.49	-0.44	
				8/18/2011	3.26	8,409.84	-0.65	

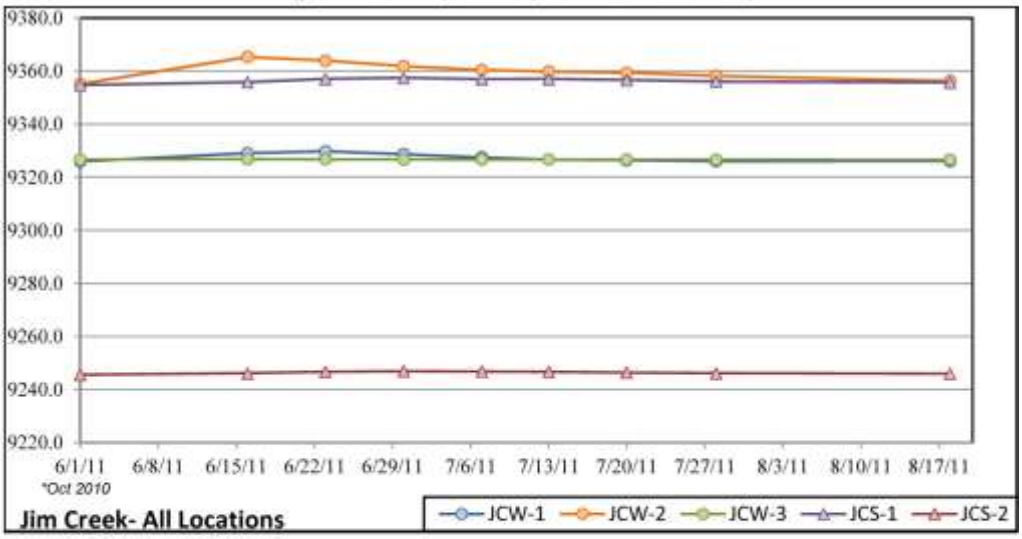
Table 3.4-1 (continued)
Summary of Stream and Groundwater Levels

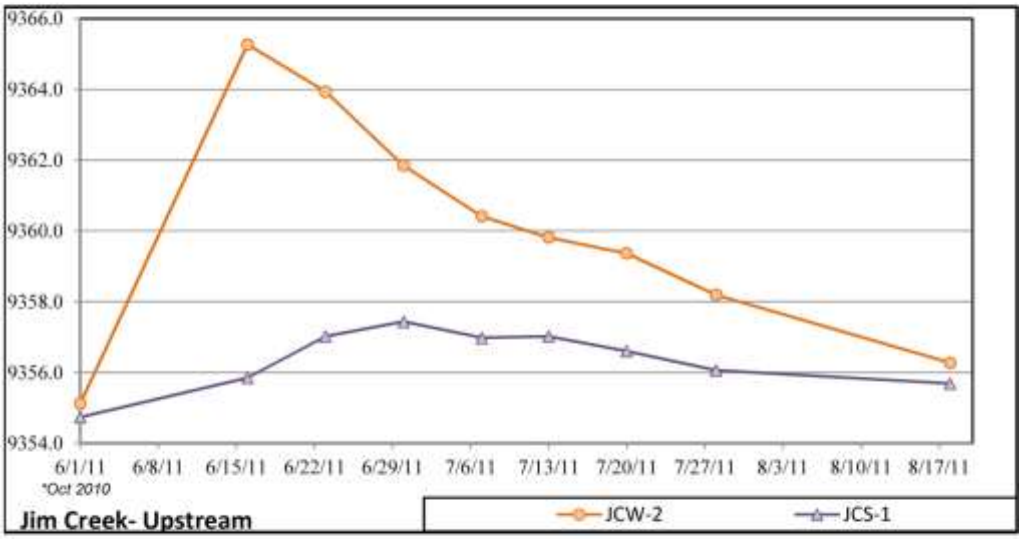
Location Information				Measurement Information				
Location ID	Ground Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)[1]	Measuring Point Reference[1]	Measurement Date	Measurement (feet)	Water Elevation (ft msl)	Change from Previous (feet)[2]	Comments/Observations
FRW-3	8377.24	8379.75	Well - Depth to Water from Top of Casing	10/15/2010	4.81	8,374.94	N/A	
				6/16/2011	3.03	8,376.72	1.78	
				6/23/2011	2.71	8,377.04	0.32	
				6/30/2011	2.27	8,377.48	0.44	0.24 ft above groundsurface
				7/7/2011	2.26	8,377.49	0.01	0.25 ft above groundsurface
				7/13/2011	2.41	8,377.34	-0.15	0.1 ft above groundsurface
				7/20/2011	2.70	8,377.05	-0.29	
				7/28/2011	3.25	8,376.50	-0.55	
				8/18/2011	4.40	8,375.35	-1.15	
FRS-1	8394.92	8394.96	Stream - Water Depth from Stream Bottom	10/15/2010	N/A	8,394.92	N/A	0.06 ft below GW at FRW-1, gradient of ~0.01 ft/ft
				6/16/2011	1.00	8,395.96	1.04	0.1 ft below GW at FRW-1, gradient of ~0.02 ft/ft
				6/23/2011	1.25	8,396.21	0.25	0.11 ft below GW at FRW-1, gradient of ~0.02 ft/ft
				6/30/2011	1.46	8,396.42	0.21	0.14 ft below GW at FRW-1, gradient of ~0.02 ft/ft
				7/7/2011	1.54	8,396.50	0.08	0.06 ft below GW at FRW-1, gradient of ~0.01 ft/ft
				7/13/2011	1.50	8,396.46	-0.04	0.05 ft below GW at FRW-1, gradient of ~0.01 ft/ft
				7/20/2011	1.33	8,396.29	-0.17	0.07 ft below GW at FRW-1, gradient of ~0.01 ft/ft
				7/28/2011	0.81	8,395.77	-0.52	0.19 ft below GW at FRW-1, gradient of ~0.03 ft/ft
				8/18/2011	0.26	8,395.22	-0.55	0.07 ft below GW at FRW-1, gradient of ~0.01 ft/ft
FRS-2	8374.94	8374.65	Stream - Water Depth from Stream Bottom	10/15/2010	N/A	8,374.94	N/A	Same as groundwater level at FRW-3
				6/16/2011	2.02	8,376.68	1.74	0.04 ft below GW at FRW-3, gradient of ~0.01 ft/ft
				6/23/2011	2.42	8,377.07	0.39	0.03 ft above GW at FRW-3, gradient of ~0 ft/ft
				6/30/2011	2.88	8,377.53	0.46	0.05 ft above GW at FRW-3, gradient of ~0.01 ft/ft
				7/7/2011	2.81	8,377.47	-0.06	0.02 ft below GW at FRW-3, gradient of ~0 ft/ft
				7/13/2011	2.83	8,377.49	0.02	0.15 ft above GW at FRW-3, gradient of ~0.02 ft/ft
				7/20/2011	2.44	8,377.09	-0.40	0.04 ft above GW at FRW-3, gradient of ~0.01 ft/ft
				7/28/2011	1.77	8,376.43	-0.67	0.08 ft below GW at FRW-3, gradient of ~0.01 ft/ft
				8/18/2011	0.56	8,375.22	-1.21	0.14 ft below GW at FRW-3, gradient of ~0.02 ft/ft

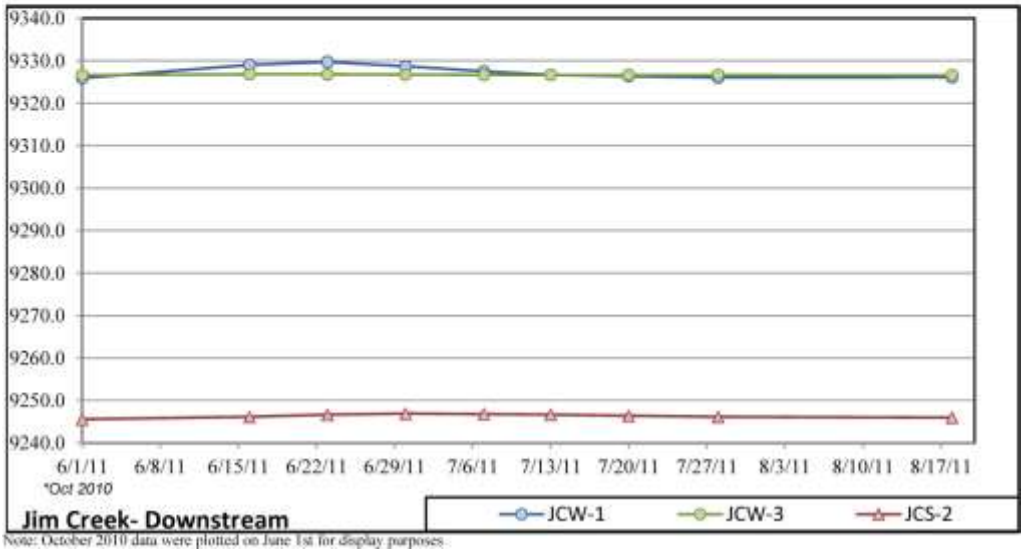
Notes:
[1]Stream level measurement point elevations for June - July monitoring are based on nearest surveyed point elevation determined on October 15, 2010.
[2]Cells highlighted in green indicate a rise (+) in water level; cells highlighted in orange indicate a fall (-) in water level.
~ = approximately ft/msl = feet per mean sea level N/A = not applicable
> = greater than GW = groundwater

Figure 3.4-14 - Hydrographs of the Jim Creek Area

Moffat Collection System Project FEIS, Grand County



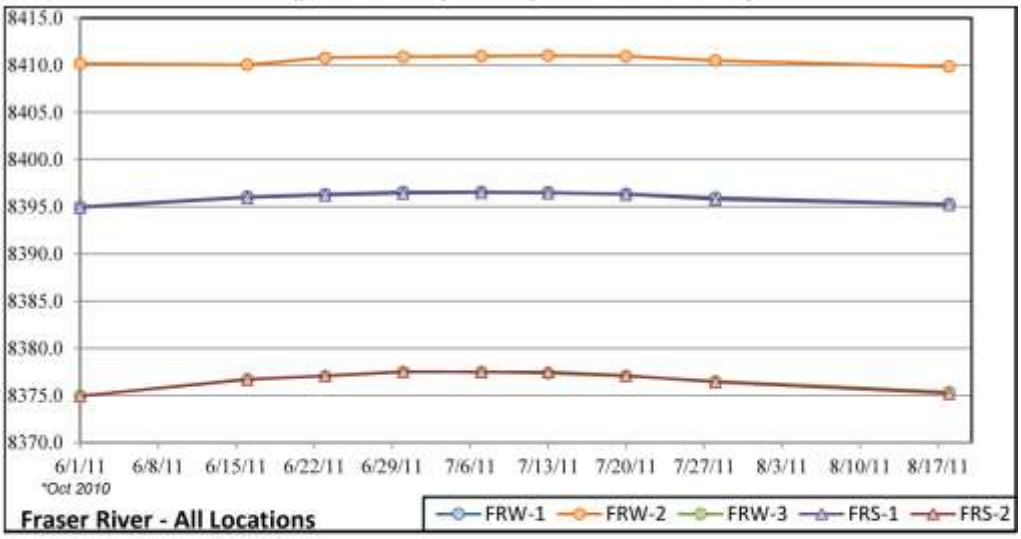


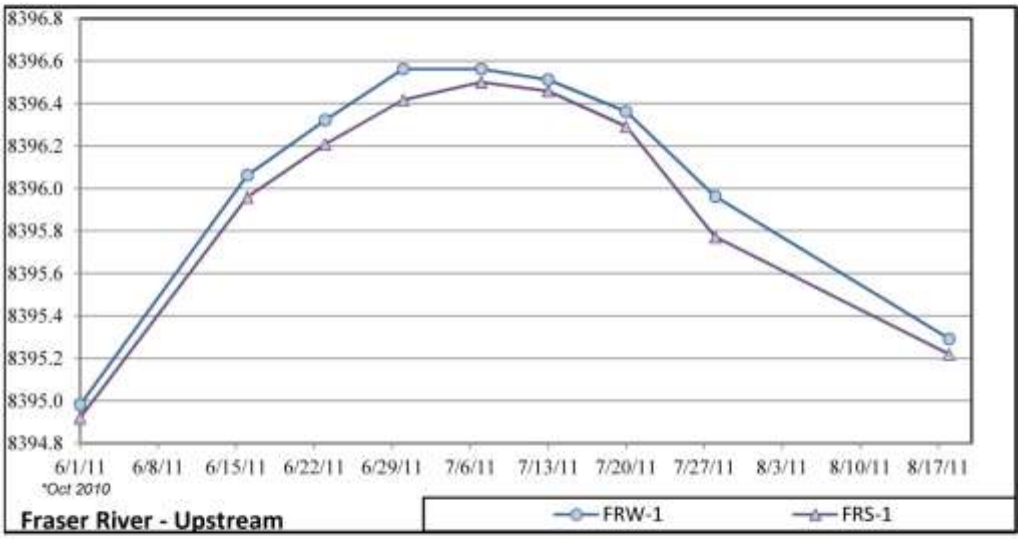


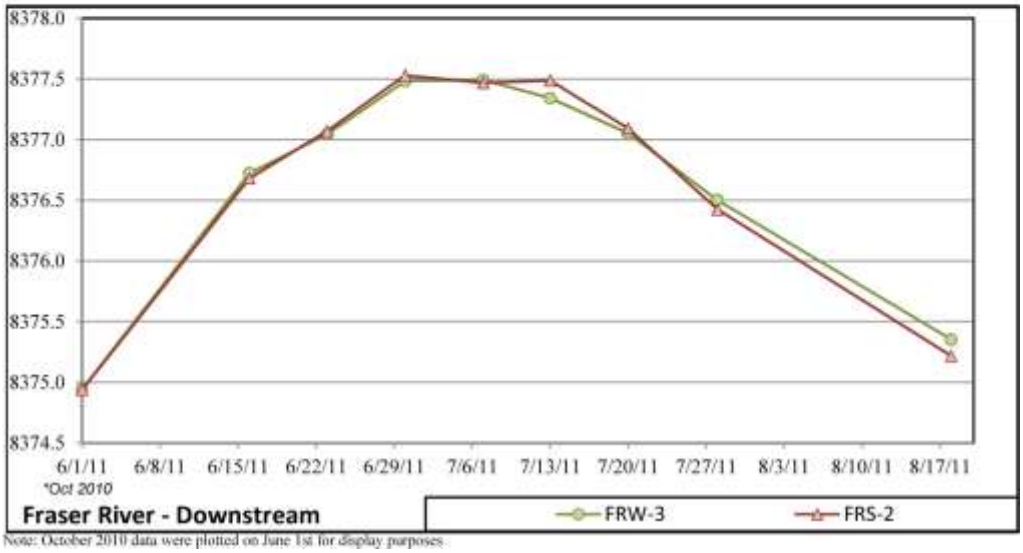
Note: October 2010 data were plotted on June 1st for display purposes

Figure 3.4-15 - Hydrographs of the Fraser River Area

Moffat Collection System Project FEIS, Grand County



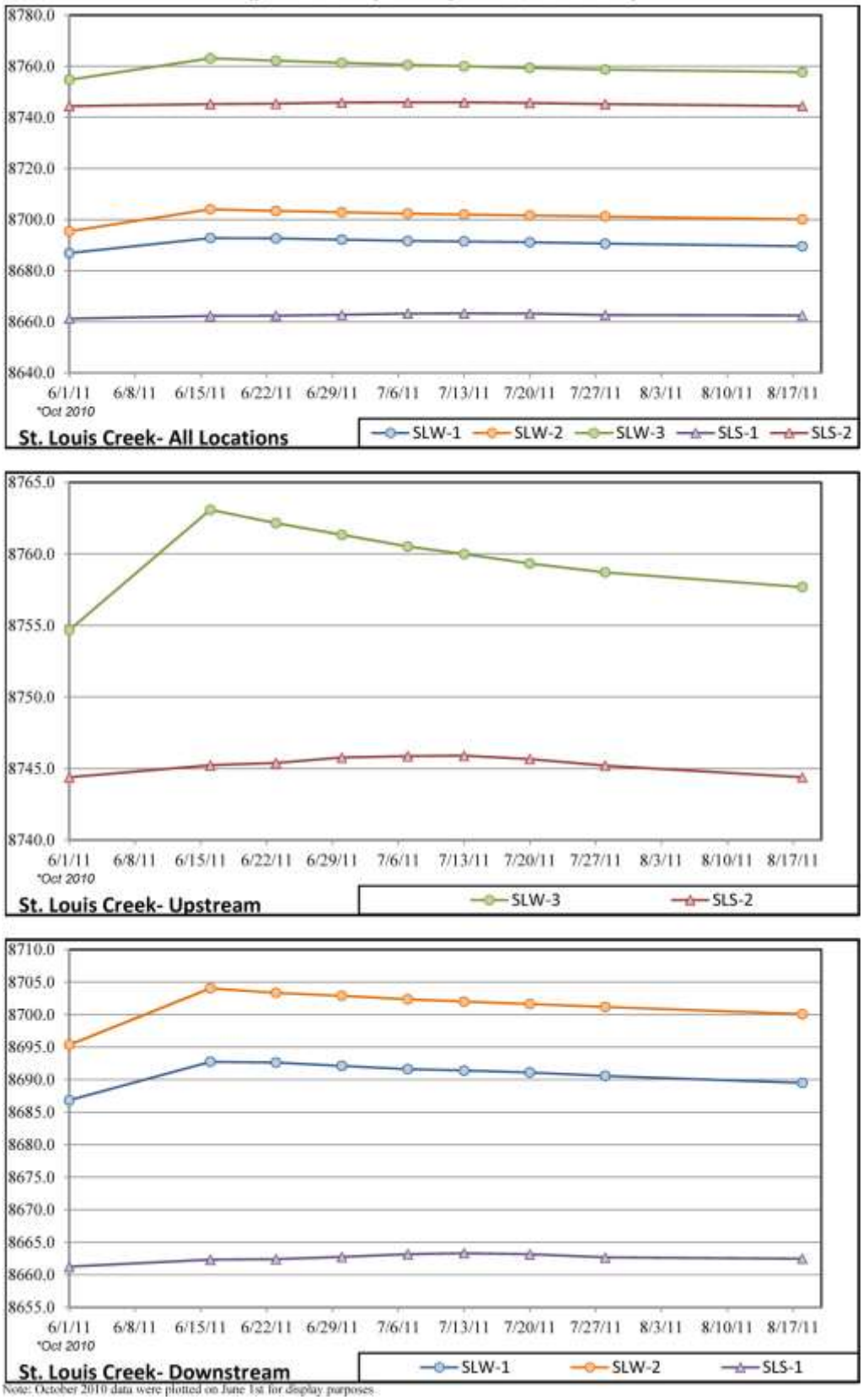




Note: October 2010 data were plotted on June 1st for display purposes

Figure 3.4-16 - Hydrographs of the St. Louis Creek Area

Moffat Collection System Project FEIS, Grand County



Note: October 2010 data were plotted on June 1st for display purposes

Figure 3.4-14 contains hydrographs of the monitoring data from the Jim Creek study site. On this figure the upper hydrograph shows the water level data from all three monitoring wells and the two stream level measurement points. However, the large elevation differences between monitoring points requires plotting at a scale that obscures the seasonal fluctuations and hydraulic relationships. Thus, two additional hydrographs are presented at a more useful expanded scale. The hydrograph in the middle of the figure presents the well data and adjacent stream data for the upstream location, while the lowermost hydrograph on the page shows the data from the downstream locations. In all cases, the groundwater levels are substantially higher in elevation than the nearby stream level throughout the high-runoff period at the Jim Creek site.

Data from Well JCW-2 (upstream to the east) show a substantial groundwater level rise caused by direct infiltration of snowmelt on the mountainside above the creek. The groundwater level in this well was about 9 feet bgs in October 2010. Snowmelt recharge caused the groundwater level to rise to 0.42 feet above ground surface on June 16, 2011, which is near the end of the snowmelt period for lands above this elevation. The hydrographs from wells JCW-3 and JCW-1 (downstream to the west) also show groundwater level increases attributable to snowmelt recharge to groundwater in the hill slope areas above these wells.

Figure 3.4-15 shows hydrographs of the monitoring data from the lower Fraser Valley study site. The upper hydrograph on this figure shows the water level data from all three monitoring wells and the two stream level measurement points. Well FRW-2 is located within a large wetland area furthest away from the river to the west. Groundwater levels at that location are near ground surface and considerably higher than the other wells located next to the stream. During late June and early July, groundwater levels in Well FRW-2 were several tenths of a foot above ground surface. Wet and boggy conditions were observed at ground surface throughout this wetland during October 2010 and even flowing water was noted during June – July 2011. There is no visible surface water drainage into that area, thus the wet conditions are attributable to groundwater discharge to the ground surface. This wetland is supported by groundwater flowing toward the river from upland recharge areas further west of the river, which is consistent with the data shown in Table 3.4-1, the data reported by the USGS (Apodaca and Bails 1999) and the data collected by URS in October 2010 (described in previous section).

To illustrate the seasonal fluctuations and relationships between the groundwater and the river two additional hydrographs are provided for monitoring points at this site. The hydrograph in the middle of Figure 3.4-15 presents the well data and adjacent stream data for the upstream location, while the lowermost hydrograph on the figure shows the data from the downstream location. Throughout the high-runoff period, groundwater levels in the wells immediately adjacent to the river are about equal to or slightly higher in elevation than the stream level.

Data from Well FRW-1 (upstream) show groundwater levels remain slightly higher than or about equal to the stream level – before, during and after the peak stream flow. Although the stream level increased because of the snowmelt runoff in June 2011, the groundwater level also rose and remained slightly above the adjacent stream level. This indicates groundwater flow into the river (groundwater discharge) throughout the high runoff period.

Recall that the data from the low-flow season (October 2010) also indicate groundwater flow toward the river.

Groundwater levels in Well FRW-3 (downstream) show a temporal pattern similar to the upstream monitoring points. Groundwater levels remain about equal to the stream level as the river rises due to increasing snowmelt runoff, peaks, and declines with diminishing runoff. Uphill from this well to the west there is a substantial wetland area. The ground surface in the wetland lies about 2-5 feet higher in elevation than the highest stream level. As there is no visible surface water drainage into that area, the marshy and boggy conditions in this wetland are attributable to groundwater discharge. Groundwater flows toward this area from recharge areas in uplands further west of the river, which is consistent with the groundwater level data provided by the USGS (Apodaca and Bails 1999) and the data collected by URS in October 2010 (described in previous section).

Figure 3.4-16 contains hydrographs of the monitoring data from the St. Louis Creek study site. As before, the upper hydrograph shows the water level data from all three monitoring wells and the two stream level measurement points. The middle hydrograph presents the data for the upstream monitoring points and the bottom hydrograph on the page shows the data from the downstream locations. Similar to the other study sites, the groundwater levels are substantially higher in elevation than the nearby stream level throughout the high-runoff period. Data from these wells show that the groundwater level in June 2011 was about 6 to 9 feet higher than in October 2010. These seasonal groundwater level increases are attributable to direct infiltration of snowmelt in upland areas.

Data from Well SLW-3 (upstream) show groundwater levels remain more than 15 feet above the creek level throughout the high-runoff period. Groundwater levels in Well SLW-1 stayed about 30 feet higher than the nearby creek level. Although the creek level increased about 1-2 feet because of the snowmelt runoff in June 2011, the groundwater level also rose during the same period and remained substantially higher than the creek level. As is true at the other study sites, this indicates groundwater was flowing into the river (groundwater discharge) throughout the high runoff period. Note that the data from October 2010 show groundwater levels were higher than the creek, which indicates groundwater flow was also toward the creek in the low flow season.

Maps of the three study sites have been prepared using the data from the peak stream flow period to illustrate groundwater levels, hydraulic gradients, flow directions and the hydraulic relationships with the streams. Figure 3.4-17 shows the data from the Jim Creek area, Figure 3.4-18 shows the data from the lower Fraser Valley area, and Figure 3.4-19 presents the data from the St. Louis Creek area. These figures show that higher groundwater levels result in hydraulic gradients converge toward the streams, even though the stream levels are also higher. In all cases the data show that groundwater flow directions remain toward the streams, which is essentially the same pattern during the low-flow period (October 2010) described in the previous section. Thus these monitoring data indicate that groundwater flows toward and into the streams even during the peak runoff period. At several locations, the data are sufficiently definitive to show that groundwater flows into wetlands lying more than a few feet above the stream level.

Overall, the available data indicate that an active gravity-driven, topographically influenced groundwater flow system exists in the Fraser Valley drainage basin. Elevations of the

groundwater levels are closely related to the land surface elevations. Infiltration of precipitation and snowmelt causes groundwater recharge throughout the watershed. Consequently the spatial distribution of hydraulic gradients causes groundwater to flow away from upland areas and toward the stream valleys and lower-elevation portions of the watershed. In those lowlands, groundwater discharges from the ground surface at seeps and springs, and contributes to stream flows. Where groundwater levels approach the ground surface in the lowlands, groundwater is consumed by phreatophyte vegetation in riparian and wetland areas. Wetlands that occur more than a few feet above the seasonal high stream level are supported primarily by groundwater that is recharged by direct infiltration of snowmelt in upland areas.

Stream flow reductions attributable to this Project are described in Section 5.1 and Section 5.3. The potential changes in groundwater levels and recharge along the potentially affected stream segments are described in Section 5.4.

3.4.5.2 Williams Fork River

The Williams Fork River watershed is located just east of the Fraser River Basin, also in Grand County. Williams Fork Reservoir lies within the basin approximately 3 miles upstream of the confluence with the Colorado River. Similar to the Fraser River Basin, snowmelt during April to July is the primary source of surface water runoff, stream flow, and groundwater recharge.

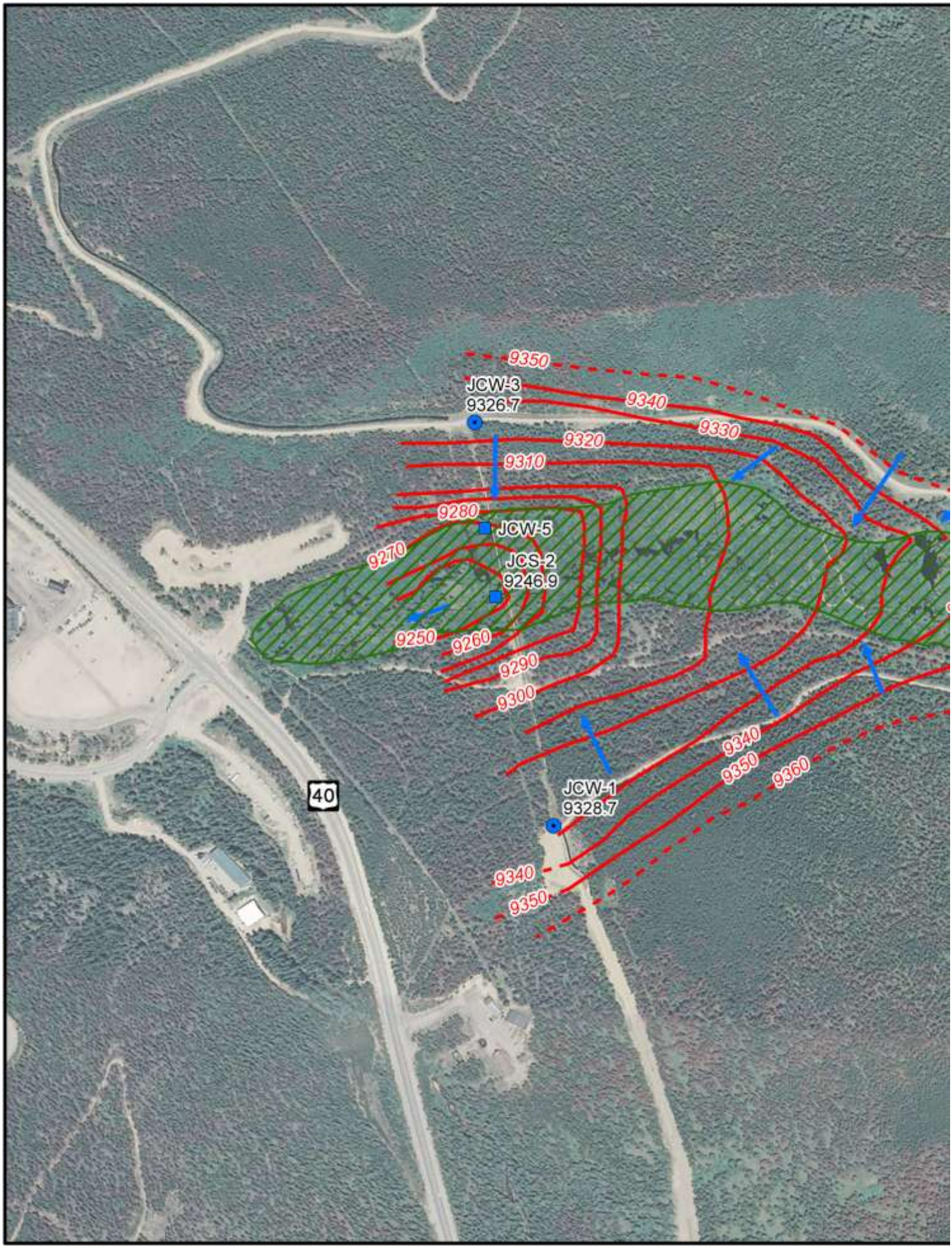
A review of the SEO water well database indicates that there are essentially no water wells in the upper portion of the Williams Fork River watershed, except two wells that are located at campgrounds within 1,000 feet of the river.

This sub-basin includes the watershed area from the upper boundary of the watershed to the gage just below Leal, about 90 square miles. Many of the components were calculated simply by scaling of relative areas from the Fraser River Basin values because watershed-specific data are not available.

On Figure 3.4-20, the Williams Fork watershed is subdivided to show the areas that would not be affected by, and the other areas that could potentially be affected by the Proposed Action. The existing Denver Water diversion structures are shown as red dots. The blue area of this map lies upstream of the Denver Water stream diversion points. This area includes some of the highest land surface elevations, precipitation rates, and snowpack amounts.

The brown area of Figure 3.4-20 does not lie downstream of any Denver Water diversion points. Stream segments within the blue and brown areas on this map, which are depicted with light blue lines, are also not downstream of any Denver Water diversion points. Likewise, the rate of groundwater discharge into those stream segments would not change. Areas outside the stream channels in the white area of this map are also not downstream of the diversion points, and thus are not potentially affected by the Proposed Action.

On the other hand, the proposed diversions could affect groundwater immediately adjacent to the streams in areas downstream of the Denver Water diversion structures. These potentially-affected stream channel segments within the Williams Fork watershed are shown as golden brown lines on Figure 3.4-20.


9350
JCW-3
9326.7
9340
9330
9320
9310
9280
JCW-5
9270
JCS-2
9246.9
9250
9260
9290
9300
40
JCW-1
9328.7
9340
9350
9360
9340
9350

Stream Level Survey Elevation
Well Location
Water Table Contour Elevations (ft msl) (June 2011)
Inferred Water Table Contour Elevations (ft msl) (June 2011)
Groundwater Flow Directions
Approximate Area of Wetland
Diversion

References:
Aerial photography from USDA (2009).

Diversions from Denver Water (2002).

Note:
Groundwater and stream level elevations shown are for peak stream flow conditions measured June 30, 2011.

N
W E
S

500 0 500 Feet

1:6,000

Moffat Collection System Project FEIS

Figure 3.4-17
Water Levels, Jim Creek Area

9/4/12

FRW-3 FRS-2
8377.5 8377.5
8380
8390
40
Wetland
FRW-1
8396.6
Wetlan
FRW-2
8410.9
8410
Upland

Stream Measurement Location
Well Location
Water Table Contour Elevations (ft msl) (July 2011)
Inferred Water Table Contour Elevations (ft msl) (July 2011)
Groundwater Flow Directions
Approximate Edge of Wetland

Reference:
Aerial photography from USDA (2009).

Note:
Groundwater and stream elevations shown are for peak stream flow conditions measured July 7, 2011.

N
W E
S

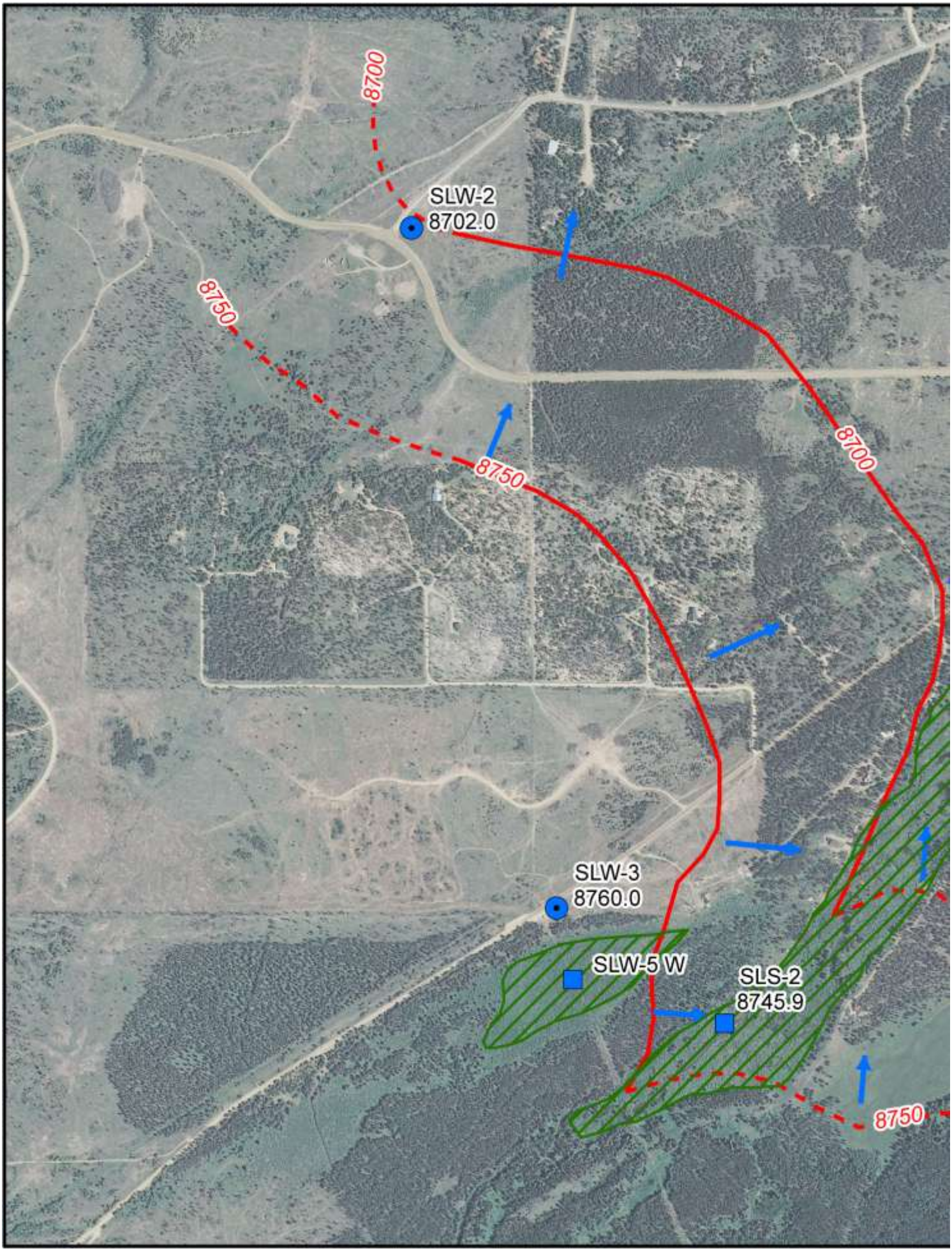
500 0 500 Feet

1:6,000

Moffat Collection System Project FEIS

Figure 3.4-18
Water Levels, Lower Fraser River Area

9/4/12


8700
SLW-2
8702.0
8750
8750
8700
SLW-3
8760.0
SLW-5 W
SLS-2
8745.9
8750

Stream Measurement Location

Well Location

Water Table Contour Elevations (ft msl) (July 2011)

Inferred Water Table Contour Elevations (ft msl) (July 2011)

Groundwater Flow Directions

Approximate Area of Wetland

Reference:
Aerial photography from USDA (2009).

Note:
Groundwater and stream elevations shown are for peak stream flow conditions measured July 13, 2011.

N
W E
S

700 0 700 Feet

1:8,400

Moffat Collection System Project FEIS

Figure 3.4-19
Water Levels,
St. Louis Creek Area

9/4/12

Williams Fork River
N
W
E
S
3
0
3
Miles
1:190,080
Denver Water Diversions
Stream Reaches Downstream of Denver Water Diversions
Williams Fork Basin
Watershed Area Upstream of Denver Water Diversions
Watershed Area Not Downstream of Denver Water Diversions
Watershed Area Contributing to Streams Downstream of Denver Water Diversions
Williams Fork Reservoir
Williams Fork River
Other Streams
Reference:
Diversions from Denver Water (2002).
Moffat Collection System Project FEIS
Figure 3.4-20 Williams Fork Watershed Areas
9/4/12

3.4.5.3 Upper Colorado River

The headwaters of the Colorado River are near the Continental Divide in Grand County and the river flows generally to the west. Major tributaries to the upper portion of the Colorado River include the Fraser River, Willow Creek, Williams Fork River, Troublesome Creek, Muddy Creek, and the Blue River. This portion of the Colorado River and its tributaries exhibit large seasonal fluctuations in stream flow. A majority of the flow results from snowmelt, and it has been estimated that about 75% of the annual flow is provided during the spring runoff period (NWCCOG 2002).

Groundwater quality of the alluvial aquifer in the Colorado River Basin is influenced by local geology and discharge of mineralized water from hot springs at some locations. The concentrations of dissolved solids, sulfate, sodium, magnesium, manganese, calcium, and chloride are elevated downstream of hot spring discharges (e.g., Hot Sulphur Springs). Additionally, irrigation return flows increase concentrations of dissolved solids as the water moves down the basin (CGS 2003).

The alluvial aquifer along the Colorado River Basin is mainly utilized for agriculture. Approximately 1,370 alluvial wells with an average depth of 72 feet bgs are included in the SEO well database. The alluvium is thin and discontinuous in the mountainous portions of the basin and thickens in the lower reaches (CGS 2003).

3.4.5.4 Blue River

The Blue River watershed is located mainly in Summit County and includes approximately 680 square miles of drainage area. The Blue River between Dillon and Green Mountain reservoirs flows through alluvium underlain by the Pierre Shale Formation. The following description of the affected environment, including the hydrologic budget, applies to the sub-watershed that lies between (but not including) the two reservoirs.

As with the other mountain watersheds described previously, most of the annual stream flow in the Blue River results from snowmelt during the spring. Thunderstorms also contribute to stream flow during the summer months. Low flows in the tributaries and main branch of the Blue River are sustained by groundwater. It has been estimated that discharge from groundwater systems contribute approximately 25% of the total surface water flow (NWCCOG 2002).

A majority of the water supply systems in the Blue River watershed that serve more than 25 people are reliant upon groundwater (NWCCOG 2002). Based on the well records contained in the SEO database, most of the water wells in the sub-watershed area along the Blue River are located near the larger established communities (e.g., Silverthorne, Dillon). The wells are generally within 0.5 mile of the river and are at elevations higher than the river channel.

3.4.5.5 South Boulder Creek

South Boulder Creek flows eastward from its headwaters just east of the Fraser River watershed. South Boulder Creek is a tributary to Boulder Creek and is part of the Platte River Basin system. Gross Reservoir is located approximately half-way between the

headwaters and the mouth of the river (refer to Section 3.4.1.1 for a description of Gross Reservoir).

The Boulder valley, which includes South Boulder Creek, exposes approximately 10,000 feet of folded and faulted sedimentary rock at the ground surface, but contains a thickness of less than 100 feet of alluvial deposits. The creek is dominated by water from snowmelt and summer thunderstorms, with highest flows during May to June and lowest flows in January and February.

There are about 30 groundwater users within a 0.5-mile corridor of South Boulder Creek between the outlet of the Moffat Tunnel to the inlet of Gross Reservoir. Additional water rights are located within this area, which rely on surface water or springs. Groundwater is mainly used as domestic water supply in this area (Denver Water 1998b). The water well database from the SEO indicates there are scattered water wells located proximal to the creek from the inlet of the Moffat Tunnel to Rollinsville. The area around Rollinsville has many water wells located up to 1 mile away from South Boulder Creek. Similar conditions exist around the towns of Pactolus, Lincoln Hills, and Pinecliffe, with some wells located along drainages to South Boulder Creek. A majority of the water wells found along this portion of South Boulder Creek are located around the towns of Wondervu and Crescent Village, south of Gross Reservoir. Additionally, communities near Retallack Gulch (north of Gross Reservoir) and Woods Gulch (east of Gross Reservoir) have many water wells listed in the database.

3.4.5.6 North Fork South Platte River and South Platte River

The alluvium found in the South Platte River valley is a major water supply aquifer in the area. This alluvial aquifer is hydraulically connected to both the underlying Denver Basin bedrock aquifer in the reach of the river between Denver and Greeley and to the surface water, classifying the groundwater resource as tributary water (USGS 1995; CGS 2003). Approximately 12,000 alluvial wells were on record for this river basin (CGS 2003). In the lower portion of the basin, the alluvium is thicker and more continuous, and the water supply wells average about 75 feet in depth (CGS 2003).

Along the North Fork South Platte River, there are scattered water wells as indicated in the SEO water well database. Most of the wells are located within 2,000 feet of the river and near the communities and small towns adjacent to the river (e.g., Grant, Santa Maria, Weller, Singleton, Shawnee, Glenisle, Insmont, Estabrook, and Riverview). There is a larger number of wells near the towns of Bailey and Pine/Crystal Lake, generally within 1 mile of the river.

Groundwater quality in the mountainous areas of the basin is generally better than groundwater in the plains areas. Concentrations of radon in samples collected in the mountains are higher than concentrations detected in plains groundwater samples due to the natural sources of radon (i.e., water from the crystalline bedrock) in the mountains.

3.5 GEOLOGY

3.5.0 Overview

Geologic features are described for each study area related to topography, lithology, geologic structures, geologic resources, and potential geologic hazards.

3.5.1 Reservoirs

3.5.1.1 Gross Reservoir

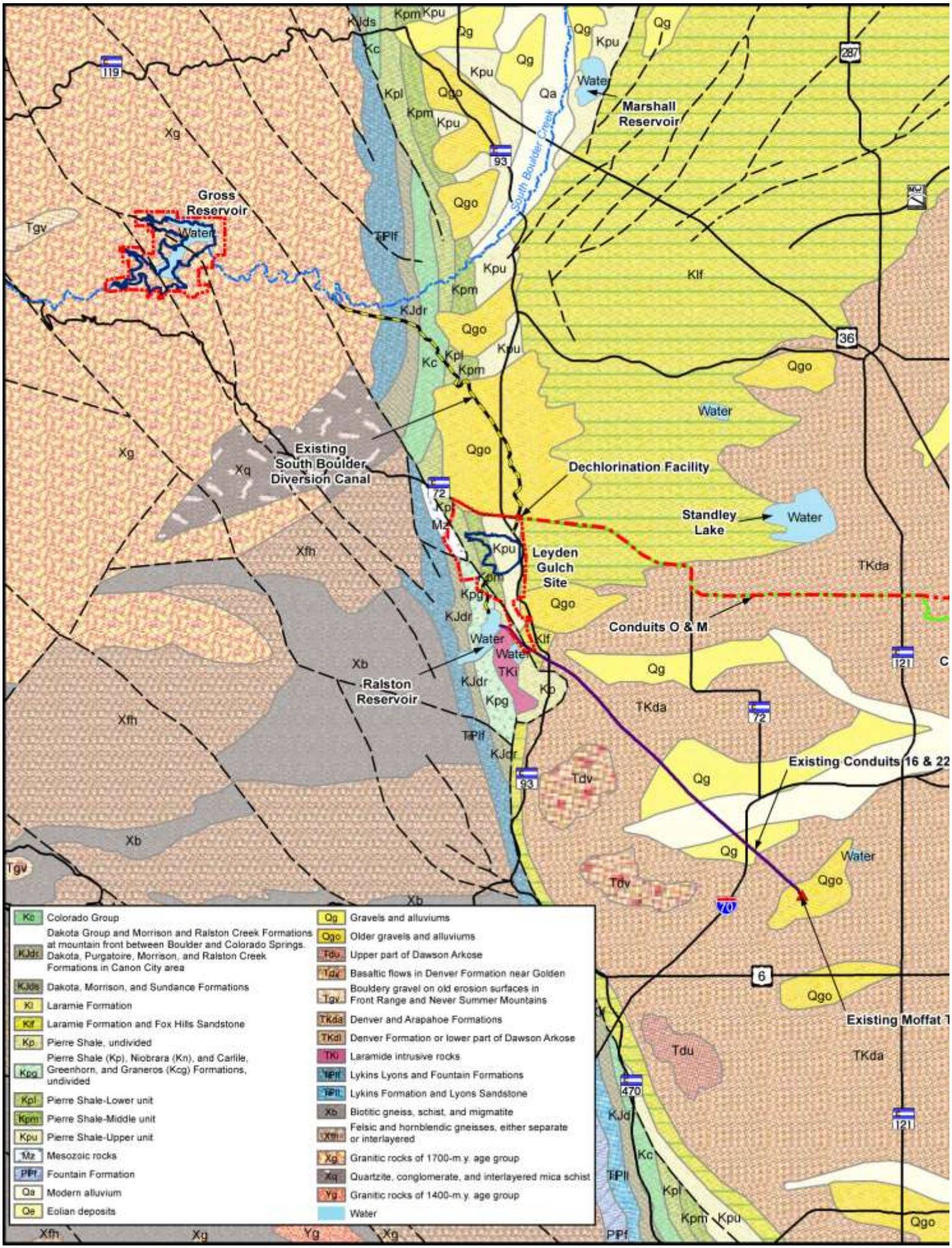
Topography

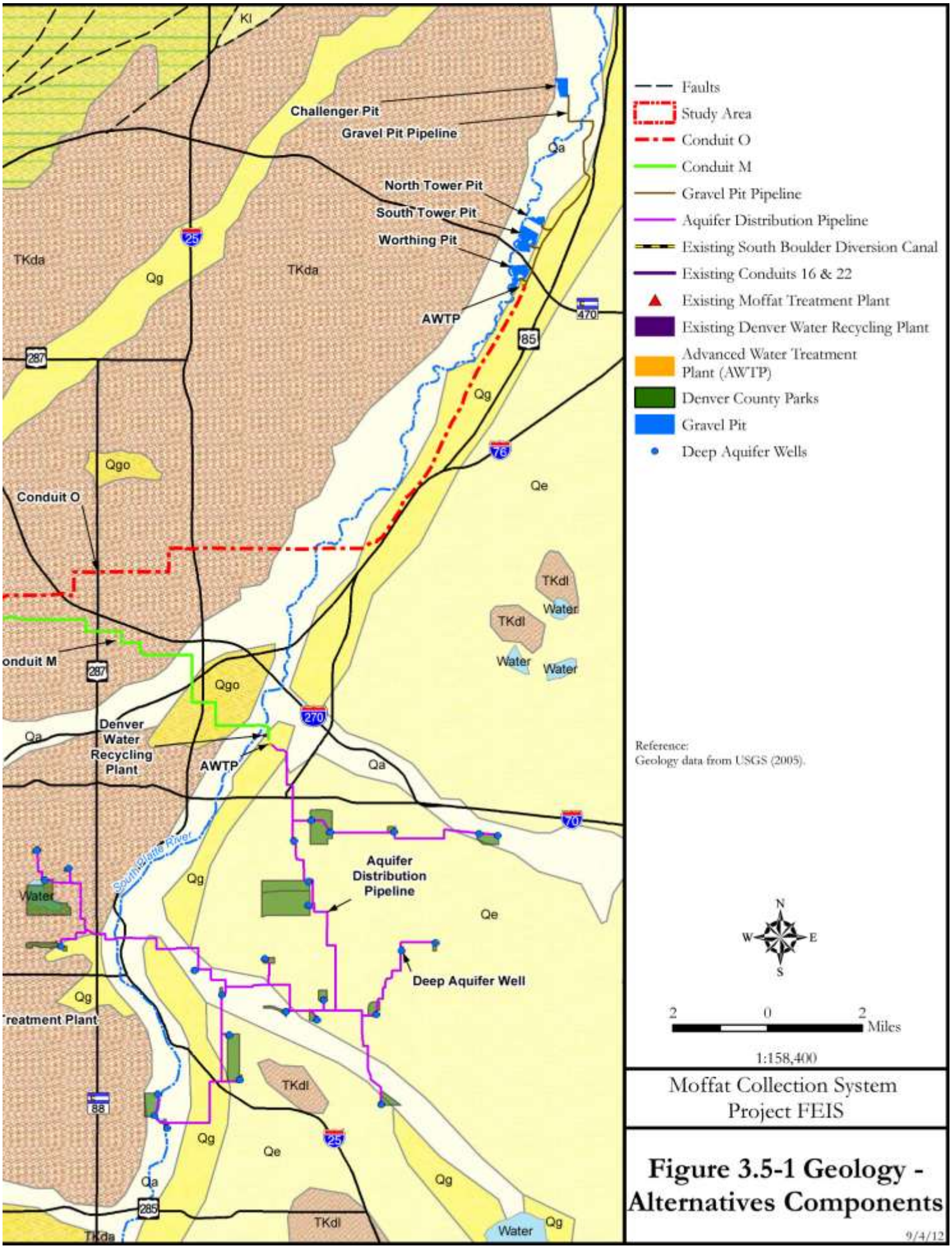
Gross Reservoir is located on the eastern slope of the Colorado Rocky Mountain Front Range, in the rugged South Boulder Creek Canyon, which contains narrow V-shaped valleys that have steep slopes (50 percent [%] and greater in places) and small areas of relatively flat topography. Numerous near vertical cliffs, up to a few hundred feet high, exist at the site. Ridges between the valleys and higher areas have more gentle slopes and some relatively small flat areas. Stream valley bottoms are steep, narrow, and filled with boulders.

Lithology

Lithology refers to the general physical character and description of rocks. Bedrock at Gross Reservoir consists almost entirely of Precambrian Boulder Creek granodiorite (Figure 3.5-1). The granodiorite is a pink, medium to coarse grained, hard, and strong intrusive igneous rock that crops out over large areas of Gross Reservoir. South Boulder Creek Canyon has near vertical cliffs hundreds of feet high composed entirely of the granodiorite. In high areas on the canyon slopes and along ridges above the canyon there are areas of highly weathered and decomposed granodiorite. Locally, the decomposed granodiorite extends tens of feet into the bedrock and is typically weathered to greater depths along joints and shears. Numerous corestones (a portion of the rock mass that remains unweathered) form in the decomposed granodiorite because rock located between joints and shears does not weather as rapidly as the surrounding non-decomposed granodiorite. The result is large, rounded, and relatively unweathered blocks of granodiorite or corestones surrounded by the soil-like decomposed granodiorite. In some areas the decomposed rock has been eroded and carried away, leaving behind surfaces covered by large boulders or corestones.

Portions of Gross Reservoir contain a relatively thin cover of soils, colluvium, talus, and alluvium. The soils at Gross Reservoir are typically gravelly, stony, and cobbly sandy loams often only a few inches thick that grade into the underlying highly weathered and decomposed bedrock. Colluvial deposits have formed in areas where weathered materials accumulate and consist of the same previously described soils, but with variable amounts of large boulder-sized rock fragments. Talus deposits are similar to colluvium but consist mostly of gravel to large boulder-sized rock fragments and sand-sized matrix materials. Relatively small alluvial deposits of sands and gravels accumulate in stream valley bottoms, and often interfinger with colluvium on adjacent valley slopes.


Gross Reservoir
Marshall Reservoir
South Boulder Creek
Existing South Boulder Diversion Canal
Dechlorination Facility
Standley Lake
Leyden Gulch Site
Conduits O & M
Ralston Reservoir
Existing Conduits 16 & 22
Existing Moffat T
Kc Colorado Group
KJdr Dakota Group and Morrison and Ralston Creek Formations at mountain front between Boulder and Colorado Springs. Dakota, Purgatoire, Morrison, and Ralston Creek Formations in Canon City area
KJds Dakota, Morrison, and Sundance Formations
Kl Laramie Formation
Klf Laramie Formation and Fox Hills Sandstone
Kp Pierre Shale, undivided
Kpg Pierre Shale (Kp), Niobrara (Kn), and Carlile, Greenhorn, and Graneros (Kcg) Formations, undivided
Kpl Pierre Shale-Lower unit
Kpm Pierre Shale-Middle unit
Kpu Pierre Shale-Upper unit
Mz Mesozoic rocks
PPf Fountain Formation
Qa Modern alluvium
Qe Eolian deposits
Qg Gravels and alluviums
Qgo Older gravels and alluviums
Tdu Upper part of Dawson Arkose
Tdv Basaltic flows in Denver Formation near Golden
Tgv Bouldery gravel on old erosion surfaces in Front Range and Never Summer Mountains
TKda Denver and Arapahoe Formations
TKdl Denver Formation or lower part of Dawson Arkose
TKi Laramide intrusive rocks
TPlf Lykins Lyons and Fountain Formations
TPll Lykins Formation and Lyons Sandstone
Xb Biotitic gneiss, schist, and migmatite
Xfh Felsic and hornblendic gneisses, either separate or interlayered
Xg Granitic rocks of 1700-m.y. age group
Xq Quartzite, conglomerate, and interlayered mica schist
Yg Granitic rocks of 1400-m.y. age group
Water



Moffat Collection System Project FEIS

Figure 3.5-1 Geology - Alternatives Components

9/4/12

Geologic Structures

Geologic structures at Gross Reservoir include faults, shears, joints, veins, and dikes. Faults and shears typically consist of a zone of fractured rock, often intensely fractured, that surrounds one or more clayey to breccia-filled gouge zones. Two of the largest geologic structures located within the reservoir, the Livingston and Copeland faults, are related to the Rogers Fault, which is a northwest trending, steeply dipping fault with a trace length of approximately 20 miles (Gable 1972; Wells 1967). The rock mass at Gross Reservoir also contains numerous smaller faults and shears that formed during numerous mountain building periods since the Precambrian granodiorite was emplaced. The rock is also jointed, with variable orientations, but typically with two nearly vertical joint sets and one low angle joint set. Thus, the rock mass has a blocky appearance due to the three dimensional interconnected jointing that allows the rock to part into blocks of rock. Areas consisting of massive rock outcrops often also contain exfoliation joints that form parallel to the surface of the outcrop and extend a few feet to tens of feet into the rock mass. Exfoliation weathering produces large tabular blocks of rock that separate from the rock mass and may slide off steeper slopes. The rock mass contains numerous veins, often quartz filled, that range from strong to weak and may form discontinuities. Dikes composed of pegmatite, granodiorite, and quartz monzonite, were also formed as the granodiorite was repeatedly intruded. The youngest intrusive dikes are Tertiary in age.

Geologic Resources

Potential gravel and rock resources associated with bedrock outcrops exist at Gross Reservoir, but are not currently being exploited at Gross Reservoir because other similar sources of gravel and rock are located much closer to markets in cities along the Front Range. The resources might be used as a local source of borrow for roller-compacted concrete gravel-sized aggregate, required for construction of the proposed dam raise. Decomposed granodiorite might also be used as a local source of sand-sized aggregate required for the roller-compacted concrete.

Geologic Hazards

Geologic hazards at Gross Reservoir include erosion and rock fall potential. The Rogers Fault is not considered to be potentially active (Kirkham and Rogers 1981).

The rim of Gross Reservoir consists of weathered granodiorite that, with the overlying colluvium, soils, and rock fragments, is prone to erosion. Within the reservoir area, rock fall potential is present at numerous granodiorite outcrops located along and above the rim of the reservoir. The nearly vertical cliffs (300 to 400 feet high) and loose material at the dam site create rock fall potential due to ice wedging, blasting, sliding, etc.

3.5.1.2 Leyden Gulch Reservoir Site

Topography

The Leyden Gulch site is located at the junction between the relatively flat to gently rolling topography of the Great Plains Physiographic Province and the rugged topography of the Rocky Mountain Physiographic Province. The site is situated in a relatively small, broad,

open valley surrounded by flat to gently rolling dissected alluvial fans and hogbacks. Areas along the proposed reservoir rim are about 50 feet high and slopes range from 8 to 35%. Some relatively steep slopes are located in areas underlain by sandstone.

Lithology

The Leyden Gulch site contains several types of surficial deposits usually less than 10 feet thick that include soils, slopewash, landslide deposits, colluvium, and alluvium. These materials typically consist of clays that have accumulated as the surrounding shale bedrock is weathered. The clays may contain a trace of sand to boulder-sized materials that occur as float on the valley slopes. The soils, slopewash, and colluvium (typically) gradually grade into the underlying shale bedrock. Recent alluvium is present in the bottom of the valley at Leyden Gulch and consists of clays with some interbedded sands and occasional cobbles and boulders. Portions of the alluvium interfinger with slopewash and colluvial soils that mantle the adjacent valley slopes. Slopewash and colluvial soils in conjunction with upper weathered claystone and shale bedrock often lead to landslides on steep slopes within the location of the proposed reservoir basin. The upper right abutment of the proposed dam contains a deposit of Pleistocene age Verdos Alluvium (5 to 40 feet thick), consisting of gravels, silt, and silty sands and possibly beds of volcanic ash. The northern margin of the proposed reservoir is located in Pleistocene age Rocky Flats alluvium that consists of 10 to 50 feet of boulders, cobbles, and gravels with some caliche (calcium carbonate) cementation (Van Horn 1972).

Bedrock at the Leyden Gulch site consists primarily of shale and sandstone of the Pierre Shale Formation (Figure 3.5-1). A relatively small portion of the proposed reservoir area is underlain by silty sandstone of the Hygiene Member of the Pierre Shale. The shale contains a cover of surficial deposits including soils, slopewash, colluvium, and alluvium; therefore, the bedrock is not exposed at most of the site. The shale includes both weathered and unweathered shale that can also be described as claystone because of the general lack of a fissile nature due to laminated or thin bedding in the rock. Weathered shale is typically yellow-brown to brown and intensely to closely fractured. The fractures are often open and form as weathering and drying of the rock occurs as the shale is exposed to air. Weathered shale was found to extend deep into the proposed dam abutments and reservoir rim slopes (URS 1999). Unweathered shale is typically gray to dark green, lacks fracturing, and has bedding visible due to variations in color. Unweathered shale is present below the water table and below the bottom of the valley at the Leyden Gulch site.

Geologic Structures

Geologic structures at the Leyden Gulch site include folds, faults, shears, bedding, jointing, and fracturing. The site also contains large geologic structures related to the margin of the Rocky Mountain and Great Plains physiographic provinces, including folds and faults that were formed as the Colorado Front Range was uplifted. Sedimentary beds were folded to a near vertical orientation and the Golden Fault formed in the sedimentary beds as thousands of feet of vertical movement occurred between the mountains and the margin of the Great Plains.

The relatively plastic and deformable sedimentary rocks at the Leyden Gulch site have allowed complex fold structures to form. Bedding within the claystone and shale of the

Pierre Shale Formation at the site ranges from 50 degrees to vertical and is related to large folds that formed in this area. In portions of the rock affected by thrust faults, the bedding may be overturned or folded as much as 120 degrees.

A complex system of faults formed as uplift occurred near the Leyden Gulch site, including the large Golden Fault, the principal fault along the Front Range (Van Horn 1972). Numerous other faults and shears are structurally related to the Golden Fault. The trace of the faults and shears in the claystone and shale are typically zones of fractured rock with clayey gouge and breccia. As the Front Range was uplifted and unloading occurred, a horizontal component of movement in the Precambrian rock overturned and folded the bedding of the Golden Fault to a near vertical orientation and consequently formed thrust faults. Faults, shears, and folding at the Leyden Gulch site are therefore complex, with numerous large faults bounded by blocks of rock that formed as the normal faults were overturned and thrust faults formed.

Claystone and shale at the Leyden Gulch site that are located below the water table are not weathered, are relatively massive, and contains some jointing and shears. Claystone and shale located above the water tables, however, are weathered and typically contain closely spaced fractures. The fractures are the result of drying, shrinkage, and formation of open fractures in the rock. The open fractures also promote weathering within the rock mass, to extend to depths of approximately 100 feet or more at Leyden Gulch (URS 1999).

Geologic Resources

Sand and gravel deposits in Rocky Flats and Verdos alluvium have been mined in areas adjacent to the Leyden Gulch site. Similar sand and gravel deposits exist in the Rocky Flats and Verdos pediment surfaces at the site. A potential borrow source for dam embankment construction is along the south margin of the Rocky Flats pediment, located along the north margin of the reservoir.

Geologic Hazards

There are no known geologic hazards associated with the existing land use of the Leyden Gulch site, although the potential for erosion and landslides exists with the highly weathered and fractured shale, colluvium, and soils. The faults at the site are not considered to be potentially active (Kirkham and Rogers 1981; URS 1999).

3.5.2 Conveyance Systems

3.5.2.1 Conduit M

Topography

Conduit M traverses generally flat to rolling topography from Rocky Flats, through Westminster residential areas, to the Clear Creek and South Platte River valleys. The conduit alignment crosses a few areas of local steep topography.

The western end of Conduit M extends along the broad east-sloping Slocum and Rocky Flats alluvial fan surfaces. Elevations range from about 6,200 feet at the western end of the conduit to about 5,700 feet at a point where the alignment leaves the alluvial fan and drops

into Leyden Creek valley. This portion of the alignment drops about 500 feet within a distance of approximately 4 miles. The eastward sloping alluvial fan surface is relatively flat and featureless with somewhat steeper local slopes between the two alluvial fan surfaces. Conduit M crosses a relatively steep (approximately 80 feet high) slope at the eastern edge of the Slocum alluvial fan surface as the alignment drops into Leyden Creek valley.

Conduit M traverses flat to rolling topography from Leyden Creek eastward across a low drainage divide and into Little Dry Creek, Clear Creek, and tributary valleys. Locally steep topography (10 to 30 foot high slopes) may exist along the proposed stream crossings within the Conduit M corridor. Additionally, Conduit M crosses a steep slope (approximately 40 to 50 feet high) along 58th Avenue as the proposed corridor drops into the bottom of the South Platte River valley.

Lithology

Geologic materials along Conduit M consist almost entirely of alluvial and soil deposits (Figure 3.5-1). A large portion of the corridor is located in Slocum, Verdos, and Rocky Flats alluvium, consisting of sand and gravel with some interbedded silt and clay. A portion of Conduit M contains a cover of surficial soil deposits including loess, eolian sand, and colluvium. In the Clear Creek and South Platte River valleys, Conduit M is underlain by recent alluvium consisting of sand and gravel with some interbedded silt and clay. Similar recent alluvium also occurs at Conduit M crossings at Dry Creek and its associated tributaries. Bedrock consisting of sandstone and conglomerate with some interbedded shale and claystone crops out at one location along the alignment (Figure 3.5-1); however, bedrock may be encountered in excavations that extend below the alluvium and soils.

Geologic Structures

Bedrock along Conduit M contains several geologic structures, including bedding, joints, fractures, shears, and faults. Bedding is common in the sedimentary rock and forms a discontinuity along portions of the rock that are composed of different types of sediment. Bedding typically has a roughly north-south strike and a dip up to 5 degrees to the east and is structurally related to the west side of the Denver Basin. The rock is typically jointed, especially the relatively brittle sandstone, with two nearly vertical joint sets oriented orthogonal to the bedding. Shale and claystone are typically not jointed, unless the rock has been weathered. Weathered shale and claystone are often intensely fractured as a result of drying in portions of the rock mass exposed to the air. The rock mass contains observable shears, but the amount and direction of movement may not be known; faults in the rock mass were not readily identified. The shears consist of fractured zones less than an inch to tens of feet wide and contain clayey gouge and breccia-filled zones surrounded by fractured rock. Some of the structures are thrust faults extending east into the otherwise relatively unfolded and faulted rocks along Conduit M from a highly folded and faulted zone located at the base of the foothills.

Geologic Resources

Geologic resources along Conduit M include a number of alluvial deposits composed of sand and gravel that could be mined. A large portion of the alignment is underlain by

alluvium. The deposits located at the east and west ends of the alignment, however, would likely be more economically attractive because they are larger and thicker. Alluvial deposits along the central portion of the alignment are located in developed urban areas.

At the east end of Conduit M, deposits of sand and gravel in recent alluvium in Clear Creek and the South Platte River valleys were being mined as of 2006. Portions of the alluvium remain in the bottom of these valleys and present potential economic resources for sand and gravel.

The western end of Conduit M crosses Rocky Flats alluvium, was being mined for sand and gravel in 2006. The alignment is located in areas underlain by similar sand and gravel deposits with potential economic value.

Geologic Hazards

No significant geologic hazards such as significant earthquake potentials or slope instabilities were identified. Geologic conditions to be addressed in typical Moffat Collection System Project (Moffat Project or Project) designs include potential weak sediments and soils, flooding, and collapsible soils. The weak materials include loose and saturated sandy alluvium at stream crossings, soft organic clays in abandoned stream channels, and soft weathered clayey bedrock and colluvium composed of weathered Pierre Shale Formation and the Denver Formation. The potential also exists for the alignment to cross areas with beds of wind deposited loess that may have the potential to collapse when wetted. The potential for flooding exists at the stream crossings.

3.5.2.2 Conduit O

Topography

The topography along the eastern portion of Conduit O is rolling to gently rolling in the urban areas of north Denver to generally flat to gently rolling in the South Platte River valley. The alignment crosses locally steep slopes at stream crossings. The western portion of Conduit O is the same as described for Conduit M in Section 3.5.2.1.

Lithology

Geologic materials along Conduit O (Figure 3.5-1) consist almost entirely of alluvium and soil deposits (Chase and McConaghy 1972). Some relatively short intervals of Conduit O contain a cover of surficial soil deposits including loess, eolian sand, and colluvium. In the South Platte River valley, Conduit O is underlain by recent alluvium consisting of sand and gravel with some interbedded silt and clay. Bedrock, consisting of sandstone and conglomerate with interbedded shale and claystone, does not crop out along Conduit O; however, bedrock may be encountered in excavations that extend below the alluvium and soils.

Geologic Structures

The geologic structures along Conduit O are generally the same as those described for Conduit M (Section 3.5.2.1), except for portions containing weathered shale and claystone. The weathered shale and claystone contains faults and shears and is typically intensely

fractured, often as a result of drying in portions of the rock mass exposed to the air. The rock mass also contains faults and shears. Most observations in the rock mass are described as shears because the amount and direction of movement may not be known. The shears consist of fractured zones less than an inch to tens of feet wide that contain clayey gouge and breccia-filled zones surrounded by fractured rock.

Geologic Resources

The western portion of Conduit O crosses Rocky Flats alluvium, which was being mined for sand and gravel in 2006. Additionally, Conduit O crosses sand and gravel deposits that may be economically viable. Geologic resources along the eastern portion of Conduit O include the alluvial deposits in the South Platte River valley, composed of potentially economic sand and gravel. The northeast end of the Conduit O is underlain by alluvium in the South Platte River valley. Relatively small areas mapped as having a cover of soil deposits are typically also underlain by similar alluvium. The potentially economic sand and gravel deposits are similar to those that have been mined in the Worthing, South Tower, and North Tower gravel pits, located further north in the South Platte River valley (Section 3.5.3). Some potential sand and gravel deposits are located in urban or industrialized developed areas, and therefore, probably are not economically viable deposits.

Geologic Hazards

The potential geologic hazards described for Conduit O are the same for Conduit M.

3.5.3 South Platte River Facilities

Topography

The topography in the South Platte River Facilities study area is generally flat to gently rolling, traversing some relatively flat areas along the south edge and in the middle of the South Platte River valley. The South Platte River Facilities study area contains locally steep slopes that may be 50 to 100 feet high in areas adjacent to the gravel pits.

Lithology

Geologic materials in the South Platte River Facilities study area consist almost entirely of alluvium and soil deposits (Chase and McConaghy 1972) (Figure 3.5-1). Some localized areas, however, contain a cover of surficial soil deposits including loess, eolian sand, and colluvium. The South Platte River valley is underlain by recent alluvium consisting of sand and gravel with some interbedded silt and clay. Bedrock consists of sandstone and conglomerate with interbedded shale and claystone covered by a layer of alluvium and soils and may be encountered in excavations that extend below the alluvium and soils, such as in the bottom of the gravel pits.

Geologic Structures

Bedrock in the South Platte River Facilities study area contains several types of geologic structures, including bedding, joints, fractures, shears, and faults. Bedding is common in the sedimentary rock and forms a discontinuity along portions of the rock composed of

different types of sediment. Bedding typically has a roughly north-south strike and a dip up to 5 degrees to the east, and is structurally related to the west side of the Denver Basin. The rock is typically jointed, especially the relatively brittle sandstone, with two nearly vertical joint sets oriented orthogonal to the bedding. Shale and claystone may not be jointed, unless the rock has been weathered. Weathered shale and claystone is typically intensely fractured, often as a result of drying in portions of the rock mass exposed to the air. The rock mass also contains faults and shears. Most observations in the rock mass are described as shears because the amount and direction of movement may not be known; faults in the rock mass are similar in appearance and indicate the amount and direction of movement. The shears consist of fractured zones less than an inch to tens of feet wide that contain clayey gouge and breccia-filled zones surrounded by fractured rock.

Geologic Resources

Geologic resources within the South Platte River Facilities study area include the alluvial deposits in the South Platte River valley, which is composed of potentially economically-viable sand and gravel. A large portion of the study area is underlain by alluvium in the South Platte River valley. Relatively small areas mapped as having a cover of soil deposits are typically also underlain by similar alluvium. The potentially economically-viable sand and gravel deposits are similar to those that have been mined in the Worthing, South Tower, and North Tower gravel pits. Some potential sand and gravel deposits are located in urban or industrialized developed areas in the South Platte River valley, and therefore not being mined.

Geologic Hazards

No significant geologic hazards such as significant earthquake potentials or slope instabilities were identified. Geologic conditions to be addressed in typical Project designs include potential weak sediments and soils, collapsible soils, and flooding. Weak materials in the study area include loose and saturated sandy alluvium at stream crossings, soft organic clays in abandoned stream channels, and soft weathered clayey bedrock and colluvium composed of weathered shale in the Denver Formation. In the existing gravel pits, slopes may only be marginally stable due to the weak materials. The potential also exists for alluvium to have a cover of wind-deposited loess that may have the potential to collapse when wetted. The potential for flooding exists along the South Platte River floodplain.

3.5.4 Denver Basin Aquifer Facilities

Topography

The topography associated with the well sites and the aquifer distribution pipeline alignments varies, depending on site conditions at locations within the City and County of Denver. Topography includes areas that are relatively flat, such as in valley bottoms, to rolling hills and sloping terrain in most of the area, to locally steep slopes. The proposed Advanced Water Treatment Plant (AWTP) is located on a relatively flat alluvial terrace located on a floodplain adjacent to the South Platte River.

Lithology

The proposed Denver Basin Aquifer Facilities occur in surficial soil deposits including loess, eolian sand, and colluvium. This portion of the South Platte River valley is underlain by recent alluvium consisting of sand and gravel with some interbedded silt and clay (Chase and McConaghy 1972). Bedrock of the Denver Formation, which underlies alluvium, consists of sandstone and conglomerate with interbedded shale and claystone. The foundation for the proposed AWTP would likely be located on alluvium; however, the possibility exists that bedrock may also be encountered in excavations. The injection wells would be drilled deep into the bedrock and completed in various sandstone aquifer units within the bedrock.

Geologic Structures

Bedrock underlying the alluvium may contain several geologic structures, including bedding, joints, fractures, shears, and faults, similar to the South Platte River Facilities study area (Section 3.5.3).

Geologic Resources

Geologic resources include a number of alluvial deposits composed of potentially-economic sand and gravel. Relatively large alluvial deposits underlay the South Platte River valley and tributary valleys, such as Cherry Creek and Clear Creek. Sand and gravel were being mined in these alluvial deposits at various locations in Denver in 2006. Many potential sand and gravel deposits are located in urban areas but are not mined.

Geologic Hazards

No significant geologic hazards such as significant earthquake potentials or slope instabilities were identified. Geologic conditions to be addressed in typical Project designs include potential weak sediments and soils, flooding, and collapsible soils for the Denver Basin Aquifer Facilities. In excavations made for the building foundations, weak materials may be encountered. The weak materials may include loose and saturated sandy alluvium at stream crossings, soft organic clays in abandoned stream channels, and soft weathered clayey bedrock and colluvium composed of weathered shale in the Denver Formation. The potential also exists for the alluvial terrace to have a cover of wind-deposited loess that may have the potential to collapse when wetted. The potential for flooding exists on the stream terrace.

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3.6 SOILS

3.6.0 Overview

Information on soils in the Moffat Collection System Project (Moffat Project or Project) area was gathered from literature review, electronic data sources, and agency coordination. Soil descriptions were obtained from published soil surveys for Adams, Boulder, and Jefferson counties. Soil information for the Denver Basin Aquifer Facilities was obtained through coordination with the Natural Resources Conservation Service (NRCS). Additionally, Geographic Information System specialists acquired spatial and attribute data from the NRCS and the U.S. Forest Service (USFS). Detailed information on soils within the Project area is located in Appendix F.

3.6.1 Reservoirs

3.6.1.1 Gross Reservoir

The upland areas at Gross Reservoir consist of gravelly, stony, and cobbly sandy loam shallow soils. The stream terraces, drainageways, alluvial fans, and floodplains consist of gravelly loam, sandy clay loam, and silt loam soils (Escobedo 2005; NRCS 1975, 2005a).

Gross Reservoir and the surrounding areas have a thin cover of soils that grade into highly weathered or decomposed granitic bedrock. Rock outcrops and the presence of large boulders on the surface are also prevalent at Gross Reservoir. Rock outcrops are created when surface soils erode. The underlying subsoils are too fine grained to “cement” larger particles together; thus, the subsoils erode away leaving behind exposed areas of bedrock (Denver Water 2002b).

The steep slopes combined with the volatile weather patterns at Gross Reservoir create highly erosive soils that are prone to landslides. Localized areas of heavy recreational use also greatly contribute to soil loss. The Gross Reservoir Erosion Control and Rehabilitation and Restoration Plan (Denver Water 2002b) states that recreational activities on trails and roads has eroded tons of soil material into the reservoir, especially in areas where vehicles drive off designated roads, climb up steep slopes, and form deep ruts and depressions from their tires. Other potential soil limitations at Gross Reservoir include shallow depth to bedrock, areas of low strength, and areas of occasional flooding (Denver Water 1998b; NRCS 1975, 2005a; USFS 2005a).

A field visit was conducted in September 2005 to assess slope stability and erosion problems around Gross Reservoir. In general, the reservoir shoreline was stable with evidence of slight erosion indicated by exposed roots, bank sloughing, and exposed bedrock. Moderate to severe erosion, however, has occurred in areas where recreational activities have been concentrated, such as off-roading in the Winiger Ridge area. While the soils appeared to be relatively stable at the time of the field visit, removal of their protective vegetative cover would make them highly susceptible to erosion. No visible evidence of landslides or avalanches were identified during the field visit. Fallen rock from outcrops, however, does periodically occur as indicated by the presence of scattered boulders along the base of steep slopes and a “Falling Rock” sign posted on the Dam Access Road.

3.6.1.2 Leyden Gulch Reservoir Site

The uplands in the Leyden Gulch site generally consist of deep stony to cobbly sandy loam, clay loam, and clay soils. Alluvial fans, low terraces, and floodplains located in the study area contain loam and clay loam soils. Gravel pits and clayey pits are also present near the Leyden Gulch site as the result of mining operations that exposed substratums of soils, shales, and mudstones (NRCS 1980, 2004). Additionally, localized areas of exposed bedrock occur in the extreme southern portion of the Leyden Gulch site as well as on the hogback near State Highway 93 in the eastern portion of the study area (NRCS 1980, 2004). Topographic, geologic, and soils evidence of slope instability and landslide activity exist at the Leyden Gulch site (URS 1999). Other potential soil limitations at the site are water and wind erosion, shrink-swell clays, areas of low strength, shallow depth to bedrock, slippage, the presence of large stones, and occasional flooding (NRCS 1980, 2004).

3.6.2 Conveyance Systems

3.6.2.1 Conduit M

Soils in the western portion of Conduit M are located on hill slopes, ridges, terraces, and tablelands. These deep upland soils consist primarily of clay loam, cobbly sandy loam, and cobbly clay loam. The alluvial fans, drainageways, floodplains, and low terraces in the western corridor contain clay loam and loam soils. The eastern portion of Conduit M contains loam and sandy loam soils on gently sloping uplands, tablelands, and high terraces. The drainageways and low terraces next to streams and the South Platte River contain clay loam soils and thin, unconsolidated layers of clay and loam underlain by sand and gravel. The primary soil limitations of soils in the Conduit M corridor include shrink-swell potential, slight to severe water and wind erosion in unprotected areas, low strength, and shallow depth to bedrock. The eastern portion of Conduit M contains areas that, if irrigated, are classified as Prime Farmland by the NRCS (NRCS 1974, 1980, 2004, 2005b).

3.6.2.2 Conduit O

The soils located in the Conduit O corridor are generally the same as described for Conduit M, plus the soil types located along and near the South Platte River, which consist primarily of loam associated with nearly level terraces. Wet alluvial soils are present along the nearly level bottomlands of streams in the Conduit O corridor. Gently sloping to steep uplands located both east and west of the South Platte River consist of thin loam soils over shale. The primary soils limitations associated with Conduit O are slight to severe water and wind erosion, shrink-swell potential, steep slope, shallow depth to bedrock, low strength, occasional flooding, and potential corrosion in the upland soils. The eastern portion of Conduit O contains areas that, if irrigated, are classified as Prime Farmland by the NRCS (NRCS 1974, 1980, 2004, 2005b).

3.6.3 South Platte River Facilities

The proposed diversion structures and the construction staging areas for the South Platte River Facilities are located in disturbed areas classified as gravel pits by the NRCS. The Worthing and South Tower pits are also classified as gravel pits with earthen dams that

contain open water. The North Tower and Challenger pits are also classified as gravel pits containing open water in addition to clay loam terraces and sandy and loamy wet alluvial soils (NRCS 1974).

The gravel pit pipeline associated with Alternative 8a contains loam and clay soils on nearly level terraces, drainageways, and terrace escarpments. Terrace escarpments occur on steep slopes that border present or former streams, bottomlands, and floodplains. The primary limitations of these soils are occasional flooding and steep slopes with a lack of binder soil particles associated with the terrace escarpments. If irrigated, these soils are classified as Prime Farmland by the NRCS. Soils in the Alternative 13a gravel pit pipeline corridor are the same as those described for Alterative 8a, with the addition of loamy wet alluvial soils located near the Challenger Pit (NRCS 1974, 2005b).

3.6.4 Denver Basin Aquifer Facilities

The soils associated with the proposed Denver Basin Aquifer Facilities vary in accordance with the conditions at locations within the City and County of Denver. In general, Denver soils are clay, loam, and clay loam, with areas of very stony and very cobbly sandy loam. Most of the soils in this area are well drained, with localized areas where poor or excessive drainage occurs. The primary limitation of soils in Denver is high shrink-swell potential. Additionally, there is a potential for asbestos, radon, trichloroethylene, lead, and other heavy metals that contaminated soils from past activities (Weber 2006).

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3.7 VEGETATION

3.7.0 Overview

This section describes vegetation types, noxious weeds, and sensitive plant communities that exist in the Moffat Collection System Project (Moffat Project or Project) area. Wetlands and riparian vegetation are described in more detail in Section 3.8 and special status plant species are discussed in Section 3.10.

Vegetation Types

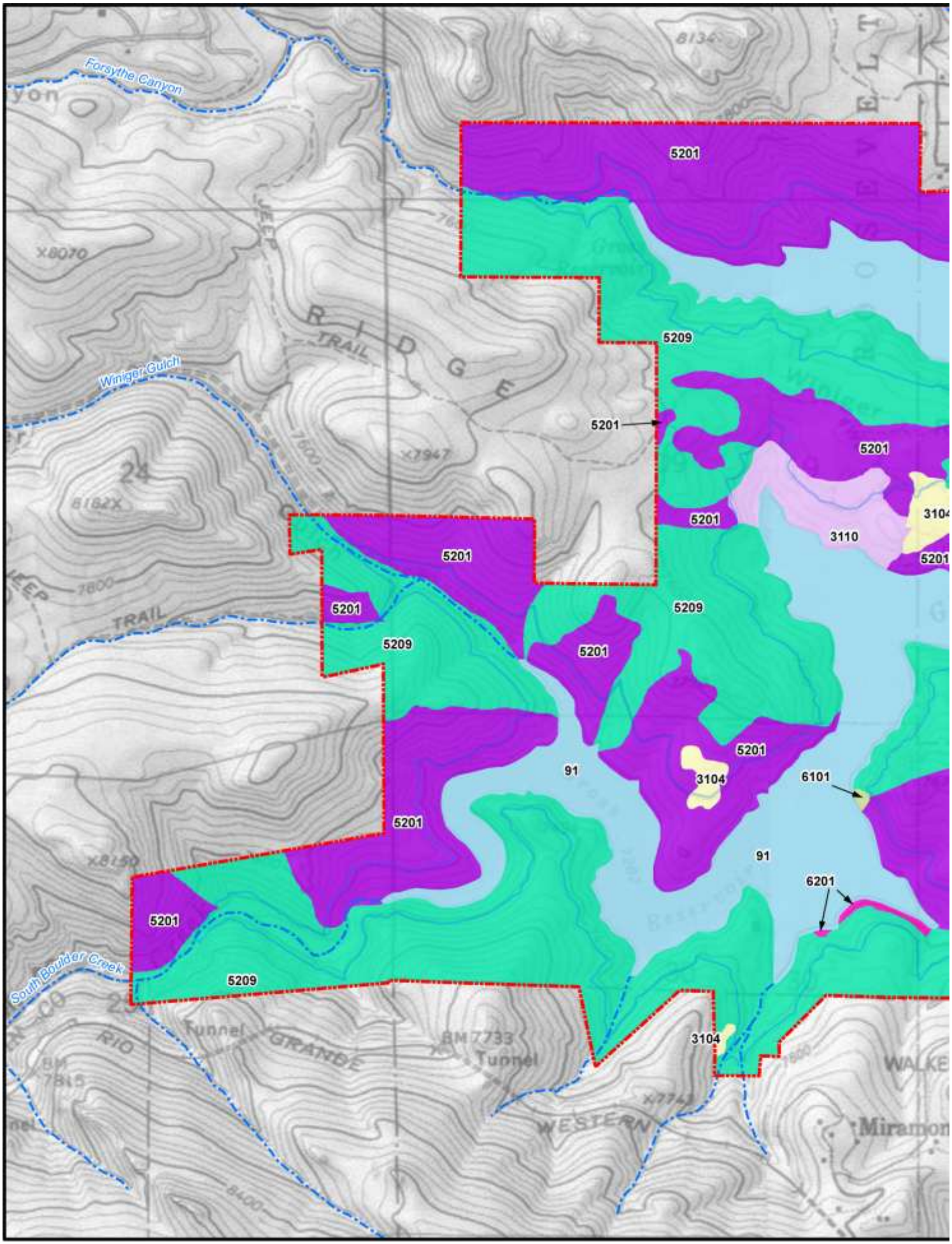
Vegetation in the Project area was surveyed and mapped in late August and September of 2005 and June of 2006. In areas of potential permanent disturbance, such as the reservoir sites and other aboveground facilities, the sites were traversed on foot to identify plant community associations and dominant species. Areas of temporary disturbance, such as conveyance facilities, were primarily observed by a vehicle reconnaissance. Areas of special interest identified during the vehicle reconnaissance, such as riparian communities, were also surveyed by foot. Observations of plant communities were compared with the cover type classification system used by the Colorado Natural Diversity Information Source, which is a hierarchical classification system based on A Land Use and Land Cover Classification System for Use with Remote Sensor Data (Anderson et al. 1976). The subsequent sections include the community type names and a discussion of the dominant species found during field assessments. Classification codes are shown on Figures 3.7-1 and 3.7-2.

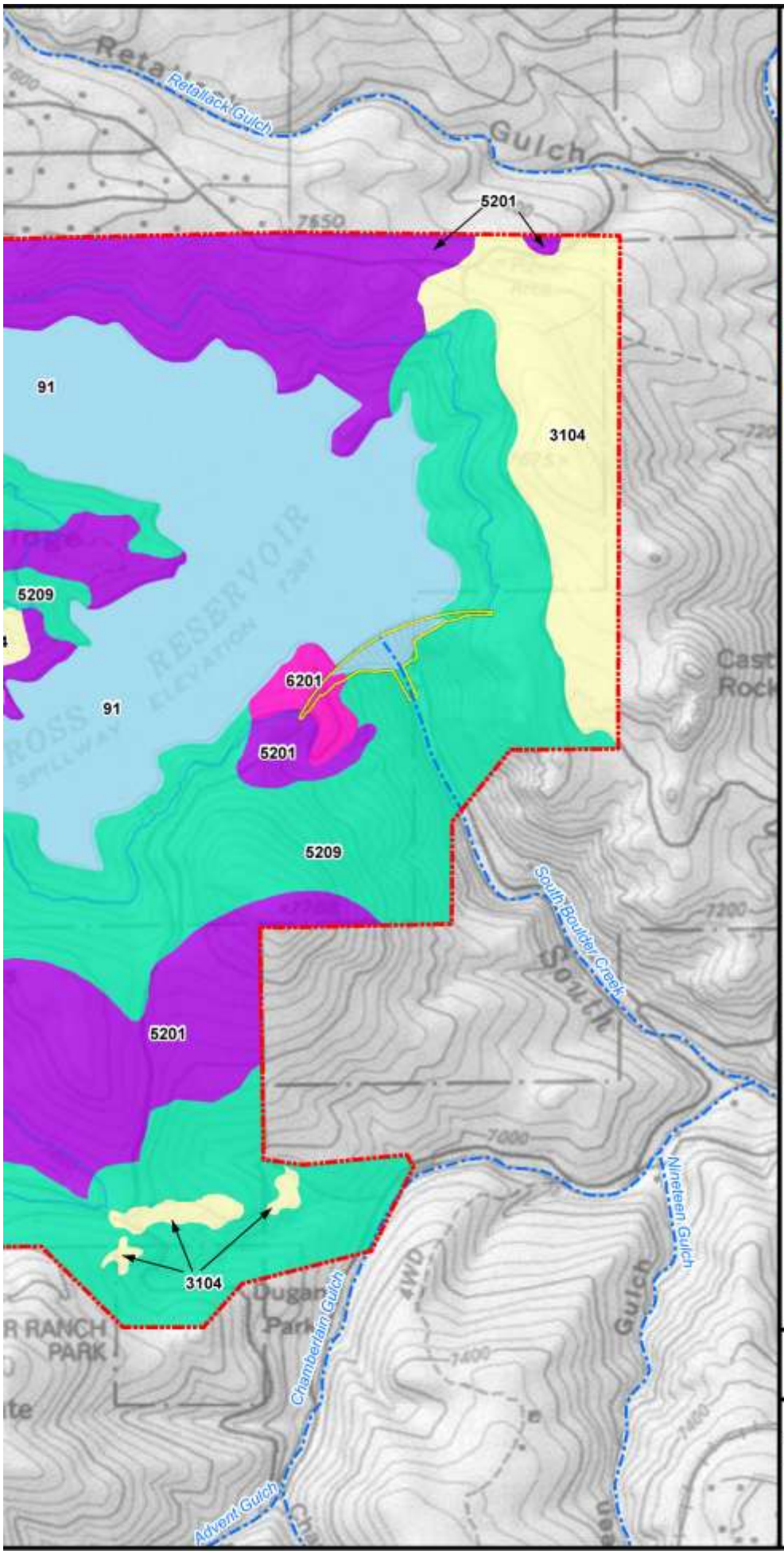
Noxious Weeds

Noxious weeds are plant species not native to Colorado that have negative impacts on crops, native plant communities, livestock, and/or the management of natural or agricultural systems. Noxious weeds are officially designated as such by the State of Colorado and/or individual counties. Management of noxious weeds is required under Executive Order (EO) 13112 – Invasive Species, State of Colorado EO D 006 99 – Development and Implementation of Noxious Weed Management Programs, and the Colorado Noxious Weed Act (Colorado Revised Statutes [C.R.S.] 35-5.5-101-119 C.R.S. 2003). The Noxious Weed Act requires all persons to use integrated methods to manage noxious weeds, if such plants are likely to be materially damaging to neighboring lands.

Under the Colorado Department of Agriculture's rules pertaining to the administration and enforcement of the Colorado Noxious Weed Act, State-listed noxious weeds are placed into one of three categories.

- List A species are designated for eradication, and require prevention of seed production or development of reproductive propagules; List A species are rare noxious weed species that can be prevented from establishing permanent populations in Colorado.
- List B species are managed by State noxious weed management plans with the goal of stopping the continued spread of these species.
- List C species are those for which the State, in consultation with other interested parties, will develop management plans with the goal of supporting jurisdictions that choose to require management of those species.


Forsythe Canyon
Winger Gulch
South Boulder Creek
RIDGE
TRAIL
5201
5209
3104
3110
91
6101
6201
Tunnel
GRANDE
RIO
WESTERN
Miramon



Grass/Forb Mix (3104)
Ponderosa Pine (5201)
Ponderosa Pine/Douglas-Fir Mix (5209)
Talus Slopes & Rock Outcrops (6101)
Disturbed Rangeland (3110)
Disturbed Soil (6201)
Standing Water (91)
Gross Reservoir Study Area
Gross Reservoir with Environmental Pool - 77,000 AF Enlargement
Dam Footprint
Stream/River

Reference:
1:24,000-scale quad maps originally from USGS (1972 & 1994) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Note:
Numeric codes represent general vegetative community type and/or dominant species and are based on "A Land Use and Land Cover Classification System for Use with Remote Sensor Data", Anderson et al. (1976).

N
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1,200 0 1,200 Feet

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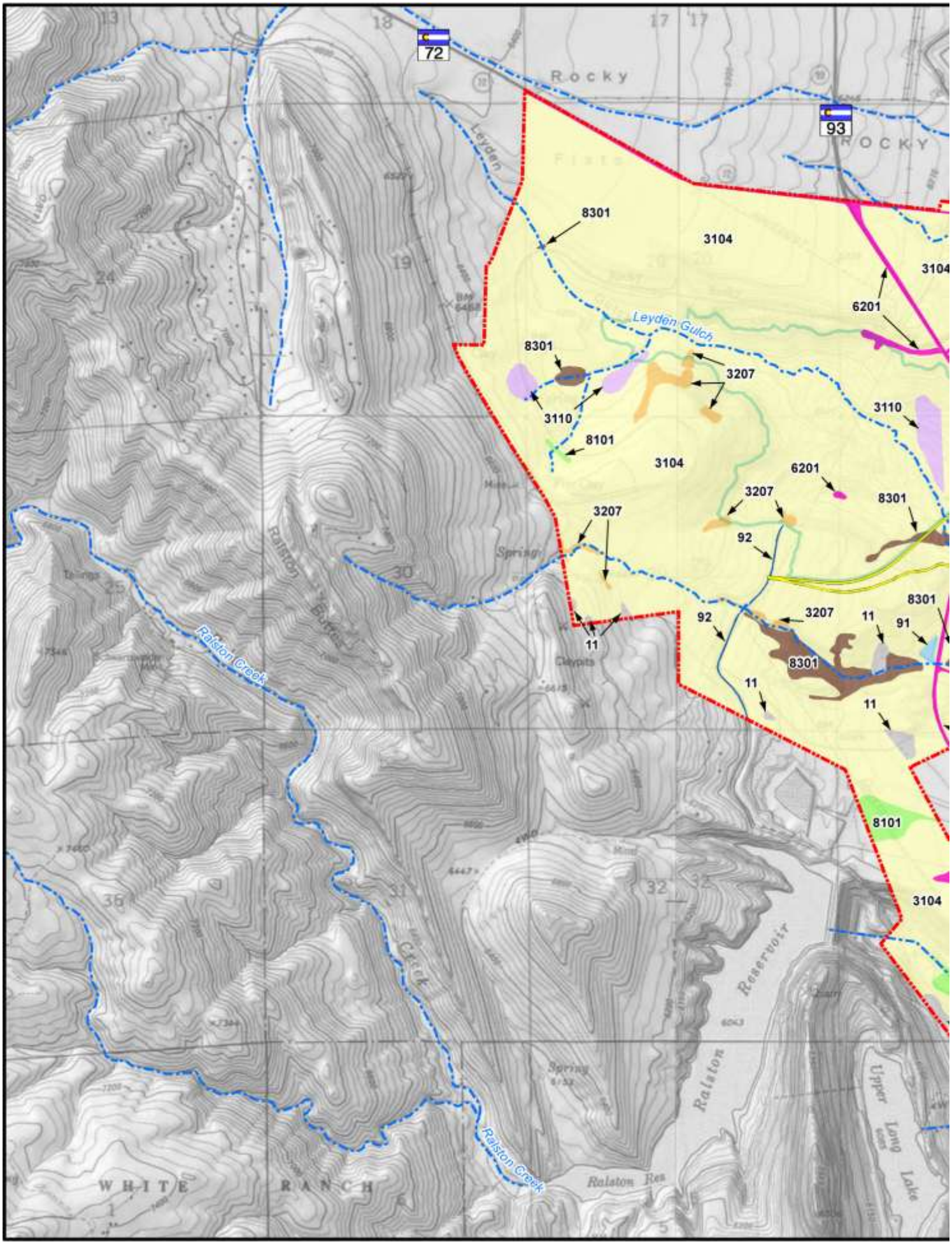
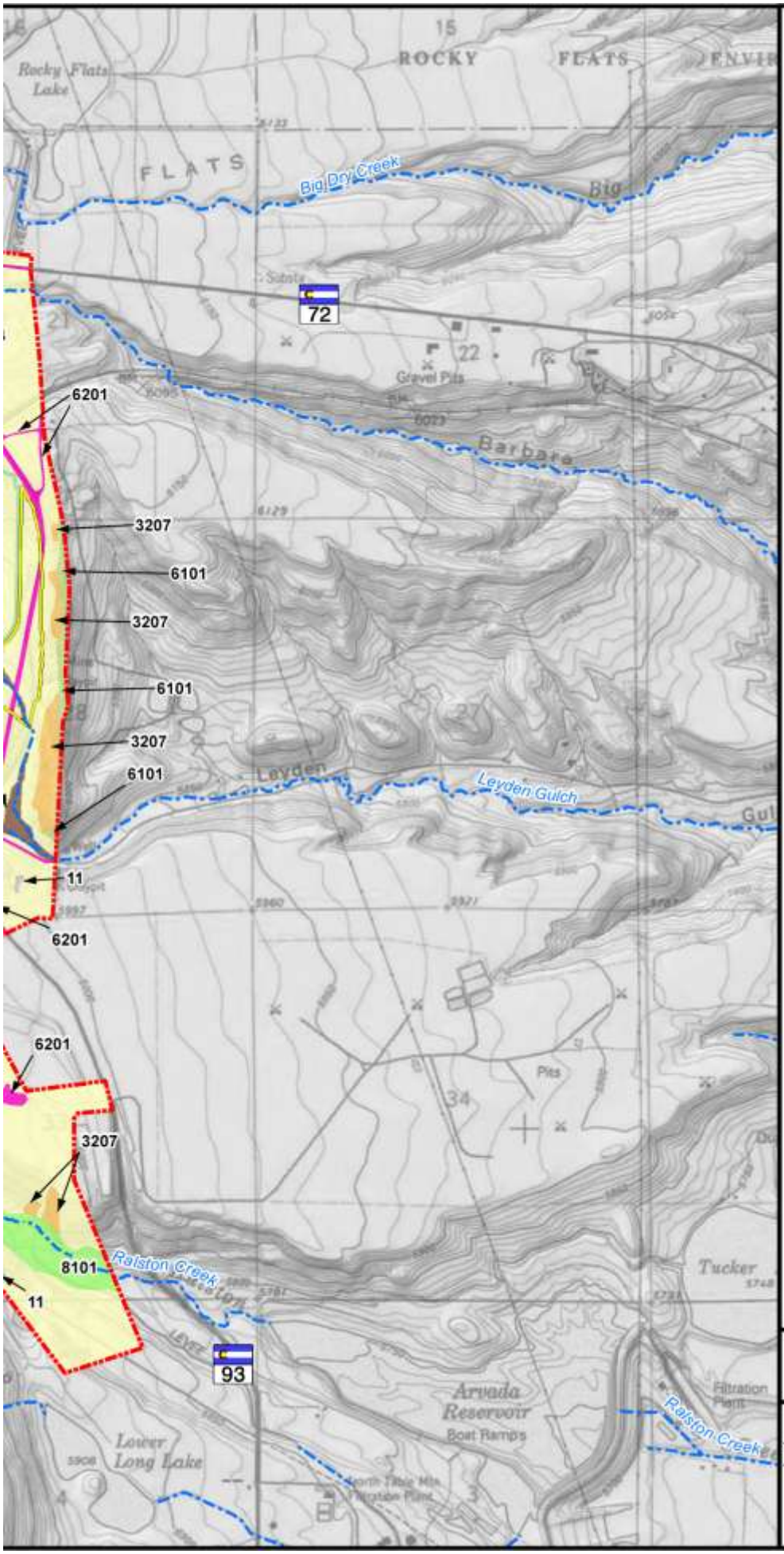
Moffat Collection System Project FEIS

Figure 3.7-1 Vegetation - Gross Reservoir

9/4/12


72
93
Rocky
ROCKY
Leyden
Leyden Gulch
8301
3104
6201
3207
3110
8101
92
11
91
Ralston Creek
Ralston Buttes
Spring
Clarpits
Ralston Reservoir
Upper Long Lake
Ralston Res
WHITE RANCH



Grass/Forb Mix (3104)
Forested Riparian (8101)
Herbaceous Riparian (8301)
Snowberry/Shrub Mix (3207)
Disturbed Rangeland (3110)
Disturbed Soil (6201)
Rural Residential (11)
Talus Slopes & Rock Outcrops (6101)
Running Water (92)
Standing Water (91)
Leyden Gulch Site Study Area
Leyden Gulch Site - 31,300 AF
Dam Footprint
Stream/River

Reference:
1:24,000-scale quad maps originally from USGS (1994) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Note:
Numeric codes represent general vegetative community type and/or dominant species and are based on "A Land Use and Land Cover Classification System for Use with Remote Sensor Data", Anderson et al. (1976).

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Moffat Collection System Project FEIS

Figure 3.7-2 Vegetation - Leyden Gulch Site

9/4/12

Each county and some cities in the Project area also maintain a list of noxious weeds that are of local priority to manage. Table 3.7-1 lists the noxious weeds observed in the Project area during field surveys, along with their State and county status and the areas where they were observed.

Table 3.7-1
Noxious Weeds Observed or Expected to be Present in the Project Area

Common Name	Scientific Name	Alternative Component					State List Category	County Lists*			
		Gross Reservoir	Leyden Gulch Site	South Platte River Facilities	Denver Basin Aquifer Facilities	Conduits M and O		Adams	Boulder	Denver	Jefferson
Bull thistle	*Cirsium vulgare*					E	B		√	√	
Canada thistle	*Cirsium arvense*	O	O	O	E	O	B	√	√	√	√
Cheatgrass (downy brome)	*Bromus tectorum*	O	O	O		O	C				
Common mullein	*Verbascum thapsus*	O	O	O	E	O	C				√
Common teasel	*Dipsacus fullonum*			O		O	B				√
Dalmatian toadflax	*Linaria dalmatica*	O	O				B	√	√	√	
Diffuse knapweed	*Centaurea diffusa*		O	O	E		B	√	√	√	√
Field bindweed	*Convolvulus arvensis*		O	O	E	O	C	√		√	
Hoary cress (whitetop)	*Cardaria draba*			E	E	E	B			√	√
Houndstongue	*Cynoglossum officinale*	O	O				B			√	√
Leafy spurge	*Euphorbia esula*			O	E	O	B	√	√	√	√
Musk thistle	*Carduus nutans*	O	O	E		E	B	√	√	√	√
Oxeye daisy	*Chrysanthemum leucanthemum*	O					B			√	√
Perennial pepperweed	*Lepidium latifolium*		O	E	E	O	B			√	
Plumeless thistle	*Carduus acanthoides*			E		E	B			√	
Puncture vine	*Tribulus terrestris*			O	E	E	C				
Poison hemlock	*Conium maculatum*		O	O	E	O	C				
Purple loosestrife	*Lythrum salicaria*			E			A	√		√	√
Quackgrass	*Elytrigia repens*		O	E		E	B				
Redstem storksbill	*Erodium cicutarium*			O		O	B				
Russian knapweed	*Centaurea repens*			E			B	√	√	√	√

Table 3.7-1 (continued)
Noxious Weeds Observed or Expected to be Present in the Project Area

Common Name	Scientific Name	Alternative Component					State List Category	County Lists*			
		Gross Reservoir	Leyden Gulch Site	South Platte River Facilities	Denver Basin Aquifer Facilities	Conduits M and O		Adams	Boulder	Denver	Jefferson
Russian olive	*Elaeagnus angustifolia*			O	E	O	B				
Salt Cedar (tamarisk)	*Tamarix parviflora, T. ramosissimum*			O	O	E	B	√			
Scotch thistle	*Onopordum acanthium*		O	O	E		B	√	√	√	√
Spotted knapweed	*Centaurea maculosa*						B	√	√	√	√
Yellow toadflax	*Linaria vulgaris*			E		E	B	√	√	√	√

Source: Colorado Department of Agriculture, 2006; 2005, 2006, 2010 Field Surveys for the Moffat Project EIS.
Notes:
*Only those counties where Project construction might occur are included in this table.
Alternative Components:
O = observed during 2005, 2006 and/or 2010 field surveys
E = expected to be present in the Project area, but not observed during field surveys
County Lists:
B = species managed by State noxious weed management plans with the goal of stopping the continued spread of these species
C = species for which the State, in conjunction with other interested parties, will develop management plans with the goal of supporting local governing bodies in implementing more effective integrated weed management

Sensitive Plant Communities

Sensitive plant communities are vegetation types that are subject to special regulations or that have been identified as rare or sensitive by government agencies. In the Project area, sensitive communities include riparian vegetation, wetland, and plant communities tracked by the Colorado Natural Heritage Program (CNHP). Information on riparian and wetland communities is discussed separately in Section 3.8, with a summary of species composition and locations provided in this section. Documented locations of CNHP plant communities in the Project area are also described in this section, where applicable.

3.7.1 Reservoirs

3.7.1.1 Gross Reservoir

In 2001, Federal Energy Regulatory Commission (FERC) renewed the license for the Gross Reservoir property. As part of the new license, FERC required that a Forest Management Plan be put in place as per Article 407 (Colorado State Forest Service 2005). Recommended forest management activities include thinning and prescribed burns. Noxious weeds are addressed in Article 406: Weed Management Plan (Denver Water n.d.b). Sensitive plant communities are managed according to Article 410: Plan to Protect Rare and Sensitive Plant Species (Denver Water n.d.c).

The Gross Reservoir study area is characterized by conifer forests, rangelands, riparian areas, and mountainous terrain. Upland vegetative communities in the Gross Reservoir study area include grass/forb mixed and disturbed rangelands, coniferous forest land, talus slopes and rock outcrops, disturbed soil, and standing water (Figure 3.7-1). Small areas of riparian vegetation are present, of which some areas have been identified as sensitive plant communities.

Grass/Forb Rangelands

The two types of grass/forb rangelands represented at Gross Reservoir are the grass/forb mix and disturbed rangeland.

The grass/forb mix community occurs primarily on the eastern shore of the reservoir, though small patches of this community frequently intermingle with the ponderosa pine (*Pinus ponderosa*) community. The boundaries between these communities are obscured by a high degree of vegetative similarity; the primary difference being the presence of a forested overstory in the ponderosa pine community. Shrubs, forbs and grasses occur in nearly equal proportions. Clumps of wax currant (*Ribes cereum*) and Fendler's ceanothus (*Ceanothus fendleri*) intermingle with forbs and grasses. Common forb species include hairy false golden aster (*Heterotheca villosa*), fringed sage (*Artemisia frigida*), sulphur buckwheat (*Erigonum umbellatum*), and common yarrow (*Achillea millefolium*). Common grass species include Colorado wildrye (*Leymus ambiguus*), cheatgrass (*Bromus tectorum*), Porter's brome (*Bromus porteri*), and mountain muhly (*Muhlenbergia montana*). Common noxious weed species in the rangeland areas at Gross Reservoir include common mullein, cheatgrass, and musk thistle (*Carduus nutans*). Small areas of disturbed soil occur within the grass/forb community on the western portion of the Gross Reservoir study area (Winiger Gulch) as a result of off-highway vehicle (OHV) use and erosion.

Disturbed rangelands occur on the western portion of the Gross Reservoir study area where a prescribed burn was conducted several years ago in a ponderosa pine community and a grass/forb community. Native plants such as fringed sage, hairy false golden aster, white sagebrush (*Artemisia ludoviciana*), geranium (*Geranium* spp.), Colorado wildrye, mountain muhly, bluebunch wheatgrass (*Pseudoroegneria spicata*), and sedge (*Carex* spp.) are common, but invasive species such as cheatgrass, common mullein, and musk thistle make a significant contribution to the relative cover in some locations. Additional disturbance to these areas include OHV use, recreational trails, litter, and erosion.

Coniferous Forest Land

The two types of coniferous forest lands represented at Gross Reservoir are the ponderosa pine and ponderosa pine/Douglas-fir (*Pseudotsuga menziesii*) mix.

The ponderosa pine communities have an aggregated structure of sparsely forested areas and rangelands. These areas are typically found on dry (xeric) slopes that have southern, eastern or western aspects. Based on field observations, these areas have a 10 to 30 percent (%) tree canopy cover and an average basal area of 53 square feet per acre. The ponderosa pine community located on the southern peninsula of the western lakeshore is an especially good example of a historic ponderosa forest. The structure and composition of this area reflects conditions that were common prior to settlement in the 1860s; there are also numerous old growth trees with fire scars, which provide an opportunity for further

research of Front Range fire intervals. Within this community type, ponderosa pine is the dominant tree but Douglas-fir and Rocky Mountain juniper (*Juniperus scopulorum*) trees also occur. Shrubs are common in the understory. Dominant shrub species include wax currant, Fendler's ceanothus, skunkbrush sumac (*Rhus trilobata*), Woods' rose (*Rosa woodsii*), common juniper (*Juniperus communis*), and yucca (*Yucca glauca*). Forbs make the largest contribution to understory cover. Dominant forb species include fringed sage, white sagebrush, hairy false golden aster, sulphur buckwheat, and geranium. Grasses and sedges are slightly less abundant in the understory. Dominant grass and sedge species include mountain muhly, Colorado wildrye, blue grama (*Bouteloua gracilis*), prairie Junegrass (*Koeleria macrantha*), cheatgrass, and sedge. Noxious weed species do not make a significant contribution to the relative cover in the ponderosa pine communities. Weed species found within this community include common mullein, cheatgrass, Canada thistle (*Cirsium arvense*), and houndstongue (*Cynoglossum officinale*). Variance in forest density has little effect on understory species composition.

The ponderosa pine/Douglas-fir mix communities have dense canopies of mixed conifer trees, which have suppressed understory production. These areas are typically found on moderately moist (mesic) slopes that have northern or western aspects. Based on field observations, tree canopy cover is greater than 30% and the average basal area is 65 square feet per acre. Ponderosa pine and Douglas fir are the dominant trees and occur in nearly equal proportions. Some Rocky Mountain juniper and Rocky Mountain maple (*Acer glabrum*) trees are also present in the canopy. Common shrub species include wax currant, chokecherry (*Prunus virginiana*), kinnikkinnik (*Arctostaphylos uva-ursi*), and common juniper. Dominant forb species include white sagebrush, hairy false golden aster, fringed sage, and bigflower cinquefoil (*Potentilla fissa*). Dominant grass and sedge species include sedge, Colorado wildrye, squirreltail (*Elymus elymoides*), and Porter's brome. Noxious weed species do not make a significant contribution to the relative cover. Weed species found within the ponderosa pine/Douglas-fir mix community include common mullein, cheatgrass, Canada thistle, musk thistle, and houndstongue.

Riparian

Riparian areas include forested riparian, shrub riparian, and herbaceous riparian along the Gross Reservoir shoreline and in surrounding drainages. Riparian communities include areas that are considered to be wetlands under the jurisdiction of the U.S. Army Corps of Engineers (Corps) under Section 404 of the Clean Water Act, and moist woodlands or shrub adjacent to creeks, wetlands, and the reservoir shoreline. More information about wetlands and riparian areas is provided in Section 3.8.

The reservoir shoreline vegetation contains small, scattered patches of riparian woodland, shrubland, and emergent wetlands. Shoreline woodlands are comprised of widely spaced plains cottonwood (*Populus deltoides*) and narrowleaf cottonwood (*Populus angustifolia*), with pockets of thinleaf alder (*Alnus incana*). Shoreline riparian shrub mostly consists of very small pockets of sandbar willow (*Salix exigua*). Reservoir shoreline emergent wetlands are dominated by creeping bentgrass (*Agrostis stolonifera*), woolly sedge (*Carex pellita*), fowl mannagrass (*Glyceria striata*), reed canarygrass (*Phalaris arundinacea*), and panicled bulrush (*Scirpus microcarpus*).

Riparian vegetation also occurs along Winiger Gulch and Forsythe Canyon on the west side of the reservoir, along several unnamed drainages on the south side of the reservoir, and along some portions of South Boulder Creek above and below the reservoir. Riparian woodlands associated with drainages are commonly dominated by plains and narrowleaf cottonwood, very tall thinleaf alder, and water birch (*Betula occidentalis*). Several conifer species are also present, including Douglas-fir, lodgepole pine (*Pinus contorta*), blue spruce (*Picea pungens*), and Engelmann spruce (*Picea engelmanni*). Wet riparian shrublands are dominated by thinleaf alder, water birch, Missouri River willow (*Salix eriocephala*), sandbar willow, and park willow (*Salix monticola*). Moist riparian shrublands along drainages are diverse, with a mix of various willows, serviceberry (*Amelanchier alnifolia*), water birch, redosier dogwood (*Cornus sericea*), cliffbush (*Jamesia americana*), ninebark (*Physocarpus monogyrus*), chokecherry, various gooseberries (*Ribes* spp.), Woods' rose, and roundleaf snowberry (*Symphoricarpos rotundifolius*), along with patches of dense herbaceous vegetation. Emergent wetlands associated with the drainages are commonly dominated by giant angelica (*Angelica ampla*), common spikerush (*Eleocharis palustris*), field horsetail (*Equisetum arvense*), fowl mannagrass, and American speedwell (*Veronica americana*).

Talus Slopes and Rock Outcrops

Talus slopes and rock outcrops are areas of rock outcrop that are nearly 100% rock. Small areas of rock can be found throughout the study area and are typically associated with slopes that exceed 75%. Talus slopes and rock outcrops occur in small patches intermingled with forests; thus, many of these areas are not presented on Figure 3.7-1.

Disturbed Soil

Disturbed soil includes areas where human activities, such as excavation and disposal sites, have created bare ground and the vegetative cover is less than 10%. This community type is found west of the dam where construction activities have resulted in a barren area and east of the boat launch where recreation has impacted the vegetation. Forbs make the largest contribution to the relative cover in disturbed areas. Dominant forb species include yellow sweetclover (*Melilotus officinalis*), hairy false golden aster, field sagewort (*Artemisia campestris*), white sagebrush, and fringed sage. Grasses make a minor contribution to the relative cover in disturbed areas. Common grass species include Canada bluegrass (*Poa compressa*), fescue (*Festuca* spp.), cheatgrass, and Porter's brome. Noxious weed species associated with disturbed soil include cheatgrass and common mullein.

Standing Water

The reservoir surface at its current capacity is approximately 418 acres. As the reservoir is drawn down, previously inundated areas become exposed that are generally devoid of vegetation. These areas support annual vegetation periodically, particularly following periods of prolonged drawdown.

Noxious Weeds

Information on the distribution of noxious weeds was obtained from observations made during biological field work in 2005, 2006, and 2010. Several county-listed noxious weeds

are present at Gross Reservoir (Table 3.7-1), including Canada thistle, Dalmatian toadflax, and musk thistle but are relatively uncommon. They were observed mostly around the reservoir rim and in moist areas such as portions of Winiger Gulch.

Sensitive Plant Communities

The CNHP (CNHP 2009) has identified two globally rare plant communities in the Gross Reservoir study area, which are also listed as plant communities of local concern by the U.S. Forest Service (USFS) Arapaho & Roosevelt National Forests (ARNF). The foothills riparian shrub river birch/mesic forb (*Betula occidentalis*/*Maianthemum stellatum*) community was reported to occur along South Boulder Creek above Gross Reservoir, and the thinleaf alder/mesic forb (*Alnus incana*/mesic forb) on Winiger Gulch upstream of the reservoir (CNHP 2009). Both of these areas are part of the Winiger Gulch Potential Conservation Area (PCA), which is described in Section 3.9. Shapins Associates (2002) reported that foothills riparian shrub (*Betula occidentalis)*/*Maianthemum stellatum*) also occurs along much of Forsythe Canyon, and a mix of these communities was also observed along two of the drainages along the south side of the reservoir during surveys by the Corps in 2010. The foothills riparian shrub (*Betula occidentalis*/ *Maianthemum stellatum*) community has a CNHP conservation rating of G4/S2, and the thinleaf alder/mesic forb (*Alnus incana*/mesic forb) community has a rating of G3/S3.

According to data provided by the USFS, about 13.8 acres of old growth ponderosa pine forest is present in the western portion of the Gross Reservoir study area. Additional information about old growth is provided in Section 3.9.1. The USFS also identified blue spruce as a plant community of local concern that may occur in the study area. Blue spruce trees are present in Forsythe Canyon, but specific blue spruce community types have not been identified.

3.7.1.2 Leyden Gulch Reservoir Site

Vegetation communities at the Leyden Gulch site are shown in Figure 3.7-2. Dominant upland vegetative communities in the proposed reservoir area include grass/forb rangelands, snowberry/shrub mix, and disturbed soil.

Grass/Forb Rangelands

The two types of grass/forb rangelands that occur in the Leyden Gulch site are the grass/forb mix and disturbed rangeland.

Grass/forb mix communities occur throughout the Leyden Gulch site. Common forb species include fringed sage, curlycup gumweed (*Grindelia squarrosa*), yellow sweetclover, white sagebrush, dotted gayfeather (*Liatris punctata*), and prairie coneflower (*Ratibida columnifera*). Common grass species include needle-and-thread grass (*Hesperostipa comata*), blue grama, sideoats grama (*Bouteloua curtipendula*), Japanese brome (*Bromus japonicus*), prairie Junegrass, smooth brome (*Bromus inermis*), and purple threeawn (*Aristida purpurea*). Broom snakeweed (*Gutierrezia sarothrae*) is evenly distributed throughout the site and makes a minor contribution to the relative cover. Some areas on the southwest portion of the site are dominated by skunkbrush sumac and western snowberry (*Symphoricarpos occidentalis*). Common noxious weeds include field bindweed (*Convolvulus arvensis*), cheatgrass, musk thistle, dalmatian toadflax (*Linaria dalmatica*),

and diffuse knapweed (*Centaurea diffusa*). Excessive browsing, trampling and cattle congregation areas are common throughout the rangeland. Noxious weeds are especially common in the valley that is the location of the proposed reservoir, but are much less evident in grasslands in the southern half of the site. Part of the eastern portion of the site is dominated by diffuse knapweed, which may be the result of grazing and road construction. Colonies of prairie dogs have also affected vegetative composition in some locations as a result of foraging.

Disturbed Rangelands

Disturbed rangelands occur in several locations at the Leyden Gulch site; one is found in the western portion of the site and the others are located in the eastern portion. The western disturbed rangeland site results from cattle grazing and congregation, which have decimated grass and forb diversity. Only three species make a significant contribution to the relative cover in one of the western areas: pepperweed (*Lepidium* sp.), field bindweed, and musk thistle. The eastern disturbed rangeland occurs outside of a fenced area and is dominated by yellow sweetclover. Pepperweed, snakeweed, and curlycup gumweed make a minor contribution to the relative cover at the eastern range site. Noxious weed species in the eastern disturbed rangeland include field bindweed, musk thistle, and Canada thistle.

Snowberry/Shrub Mix

The snowberry/shrub mix is the only type of shrub/brush rangeland represented at the Leyden Gulch site. This community is mostly found on steep north facing slopes along Leyden Gulch and its tributaries and on the west side of the hogback that parallels State Highway (SH) 93. In these areas, skunkbrush sumac or western snowberry contributed more than 50% of the relative cover, but understory composition was similar to the grass/forb mix community discussed above. Skunkbush sumac was visually dominant in most areas and was the only shrub present in some areas. The most diverse area was in a steep-sided drainage crossed by the South Boulder Creek Diversion Canal, which had skunkbush sumac and western snowberry on the upper slopes and a diverse mix of species on the middle to lower slopes, including chokecherry, whitestem gooseberry (*Ribes inerme*), boxelder (*Acer negundo*), hawthorn (*Crataegus* sp.), peachleaf willow, western poison ivy (*Toxicodendron rydbergii*), golden currant, and pin cherry (*Prunus pensylvanica*).

Riparian

Forested riparian occurs in the southern end of the site along Ralston Creek and in the emergency spillway, and in small areas along Leyden Gulch and one of its tributaries. Common species include lanceleaf cottonwood (*Populus acuminata*), plains cottonwood, peachleaf willow (*Salix amygdaloides*), Russian olive (*Elaeagnus angustifolia*), sandbar willow, and crack willow (*Salix fragilis*). Understory vegetation is a diverse mix of grass and forbs, with various species of wheatgrass (*Elymus* and *Agropyron*) most abundant.

Shrub riparian vegetation occurs in limited areas including a tributary of Leyden Gulch, the South Boulder Diversion Canal, and small portions of Ralston Creek, and is usually dominated by sandbar willow. These areas are too small to illustrate on Figure 3.7-2.

The herbaceous riparian areas are associated Leyden Gulch and its tributaries, and include areas of groundwater discharge. The wetlands are dominated by redtop grass (*Agrostis gigantea*), Nebraska sedge (*Carex nebrascensis*), common spikerush, foxtail barley, Baltic rush (*Juncus arcticus*), annual rabbitsfoot grass (*Polypogon monspeliensis*), common threesquare (*Schoenoplectus pungens*), cloaked bulrush (*Scirpus pallidus*), and broadleaf cattail (*Typha latifolia*), and various sedges and rushes.

Noxious weed species observed in riparian areas at the Leyden Gulch site include Canada thistle, perennial pepperweed, poison hemlock (*Conium maculatum*), quackgrass (*Elytrigia repens*), and Russian olive.

Talus Slopes and Rock Outcrops

A narrow band of rock outcrop is present at the hogback on the east side of SH 93.

Disturbed Soil

Disturbed soil is classified as areas where vegetative cover is less than 10%. This community type is found in several locations at the site, including a tributary of Leyden Gulch where cattle have congregated in the valley bottom, in the northeast portion of the site where there is an access road and parking lot, in a portion of the proposed emergency spillway where there is a soil disposal area, and along SH 93 and SH 72.

Residential

Several isolated residences and groups of ranch buildings are present in the southern half of the site.

Standing Water and Running Water

Areas mapped as standing water consist of one small pond located just west of SH 93 and running water includes an open portion of the South Boulder Creek Diversion Canal.

Noxious Weeds

Noxious weeds are common to abundant on this site, as discussed above under grass/forb rangelands.

Sensitive Plant Communities

The northern portion of the Leyden Gulch site is within the Rocky Flats PCA (CNHP 2009), which contains a globally rare plant community *Andropogon gerardii – Schizachryrium scoparium* (big bluestem – little bluestem) Western Great Plains Herbaceous Vegetation (xeric tallgrass prairie). No tallgrass prairie species were observed during 2005 and 2006 field surveys in the portion of the PCA that overlaps with the Leyden Gulch site. Xeric tallgrass prairie remnants do occur in nearby areas, but this community is not present in the Leyden Gulch site.

3.7.2 Conveyance Systems

3.7.2.1 Conduit M

Conduit M includes grass/forb rangeland, and irrigated and dryland agriculture.

The western 3 miles of Conduit M is primarily grass/forb rangeland. Species are characteristic of disturbed rangeland and consist of broom snakeweed, cactus, yucca, cheatgrass, Russian thistle, and tall tumble mustard (*Sisymbrium altissimum*). Forb species include fringed sage, curlycup gumweed, yellow sweetclover, white sagebrush, dotted gayfeather, and prairie coneflower. Common grass species include needle-and-thread grass, blue grama, sideoats grama, Japanese brome, prairie Junegrass, smooth brome, purple threeawn, and cheatgrass.

Dryland cropland and irrigated cropland occur in several areas, especially in the western portion of Conduit M near Indiana Street and near Clear Creek. This type includes both active and fallow agricultural areas. Active cropland includes cultivated areas and pastures and hay meadows. Pastures and hay meadows are typically dominated by non-native grass species, especially smooth brome (*Bromus inermis*), and weedy species such as field bindweed.

The majority of Conduit M travels through an urban area dominated by residential and commercial land uses. Residential consists of homes, lawns, and planted trees as well as developed parks and golf courses. Commercial is characterized by urban areas with little vegetation, parking lots, buildings, and other developments. The eastern/southern terminus of Conduit M travels through areas characterized by high density commercial and residential development.

Disturbed soil occurs along road edges and on vacant land. Typical species in disturbed areas include weedy annuals such as kochia (*Kochia scoparia*) and Russian thistle (*Salsola tragus*), and weeds such as field bindweed.

Riparian vegetation occurs along several creeks and canals and ditches, including the South Platte River, Little Dry Creek, lower Clear Creek Canal, and Clear Creek. Riparian woodlands and shrublands are dominated by plains cottonwood, peachleaf willow, sandbar willow, Woods' rose, Siberian elm (*Ulmus pumila*), and Russian olive. Herbaceous riparian consists of emergent wetlands dominated by broadleaf cattail, softstem bulrush (*Schoenoplectus tabernaemontani*), common reed (*Phragmites australis*), Baltic rush, reed canarygrass, woolly sedge, and common threesquare. Noxious weeds are often abundant in urban riparian areas and often include Canada thistle, cheatgrass, common teasel (*Dipsacus fullonum*), hoary cress, leafy spurge (*Euphorbia esula*), perennial pepperweed, poison hemlock, quackgrass, Russian olive, salt cedar (*Tamarix parviflora, T. ramosissimum*), and Scotch thistle (*Onopordum acanthium*).

Standing water consists of one pond on the south side of Clear Creek, which has duckweed (*Lemna minor*) and may contain other aquatic species. Running water is present in Clear Creek, South Platte River, and in several canals and ditches.

3.7.2.2 Conduit O

The western third of Conduit O is the same alignment as Conduit M. The central third of Conduit O crosses mostly urban areas and the eastern third extends northeast down the South Platte River valley. The vegetation types are the same as described for Conduit M.

Grass/forb rangeland occurs on the westernmost 3 miles of the conduit alignment, and is the same as described for Conduit M.

Dryland and irrigated cropland occurs on the western end of Conduit O near Indiana Street, near Federal Boulevard, and in the South Platte River valley. Crested wheatgrass (*Agropyron cristatum*) and smooth brome are the most common species in grass fields, and prairie dogs have occupied some areas of fallow cropland.

About half of Conduit O travels through urban areas dominated by residential and commercial land uses, and scattered areas are present in the South Platte River valley. Disturbed soil is present primarily at gravel pits in the South Platte River valley.

Riparian vegetation is present along rivers, streams, ditches, and ponds. Several areas of riparian woodland occur on the eastern portion of Conduit O, associated with the South Platte River. Common species include plains cottonwood, peachleaf willow, sandbar willow, Russian olive, and Siberian elm. Mixed areas of woodland and shrub have the same species, plus maple (*Acer* sp.), chokecherry, western snowberry, and golden currant (*Ribes aureum*). Herbaceous riparian areas are dominated by broadleaf cattail, softstem bulrush, Emory's sedge (*Carex emoryi*), and reed canarygrass. Noxious weeds in riparian areas are similar to Conduit M.

Standing water is present at several ponds near the crossing of the South Platte River, and in gravel pits in the South Platte River valley.

3.7.3 South Platte River Facilities

Gravel Pits

Vegetation and land cover types present at and adjacent to the gravel pits include standing water, running water in the South Platte River, disturbed soil, disturbed rangeland, forested riparian, shrub riparian, and herbaceous riparian.

The Worthing and Challenger pits were active gravel pits in 2006 and contained disturbed soil resulting from mining and stockpile operation. In 2006, the North and South Tower pits contained standing water. The South Platte River and riparian woodland are adjacent to portions of the Worthing and North and South Tower pits. These woodlands are dominated by plains cottonwood, peachleaf willow, and Siberian elm, and typically have an open canopy. The understory consists mostly of sand dropseed (*Sporobolus cryptandrus*) and weed species. Portions of the Worthing Pit shorelines have small areas of riparian shrub and emergent wetland, dominated by sandbar willow, young peachleaf willow, curlytop knotweed, broadleaf cattail, and other species.

Grasslands that can be characterized as disturbed rangelands (although they probably developed from abandoned cropland) occur adjacent to the Worthing and North and South Tower pits. Common species observed include sand dropseed, rubber rabbitbrush

(*Chrysothamnus nauseosus*), cheatgrass, field bindweed, prickly lettuce (*Lactuca serriola*), ragweed (*Ambrosia psilostachya*), Canadian horseweed (*Conyza canadensis*), puncturevine (*Tribulus terrestris*), curly dock (*Rumex crispus*), diffuse knapweed (*Centaurea diffusa*), redstem stork's bill (*Erodium cicutarium*), and common mullein. The Worthing Pit is also bordered by disturbed soil (other active gravel pits), and the Challenger Pit is bordered by gravel operations and cropland.

Diversion

The diversion facilities are comprised of the diversion in the South Platte River and its banks, and a short conveyance pipeline to the Worthing Pit. Vegetation types include riparian herbaceous along the South Platte River, riparian woodland, and disturbed rangeland.

Much of the upland community at the site is characterized as disturbed rangeland. Shrubs observed include pricklypear cactus (*Opuntia polycantha*) and rubber rabbitbrush. Common forbs include hairy false golden aster, field sagewort, curly dock, hoary alyssum (*Berteroa incana*), ragweed, and curlycup gumweed. Purple threeawn was the only common native grass. This community is dominated by noxious weed species such as knapweed, Scotch thistle, cheatgrass, redstem stork's bill, field bindweed, leafy spurge, and common mullein.

Riparian woodlands are also present, dominated by plains cottonwood and Siberian elm, and with an understory of mostly weedy herbaceous species including those listed for the disturbed rangeland.

Herbaceous riparian vegetation is present along the banks of the South Platte River, and is dominated by reed canarygrass, curlytop knotweed, curly dock, and sandbar willow. An area of mixed herbaceous and shrub riparian occurs on the edge of a pond and is dominated by barnyard grass (*Echinochloa crusgalli*), softstem bulrush, curly top knotweed, sandbar willow, and young peachleaf willow.

Conveyance

Vegetation types present along the gravel pit pipeline and laterals include irrigated cropland, disturbed rangeland, riparian shrub, herbaceous riparian, residential, standing water, running water, and disturbed soil. These communities and their noxious weeds are similar to previous descriptions. Herbaceous riparian vegetation occurs along ditches, along the banks of the South Platte River, and in an oxbow on the floodplain of the South Platte River, and is dominated by species such as broadleaf cattail and reed canarygrass. Riparian shrub occurs along the South Platte River and is dominated by sandbar willow.

Treatment

The proposed Advanced Water Treatment Plant (AWTP) would be located adjacent to the Worthing Pit. The gravel pit site is dominated by disturbed soil resulting from mining operations. It also contains standing water, and small herbaceous and shrub wetlands on the edge of the pond, dominated by sandbar willow and cattail.

3.7.4 Denver Basin Aquifer Facilities

Some of the injection/recovery well site locations would be located in Denver parks that primarily consist of residential cover types; some of the well site locations also have standing water nearby in the form of ponds and lakes. The residential classification includes parks and golf courses with planted trees and lawns. The Denver International Airport nursery site is highly disturbed, and the Lakewood Gulch area contains disturbed rangeland and riparian shrub.

Pipelines would follow streets and urban utility corridors, but would cross riparian woodlands at several stream crossings, including the South Platte River (two locations), Cherry Creek (three locations), and Sand Creek. Species composition and noxious weeds are generally the same as riparian areas described for Conduit M.

The proposed AWTP would be located near the existing Board of Water Commissioners (Denver Water) Recycling Plant, which is sparsely vegetated disturbed soil in an industrial area.

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3.8 RIPARIAN AND WETLAND AREAS

3.8.0 Overview

This section addresses riparian areas, wetlands, and other water features. Riparian areas are unique vegetation communities located adjacent to waterways and wetlands that provide important habitat for numerous plant and animal species. They generally occupy transition areas between aquatic and upland habitats and may function as excellent vegetative buffers for aquatic resources. Although riparian habitats are often combined with wetland habitats as a result of their intimate relationship to the hydrologic regime, they differ in that riparian areas are generally linear, more terrestrial, are often dependent on a natural disturbance regime, and do not include the instream environment (Naiman et al. 2005). Riparian areas are defined as:

> Those plant communities adjacent to and affected by surface or groundwater of perennial or ephemeral water bodies such as rivers, streams, lakes, ponds, playas, or drainage ways. These areas have distinctly different vegetation than adjacent areas or have species similar to surrounding areas that exhibit a more vigorous or robust growth form (CDOW 2006a).

Wetlands are areas that are inundated or saturated with water at or near the surface of the soil for a sufficient duration during the growing season to develop characteristic soils and vegetation adapted to anaerobic conditions (Environmental Laboratory 1987). Many wetlands are protected under Section 404 of the Clean Water Act (CWA) as waters of the United States (U.S.) and special aquatic sites. Non-wetland riparian areas include areas that receive extra moisture but do not meet the criteria to be considered wetlands. Other waters include surface water features such as streams, ditches, and ponds, many of which are also under the jurisdiction of the U.S. Army Corps of Engineers (Corps) under Section 404 of the CWA.

Fens are wetlands that primarily have saturated organic soils (peat or muck) and hydrology provided by groundwater. They are considered regionally important because they take thousands of years to develop, are generally not replaceable, and have important hydrological and water quality functions (USFWS 1999). The U.S. Fish and Wildlife Service (USFWS) goal for mitigation is no net loss of habitat value, meaning that impacts should be avoided. The Corps protects these areas under its Section 404 permitting program, and USFS Arapaho & Roosevelt National Forests (ARNF) identifies them as plant communities of local concern. Fens in Colorado typically occur at mid to high elevations where they occupy only a small portion of the landscape. Most fens in Colorado are dominated by sedges, grasses and willows. They are more nutrient rich than bogs (which do not occur in Colorado). Fens contain soils that are classified as histosols, which includes organic soil materials (peat or muck) that are saturated with water for long periods, and that have an organic carbon content of 12 to 18 percent (%) organic carbon by weight, excluding live roots, depending on the clay content of the soil. Fens are present in portions of the Fraser Valley and upper Williams Fork and are discussed below for the river segments (Section 3.8.5), based in part on a fen survey conducted in October 2010. They

are not present at any of the East Slope study areas, which include Gross Reservoir, Leyden Gulch Site, South Platte River Facilities, Denver Basin Aquifer Facilities, and the conduits.

Two different methodologies were used to describe the affected environment for riparian and wetlands areas. The first methodology was applied to the East Slope facilities (Sections 3.8.1, 3.8.2, 3.8.3, and 3.8.4) because these areas could be affected by a variety of direct and indirect impacts during construction and operation including ground-disturbing activities. These facilities were evaluated using field studies within the proposed or representative affected areas to delineate wetlands and other waters and to map riparian woodland and shrubland communities. Because wetlands are addressed in detail for these facilities, the discussion of riparian areas covers the remaining non-wetland riparian areas.

The river segments (Section 3.8.5) were evaluated using the second method because they cover a much larger area and would be affected only by changes in river flows during Moffat Collection System Project (Moffat Project or Project) operation (i.e., no ground-disturbing activities). This methodology consisted of using existing Colorado Parks and Wildlife (CPW) (previously called Colorado Division of Wildlife) riparian mapping data, combined with detailed field studies at 12 sample sites. These sites were also used for hydraulic analysis and the channel dynamics study (ERC 2006). The discussion of the river segments addresses riparian in its broader sense, including all of the areas along the stream segments that could be affected by stream flow, both wetland and non-wetland. Changes in stream flow would not trigger a requirement for Section 404 permitting, therefore wetlands and other waters were not delineated. Wetland and riparian areas provide a number of functions and societal values. Functions are natural processes that operate regardless of their perceived value to people. They include hydrological controls such as short- and long-term water storage and flood attenuation; geomorphic functions such as bank stabilization and sediment retention; biogeochemical functions such as nutrient and toxicant removal; and habitat functions such as support of fish and wildlife habitat and food chain support. The Corps Denver Regulatory Office uses the FACwet (Functional Assessment of Colorado Wetlands) Method (Johnson et al. 2011) in its review of individual permits, including mitigation planning. Assessment of the functions of the wetlands that would be affected by East Slope activities will be performed as part of the Individual Permit approval process. A summary of riparian functions along the river segments is provided in Section 3.8.5.

The remainder of this introduction provides a summary of the riparian, wetland, and other waters associated with the East Slope facilities along with a more detailed description of the methodology used. A summary of riparian communities associated with the river segments is provided in Section 3.8.5.

Riparian Areas

Riparian areas within the East Slope facilities study areas have been broadly defined as those non-wetland areas dominated by woody vegetation that are adjacent to aquatic habitats. They have been classified into three groups: (1) woodland, (2) shrubland, and (3) woodland/shrubland combination (wood/shrub). These groups are generally defined based on the dominant vegetation type. Most of the riparian woodland areas are very small and are dominated by widely spaced riparian deciduous tree species with canopy cover less

than 60% (Carsey et al. 2003). The riparian shrublands are generally small and dominated by dense populations of shrub species.

Riparian areas within the East Slope facilities study areas have also been described using plant associations available in the Field Guide to the Wetland and Riparian Plant Associations of Colorado (Carsey et al. 2003). For riparian areas that have been classified as wood/shrub combination, both woodland and shrubland association components have been identified. Eight of the riparian plant associations included in the document were identified within the study areas. Three additional associations were added to address communities not described in Carsey et al. (2003).

The Carsey plant associations (Carsey et al. 2003) identified in the East Slope study areas include:

- **Narrowleaf cottonwood (*Populus angustifolia*)/Thin-leaf alder (*Alnus incana*) Woodland** – Thin-leaf alders (and sometimes other less dominant shrubs) along other waters with an open to nearly closed canopy of narrowleaf cottonwood trees. This plant association is considered a mid-seral community (not the youngest or oldest cottonwood stands in the area) and occurs at Gross Reservoir.
- **Narrowleaf cottonwood/River birch (*Betula occidentalis*) Woodland** – One of the wettest narrowleaf cottonwood communities that grows thick along stream banks with river birch, a co-dominant and other less dominant shrub species. This plant association is considered an early- to mid-seral community and also occurs at Gross Reservoir.
- **Peachleaf willow (*Salix amygdaloides*) Woodland** – Peachleaf willow stands usually grow within 3 feet of the water table (during the growing season), with a variable understory dependent on the location's water regime, and contains few to no cottonwoods. This association was observed along Conduit M and at the South Platte River Facilities.
- **Sandbar willow *(Salix exigua*)/Barren Ground Shrubland** – An almost exclusive thick shrub canopy of sandbar willow associated with annual flooding that is found along the edge of rivers and streams and can grow into the channel. This plant association is considered an early-seral community. It was observed at Gross Reservoir, the Leyden Gulch site, along Conduit M, and the Denver Basin Aquifer Facilities study area.
- **Sandbar willow/Mesic graminoid Shrubland** – Sandbar willow dominated shrubland with other shrub species possible, including various willow species and thin-leaf alder in the shrub layer, and at least 30% ground cover of grasses and forbs. This is considered an early-seral community. This plant association was observed in all East Slope study areas.
- **Thin-leaf alder/Mesic graminoid Shrubland** – Medium-tall thin-leaf alder stands with a thick understory of grass and some forb species. There is no larger tree canopy as the alders are shade-intolerant. This plant association is considered a long-lived early-seral community and is located in the South Platte River Facilities study area.
- **River Birch/Mesic forb Shrubland** – A tall-shrub to small-tree community with a limited forb understory due to the thick shrub canopy. River birch dominates the

tree/shrub layer with other possible species, including thin-leaf alder, red-osier dogwood (*Cornus sericea*), Utah serviceberry (*Amelanchier utahensis*), cliffbush (*Jamesia americana*), chokecherry (*Prunus virginiana*), and mountain willow (*Salix monticola*). This is considered a mid-seral community. This plant association was observed at Gross Reservoir.

- **Chokecherry (*Prunus virginiana*) Shrubland** – Dense vegetation community includes a tall layer of shrubs dominated by chokecherry with a medium-height shrub layer usually dominated by western snowberry (*Symphoricarpos occidentalis*) and a grassy forb understory. This community is often found at the edge of riparian areas and probably represents the site potential in ungrazed areas. This plant association was found at the Leyden Gulch site and along the Conduit O alignment.

Other plant associations identified in the study areas include:

- **Plains cottonwood/Peachleaf willow (Crack willow [*Salix fragilis*]) Woodland** – Community along streams with medium to larger plains cottonwood in an open canopy that may include some older peachleaf willow and a mid-layer of tall-shrub small-tree peachleaf willow closer to the stream. Crack willow can be seen in this community instead of peachleaf willow or as a co-dominant. In disturbed areas, this community is often invaded by Siberian elm (*Ulmus pumila*) and/or Russian olive (*Elaeagnus angustifolia*). This plant association was observed in the Leyden Gulch site, along Conduits M and O, South Platte River Facility, and Denver Basin Aquifer Facility study areas.
- **Lanceleaf cottonwood (*Populus acuminata*) Woodlands** – Canopy of medium to large lanceleaf cottonwood along narrow drainages in or near the foothills, or on the outer edge of larger stream-associated riparian areas. The community often includes some plains cottonwood and/or peachleaf willow. This plant association was found in the Leyden Gulch site.
- **Crack willow/Sandbar willow Shrubland** – Tall-shrub to small-tree canopy of crack willows with sandbar willow understory along streams. This plant association was found in the South Platte River Facilities study area.

Riparian areas at Gross Reservoir, the Leyden Gulch site, Conduits M and O, South Platte River Facilities, and Denver Basin Aquifer Facilities study areas are shown in Figures 3.8-1 through 3.8-5 and summarized in Table 3.8-1.

Table 3.8-1
Summary of Riparian Areas and Wetlands in the East Slope Study Areas

Location	Riparian Type (acres)			Total (acres)	Wetland Type[1] (acres)			Total (acres)
	Woodland	Shrubland	Wood/ Shrub		PEM	PSS	PEM/ PSS	
Gross Reservoir	0.73	2.37	1.14	**4.24**	0.43	1.06	0.64	**2.13**
Leyden Gulch Reservoir Site	0.40	0.82	0.51	**1.73**	19.85	0.06	0.73	**20.64**
Conduit M	0.41	<0.01	2.01	**2.42**[2]	1.82	0.47	0.88	**3.17**[3]
Conduit O	1.53	0.00	3.28	**4.81**[2]	3.34	0.48	1.94	**5.76**[3]
South Platte River Facilities	1.00	0.00	0.35	**1.35**	2.04	0.07	2.22	**4.33**
Denver Basin Aquifer Facilities	0.00	0.00	0.88	**0.88**	0.01	0.27	0.03	**0.31**
Total (acres)	**4.07**	**3.19**	**8.17**	**15.43**[2]	**27.49**	**2.41**	**6.44**	**36.34**[3]

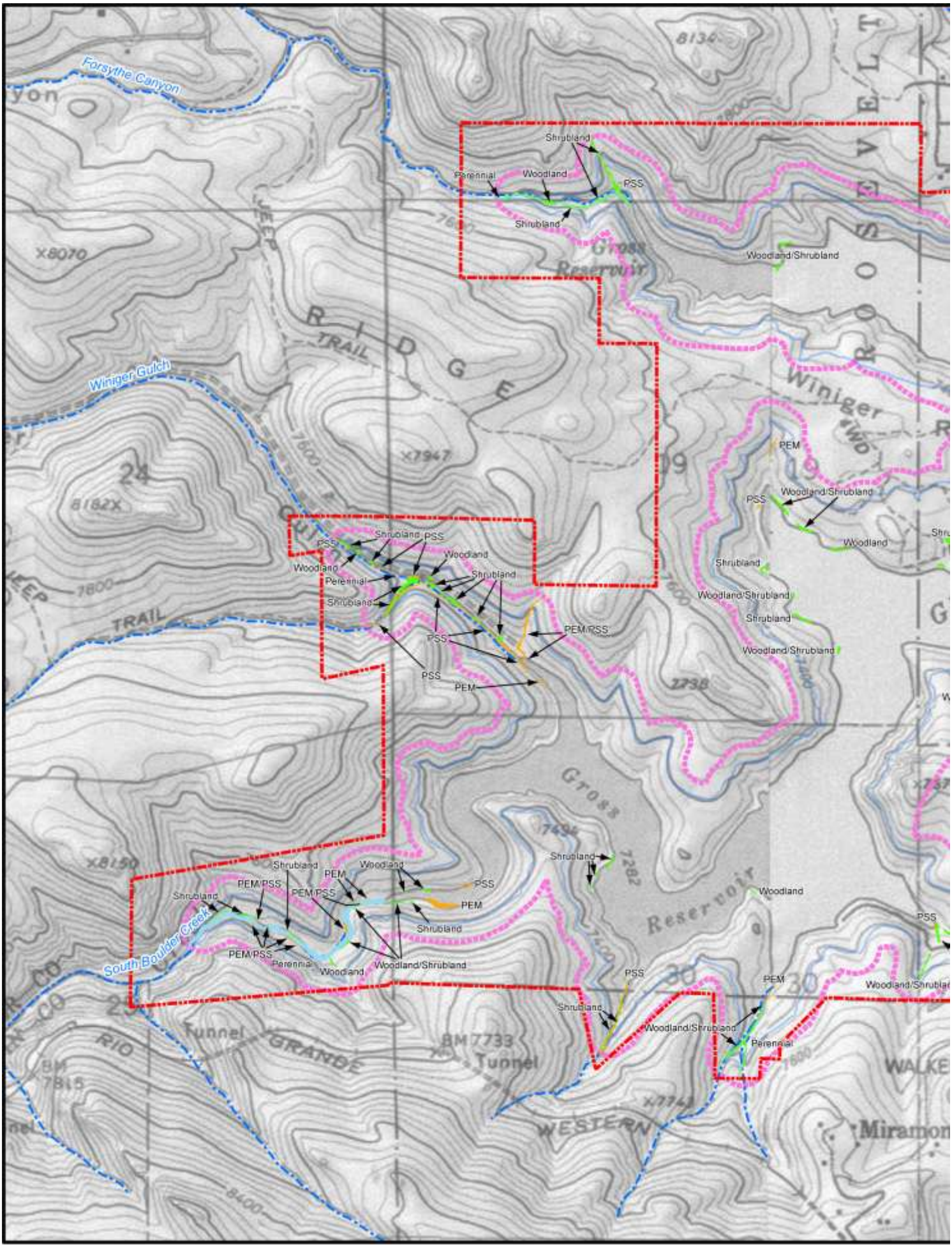
Notes:
[1]Wetland type is based on Cowardin et al. 1979.
[2]0.95 acre of these riparian areas are common between Conduits M and O.
[3]2.14 acres of these wetlands are common between Conduits M and O.
PEM = Palustrine Emergent
PSS = Palustrine Scrub/Shrub

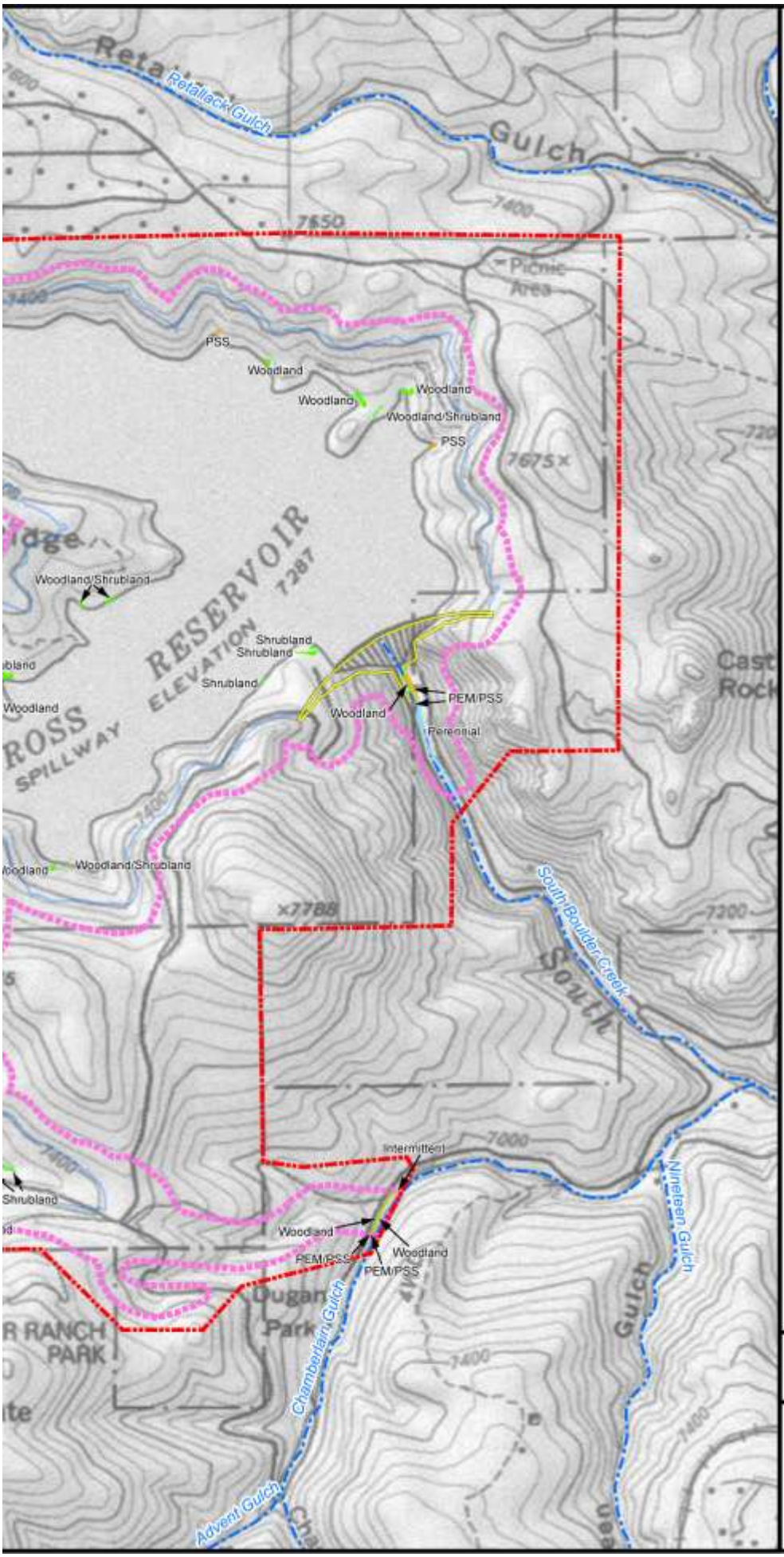
Wetlands

Wetlands are important biological resources that perform many functions, including groundwater recharge, stormwater and flood flow attenuation, erosion control, and water quality improvement. They also provide habitat for many plants and animals, including threatened and endangered species.

Many wetlands and other water features including reservoirs, ponds, intermittent and perennial streams, and some stormwater and irrigation ditches are considered "waters of the U.S." by the Corps. These "jurisdictional" areas require a permit from the Corps for any discharge of dredged or fill material into such waters. Furthermore, Executive Order 11990 – Protection of Wetlands, directs all Federal agencies to "minimize the destruction, loss or degradation of wetlands."

Wetland areas were delineated for all East Slope study areas that were officially accessible, including Gross Reservoir and the Leyden Gulch site. At most other wetland sites that were not officially accessible, vegetation and hydrology indicators were observed with the aid of binoculars (when needed), but no soils data were recorded. Some areas had no access and no visibility. Aerial photography for these areas was analyzed and compared with similar surrounding areas that were visible. Wetland and other water feature and riparian area data were generated from this photo interpretation, though vegetation species were not always determined.


Forsythe Canyon
Winiger Gulch
South Boulder Creek
Shrubland
Perennial
Woodland
PSS
Woodland/Shrubland
PEM
PEM/PSS
Gross Reservoir
Winiger
RIDGE
TRAIL
Tunnel
RIO
GRANDE
WESTERN
BM 7733
Miramon



Wetland

Other Water

Riparian

Wetlands Study Area

Gross Reservoir Study Area

Gross Reservoir with Environmental Pool - 77,000 AF Enlargement

Dam Footprint

Stream/River

Reference:
1:24,000-scale quad maps originally from USGS (1972 & 1994) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Note:
PEM denotes Palustrine Emergent wetland and PSS denotes Palustrine Scrub/Shrub wetland.

N
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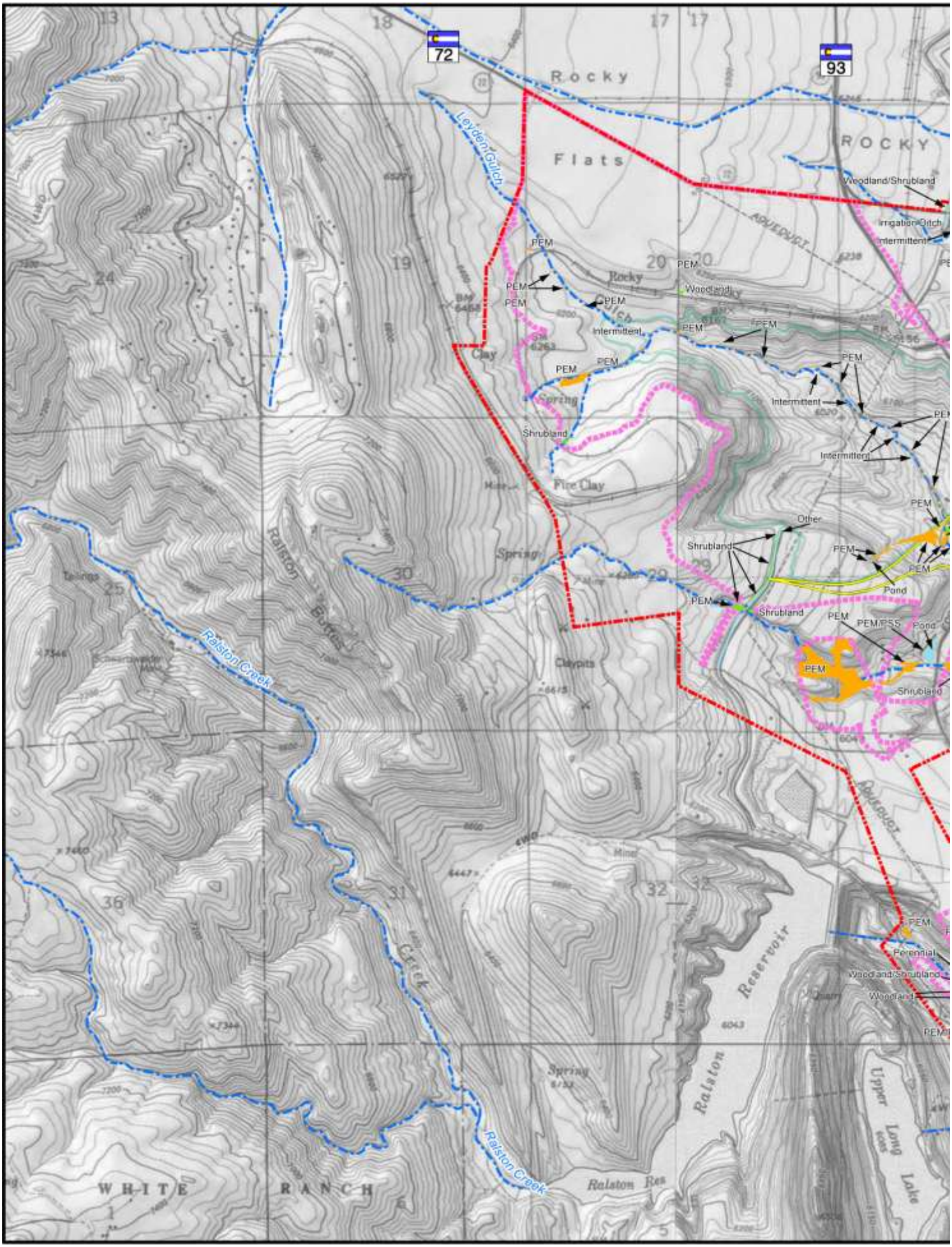
1,200 0 1,200 Feet

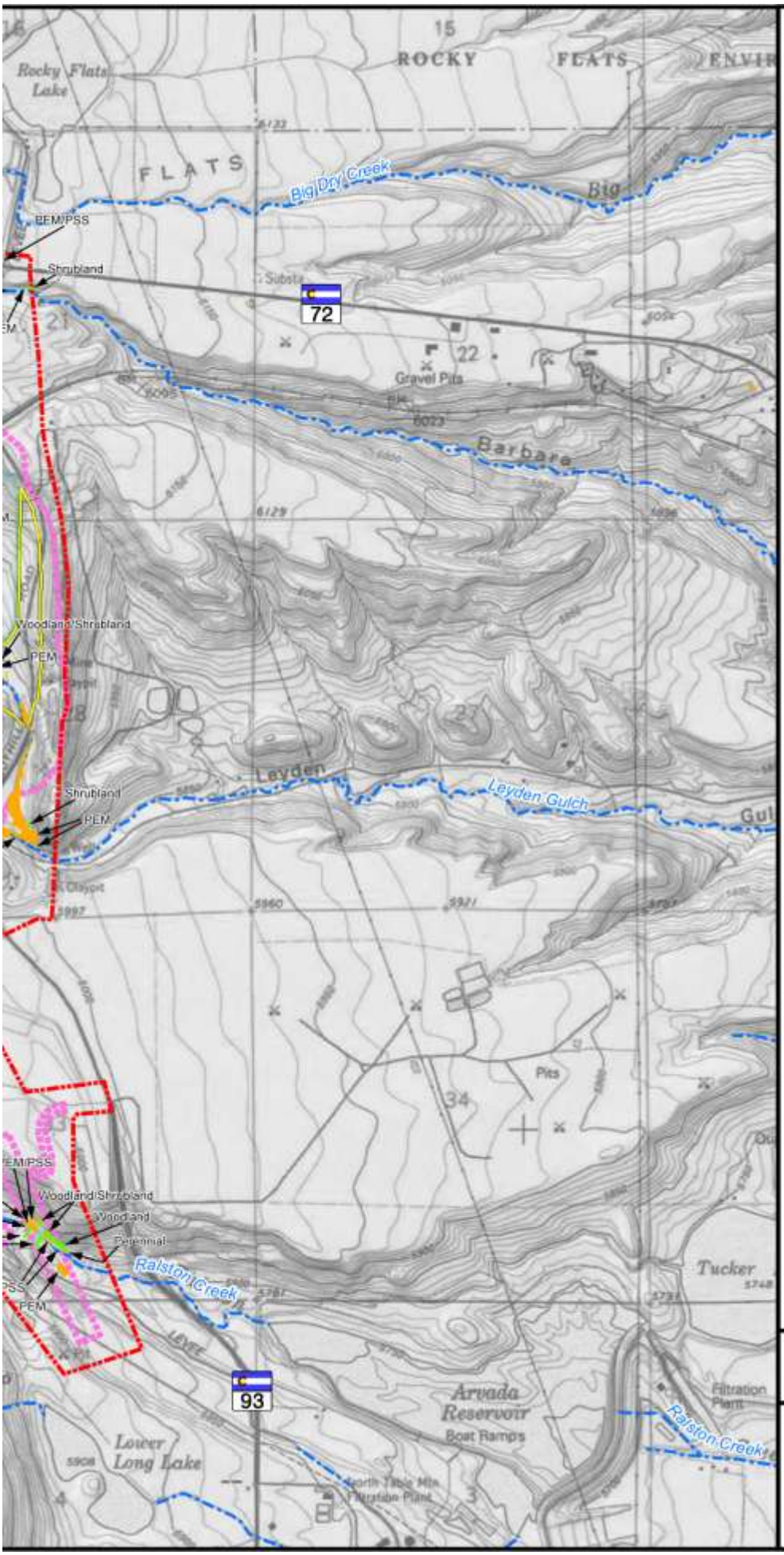
1:14,400

Moffat Collection System Project FEIS

Figure 3.8-1 Wetlands - Gross Reservoir

9/4/12


72
93
Rocky
Flats
ROCKY
Leyden Gulch
Rocky
Gulch
Clay
Spring
Fire Clay
Spring
Ralston
Buttes
Ralston Creek
Claypits
Creek
Ralston
Reservoir
Ralston Res
Upper
Long
Lake
WHITE
RANCH
AQUEDUCT
Aqueduct
Woodland/Shrubland
Irrigation Ditch
Intermittent
Woodland
Shrubland
Other
Pond
PEM
PEM/PSS
Perennial
Wood and Shrubland



Wetland
Other Water
Riparian
Wetlands Study Area
Leyden Gulch Site Study Area
Leyden Gulch Site - 31,300 AF
Dam Footprint
Stream/River

Reference:
1:24,000-scale quad maps originally from USGS (1972 & 1994) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Note:
PEM denotes Palustrine Emergent wetland and PSS denotes Palustrine Scrub/Shrub wetland.

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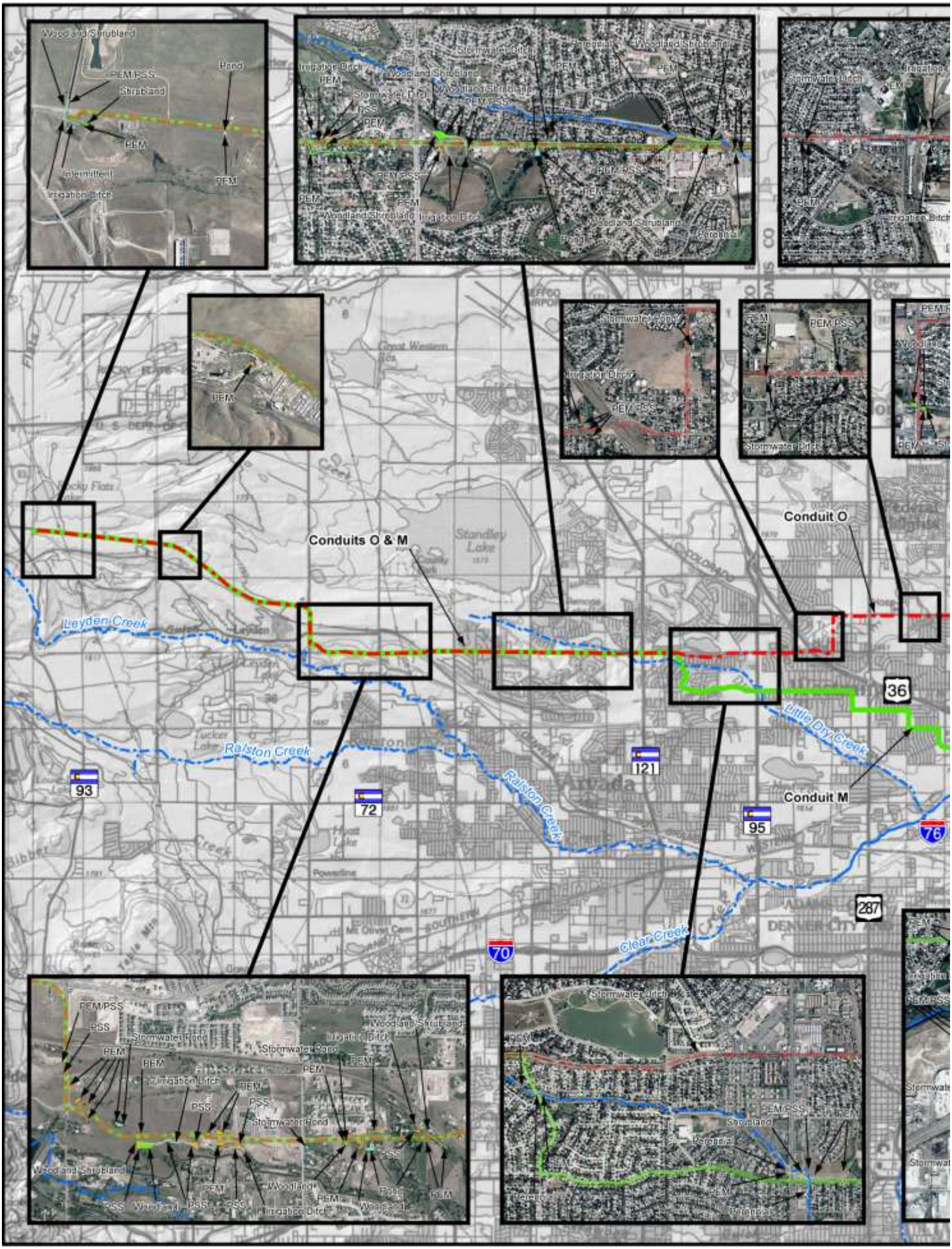
2,000 0 2,000 Feet

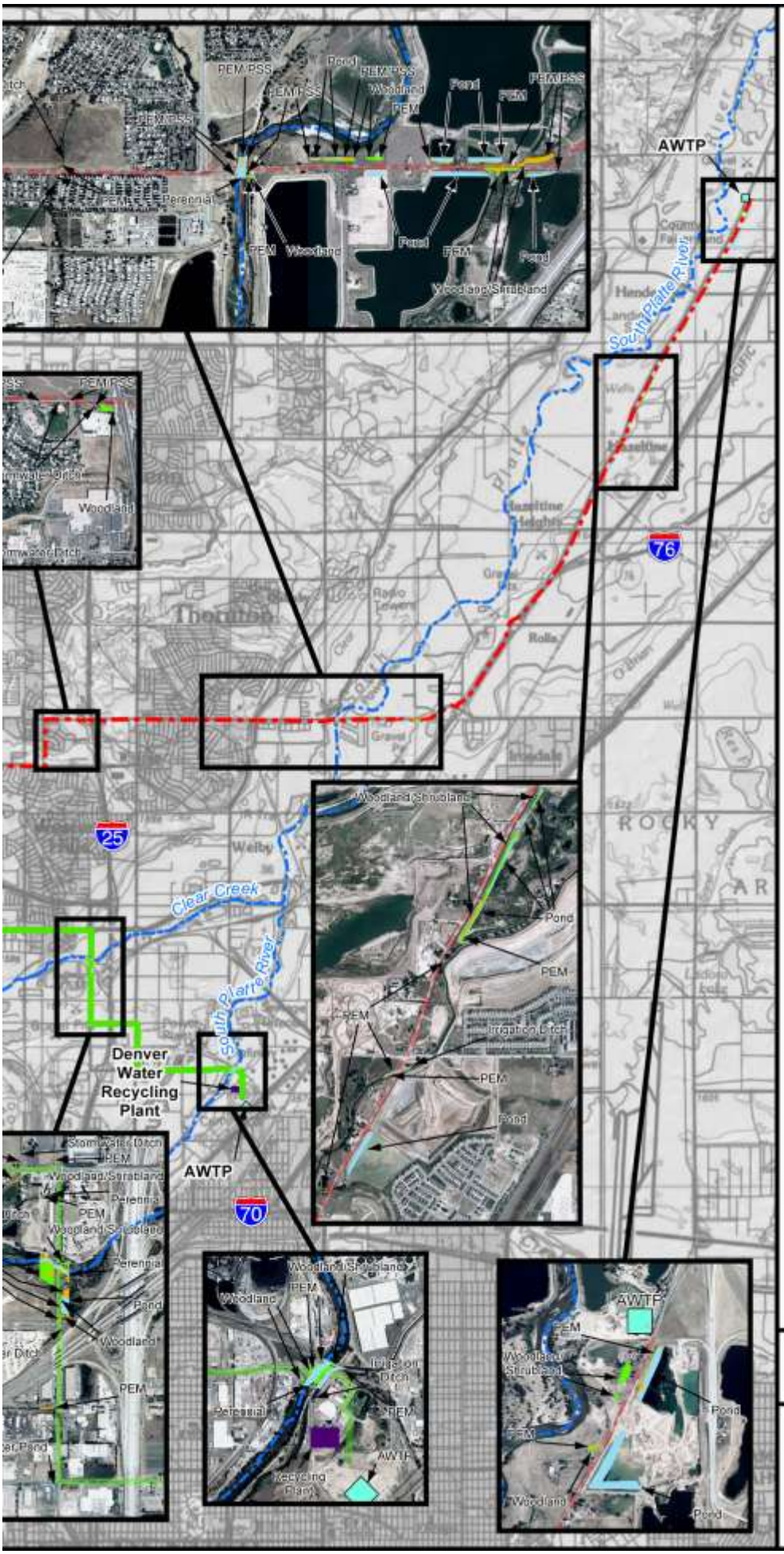
1:24,000

Moffat Collection System Project FEIS

Figure 3.8-2 Wetlands - Leyden Gulch Site

9/4/12


Conduits O & M
Conduit O
Conduit M
Leyden Creek
Ralston Creek
Little Dry Creek
Clear Creek
Standley Lake
Arvada
DENVER CITY
36
93
72
121
95
76
287
70
Woodland Shrubland
PEM/PSS
Shrubland
Pond
PEM
Intermittent
Irrigation Ditch
Stormwater Ditch
Stormwater Pond
PSS
Forested



Wetland

Other Water

Riparian

Conduit O

Conduit M

Advanced Water Treatment Plant (AWTP)

Existing Denver Water Recycling Plant

Stream/River

References:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Aerial photography from USDA (2005); used for the wetland field surveys in 2005.

Notes:
All inset maps are at 1:30,000 scale.

PEM denotes Palustrine Emergent wetland and PSS denotes Palustrine Scrub/Shrub wetland.

N
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S

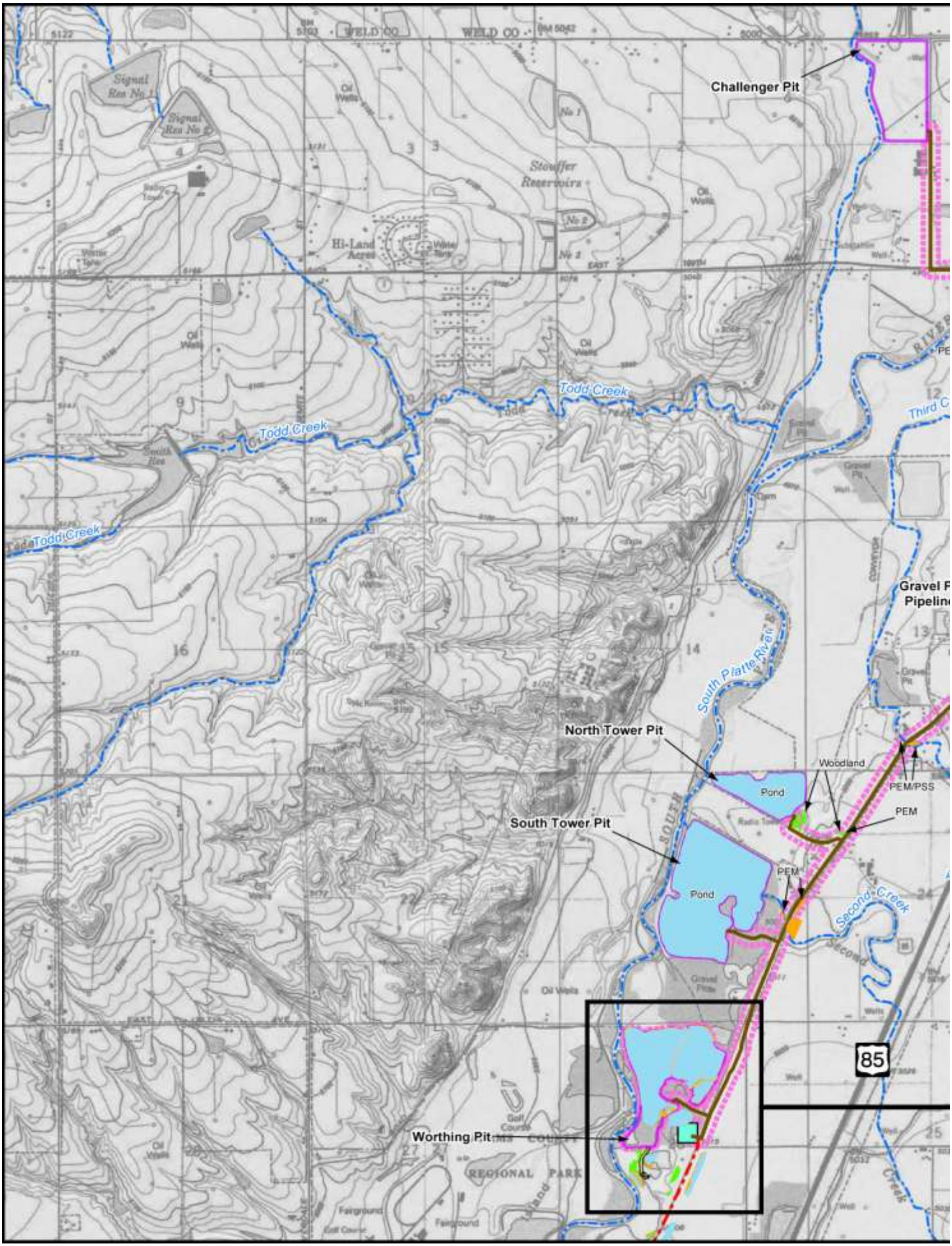
1.5 0 1.5 Miles

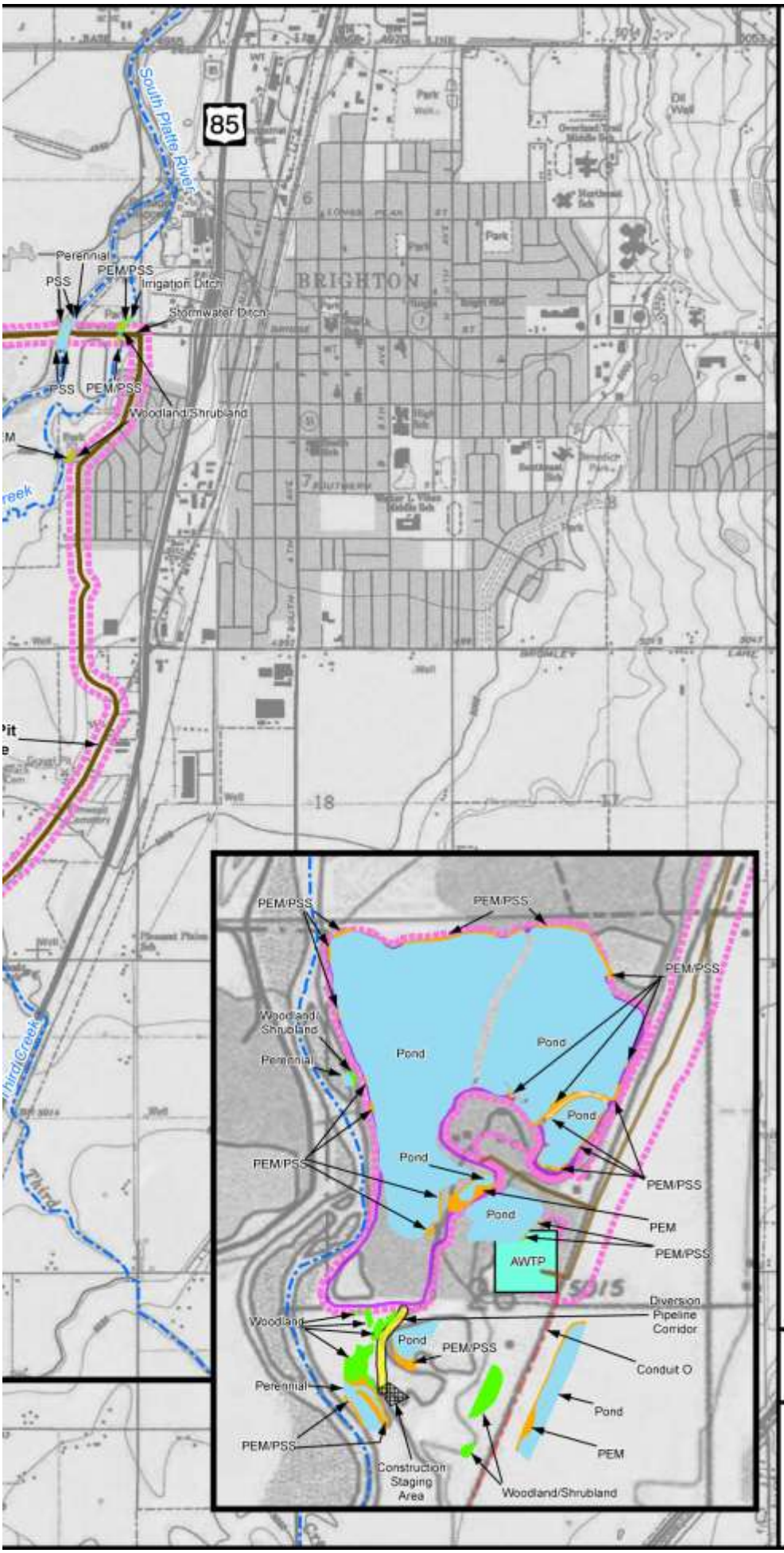
1:100,000

Moffat Collection System Project FEIS

Figure 3.8-3 Wetlands - Conduits M and O

9/4/12


Challenger Pit
Todd Creek
Stouffer Reservoirs
Hi-Land Acres
Signal Res No 1
Signal Res No 2
South Platte River
North Tower Pit
South Tower Pit
Pond
Pond
Woodland
PEM/PSS
PEM
PEM
Second Creek
Third Creek
Gravel Pipeline
85
Worthing Pit
REGIONAL PARK
Fairground
Golf Course



Wetland
Other Water
Riparian
Wetlands Study Area
Conduit O
Gravel Pit Pipeline
Gravel Pit
Construction Staging Area
Diversion Pipeline Corridor
Advanced Water Treatment Plant (AWTP)
Stream/River

Reference:
1:24,000-scale quad maps originally from USGS (1972 & 1994) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Notes:
Inset map is at 1:12,000 scale.

PEM denotes Palustrine Emergent wetland and PSS denotes Palustrine Scrub/Shrub wetland.

N
W E
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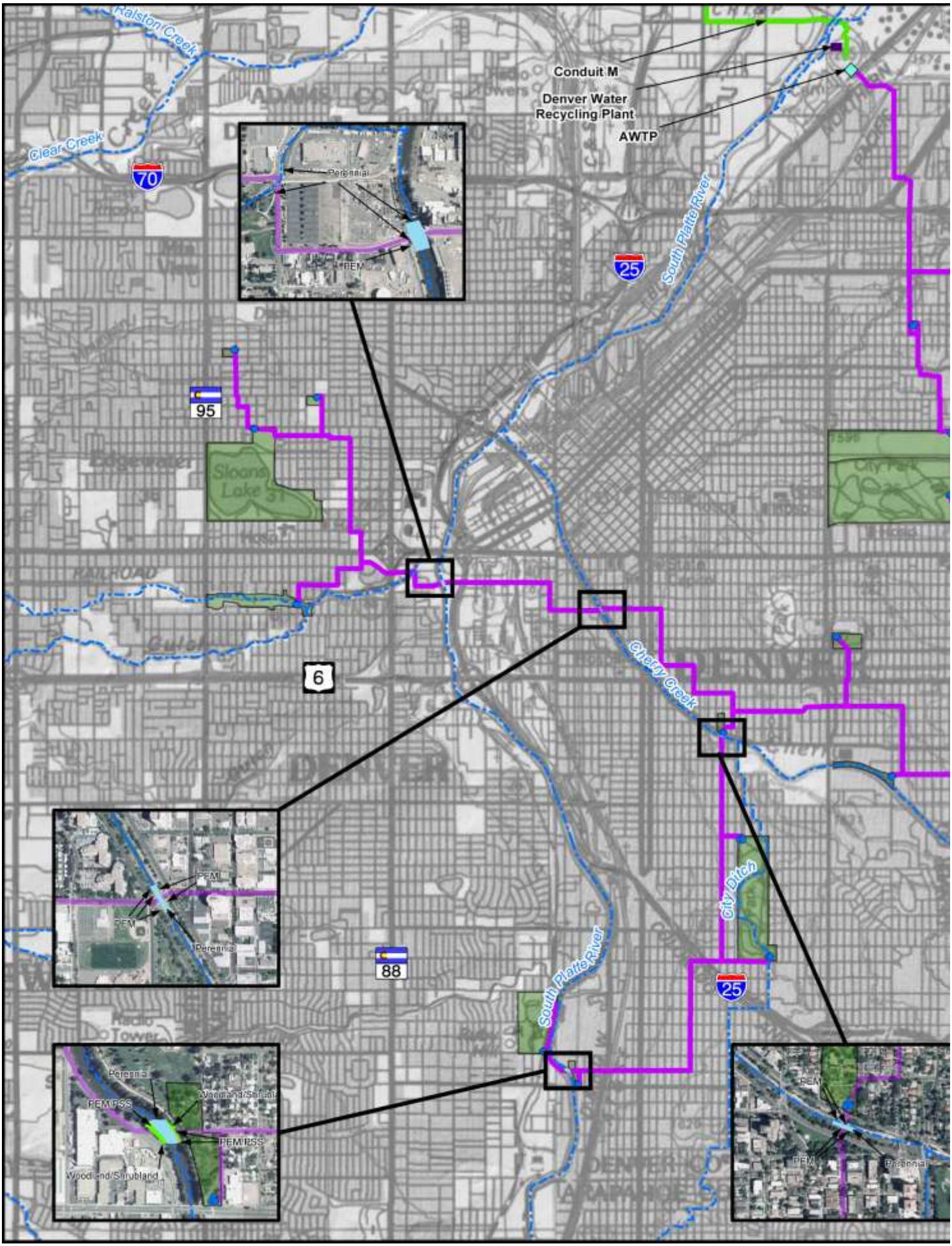
2,500 0 2,500 Feet

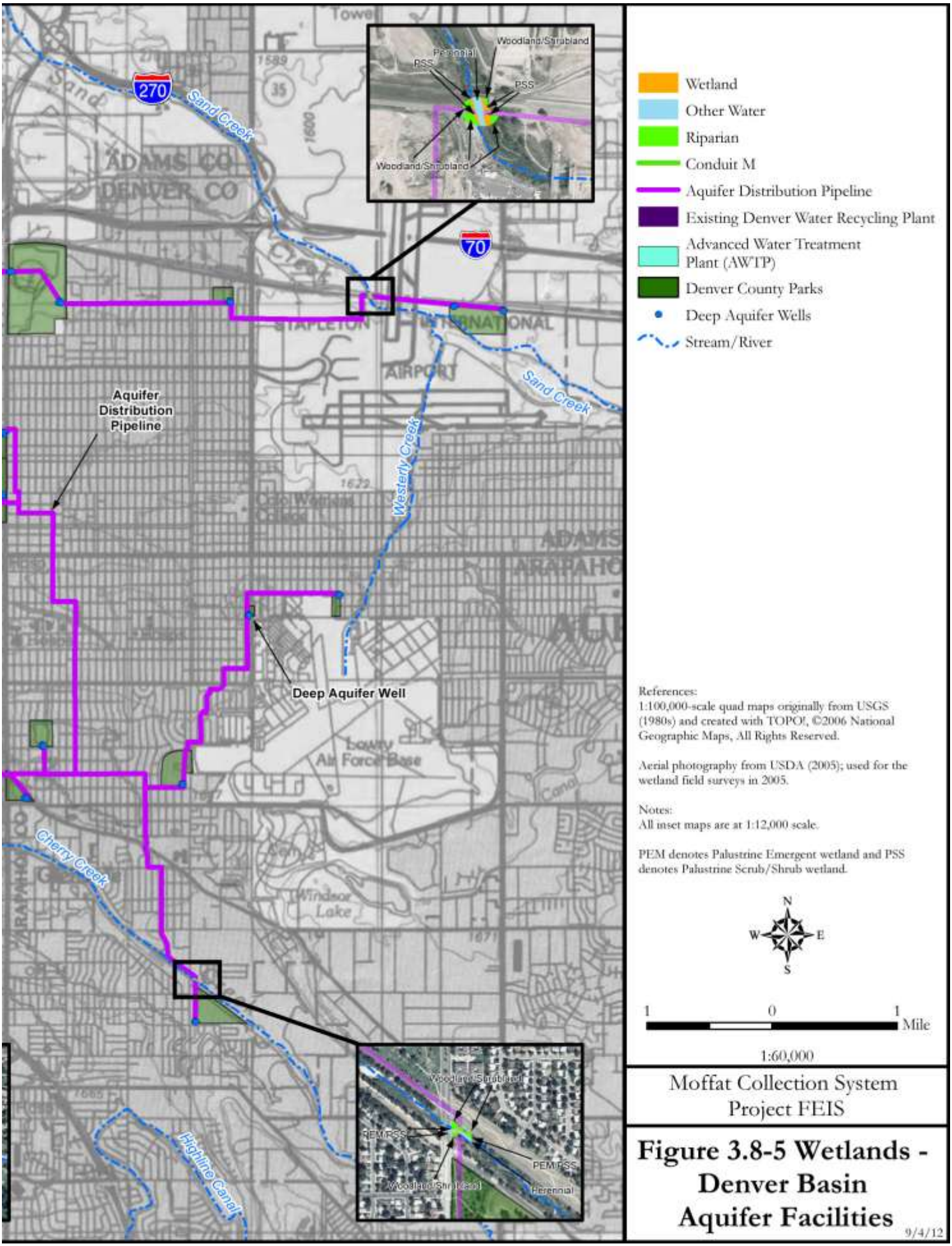
1:30,000

Moffat Collection System Project FEIS

Figure 3.8-4 Wetlands - South Platte River Facilities

9/4/12


Ralston Creek
Clear Creek
Conduit M
Denver Water
Recycling Plant
AWTP
South Platte River
Perennial
PEM
Sloans Lake
Cherry Creek
City Ditch
PFM
Perennial
PEM/PSS
Wooland/Shrubland
PEM/PSS
Wooland/Shrubland
PEM
Perennial



Moffat Collection System Project FEIS

Figure 3.8-5 Wetlands - Denver Basin Aquifer Facilities

9/4/12

Delineation methods followed the Routine Determination procedures outlined in the 1987 Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory 1987). This method involves a detailed examination of the plants, soils, and hydrologic indicators present. The same procedures were used for those wetlands observed in non-accessible areas except all soils were interpolated from existing data, and all hydrologic and vegetation data collected were limited to those observable from the closest accessible vantage point(s) with the aid of binoculars (if needed).

After determining the approximate extent of the wetlands, the wetland boundaries were mapped on 1-inch equals 200-foot (1:200) color aerial photographs, and then (if officially accessible) with the area was determined using a Global Positioning System device with sub-meter accuracy. The surveyed and/or mapped wetland locations and boundaries were then transferred to ArcGIS computer software for area calculations and map generation. Prior to impacting any of the wetlands in the study area, a formal wetland delineation and assessment of jurisdiction by the Corps would be required.

Wetlands were classified using Classification of Wetlands and Deep Water Habitats of the U.S. (Cowardin et al. 1979). The wetlands in the study areas were classified as either palustrine emergent (PEM), palustrine scrub/shrub (PSS), or a palustrine emergent and palustrine scrub/shrub combination (PEM/PSS). PEM wetlands are defined by Cowardin et al. (1979) as those wetlands that are dominated by erect, rooted, herbaceous plants. PSS wetlands are those wetlands that are dominated by woody vegetation less than 20 feet tall. PEM/PSS wetlands are those wetlands that are composed of distinct communities of both PEM and PSS vegetation. Wetlands observed in each study area are shown in Figures 3.8-1 through 3.8-5 and summarized in Table 3.8-1.

Other Water Features

Other water features identified in the study areas include intermittent and perennial streams, irrigation and stormwater ditches, ponds (natural and man-made), and a diversion canal. The linear features must have a defined bed and bank, and a scoured bed that contains less than 50% vegetation cover to be classified as other water features. Other water features observed in each study area are shown in Figures 3.8-1 through 3.8-5 and summarized in Table 3.8-2.

Table 3.8-2
Summary of Other Water Features in the East Slope Study Areas

Hydrologic Source	Type			Total (acres)
	Natural	Irrigation-related	Stormwater-related	
Gross Reservoir[1]	412.06	0.00	0.00	**412.06**
Leyden Gulch	2.04	0.94	0.09	**3.07**
Conduit M	2.07	1.92	0.97	**4.96**[2]
Conduit O	9.46	1.84	0.35	**11.65**[2]
South Platte River Facilities[3]	60.52	0.18	0.01	**60.71**
Denver Basin Aquifer Storage	2.27	0.00	0.00	**2.27**

Notes:
[1]Includes Gross Reservoir (418 acres).
[2]1.57 acres of these other water features are common between Conduits M and O.
[3]Includes 57.7 acres of gravel pit reservoirs.

3.8.1 Reservoirs

3.8.1.1 Gross Reservoir

The study area was observed by pedestrian, automobile, and boat surveys in July 2005, and revisited in June 2006, to identify riparian areas, wetlands, and other water features. The study area includes the enlarged extent of Gross Reservoir, and all areas of proposed construction disturbance, including dam modifications and access roads (Figure 3.8-1). Riparian areas and/or wetlands were observed in the study area along the Gross Reservoir shoreline and along drainages associated with the reservoir including South Boulder Creek upstream and downstream of the reservoir, Winiger Gulch and its tributaries, Forsythe Canyon, and several unnamed tributaries to the reservoir.

Riparian

A total of 4.24 acres of riparian areas were observed within the Gross Reservoir study area (Table 3.8-3).

Table 3.8-3
Summary of Riparian Areas and Wetlands in the Gross Reservoir Study Area

Location	Riparian Type (acres)			Total (acres)	Wetland Type[1] (acres)			Total (acres)
	Woodland	Shrubland	Wood/ Shrub		PEM	PSS	PEM/ PSS	
Gross Reservoir Shoreline	0.43	0.71	0.63	**1.77**	0.32	0.14	0.00	**0.46**
South Boulder Creek Upstream	0.08	0.14	0.09	**0.31**	0.02	0.00	0.11	**0.13**
South Boulder Creek Downstream	0.04	0.00	0.00	**0.04**	0.00	0.00	0.16	**0.16**
Winiger Gulch	0.06	0.55	0.00	**0.61**	0.00	0.41	0.00	**0.41**

Table 3.8-3 (continued)
Summary of Riparian Areas and Wetlands in the Gross Reservoir Study Area

Location	Riparian Type (acres)			Total (acres)	Wetland Type[1] (acres)			Total (acres)
	Woodland	Shrubland	Wood/ Shrub		PEM	PSS	PEM/ PSS	
Winiger Gulch Tributaries	0.00	0.14	0.00	**0.14**	0.00	0.18	0.30	**0.48**
Winiger Ridge Tributary	0.00	0.00	0.00	**0.00**	0.05	0.00	0.00	**0.05**
Forsythe Canyon	0.04	0.73	0.00	**0.77**	0.00	0.02	0.00	**0.02**
Unnamed Southern Tributaries	0.00	0.10	0.42	**0.52**	0.04	0.31	0.00	**0.35**
Chamberlain Gulch	0.08	0.00	0.00	**0.08**	0.00	0.00	0.07	**0.07**
Total (acres)	**0.73**	**2.37**	**1.14**	**4.24**	**0.43**	**1.06**	**0.64**	**2.13**

Notes:
[1]Wetland type is based on Cowardin et al. 1979.
PEM = Palustrine Emergent
PSS = Palustrine Scrub/Shrub

Riparian deciduous woodlands encompassing 0.73 acre were observed in the study area, 0.43 acre are associated with the reservoir shoreline, and 0.30 acre are associated with drainages within the reservoir study area.

The reservoir shoreline riparian woodlands is categorized in the Narrowleaf cottonwood/Thin-leaf alder Association with the additional dominant of plains cottonwood in the community. They are characterized by very widely-spaced narrowleaf and plains cottonwood, with pockets of very tall thin-leaf alder.

The riparian woodlands associated with drainages are categorized in the Narrowleaf cottonwood/River birch Association with the additional dominant of plains cottonwood in the community. They are characterized by an overstory of narrowleaf and plains cottonwood with pockets of very tall thin-leaf alder, and river birch. These areas are generally lined with various evergreen species, including Douglas fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), blue spruce (*Picea pungens*), and Engelmann spruce (*Picea engelmannii*).

Riparian shrublands encompassing 2.37 acres were observed in the study area: 0.71 acre is associated with the reservoir shoreline and 1.66 acres are associated with drainages within the reservoir study area.

The reservoir shoreline riparian shrublands generally occur in very small pockets and are dominated by sandbar willow. These areas are categorized in the Sandbar willow/Barren ground or Sandbar willow/Mesic graminoid Association with those in barren ground closer to the shoreline where more frequent flooding occurs. The riparian shrublands associated with drainages (especially South Boulder Creek above the reservoir) are much more diverse and are categorized in the River birch/Mesic forb Shrubland Association. Other species commonly observed in the areas include various willows (*Salix* spp.), serviceberry (*Amelanchier alnifolia*), river birch, redosier dogwood, cliffbush, ninebark (*Physocarpus*

monogymus), chokecherry, various gooseberries (*Ribes* spp.), Wood's rose (*Rosa woodsii*), and snowberry, along with pockets of dense herbaceous vegetation.

Wood/shrub riparian areas encompassing 1.14 acres were observed in the study area, including a 0.63 acre area associated with the reservoir shoreline and a 0.51 acre area associated with drainages within the reservoir study area. These areas generally contain a mix of the riparian woodland and riparian shrubland associations and the same species listed above for these communities.

Wetlands

A total of 2.13 acres of wetlands were observed within the Gross Reservoir study area (Table 3.8-3). Wetland locations and boundaries are shown in Figure 3.8-1.

PEM wetlands encompassing 0.43 acre were observed in the study area, including 0.32 acre along the reservoir shoreline and 0.11 acre along drainages associated with the reservoir. The reservoir shoreline PEM wetlands are commonly dominated by creeping bentgrass (*Agrostis stolonifera*), woolly sedge (*Carex pellita*), fowl mannagrass (*Glyceria striata*), reed canarygrass (*Phalaris arundinacea*), and panicled bulrush (*Scirpus microcarpus*). The PEM wetlands associated with the drainages are commonly dominated by giant angelica (*Angelica ampla*), common spikerush (*Eleocharis palustris*), field horsetail (*Equisetum arvense*), fowl mannagrass, and American speedwell (*Veronica americana*).

PSS wetlands encompassing 1.06 acres were observed in the study area, comprised of 0.14 acre along the reservoir shoreline and 0.92 acre along drainages associated with the reservoir. The reservoir shoreline wetlands are commonly dominated by sandbar willow. The wetlands associated with drainages are commonly dominated by thin-leaf alder, river birch, Missouri River willow, sandbar willow, and park willow.

PEM/PSS wetlands encompassing 0.64 acre were observed in the study area, including 0.27 acre along South Boulder Creek upstream and downstream of the reservoir, 0.30 acre along a tributary to Winiger Gulch, and 0.07 acre along Chamberlain Gulch. The dominant vegetation in these wetlands reflects a combination of vegetation found in the PEM and PSS wetlands of the area.

The water source for wetlands associated with the reservoir shoreline is primarily the reservoir itself. The water source for wetlands associated with the drainages is primarily provided by groundwater discharges (seeps), capillary action, and overbank flooding.

Functions provided by the wetlands at Gross Reservoir vary with location, dominant vegetation, and size. All of the wetlands provide good general wildlife habitat and many also provide good fish/aquatic habitat. Many of the wetlands in the study area provide good shoreline stabilization and production export/food chain support due to the vegetation density, type, and structure in the wetlands.

Wetlands along the edges of the perennial drainages (which include all but the unnamed southern tributary and Chamberlain Gulch) provide habitat for State species of concern, including the northern leopard frog (*Lithobates pipiens*).

Other Water Features

Seven other water features were identified in the Gross Reservoir study area, including the reservoir itself and six linear features. Gross Reservoir covers a total of 418 acres at normal water elevation (7,282 feet) capacity. The linear features encompass a total of 4.06 acres (13,790 linear feet), including South Boulder Creek (3.27 acres, 2,550 linear feet), Winiger Gulch (0.21 acre, 2,290 linear feet) and its tributary (0.05 acre, 700 linear feet), Forsythe Canyon (0.36 acre, 6,350 linear feet), Chamberlain Gulch (0.03 acre, 400 linear feet), and an unnamed southern tributary (0.14 acre, 1,500 linear feet).

All of these linear features are natural tributaries associated with Gross Reservoir, except for Chamberlain Gulch, and all are perennial, except for the intermittent unnamed southern tributary and Chamberlain Gulch. Chamberlain Gulch is classified as a perennial feature on topographic maps, but only occasional shallow pools were observed in the channel during field visits. Details of the linear features are described below.

South Boulder Creek enters the reservoir at the southwest end of Gross Reservoir and exits at the dam outlet. It has a cobble bed with 1 to 2-foot high banks. The channel width is 30 to 80 feet with an observed water depth of 6 to 30 inches.

The tributary to Winiger Gulch enters Winiger Gulch approximately 1,300 feet upstream (northwest) of the reservoir. Winiger Gulch enters the reservoir near the southwest end just northeast of where South Boulder Creek enters. Both are approximately 3 feet wide with 1 to 3 inches of water and a sandy bed.

Forsythe Canyon enters the reservoir at the northwest arm of the reservoir. It is approximately 5 feet wide with an observed water depth of 0 to 6 inches and a cobble bed with intermittent boulders.

There are two unnamed southern tributaries associated with Gross Reservoir, but only the eastern one has a scoured bed and defined banks with less than 50% vegetation cover and is therefore classified as another water feature. This eastern tributary is approximately 2 feet wide with an observed water depth of less than 1 inch and a cobble bed.

Chamberlain Gulch is the only linear water feature in the study area that is not a tributary to Gross Reservoir. It parallels the east side of Gross Dam Road at the southeastern edge of the study area. The channel has a varied width of approximately 2 to 3 feet with a sand and cobble bed. Though topographic maps show it as a perennial stream, there was no water observed in the channel during field visits except for occasional pools of water no more than 2 inches deep.

3.8.1.2 Leyden Gulch Reservoir Site

The Leyden Gulch site was observed by pedestrian and automobile surveys in July and August 2005, and June 2006, to identify riparian areas, wetlands, and other water features. The study area includes the proposed reservoir extent and all areas associated with construction of proposed facilities, the southern tributary to Leyden Gulch, and Ralston Creek in the southern pipeline area (Figure 3.8-2). Riparian areas and/or wetlands were observed in the study area along Leyden Gulch and its tributaries, Ralston Creek and a tributary, the South Boulder Diversion Canal, three ponds and two seeps.

Riparian

A total of 1.73 acres of riparian areas were observed within the Leyden Gulch site (Table 3.8-4).

Table 3.8-4
Summary of Riparian Areas and Wetlands in the Leyden Gulch Study Area

Location	Riparian Type (acres)			Total (acres)	Wetland Type[1] (acres)			Total (acres)
	Woodland	Shrubland	Wood/ Shrub		PEM	PSS	PEM/ PSS	
Leyden Gulch	0.00	0.00	0.13	**0.13**	2.66	0.06	0.00	**2.72**
Northern Tributaries – Leyden Gulch	0.08	0.12	0.00	**0.20**	1.22	0.00	0.00	**1.22**
Central Tributaries – Leyden Gulch (near hillside seep)	0.00	0.00	0.00	**0.00**	0.08	0.00	0.00	**0.08**
Hillside Seeps	0.00	0.00	0.00	**0.00**	2.07	0.00	0.00	**2.07**
Wetland at Confluence of Leyden Gulch and Hillside Seep	0.00	0.00	0.00	**0.00**	0.32	0.00	0.00	**0.32**
South Tributary to Leyden Gulch	0.00	0.28	0.00	**0.28**	13.06[2]	0.00	0.08	**13.14**
Stormwater Ditch – northeast edge of study area	0.00	0.00	0.00	**0.00**	0.04	0.00	0.00	**0.04**
South Boulder Diversion Canal	0.00	0.42	0.00	**0.42**	0.00	0.00	0.00	**0.00**
Ralston Creek Area	0.32	0.00	0.38	**0.70**	0.40	0.00	0.65	**1.05**
Total (acres)	**0.40**	**0.82**	**0.51**	**1.73**	**19.85**	**0.06**	**0.73**	**20.64**

Notes:
[1]Wetland type is based on Cowardin et al. 1979.
[2]11.67 acres of these wetlands is based on a photo interpreted boundary because access was not available.
PEM = Palustrine Emergent
PSS = Palustrine Scrub/Shrub

Riparian deciduous woodland areas encompassing 0.40 acre were observed in the study area; including 0.08 acre associated with a northern tributary to Leyden Gulch, and 0.32 acre associated with Ralston Creek. The areas primarily consist of Lanceleaf cottonwood Woodland Association. Peachleaf willow was also observed along the north tributary to Leyden Gulch and plains cottonwood was observed along Ralston Creek.

Riparian shrublands encompassing 0.82 acre were observed in the study area, including 0.12 acre associated with a northern tributary to Leyden Gulch, 0.42 acre associated with the South Boulder Diversion Canal, and 0.28 acre in the westernmost portion of the southern tributary to Leyden Gulch.

The northern tributary shrubland area is categorized in the Chokecherry Shrubland Association with wax current (*Ribes cereum*) as the other dominant species observed.

The South Boulder Diversion Canal shrubland is categorized in the Sandbar willow/Barren ground Shrubland Association. It is characterized by stretches of sandbar willow and several weedy species observed with less than 20% ground cover in sandy soil.

The southern tributary shrubland area is categorized in the Chokecherry Shrubland Association with other species observed, including thin-leaf alder, snowberry, wax currant, hawthorn (*Crataegus* sp.), crack willow, box elder (*Acer negundo*), and golden currant (*Ribes aureum*).

Wood/shrub riparian areas encompassing 0.51 acre were observed in the study area, including 0.13 acre along Leyden Gulch just west of State Highway (SH) 93, and 0.38 acre along Ralston Creek.

The wood/shrub riparian area along Leyden Gulch is categorized in the Plains cottonwood/ Peachleaf willow (Crack willow) Woodland Association with both peachleaf and crack willow present and other species observed, including lanceleaf cottonwood and Russian olive. The shrub component is categorized in the Sandbar willow/Mesic graminoid Association. Observed grassy species in the understory included tall wheatgrass (*Thinopyrum smithii*) and western wheatgrass (*Pascopyrum smithii*).

The wood/shrub riparian areas along Ralston Creek are categorized in the Lanceleaf cottonwood Association with some observed plains cottonwood. The shrub component is categorized in the Chokecherry/Shrubland Association with other species observed, including snowberry, box elder, and golden current.

Wetlands

A total of 20.64 acres of wetlands are located within the Leyden Gulch site (Table 3.8-4).

PEM wetlands encompassing approximately 19.85 acres were observed in the study area. Wetlands were identified along Leyden Gulch and its tributaries, along the west side of SH 93 between the railroad crossings in the northeast end of the study area (Wetland LG 16-1), associated with a hillside seep just west of where Leyden Gulch crosses SH 93, associated with the southern tributary to Leyden Gulch, and south of Ralston Creek in the southern pipeline area.

Most of the PEM wetlands are commonly dominated by redtop (*Agrostis gigantea*), Nebraska sedge (*Carex nebrascensis*), common spikerush, foxtail barley (*Hordeum jubatum*), Baltic rush (*Juncus balticus*), annual rabbitsfoot grass (*Polypogon monspeliensis*), common threesquare (*Scirpus pungens*), cloaked bulrush (*Scirpus pallidus*), and broadleaf cattail (*Typha latifolia*). Wetland LG 16-1 is dominated by foxtail barley, common spikerush, and barnyard grass (*Echinochloa crus-galli*).

There was no access to the large PEM wetland (Wetland LG12-19) in the central portion of the southern tributary to Leyden Gulch (proposed emergency outlet area) just south of the proposed reservoir. The boundary was determined using interpretation of color aerial photography. The general vegetation classification was determined to be sedge (*Carex* spp.). This wetland would require a formal delineation and determination of jurisdiction by the Corps prior to any Project impacts.

One PSS wetland, encompassing approximately 0.06 acre, was observed in the study area, along Leyden Gulch, and is dominated by sandbar willow. PEM/PSS wetlands

encompassing approximately 0.73 acre were observed in the study area along Leyden Gulch, in the southern tributary to Leyden Gulch just east of SH 93, and along Ralston Creek. These wetlands are dominated by Baltic rush, broadleaf cattail, Nebraska sedge, and sandbar willow.

The water source for wetlands associated with Leyden Gulch and its tributaries is seasonal flooding, seeps, and stormwater. Wetland LG18-4 (hillside seep wetland near Leyden Gulch) receives water from seeps probably associated with the South Boulder Diversion Canal. Water for Ralston Creek wetlands is primarily provided by capillary action and overbank flooding. Wetland LG 22-2 (south of Ralston Creek) receives water from seeps associated with the lakes on the hills to the south and west, and possibly some seasonal groundwater and flooding associated with Ralston Creek.

Functions provided by the wetlands in the study area vary with location, dominant vegetation, and size. The wetlands at the southeast end of Leyden Gulch provide good general wildlife habitat as indicated by the numerous species observed during field visits including cottontail rabbits (*Sylvilagus* sp.), a bull snake (*Pituophis catenifer*), a coyote (*Canis latrans*), and various birds, including redwing blackbirds (*Agelaius phoeniceus*), and robins (*Turdus migratorius*). The wetlands along Ralston Creek provide good wildlife habitat indicated by the numerous birds observed. They also provide production export/food chain support and good shoreline stabilization due to the thick sandbar willow populations along the shoreline.

Wetlands at Ralston Creek and the largest pond provide habitat for State species of concern, including northern leopard frog. The seep wetlands provide groundwater discharge.

Other Water Features

A total of nine other water features, encompassing 3.07 acres and 4,025 linear feet, were observed in the Leyden Gulch site, including sections of Leyden Gulch that are intermittent (0.17 acre, 1,120 linear feet), along the South Boulder Diversion Canal (0.83 acre, 1,490 linear feet), along an unnamed irrigation canal (0.11 acre, 600 linear feet), along Ralston Creek (0.40 acre, 630 linear feet) and one of its tributaries (0.01 acre, 50 linear feet), around three ponds (1.47 acres), and along one stormwater ditch (0.08 acre, 135 linear feet).

The upper reaches of Leyden Gulch contain pockets of herbaceous wetland and weedy vegetation inter-mixed with scoured bed and banks that are generally 6 to 8 feet wide. As the gulch approaches the west side of SH 93, the channel widens to 10 to 14 feet. East of SH 93 the floodplain spreads out and the channel is filled with wetland vegetation.

The South Boulder Diversion Canal has a soil bed and banks for most of its length, with sections of concrete and/or riprap. The channel is approximately 6 feet wide with an observed water depth of approximately 2 feet.

The unnamed irrigation canal is 6 to 8 feet wide with a concrete bed and banks, and observed water depth of 3 to 4 inches.

Ralston Creek is 15 feet wide along most of its channel (at the time of visit it was flooded beyond its banks to 20 to 25 feet wide at the control gate) with a bed and banks of sand and

silt. The tributary to Ralston Creek is 6 feet wide with a bed and banks of sand and silt, and 4- to 6-inch water depth.

Standing water was observed at all three ponds in the study area. The two smaller ponds had 4- to 10-inch water depths and a larger one near the southern tributary to Leyden Gulch had an estimated depth of 12 to 24 inches.

The stormwater ditch along the west side of SH 93 had an observed water depth of 6 to 10 inches with a width of approximately 20 feet that inundated the wetland vegetation along the edges.

3.8.2 Conveyance Systems

Riparian areas, wetlands, and other water features were mapped in 320-foot wide study areas along proposed Conduits M and O centered on their proposed alignments (Figure 3.8-3). The Conduit M study area was observed by pedestrian and/or automobile surveys in October and November 2005. The Conduit O study area was observed by pedestrian and/or automobile surveys in November 2005 and July 2006. Areas along the conduits that had limited or no access required data to be collected by visual confirmation, often with binoculars and aerial photography. The total acreage of the riparian and wetland areas observed is summarized in Table 3.8-1.

3.8.2.1 Conduit M

Riparian

A total of 2.42 acres of riparian areas were observed along Conduit M study area (Table 3.8-1). There are 0.95 acre of riparian areas within the western section of the study area that are common with Conduit O.

Two riparian deciduous woodland areas encompassing 0.41 acre were observed along Conduit M. One occurs along the South Platte River that is categorized in the Plains cottonwood/Peachleaf willow (Crack willow) Woodland Association. The other is located by a pond that is categorized in the Peachleaf willow Woodland Association with numerous Russian olive in the community.

One riparian shrubland area of less than 0.01 acre was observed in the Conduit M study area along Little Dry Creek. This area is categorized in the Sandbar willow/Mesic graminoid Shrubland Association with other shrub species including Woods' rose, young Siberian elm, and young peachleaf willow.

Wood/shrub riparian areas encompassing 2.01 acres were observed along Conduit M, including areas in Two Ponds National Wildlife Refuge (NWR), along the South Boulder Diversion Canal, Farmers Highline Canal, Church Ditch, Croke Canal, Little Dry Creek, Colorado Irrigation Canal, Clear Creek, and the South Platte River. These wood/shrub riparian areas are categorized in the Plains cottonwood/Peachleaf willow (Crack willow) Woodland Association with other species observed including Siberian elm and Russian olive. The shrub component of these areas may be categorized in either the Sandbar willow/Mesic graminoid Shrubland Association or the Sandbar willow/Barren ground Shrubland Association.

Wetlands

A total of 3.17 acres of wetlands were observed within the Conduit M study area (Table 3.8-1). There are 2.14 acres of wetland areas within the western section of the study area that are shared with Conduit O.

PEM wetlands covering 1.82 acres were observed along Conduit M study area, including along Church Ditch, Little Dry Creek, Colorado Agricultural Canal, Clear Creek, South Platte River, Burlington Ditch, and some ponds and depressions. The PEM wetlands were commonly dominated by broadleaf cattail, softstem bulrush (*Scirpus validus*), common reed (*Phragmites australis*), Baltic rush, reed canarygrass, woolly sedge, and common threesquare.

PSS wetlands encompassing 0.47 acre were observed along Conduit M, including one along Farmers Highline Canal, and several associated with stormwater drainage.

PEM/PSS wetlands encompassing 0.88 acre were observed along Farmers Highline Canal, Croke Canal, Clear Creek, a pond, and stormwater ditches. They were dominated by sandbar willow, broadleaf cattail, common reed, reed canarygrass, and woolly sedge.

The water sources for the wetlands along drainages in the Conduit M study area are alluvial groundwater and overbank flooding. The sources for the wetlands associated with the ponds are primarily groundwater and stormwater. Wetlands associated with the ditches and depressions are maintained by stormwater.

Functions provided by the Conduit M wetlands vary with location, dominant vegetation, and size. Most are along natural and irrigation drainages provide good shoreline stabilization because of the type and density of vegetation, as well as some production export/food chain support. Wetlands along Clear Creek provide good wildlife habitat, and production export/food chain support. Wetlands along the stream bank provide stabilization, and as they extend farther out in the floodplain, provide sediment/nutrient retention and removal, and flood attenuation due to the type, density, and structure of the vegetation, and their position in the landscape.

Wetlands at Two Ponds NWR, Little Dry Creek, Clear Creek and its tributary, and the stormwater pond near Clear Creek provide habitat for State species of concern along Conduit M, including the northern leopard frog.

Other Water Features

A total of 24 other water features, encompassing 4.96 acres and 7,685 linear feet, were observed along Conduit M. Fourteen of these features, encompassing 1.57 acres and 4,105 linear feet, are in the section of study area common to both Conduits M and O, and include:

- South Boulder Diversion Canal – covers 0.11 acre (210 linear feet), with a channel that is concrete near and under SH 72 and soil in the remainder of the study area. The canal is approximately 15 feet wide with an estimated depth of 18 inches.
- Barbara Gulch – encompasses 0.08 acre (120 linear feet) and is approximately 12 feet wide with no water. Substrate is unknown due to lack of access.

- Church Ditch (crossed three times) – encompasses 0.26 acre (1,270 linear feet) with an estimated width of 6 to 9 feet, no water in two of the crossings, and 4 inches of water in the remaining crossing. It has a sandy soil bed with some cobble.
- Farmers Highline Canal (crossed two times) – encompasses 0.55 acre (960 linear feet) with an estimated 10 to 15 feet channel width range, 0- to 4-inch water depth, and a sandy soil bed.
- Croke Canal – encompasses 0.30 acre (630 linear feet) with an estimated 20-foot channel width, 12- to 24-inch water depth, and a soil bed.
- Two Ponds NWR northern pond – encompasses 0.04 acre with an estimated depth of 4 to 6 feet.
- Little Dry Creek (one crossing in this common area) – encompasses 0.11 acre (750 linear feet) and is approximately 6 feet wide with an observed water depth of 6 to 10 inches and has a sandy soil bed.
- Five stormwater ponds – encompass 0.12 acre; one plastic-lined and only one contained water (approximately 4 to 6 inches).
- Two stormwater ditches – encompass 0.01 acre (165 linear feet), are 2 to 3 feet wide with sand and cobble bed, and no observed water.

The remaining other water features (3.39 acres and 3,580 linear feet) occur in the section of the Conduit M study area not shared with Conduit O and include:

- Colorado Agricultural Canal – encompasses 0.05 acre (310 linear feet); the canal has a channel approximately 6 feet wide with a sandy soil bed and water 12 to 18 inches deep.
- Clear Creek and its tributary – encompass 0.45 acre (470 linear feet); the creek is perennial and is approximately 30 to 35 feet wide with a cobble bed and water 8 inches deep. Its tributary is intermittent, 8 feet wide with water 4 inches deep, and connects Clear Creek to one of the stormwater ponds.
- South Platte River – encompasses 1.08 acres (320 linear feet); the river is perennial, approximately 100 feet wide with water approximately 1 to 2 feet deep, and contains a sand and cobble bed.
- Burlington Ditch – encompasses 0.66 acre (390 linear feet); the ditch is 50 to 60 feet wide with water 2.5 to 3 feet deep.
- Two stormwater ditches – encompass 0.02 acre (350 linear feet); one ditch extends along North Broadway and is 6 feet wide with a soil bed, and the other is 3 feet wide and feeds a stormwater pond near Clear Creek (see next bullet). No water was observed in either ditch.
- Two stormwater ponds – encompass 0.82 acre; one pond was observed near Clear Creek with a depth of 30 to 36 inches, and is fed by large concrete culverts beneath Interstate (I-) 25 and a stormwater ditch. This pond feeds a tributary to Clear Creek, and may also receive groundwater associated with Clear Creek during high water events

and/or seasonal highs. The other is an L-shaped pond at a street intersection with a cobble bed and water approximately 1 inch deep.

- Little Dry Creek (two crossings only in Conduit M study area) and its tributary – encompass 0.31 acre (1,740 linear feet); the creek is perennial with a tributary, both of which are 4 to 6 feet wide with water 2 to 10 inches deep. Both have soil beds and banks, except for sections stabilized with concrete and riprap.

3.8.2.2 Conduit O

Riparian

A total of 4.81 acres of riparian areas were observed along Conduit O (Table 3.8-1). There is 0.95 acre of riparian areas within the western section of the study area that are common with Conduit M.

Riparian woodland areas encompassing 1.53 acres (all deciduous) were observed along Conduit O. Two are located near stormwater ditches west of I-25: one is associated with several ponds east of Brighton Boulevard and just north of 112th Avenue, and one is located near the end of Conduit O between South Platte River and Brighton Boulevard (within an old oxbow of South Platte River). These areas are categorized in the Plains cottonwood/ Peachleaf willow (Crack willow) Woodland Association with other species observed, including Siberian elm and Russian olive.

Wood/shrub riparian communities encompassing 3.28 acres were observed along Conduit O. These riparian areas occur along the South Boulder Diversion Canal, Farmers Highline Canal, Church Ditch, Croke Canal, Little Dry Creek, Fulton Ditch, South Platte River, and two near the eastern end of Conduit O between South Platte River and Brighton Boulevard.

These wood/shrub riparian areas are categorized in the Plains cottonwood/Peachleaf willow (Crack willow) Woodland Association with crack willow (not peachleaf willow) as the co-dominant. The shrub component is categorized in the Chokecherry Shrubland Association with other species observed, including Siberian elm, sandbar willow, snowberry, and golden current.

There were no riparian shrubland areas observed within the Conduit O study area.

Wetlands

A total of 5.76 acres of wetlands were observed along Conduit O (Table 3.8-1). There are 2.14 acres of wetland areas within the western section of Conduit O that overlap with Conduit M.

PEM wetlands encompassing 3.34 acres were observed in the Conduit O study area, including along Church Ditch, Little Dry Creek, lower Clear Creek, the South Platte River and an associated oxbow, Allen Ditch, Fulton Ditch, some ponds and depressions, and numerous agricultural and stormwater ditches. The PEM wetlands are commonly dominated by broadleaf cattail, softstem bulrush, Emory's sedge, and reed canarygrass with other dominants, including Baltic rush, barnyard grass, creeping bentgrass, common

spikerush, poison hemlock (*Conium maculatum*), curlytop knotweed (*Polygonum lapathifolium*), and stinging nettle (*Urtica dioica*).

PSS wetlands encompassing 0.48 acre were observed along Conduit O, including one along Farmers Highline Canal, and several associated with stormwater drainage. All these wetlands are common with Conduit M.

PEM/PSS wetlands encompassing 1.94 acres were observed along Farmers Highline Canal, Croke Canal, and stormwater ditches. The dominant scrub/shrub species of each wetland is sandbar willow with a dominant emergent species of broadleaf cattail, creeping spike rush, or Emory's sedge.

Stormwater is the primary water source for the wetlands located along the stormwater ditches and the depressions. The water sources for the wetlands located along the irrigation ditches in the Conduit O study area are primarily overbank flooding and capillary action associated with the seasonal flow of the ditches. The water source for wetlands associated with lower Clear Creek and South Platte River is primarily alluvial groundwater and overbank flooding. The water sources for the wetlands associated with the ponds are primarily groundwater and stormwater.

Functions provided by the wetlands vary with location, dominant vegetation, and size. Most of the fringe wetlands along natural and irrigation drainages provide good shoreline stabilization because of the type and density of vegetation, and some provide production export/food chain support. Wetlands associated with Fulton Ditch at 88th Avenue provide good wildlife habitat, flood attenuation, sediment/nutrient/toxicant retention and removal, and production export/food chain support due to the type, density, and structure of the vegetation, and their size and low position in the landscape.

Other Water Features

A total of 39 other water features, encompassing 11.65 acres and 8,275 linear feet, were observed along Conduit O. Those that are unique to Conduit O (not shared with Conduit M) encompass 10.08 acres and 4,170 linear feet, and include:

- Tributary to Little Dry Creek – encompasses 0.01 acre (80 linear feet) with an observed range of water depth of 2 to 8 inches, width of 4 to 6 feet, and bed of sand with some scattered rocks.
- Allen Ditch – encompasses 0.04 acre (420 linear feet) with an observed range of water depth of 7 to 9 inches, width of 5 to 6 feet, and bed of silt with some scattered rocks.
- Tributary to Niver Creek – encompasses 0.01 acre (90 linear feet) with an observed water depth of approximately 2 to 8 inches, width of 4 to 7 feet, and bed of sand and silt with some scattered riprap.
- Colorado Agricultural Canal – encompasses 0.04 acre (230 linear feet) with an observed water depth of approximately 24 inches, width of 6 to 7 feet, and bed of soil with some concrete.
- Lower Clear Creek Canal – encompasses 0.04 acre (210 linear feet); the canal has a channel approximately 6 to 8 feet wide with an observed water depth of 12 inches and a silt bed.

- South Platte River – encompasses 1.15 acres (320 linear feet); the river is perennial, approximately 100 feet wide with water approximately 1 to 3 feet deep, and contains a sand and cobble bed.
- Fulton Ditch – encompasses 0.51 acre (830 linear feet); the canal has a channel approximately 18 to 20 feet wide with an observed water depth of approximately 2 feet and a soil bed.
- Six stormwater ditches – encompass 0.14 acre (1,990 linear feet), ranging from 2 to 7 feet wide with observed water depths between 0 and 8 inches, and sand or silt substrate.
- Thirteen man-made ponds – encompass 8.14 acres. Many were not accessible and water depth and substrate data could not be collected. Aerial photography was used to determine their shoreline locations. All but one (0.08 acre) are in the South Platte River floodplain and probably receive input from groundwater associated with the river.

3.8.3 South Platte River Facilities

The South Platte River Facilities study area was observed by pedestrian and automobile surveys in November 2005 and July 2006 to identify riparian areas, wetlands, and other water features (Figure 3.8-4). Delineation and mapping of wetlands, other waters and riparian areas along the proposed pipeline were conducted in accessible areas around the gravel pits and within a 300-foot wide study corridor centered on the proposed alignment of the gravel pit pipelines.

Gravel Pits

Detailed wetland, other water and riparian studies were conducted at Worthing Pit. Limited access was available around the North and South Tower pits, so they were observed and mapped from the closest accessible vantage point(s) with binoculars. There were no accessible vantage points near the Challenger Pit.

Riparian

A total of 0.03 acre of riparian deciduous woodlands was observed on the southern edge of Worthing Pit and is categorized in the Plains cottonwood/Peachleaf willow (Crack willow) Woodland Association (Table 3.8-5).

Wetlands

A total of 1.92 acres of wetlands were observed at Worthing Pit (Table 3.8-5).

Table 3.8-5
Summary of Riparian Areas and Wetlands Associated with South Platte River Facilities

Location	Riparian Type (acres)			Total (acres)	Wetland Type[1] (acres)			Total (acres)
	Woodland	Shrubland	Wood/ Shrub		PEM	PSS	PEM/ PSS	
Worthing Pit	0.03	0.00	0.00	**0.03**	0.51	0.00	1.41	**1.92**
Diversion	0.03	0.00	0.00	**0.03**	0.00	0.00	0.23	**0.23**
Pipeline	0.94	0.00	0.29	**1.23**	1.53	0.07	0.58	**2.18**
Outlet Structure	0.00	0.00	0.06	**0.06**	0.00	0.00	<0.01	**<0.01**
Treatment	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	**0.00**
Total (acres)	**1.00**	**0.00**	**0.35**	**1.35**	**2.04**	**0.07**	**2.22**	**4.33**

Notes:
[1]Wetland type is based on Cowardin et al. 1979.
< = less than
PEM = Palustrine Emergent
PSS = Palustrine Scrub/Shrub

PEM wetlands encompassing 0.51 acre were observed on the shoreline of four ponds and a portion of one smaller pond in the Worthing Pit study area. The shoreline wetlands are commonly dominated by broadleaf cattail and curlytop knotweed. The wetland associated with the smaller pond is dominated by bearded sprangletop (*Leptochloa fusca*), common spikerush, narrowleaf cattail (*Typha angustifolia*), barnyard grass, and curly dock.

PEM/PSS wetlands encompassing approximately 1.41 acres were observed on the shoreline of four existing ponds. These wetlands are dominated by sandbar willow, young peachleaf willow, curlytop knotweed, and broadleaf cattail.

The water source for all Worthing Pit wetlands is primarily groundwater with some runoff.

Functions provided by the wetlands vary with location, dominant vegetation, and size. PSS wetlands in the Worthing pit study area provide good shoreline stabilization because of the type and density of vegetation.

Wetlands at the man-made ponds provide habitat for State species of concern, including northern leopard frog and common garter snake.

Other Water Features

The five other water features (57.70 acres) observed in the Worthing Pit study area are man-made ponds (gravel pits) with water depths that range from less than 1 foot to greater than 10 feet deep.

Diversion

Riparian

A total of 0.03 acre of riparian deciduous woodland areas was observed north of the South Platte River diversion area and can be categorized in the Plains cottonwood/Peachleaf willow (Crack willow) Woodland Association (Table 3.8-5). No shrubland or wood/shrub riparian areas were observed in the study area.

Wetlands

One PEM/PSS wetland encompassing approximately 0.23 acre was observed in the South Platte River diversion area (Table 3.8-5). Dominant vegetation observed includes reed canarygrass, curlytop knotweed, curly dock, and sandbar willow. There are no PEM or PSS wetlands in South Platte diversion area.

The water source for the wetland is the South Platte River via overbank flooding and groundwater.

Functions provided by the wetlands along the South Platte River include sediment/nutrient/ toxicant removal and sediment/shoreline stabilization because of the density, type and structure of vegetation, and their position in the landscape within the floodplain.

This wetland along the South Platte River provides habitat for State species of concern, including northern leopard frog and common garter snake.

Other Water Features

One other water feature (a section of the South Platte River), encompassing 0.38 acre, was observed in the South Platte River diversion area. The South Platte River is perennial, approximately 80 to 100 feet wide, and several feet deep with a sandy bed.

Conveyance

The South Platte River Facilities pipeline extends from the northern end of Conduit O to the southeast corner of Challenger Pit. The study area includes arterial pipelines connecting North Tower Pit, South Tower Pit and Challenger Pit to the main pipeline (Figure 3.8-4).

Riparian

A total of 1.23 acres of riparian areas were observed within the South Platte River Facilities pipeline study area (Table 3.8-5).

One riparian deciduous woodland area encompassing approximately 0.94 acre was observed along an irrigation ditch near Brighton Road southeast of North Tower Pit. It can be categorized in the Thin-leaf alder/Mesic graminoid Shrubland Association with crack willow as another dominant, and an understory of smooth brome (*Bromus inermis*). Another riparian woodland area was observed on aerial photography at the location of the proposed pipeline artery to North Tower Pit. This area was not accessible and specific vegetation species were not recorded.

Wood/shrub riparian areas encompassing approximately 0.29 acre were observed along the McCann Ditch and in an old oxbow of South Platte River. They can be categorized in the Crack willow/Sandbar willow Shrubland Association with young and older (woodland component) crack willow and other species, including Siberian elm and Russian olive.

No riparian shrubland areas were observed along the South Platte River Facilities pipeline study area.

Wetlands

A total of 2.18 acres of wetlands were observed within South Platte River Facilities pipeline study area (Table 3.8-6).

Three PEM wetlands encompassing approximately 1.53 acres were observed in South Platte River Facilities pipeline study area, including two fringe wetlands along irrigation ditches, and one in an oxbow in its floodplain. The wetlands are commonly dominated by broadleaf cattail and reed canarygrass, with other dominants unique to individual wetlands including curly dock, foxtail barley, common spike rush, poison hemlock, and curlytop knotweed.

One PSS wetland encompassing approximately 0.07 acre was observed along South Platte River and is dominated mostly by sandbar willow with some smaller sections dominated by reed canarygrass.

Two PEM/PSS wetlands encompassing approximately 0.58 acre were observed in the South Platte River Facilities pipeline study area along irrigation ditches. The wetlands are commonly dominated by sandbar willow and reed canarygrass, with other dominants unique to individual wetlands including crack willow, broadleaf cattail, narrowleaf cattail, common duckweed (*Lemna minor*), and Canada thistle (*Cirsium arvense*).

The water sources for the wetlands along drainages in the South Platte River Facilities pipeline study area include three irrigation ditches, one stormwater ditch, Second Creek, and the South Platte River.

Functions provided by the wetlands vary with location, dominant vegetation, and size. Most of the fringe wetlands in the South Platte River Facilities pipeline study area provide good shoreline stabilization because of the type and density of vegetation. Wetlands associated with Second Creek provide good wildlife habitat, shoreline stabilization, and sediment/nutrient/toxicant retention and removal. Wetlands associated with McCann Ditch provide good wildlife habitat and shoreline stabilization.

Wetlands along the South Platte River provide habitat for State species of concern, including northern leopard frog and common garter snake.

Other Water Features

Seven other water features, encompassing 2.52 acres and 1,430 linear feet, were observed in the South Platte River Facilities pipeline study area and include:

- South Platte River – encompasses 1.41 acres (320 linear feet), the river is perennial, approximately 100 feet wide with water approximately 1 to 2 feet deep, and contains a sand and cobble bed.
- McCann Ditch – encompass 0.14 acre (330 linear feet), is approximately 18 to 20 feet wide, with an observed water depth of 6 to 8 inches and a silt bed.
- One stormwater ditch – encompasses 0.01 acre (190 linear feet), the ditch is a tributary to McCann Ditch with an observed width of 1 to 2 feet and a sandy/silty bed. No water was observed in the ditch.
- Three unnamed irrigation ditches – encompass 0.04 acre (590 linear feet), with canal widths ranging from 3 to 8 feet, observed water depths of 12 inches and silt beds for both.
- Two man-made ponds – encompass 0.92 acre, including the eastern edge of South Tower Pit and the eastern edge of a pond near Worthing Pit.

Outlet Structure

The study area for the outlet structure is 100 feet wide and extends from Worthing Pit to South Platte River. The study area at the Worthing Pit shoreline includes part of a wetland that was covered in the Worthing Pit subsection and will not be addressed here. Along South Platte River, the study area contains a riparian area and a fringe wetland.

Riparian

A total of 0.06 acre of riparian wood/shrub was observed in the study area along the South Platte River (Table 3.8-5), which can be categorized in the Peachleaf willow Woodland Association, and the shrub component can be categorized in the Sandbar willow/Mesic graminoid Shrubland Association. One plains cottonwood was observed in the community. No shrubland or woodland riparian areas were observed in the study area.

Wetlands

One PEM/PSS wetland encompassing less than 0.01 acre was observed along the banks of the South Platte River in the outlet area. It is dominated by sandbar willow (80%) and reed canarygrass (35%). No PEM or PSS wetlands were observed in the study area.

Water is provided for the wetland via overbank flooding and capillary action associated with South Platte River.

The wetland provides good shoreline stabilization because of the type and density of vegetation, and its location along the shoreline of the South Platte River. It also provides habitat for State species of concern, including the northern leopard frog and common garter snake.

Other Water Features

A section of South Platte River (0.11 acre, 80 linear feet) was included in the outlet structure study area. South Platte River is perennial, approximately 80 to 100 feet wide, and several feet deep with a sandy soil bed.

Treatment

One other water feature, an industrial pond, occupies about 1 acre of the 4-acre Advanced Water Treatment Plant (AWTP) site adjacent to Worthing Pit. There are no wetlands or riparian areas at this site.

3.8.4 Denver Basin Aquifer Facilities

Riparian field studies for the Denver Basin Aquifer Facilities were conducted at seven locations where the pipeline crosses four streams (Figure 3.8-5). Many of the crossing locations also contain wetlands and riparian areas. No wetlands, other waters, or riparian areas were observed at the AWTP site located adjacent to the Board of Water Commissioners (Denver Water) Recycling Plant.

Riparian

A total of 0.88 acre of riparian areas were observed within the Denver Basin Aquifer Facilities study area, as summarized in Table 3.8-6.

Table 3.8-6
Summary of Riparian Areas and Wetlands along the Denver Basin Aquifer Facilities Distribution Pipeline

Other Waters of the U.S.	Riparian Type (acres)			Total (acres)	Wetland Type[1] (acres)			Total (acres)
	Woodland	Shrubland	Wood/ Shrub		PEM	PSS	PEM/ PSS	
South Platte River	0.00	0.00	0.31	**0.31**	<0.01	0.00	0.01	**0.01**
Cherry Creek	0.00	0.00	0.17	**0.17**	0.01	0.00	0.02	**0.03**
Sand Creek	0.00	0.00	0.40	**0.40**	0.00	0.27	0.00	**0.27**
Total (acres)	**0.00**	**0.00**	**0.88**	**0.88**	**0.01**	**0.27**	**0.03**	**0.31**

Notes:
[1]Wetland type is based on Cowardin et al. 1979.
Totals may not equal 100% due to rounding.
< = less than
PEM = Palustrine Emergent
PSS = Palustrine Scrub/Shrub

No riparian woodland or riparian shrubland areas were observed in the Denver Basin Aquifer Facilities study area.

However, three wood/shrub riparian areas encompassing 0.88 acre were observed along Cherry Creek, Sand Creek, and South Platte River. These wood/shrub riparian areas are classified in the Plains cottonwood/Peachleaf willow (Crack willow) Association with crack willow as the dominant willow. Other species observed included thin-leaf alder, Siberian elm, and Russian olive. The shrub component of these areas are either categorized in the Sandbar willow/Barren ground Shrubland Association or the Sandbar willow/Mesic graminoid Shrubland Association. Areas with the graminoid understory were observed where flooding is less likely to occur.

Wetlands

A total of 0.31 acre of wetlands were identified along the South Platte River, Cherry Creek, and Sand Creek (Table 3.8-6). Three PEM wetlands encompassing 0.01 acre were observed. The wetland along South Platte River is dominated by Emory's sedge, and the two wetlands along Cherry Creek are dominated by creeping bentgrass. One PSS wetland encompassing 0.27 acre was observed along Sand Creek, and was dominated by sandbar willow with an understory dominated by reed canarygrass.

Two PEM/PSS wetlands encompassing approximately 0.03 acre were observed. The wetland along the South Platte River is dominated by sandbar willow, Emory's sedge, and showy milkweed (*Asclepias speciosa*). The wetland along Cherry Creek is dominated by Emory's sedge, reed canarygrass, creeping bentgrass, smooth brome, and sandbar willow.

The water sources for the wetlands along the Denver Basin Aquifer Facilities distribution pipeline are primarily alluvial groundwater, capillary action, and/or overbank flooding associated with South Platte River, Cherry Creek, or Sand Creek.

Functions provided by the wetlands vary with location, dominant vegetation, and size. Most of the wetlands in the Denver Basin Aquifer Facilities study area provide good stream bank stabilization because of the type and density of vegetation.

The wetland along Sand Creek provides good wildlife habitat. Killdeer (*Charadrius vociferus*) was observed during field visits along with other wildlife signs including raccoon (*Procyon lotor*), deer (*Odocoileus hemonius*), and numerous types of shorebird tracks. It also provides good shoreline stabilization and production export/food chain support due to the type, density, and structure of the vegetation, and its position along the stream bank.

Wetlands along the South Platte River, Cherry Creek, and Sand Creek provide potential habitat for State species of concern, including northern leopard frog and common garter snake.

Other Water Features

A total of four other water features (some with multiple crossings), encompassing 2.27 acres and 1,565 linear feet, were observed in the Denver Basin Aquifer Facilities study area, including:

- **South Platte River** – two crossings encompass 1.34 acres (470 linear feet); the river is perennial and has concrete banks at one of the crossings, where it is more than 100 feet wide, and soil banks at the other crossing where it is 70 to 80 feet wide. Both crossings have sand and soil beds and the water depth is unknown.
- **Lakewood Gulch** – one crossing encompasses 0.04 acre (170 linear feet); the creek is a channelized perennial tributary to South Platte River and is 7 to 10 feet wide with an observed water depth of 6 to 10 inches. Its bed is sand and silt with scattered riprap, and a concrete bank on the west/north side, and a soil bank on the east/south side.
- **Cherry Creek** – three crossings encompass 0.54 acre (675 linear feet); the creek is perennial and ranges from 15 to 25 feet wide with a sandy bed. Observed water depth among crossings varies from 3 to 13 inches with an ordinary high water mark of 6 to 24 inches.
- **Sand Creek** – one crossing encompasses 0.35 acre (250 linear feet); the creek is perennial, approximately 50 feet wide with an observed water depth approximately 6 to 18 inches, an ordinary high water mark of 12 to 24 inches, and a sandy bed.

3.8.5 River Segments

The characterization of existing conditions for riparian and wetlands areas was concentrated on the river reaches as described in Section 3.0 and shown in Figures 3.0-2 through 3.0-4. River segments were characterized using existing data sources, field reconnaissance, and field sampling at a series of representative sample sites. As a first step, the overall river segments potentially affected by flow modifications were characterized using CPW riparian mapping, where available. Areas not mapped by CPW were mapped using a similar methodology. CPW mapping was used to determine the approximate extent of potentially affected riparian vegetation within the larger study area, i.e., the entire approximately 200 miles of river segments, and to generally characterize the distribution of vegetative community types using broad classes such as herbaceous, shrub, and forested. The CPW

mapping data does not specifically identify wetland conditions and the riparian map units include both wetland and non-wetland areas.

Along six of the river segments (all except South Platte River), a series of 12 sample sites were selected, which are generally representative of the types of riparian communities documented through the CPW mapping. The selection and location of sample sites is described in Section 3.0. A sample site was not selected along the South Platte River mainstem because annual and monthly flow changes in almost all months would not be greater than 10%.

In August and September 2005, field studies were conducted to further characterize riparian vegetation at the 12 sample sites. All segments are described looking downstream (i.e., right bank and left bank). Additional information on the field studies, including vegetation mapping, is presented in the technical report on riparian habitat. Sample site selection was based, in part, on a preliminary stratification of river segments into Rosgen (1994) stream types (refer to Section 3.3 for more detail) followed by field reconnaissance to evaluate other site characteristics and to become familiar with the range of site conditions. Other factors considered in site selection included a site's suitability for hydraulic modeling, the quality and type of riparian and wetland vegetation, land use or disturbance history, as well as accessibility to the site.

Sample sites included study reaches on each of the river segments and the study reach lengths varied between 300 and 1,157 feet. A multidisciplinary approach was followed at the sample sites so that riparian vegetation sampling was coordinated with hydraulic analysis and the channel dynamics study. In some cases, lack of access onto private land prevented the establishment of sample sites at locations representative of certain types of riparian vegetation communities. At these locations, the EIS team relied on available published information to complete the riparian vegetation inventory and assessment.

The riparian and wetland data collected at each sample site included the following:

- Dominant and most frequently occurring plant species.
- Horizontal and vertical measures of vegetation breaks along transect.
- Detailed mapping of vegetation types based on the Colorado Natural Heritage Program's (CNHP) Field Guide to Wetland and Riparian Plant Associations of Colorado (Carsey et al. 2003).
- Quantitative and qualitative data on active channel and floodplain features, such as beaver ponds, overflow and side channels, seepage areas, and gravel bars.

The Field Guide to the Wetland and Riparian Plant Associations of Colorado (Carsey et al. 2003) is a comprehensive, field-based classification of 184 riparian and wetland plant associations for the State of Colorado produced by the CNHP. This classification scheme was used to classify riparian and wetland plant associations at the 12 sample sites in the six affected river basins. The field data associated with the CNHP report were also utilized to identify each association's position relative to the stream channel, hydrologic affinity, and other relevant characteristics. Wetland delineation was not conducted at the sample sites.

Additional field observations were conducted in September 2010 to evaluate presence of wetlands, sources of hydrology, and presence of fens at the sample sites and some other

portions of the Fraser River and upper Williams Fork. Observations for presence of fens were made at the sample sites, groundwater sampling sites, diversions and other locations. Soil samples were collected from some potential fen locations to validate field observations and were analyzed for organic matter and clay content at Colorado State University.

Rosgen stream types (A, B, or C) were used to further describe river segments (Rosgen 1994). The Rosgen system is based on the channel width-to-depth ratio, available floodplain width, and channel gradient. Different riparian communities are often associated with stream characteristics of slope, sinuosity, and bed material. The Fraser River Basin drainages and some reaches of South Boulder Creek have relatively lengthy areas of steeper, low sinuosity reaches typical of streams at higher elevations in Colorado; these are classified as Rosgen Type A streams. The Fraser River, as well as the Williams Fork and some reaches of South Boulder Creek, have portions of their lengths in less steep, moderate sinuosity reaches classified as Rosgen Type B streams. The entire river segment lengths of the Colorado River, Blue River, and the North Fork South Platte River are low gradient, moderate to high sinuosity streams classified as Rosgen Type C streams, which is typical of many mid-elevation, larger streams in Colorado (ERC 2006).

A total of 208 miles of potentially affected river segments were investigated; approximately 144 miles are located on the West Slope and 64 miles are located on the East Slope. The Fraser River, Williams Fork River, and South Boulder Creek segments are located near the upper reaches of their watersheds at relatively higher elevations. The Colorado River, Blue River, and North Fork South Platte River segments are located below headwater areas at moderate elevations.

Approximately 9,000 acres of riparian communities were identified along the six river segments. Based on CPW mapping, herbaceous communities comprised the majority of riparian vegetation (60.6%) along the six river segments (Table 3.8-7). Shrub communities represented 24% of the riparian area whereas the riparian evergreen (7.2%) and riparian deciduous tree communities (8.2%) comprised smaller areas overall. Larger areas of deciduous trees are present along the Blue River, Colorado River, and South Boulder Creek. Riparian evergreen and riparian shrub areas were more common along the Williams Fork River segment. Herbaceous riparian vegetation is most common along the Fraser River drainages. A summary description of each of these communities is provided in the remainder of this section.

Table 3.8-7
Acreage of CPW Riparian Vegetation Types Along the River Segments

River Segment	Length (miles)	Riparian Evergreen (RE)		Riparian Deciduous Tree (RT)		Riparian Shrub (RS)		Riparian Herbaceous (RH)		Total Area (acres)
		Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	
Fraser River	(92.9)									
Fraser Canyon	5.1	10	26.9	1	3.9	18	46.4	9	22.9	**38**
Valley	23.3	38	1	12	0.3	396	10.5	3,329	88.2	**3,775**
Upper	64.5	233	21.1	2	0.2	583	52.9	284	25.8	**1,102**
Upper Williams Fork River	12.3	126	37.5	0	0.0	164	48.8	46	13.7	**336**

Table 3.8-7 (continued)
Acreage of CPW Riparian Vegetation Types Along the River Segments

River Segment	Length (miles)	Riparian Evergreen (RE)		Riparian Deciduous Tree (RT)		Riparian Shrub (RS)		Riparian Herbaceous (RH)		Total Area (acres)
		Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	
Colorado River	15.5	4	0.3	314	21.7	295	20.4	833	57.6	**1,446**
Blue River	21.8	53	5.9	346	38.8	223	25.0	269	30.2	**891**
South Boulder Creek	22.0	56	18.8	37	12.4	93	31.2	112	37.6	**298**
North Fork South Platte River	39.7	131	11.5	31	2.7	395	34.6	584	51.2	**1,141**
Total Area (acres)	204.2	651	7.2	743	8.2	2,167	24.0	5,466	60.6	**9,027**

Source: CDOW, 2006a.
Note:
Totals may not equal 100% due to rounding.

Additional data on existing conditions of riparian habitat along streams in Grand County was obtained from the Grand County Stream Management Plan (Grand County 2010). The data, summarized in Table 3.8-8 include a rating of bank cover and riparian zone width based on the U.S. Environmental Protection Agency (EPA) Rapid Assessment Methodology (EPA 1999). Data was collected at one sample site for most stream reaches. Riparian cover is a measure of the amount of vegetation growing on the banks and in the near-stream portion of the riparian zone, based on the percent of vegetation cover (from less than 50 to more than 90%), amount of disturbance (from high to not evident) and stubble height (from less than 5 centimeters [cm] in height) to situations where plants grow relatively naturally. Riparian zone width measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. Ratings are based on the width of the riparian zone – from less than 6 meters to more than 18 meters. Each bank is scored separately from 0 to 10 and the scores are combined to provide a rating from 0 to 20. The range of scores are divided into four categories, combined scores of 18-20 represent optimal conditions, 12 to 16 suboptimal, 6 to 10 are marginal, and 0-4 are poor.

Table 3.8-8
Riparian Data from Grand County Stream Management Plan

Stream Name	Stream Reach	Approximate Length of Channel (miles)	Ratings (0-20)		Description of Overbank Vegetation
			Riparian Vegetation Cover and Disturbance	Riparian Vegetation Zone Width	
Fraser River	F2: Denver Water Diversion to Winter Park intake at Idlewild	3	18	18	Varies between wetlands-type vegetation and pine forests.
Fraser River	F3: Winter Park intake at Idlewild to Town of Winter Park	2.5	18	16	Upper part is open meadow and wetland, downstream is pine forest.
Fraser River	F4: Town of Winter Park to Town of Fraser	3	18	16	Transition from pine forest to wetland meadows.
Fraser River	F5: Town of Fraser to Fraser Wastewater Treatment Plant	1.25	14	10	Upper ½ mile developed, rest well vegetated with shrubs and willows.
Fraser River	F6: Fraser Wastewater Treatment Plant to Ranch Creek	4.25	12	14	Grasses, wetlands, willows.
Fraser River	F7: Ranch Creek to Mouth of Canyon	1.5	15	15	Large wetlands complex near the Town of Tabernash.
Fraser River	F8: Canyon	5	10	10	Narrow, confined and relatively steep canyon, opening to meadows at downstream end.
Fraser River	F9: Canyon to Granby	3.75	12	10	Wetlands-type vegetation with scattered trees.
Fraser River	F10: Granby to Colorado River at Windy Gap	3.5	18	16	Wetland-type vegetation.
Fraser River Tributary - Jim Creek	F-JC: Denver Water Diversion to Fraser River	1	20	20	Optimal riparian vegetation cover and width.
Fraser River Tributary - Ranch Creek	F-RC1 (upper): Denver Water Diversion to Devil's Thumb	3,25	14	12	Mostly pine forest above CR8, open meadows with willows and shrubs to Devil's Thumb.
Fraser River Tributary - Ranch Creek	F-RC2 (lower): Devil's Thumb to Fraser River	10.25	16	16	Relatively dense wetlands vegetation and willow overstory.

Table 3.8-8 (continued)
Riparian Data from Grand County Stream Management Plan

Stream Name	Stream Reach	Approximate Length of Channel (miles)	Ratings (0-20)		Description of Overbank Vegetation
			Riparian Vegetation Cover and Disturbance	Riparian Vegetation Zone Width	
Fraser River Tributary - St. Louis Creek	F-Stl: St. Louis Campground to Fraser River	4	14	14	Wetlands near the active channel and timber overstory near uplands; agricultural land uses near Fraser.
Fraser River Tributary - Vasquez Creek	F-VC: Denver Water Diversion to Fraser River	5.5	18	18	Upper half has open meadow/wetlands; lower is pine forest.
Colorado River	CR4: Windy Gap to Williams Fork	14.25	14, 2, 12 (3 sites)	12. 2, 12 (3 sites)	Steep canyon walls in Byers Canyon, near Hot Sulphur Springs is agricultural land uses with narrow cottonwood canopy along river.
Colorado River	CR5: Williams Fork to KB Ditch	6.75	16	16	Healthy vegetation including willows, sedges and cottonwood canopies.
Colorado River	CR6: KB Ditch to Blue River Confluence	9.75	12	10	Many remnant oxbows; mainly agriculture; some ranches have cottonwood overstory and others do not.
Blue River	County line downstream of Green Mountain Reservoir to Colorado River	12.5	20	18	Eight miles are on Blue River Ranch where there has been a large-scale restoration effort.

Source: Grand County, 2010.

River Segment Riparian Functions

Riparian areas along the stream segments provide a variety of functions. Many of these functions are interrelated, and result from the interaction between the stream and its adjoining riparian community and floodplain.

- Support of wildlife habitat and populations. Riparian areas tend to have higher vegetation production than upland areas because of greater moisture availability during the growing season. The higher productivity combined with heterogeneous habitats results in riparian habitat being important for a diversity of wildlife. A large portion of vertebrate species use them at some point in their life. Riparian ecosystems provide corridors for migration and dispersal.

- Support of fish and aquatic habitat and populations. Riparian vegetation helps to shape aquatic habitat by stabilizing streambanks and trapping sediment to maintain water quality. Shading of streams also provides temperature control for aquatic habitat, and large woody debris help to create habitat diversity of habitats for aquatic organisms.
- Flood attenuation. Riparian vegetation slows the movement of surface water runoff and floods and spreads it more slowly over floodplains, increasing the time available for water to infiltrate into the soil.
- Short- and long-term water storage. Riparian and wetland areas store and slowly release surface water, rain, groundwater, and flood waters. Alluvial soils stores large amounts of water from rainfall and runoff.
- Nutrient and toxicant removal. Sediments and nutrients carried by overland flow may be trapped or filtered, and nutrients in surface or subsurface flows are taken up by riparian vegetation. Riparian vegetation helps to maintain water quality by removing excess nutrients such as nitrates and phosphates. Riparian areas can also affect water quality in adjacent streams.
- Sediment retention and shoreline stabilization. Riparian areas help to trap sediment and to stabilize shorelines with root wads.
- Production export and food chain support. Litterfall produced within riparian areas may be moved laterally or downstream to support aquatic habitats. Organic matter produced in riparian areas supports by terrestrial and aquatic habitats.

3.8.5.1 Fraser River

The affected river segments in the Fraser River Basin include the mainstem downstream of Denver Water's diversion points to its confluence with the Colorado River below Granby, and approximately 30 tributaries to the mainstem. The affected Fraser River segments are subdivided into three geographic locations:

1. **Upper Reach** – including the Fraser River mainstem and its tributaries such as St. Louis Creek, Ranch Creek, and others. Elevations in this segment range from approximately 8,500 to 9,600 feet.
2. **Fraser Canyon Reach** – extending from near Tabernash downstream to Strawberry Creek. This segment has a fairly uniform elevation range, extending from approximately 8,000 to 8,300 feet.
3. **Valley Reach** – extending downstream from Strawberry Creek to the confluence with the Colorado River. Elevations in this segment range from approximately 7,800 to 8,600 feet. Both valley segments have a low gradient; however, the upper segment (8,350 feet) is 300 to 400 feet higher than the lower segment (7,900 feet). The lower portion of Ranch Creek, upstream of the confluence with the Fraser, is also included in the valley reach.

A total of 4,915 acres of riparian habitat were mapped according to CPW riparian vegetation types along all Fraser River segments. The following sections describe the vegetation communities within the river segment and at the four sample sites.

Upper Reach

The upper reach mainstem section is predominantly a Rosgen Type B stream. Some of the higher elevation tributaries are Rosgen Type A streams. The following sections describe the vegetation communities within the affected segments.

CPW Mapping

The mapping of CPW riparian vegetation categories along the upper reach of the Fraser River covers approximately 1,102 acres (Table 3.8-7). The following bullets describe the vegetation communities along the affected river segment.

- *Riparian Evergreen (RE):* The riparian evergreen category is mapped on 233 acres or 21.1% of the upper reach. Many conifer dominated stands were observed along this section, but determining whether or not they have a predominance of hydrophytic species in the understory using aerial photo interpretation techniques was difficult.
- *Riparian Deciduous Tree (RT):* The riparian deciduous tree category was mapped on 2 acres or 0.2% of the upper reach.
- *Riparian Shrub (RS):* The riparian shrub category was mapped on 583 acres or 52.9% of the upper reach; the riparian shrub category is the dominant CPW riparian vegetation type on this reach.
- *Riparian Herbaceous (RH):* The riparian herbaceous category is mapped on 284 acres or 25.8% of the upper reach.

Grand County Stream Management Plan

The Grand County Stream Management Plan includes data for nine reaches of the Fraser River below the Denver Water diversion, and data for four tributaries including Ranch Creek, St. Louis Creek, Jim Creek, and Vasquez Creek (Table 3.8-8; Grand County 2010). Most sampled stream reaches had riparian cover and width rated as optimal or suboptimal. Optimal conditions were present on portions of the upper Fraser River and on Vasquez and Jim creeks. Three reaches of the Fraser River had marginal ratings (score of 10), including Reach F5 near the Town of Fraser, and the two lower reaches of the Fraser River, F8 in the Fraser River Canyon and F9 from the Canyon to Granby.

FR1 – Fraser River above Winter Park Gage; FR3 – St. Louis Creek, and FR4 – Ranch Creek

Three sample sites were established by the Corps on the upper reach: FR1, FR3, and FR4 (refer to Figure 3.0-2). Sample site FR1 is a 3.1-acre site located at the Idlewild Campground; the length of the study reach at this sample site was 539 feet. This stream is a Rosgen Type B with gentle to vertical bank slopes. Sample site FR3 is a 1.5-acre site located on St. Louis Creek approximately 4 miles west of Fraser; the length of the study reach at this sample site was 335 feet. This stream is also a Rosgen Type C3 stream with steep cutbanks and a relatively wide floodplain. Sample site FR4 is a 0.2-acre site located on Ranch Creek just below the confluence of the North Fork South Platte River of Ranch Creek; the length of the study reach at this sample site was 571 feet. This stream is a Rosgen Type A stream with steep to vertical cutbanks and riparian vegetation narrowly

confined to the margins of the stream. The acres of CNHP groups/plant associations mapped at each sample site are provided in Table 3.8-9.

Table 3.8-9
Acreage of CNHP Groups/Plant Associations: Sampling Sites FR1, FR3, and FR4 on the Upper Reach of the Fraser River

Sample Site	FR1		FR3		FR4		Total Combined	
CNHP Group/Association	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
Evergreen Riparian Forest (RE-CPW[1])								
Subalpine fir-Engelmann spruce/ bluejoint reedgrass[2]	0.0	1			0.0	1	**0.0**	**1**
Subalpine fir-Engelmann spruce/field horsetail	0.4	14					**0.4**	**9**
Subalpine fir-Engelmann spruce/tall fringed bluebells	2.0	64	0.4	28	0.1	31	**2.5**	**52**
Subalpine fir-Engelmann spruce/ Drummond's willow					0.0	6	**0.0**	**0**
Subalpine fir-Engelmann spruce/ thinleaf alder			0.5	30	0.0	19	**0.5**	**10**
Evergreen Riparian Forest Total	***2.4***	***79***	***0.9***	***59***	***0.1***	***57***	***3.4***	***72***
Shrub-dominated Riparian (RS-CPW)								
Drummond's willow/bluejoint reedgrass	0.0	1					**0.0**	**1**
Drummond's willow/mesic forb	0.0	1					**0.0**	**1**
Drummond's willow/water sedge	0.0	0	0.2	13			**0.2**	**4**
Park (mountain) willow/beaked sedge	0.5	16					**0.5**	**10**
Thinleaf alder-Drummond's willow	0.0	1	0.4	28			**0.5**	**10**
Shrub-dominated Riparian Total	***0.6***	***19***	***0.6***	***41***	***0.0***	***0%***	***1.2***	***26***
Herbaceous Vegetation (RH-CPW)								
Heartleaf bittercress-tall fringed bluebells-arrowleaf ragwort	0.0	1	0.0	1	0.1	43	**0.1**	**3**
Herbaceous Vegetation Total	***0.0***	***1***	***0.0***	***1***	***0.1***	***43***	***0.1***	***3***
Total Acres Mapped[3]	**3.1**	**100**	**1.5**	**100**	**0.2**	**100**	**4.8**	**100**

Source: Carsey et al., 2003.
Notes:
[1]The CPW vegetation type equivalent to the CNHP Group/Association is provided in parentheses, e.g., RE-CPW.
[2]Scientific names are first mentioned in discussion text.
[3]Total does not include active channel or upland vegetation community acreages. Totals may not equal 100% due to rounding.
CNHP = Colorado Natural Heritage Program
CPW = Colorado Parks and Wildlife
FR = Fraser River
RE = riparian evergreen
RH = riparian herbaceous
RS = riparian shrub

Five CNHP plant associations in the Evergreen Riparian Forest group were mapped in the upper reach and represent approximately 72% of the riparian vegetation at the samples sites. All of these associations were dominated by Engelmann spruce in the tree layer. The herb and shrub layer species dictated whether these stands were classified as riparian or upland. The understory species in these stands included tall fringed bluebells (*Mertensia ciliata*), bluejoint reedgrass (*Calamagrostis canadensis*), claspleaf twistedstalk (*Streptopus amplexifolius*), arrowleaf ragwort (*Senecio triangularis*), twinberry honeysuckle (*Lonicera involucrata*), and Richardson's geranium (*Geranium richardsonii*). These species typically occupied low-lying depressions or swales that are inundated during high water. Adjacent, higher elevation sites would support species associated with mesic, shaded upland forest. The associations with tall fringed bluebells and bluejoint reedgrass occurred at elevations approximately 3 feet above the water surface on wide, relatively flat areas on the valley floor between the river and the hillslope. These wide valley floor areas generally had a high water table. Engelmann spruce stands, influenced by obvious groundwater seepage, were dominated by field horsetail and brook saxifrage (*Saxifraga odontoloma*) in the herb layer at elevations as high as 15 feet above the water surface.

Additional information on the hydrologic regime and other relevant data from the CNHP descriptions of the predominant Evergreen Riparian Forest plant associations at FR1, FR3, and FR4 is excerpted below in order to supplement the 2005 field observations and provide further context.

> The subalpine fir (*Abies lasiocarpa*)-Engelmann spruce/Tall fringed bluebells Association is a common community in the subalpine zone that is limited to the immediate stream channel edge and overflow areas. It usually establishes within 15 feet of the channel and within 2 feet of channel bankfull height. Typically this association occurs along steep (2 to 15% gradient), narrow streams, but it can also be found along moderate gradient stretches (Carsey et al. 2003).
>
> The subalpine fir-Engelmann spruce/Field horsetail Association is dependent on flood disturbance (deposition of sand and silt) to maintain the understory dominance of field horsetail. It occurs below 10,000 feet and is often a disturbance (flooding) dependent community. However, in some situations this association may persist for long periods in the absence of disturbance. It is relatively rare in Colorado. In Colorado, this association is considered an early seral type (Carsey et al. 2003).

Each of the other three evergreen associations represented a very minor component of the vegetation at the three sample sites.

The Shrub-dominated Riparian group is represented by five CNHP associations and occupies approximately 26% of the riparian vegetation at the sample sites. They are dominated by Drummond's willow (*Salix drummondiana*) and occur primarily as narrow, fragmented stands along the river and grow approximately in the 0.6 to 4.5 feet elevation zone. The herb layer species in these stands are identical to the plant association described below. Additional CNHP information on the hydrologic regime and other relevant data is excerpted below.

> [Park] willow/beaked sedge (*Salix monticola/Carex utriculata*) association…requires a high water table and saturated soils for much of the growing season. Beaked sedge occurs on the wettest sites, such as shallow pond margins, low-lying swales, and overflow channels with the shallowest water tables. Water sedge (*Carex aquatilis*) occurs on intermediate sites with saturated but not inundated soils. Bluejoint reedgrass dominates the drier sites with lower water tables (Carsey et al. 2003).

The Drummond's willow associations are minor components at the sample sites and are generally limited to saturated wetland sites.

The Herbaceous Vegetation group is represented by one CNHP plant association representing approximately 3% of the riparian vegetation at the three sites. The Heartleaf bittercress (*Cardamine cordifolia*)-Tall fringed bluebells-Arrowleaf ragwort plant association occurs as a narrow fringe at the tops of low cutbanks, and on gentler sections of shoreline and small benches along the river edge. The elevations of these sites range from approximately 1.3 to 2.1 feet above the water surface, although, one point measured within this stand was 6.0 feet above the river. Additional information on the hydrologic regime and other relevant data from the CNHP description of this plant association is excerpted below:

> The Heartleaf bittercress-Tall fringed bluebells-Arrowleaf ragwort plant association is found in and near running water of small streams, seeps, and springs. This association is found in a habitat which is early-seral and experiences frequent fluvial depositions, keeping any invading conifers from advancing beyond the sapling stage. Although it is an early-seral community, the Heartleaf bittercress-Tall fringed bluebells-Arrowleaf ragwort plant association is reasonably stable because it is maintained by frequent disturbance (Carsey et al. 2003).

A map of the vegetation associations at FR1 is provided as Figure 5.8-1. Field observations were conducted in September 2010 to evaluate presence of wetlands, sources of hydrology, and presence of fens. Wetlands are present in narrow areas along the river that appear to be supported by surface water flows, and also occur in a fen on the west side of the river that appears to be supported by groundwater that emerges near the base of a steep slope 150 to 200 feet to the west of the river. The slope was the west edge of the sample site. The fen includes the mountain willow/beaked sedge community and some adjacent areas mapped as subalpine fir – Engelmann spruce – field horsetail. The fen surface drops gradually to the north and northeast, toward the Fraser River, but no discharge of water was observed where the fen connects with the river north of the sample site. No areas of saturated soils or fens were observed east of the river during the September 2010 visit.

The plant associations at FR3 on St. Louis Creek are shown on Figure 5.8-2. The areas mapped as Drummond's willow-water sedge and thinleaf alder-Drummond's willow shrubland associations appear to be wetlands, as are areas mapped in several smaller associations that are narrowly confined to the river's edge. No fens are present. The primary source of hydrology for this site appears to be surface flow and alluvial groundwater connected to surface flows and regional groundwater flows.

Sample site FR4 on Ranch Creek has riparian vegetation closely confined to the edge of the stream. The primary source of hydrology appears to be surface flows.

Fraser Canyon Reach

The Fraser Canyon section downstream of St. Louis Creek is predominantly a Rosgen Type C stream within a broad U-shaped valley.

CPW Mapping

The mapping of CPW riparian vegetation categories along the Fraser Canyon Reach covers approximately 38 acres (refer to Table 3.8-7). The following bullets describe the vegetation communities within the affected river segment:

- *Riparian Evergreen (RE)* – The riparian evergreen category is mapped on 10 acres or 26.9% of the Fraser Canyon Reach. Small stands of conifers were observed along some portions of the mainstem and were generally incorporated into other riparian vegetation categories due to their small patch sizes.
- *Riparian Deciduous Tree (RT)* – The riparian deciduous tree category is mapped on 1 acre or 3.9% of the Fraser Canyon Reach.
- *Riparian Shrub (RS)* – The riparian shrub category is mapped on 18 acres or 46.4% of the Fraser Canyon Reach; the riparian shrub category is the dominant CPW riparian vegetation type on this reach.
- *Riparian Herbaceous (RH)* – The riparian herbaceous category is mapped on 9 acres or 22.9% of the Fraser Canyon Reach.

FR2 – Fraser River Near Tabernash

The Fraser Canyon Reach is represented by sample site FR2. FR2 is a 6.3-acre site located approximately 1 mile downstream of Tabernash; the study reach length at this sample site was 872 feet. The stream at the sample site is a Rosgen Type C stream with gently sloping to steep banks. The valley bottom slopes gently up and away from the right bank of the river making it difficult to determine where surface flows and groundwater dictate vegetation patterns. Within the active channel, gravel bars extend up to 2.1 feet above the water surface elevation at the site, indicating that periodic high flows affect substrate and vegetation colonization. The acres of CNHP groups/plant associations mapped at sample site FR2 are provided in Table 3.8-10.

Table 3.8-10
Acreage of CNHP Groups/Plant Associations: Sampling Site FR2 on the Fraser Canyon Reach of the Fraser River

CNHP Group/Association	Acres	Percent
Evergreen Riparian Forest (RE-CPW)		
Lodgepole pine/mountain rush	0.2	2
Tall Willow Shrubland (RS-CPW)		
Geyer's willow - park willow/bluejoint reedgrass	3.5	56
Short Willow Shrubland (RS-CPW)		
Wolf's willow/mesic forb	0.8	13
Non-willow Shrubland (RS-CPW)		
Shrubby cinquefoil/tufted hairgrass	1.0	16
Shrub-dominated Riparian Total	***5.5***	***87***
Herbaceous Vegetation (RH-CPW)		
Bluejoint reedgrass	0.1	2
Beaked sedge	0.1	2
Mountain rush	0.2	3
Herbaceous Vegetation Total	***0.4***	***7***
Total Acres Mapped	**5.9**	**94**

Notes:
All footnotes listed for Table 3.8-9 apply.
CNHP = Colorado Natural Heritage Program
CPW = Colorado Parks and Wildlife
RE = riparian evergreen
RH = riparian herbaceous
RS = riparian shrub

Two small Evergreen Riparian Forest stands occur at the FR2 sample site. These stands are dominated by lodgepole pine and have a sparse understory of mountain rush (*Juncus balticus* var. *montanus*), bog birch (*Betula nana*), shrubby cinquefoil (*Dasiphora floribunda*), and twinberry honeysuckle, in addition to species common in drier, upland sites. Based on the species composition, these drier communities could not be matched with a recognized CNHP plant association within the Evergreen Riparian Forest group. The two lodgepole pine/mountain rush stands and were mapped in locations 2.6 to 4.53 feet above the water surface elevation on the day of sampling.

The Shrub-dominated Riparian group is represented by the Tall Willow Shrubland, Short Willow Shrubland and Non-willow Shrubland groups at the FR2 site. Collectively, they cover 5.3 acres or 85% of the 7-acre study site. These three types frequently intermingle at the site and have a dense herbaceous understory. The dominant shrub species include Geyer's willow (*Salix geyeriana*) and park (mountain) willow in the Tall Willow Shrubland group, Wolf's willow (*Salix wolfii*) with some planeleaf willow (*Salix planifolia*) in the Short Willow Shrubland group, and shrubby cinquefoil in the Non-willow Shrubland group.

The understory is diverse with many mesic herb species including bluejoint reedgrass, tall fringed bluebells, common cowparsnip (*Heracleum maximum*), Virginia strawberry (*Fragaria virginiana*), mountain rush, timothy (*Phleum pratense*), and tufted hairgrass (*Deschampsia caespitosa*). The Short and Tall Willow Shrubland types occupied a similar

elevation range between 2.1 and 3.1 feet above the water surface; Non-willow Shrubland was mapped from 3.1 to 6.6 feet above the water surface.

Three CNHP plant associations represent the majority of the Shrub-dominated Riparian community at this site. CNHP information on the hydrologic regime and other relevant data from the descriptions of these plant associations is excerpted below:

> The Geyer's willow/Bluejoint reedgrass plant association, the dominant shrub association at this site, is relatively uncommon in Colorado. The Geyer's willow dominated associations appear to be long-lived and late-seral, remaining in areas where a shallow water table saturates soils, not dropping below 3 feet for much of the growing season. Beaked sedge occurs on the wettest sites, such as shallow pond margins, low-lying swales, and overflow channels with the shallowest water tables. Water sedge occurs on intermediate sites that have saturated but not inundated soils. Bluejoint reedgrass dominates the drier sites with lower water tables (Carsey et al. 2003).
>
> The Wolf's willow/Mesic forb plant association occurs at mid to upper montane and lower subalpine elevations. The water table is usually within the top 3 feet of soil and groundwater slowly seeps to the surface. The soils may be saturated in the spring and early summer, but dry somewhat during the summer as the water table drops. Stands of Wolf's willow are less frequently encountered, and are usually limited in size (Carsey et al. 2003).
>
> Another important plant association at this site is the Shrubby cinquefoil/Tufted hairgrass plant association, which occurs on terraces above the stream channel and along the drier edges of isolated wetlands and rich fens (Carsey et al. 2003).

At the FR2 sample site, the Herbaceous Vegetation group is represented by three CNHP plant associations: beaked sedge, bluejoint reedgrass, and mountain rush. The Beaked sedge and Bluejoint reedgrass associations tend to form pure stands in overflow channels and groundwater-fed depressions at elevations from 0.5 feet above the water surface in areas influenced by surface water and 2.5 feet above the water surface in areas influenced by groundwater. The mountain rush association was mapped on terraces generally at 3.2 to 4.4 feet elevation that were previously disturbed (cattle grazing) and supported several escaped pasture grass species. All of these herbaceous associations were only minor components of the vegetation at sample site FR2.

FR2 was revisited in September 2010. Wetlands appear to be limited at FR2, occurring mostly along the banks of the Fraser River and in a few oxbows and side channels mapped in the beaked sedge association. Relatively large emergent and shrub wetlands supported by groundwater occur outside of the study site on the edge of the valley floor adjacent to the base of the mountain slope about 100 feet northeast of the edge of the study site. No fens are present at or near this site. The primary sources of hydrology appear to be surface water near the edge of the Fraser River and regional groundwater discharge.

Valley Reach

This section of the Fraser River is predominantly a Rosgen Type C stream. Valley reach segments are generally low gradient riparian areas where vegetation extends across a broad area.

CPW Mapping

The mapping of CPW riparian vegetation categories along the valley reach covers approximately 3,775 acres (Table 3.8-7). The following bullets describe the vegetation communities within the affected river segment:

- *Riparian Evergreen (RE)* – The riparian evergreen category is mapped on 38 acres or 1% of the valley reach.
- *Riparian Deciduous Tree (RT)* – The riparian deciduous tree category is mapped on 12 acres or 0.3% of the valley reach.
- *Riparian Shrub (RS)* – The riparian shrub category is mapped on 396 acres or 10.5% of the valley reach.
- *Riparian Herbaceous (RH)* – The riparian herbaceous category is mapped on 3,329 acres or 88.2% of the valley reach, the dominant CPW riparian vegetation type on this reach.

Sample Site

There were no sample sites selected in the valley reach. The valley reach riparian areas are located on private property where sample site access was not available. Broad areas of vegetation are supported either by irrigation ditches along the outer margins, groundwater supplied from the creeks and streams, or upgradient springs and seeps. Much of the area is used either for hay production or cattle grazing. CNHP plant associations found in the area may include beaked sedge, mountain rush, and bluejoint reedgrass as well as smaller areas of the Drummond's willow/Mesic forb association. CNHP information on the hydrologic regime and other relevant data from the descriptions of these plant associations is excerpted below:

> Beaked sedge grows in standing water or saturated soils where the water table is usually near the surface for most of the growing season. It is an early-seral community. Over time, the beaked sedge plant association will grade into water sedge and bluejoint reedgrass associations. Beaked sedge commonly occurs at the stream channel or pond edge where the water table is close to or at the ground surface. As the floodplain surface becomes higher with increased distance from the channel edge, the ground becomes slightly less saturated and shifts to mesic meadows of water sedge, or on higher surfaces, to slightly drier meadows of bluejoint reedgrass (Carsey et al. 2003).
>
> The bluejoint reedgrass plant association is a relatively small meadow association that occurs in broad glaciated valleys, openings in moist forests, silted-in beaver ponds, and narrow floodplains of lower montane canyons. The bluejoint reedgrass plant association appears to be a long-lived, mid-seral meadow association. Increased available soil moisture allows for the expansion of the bluejoint reedgrass plant association at the meadow/forest ecotone (Carsey et al. 2003).
>
> The mountain rush plant association occurs as small, dense patches on flat stream benches, along overflow channels, near springs, and around ponds. This association is often considered to be a grazing-induced community since it is not

palatable to livestock and increases with grazing. In low-disturbance areas, this plant association appears to be a stable, climax community, often persisting in the absence of wetland conditions. It occupies frequently inundated swales and wet, low to mid-elevation sites (Carsey et al. 2003).

Fraser River Tributaries

In addition to 27.7 miles of the Fraser River below the diversion, there are 33 tributaries from which water is diverted, representing 67.4 miles of stream (Table 3.8-11). Two of the major tributaries, St. Louis and Main Ranch creeks, were included in the 2005 field sampling.

Table 3.8-11
Summary of Diverted Streams in the Fraser River Valley

Stream with Riparian Sample Site	Primary Rosgen Type	Bypass Flows*	Names of Creeks	Miles of Stream Below Diversion
Yes	B, C	Yes	St. Louis	9.7
Yes	B, C	Yes	Main Ranch	10.6
No	B, C	Yes	Vasquez	3.0
No	B, C	No	West St. Louis, Main Elk, Jim (3)	8.0
No	A or Aa+	Yes	Little Cabin, Cabin, Hamilton, Hurd, North and South Trail, Meadow (7)	21.2
No	A or Aa+	No	Short, Iron, Byers, East St. Louis, Fool, King, West Elk, East Fork Main Elk, West Fork Main Elk, East Elk, Little Vasquez, Cooper, Buck, Cub, South Fork Ranch, Middle Fork Ranch, Dribble, North Fork Ranch (20)	14.9

Note:
*Details on bypass flows are provided in Table 3.1-8.

Most of the diverted tributaries in the Fraser Valley are headwater streams that are Rosgen Type A or Aa+ streams occurring in relatively narrow and steep-sided valleys that have very limited riparian and wetland vegetation. Where they occur, wetland species are typically limited to the immediate edge of the stream or occur in areas of groundwater discharge adjacent to the stream. Riparian vegetation may extend a short distance up the slopes and its presence may be partially related to factors other than stream flow such as slope runoff, groundwater discharge, and a cool moist microclimate partly supported by cold air drainage and shading.

Streams that are Rosgen Type B or C occur in wider valleys with lower gradients typically at lower elevations. Wetland and riparian vegetation may extend across the valley for a quarter mile or more. Wetland vegetation may occupy large areas and may be related both to groundwater and to surface flows (including irrigation in some areas). Streams with USFS bypass flows have requirements for minimum flows that help to maintain wetland and riparian vegetation during the growing season. Some streams that do not have required bypass flows have groundwater discharge below the diversions that help to support wetland and riparian vegetation, for example at Vasquez Creek where a fen occurs adjacent to the creek below the diversion. Fens were also observed along portions of Jim Creek below the diversion and above the West St. Louis Creek Diversion.

3.8.5.2 Williams Fork River

The Williams Fork River Basin extends approximately 30 miles from its confluence with the Colorado River upstream to its headwaters in the Vasquez and Williams Fork mountains. Elevations along the river segment range from approximately 8,900 feet to 11,200 feet. The characterization of existing riparian and wetland acres focused on the 12.3 mile river segment along the Williams Fork River mainstem from its confluence with the South Fork Williams Fork near the South Fork Campground upstream to its confluence with Steelman Creek. It also includes Steelman, Bobtail, Jones, and McQueary creeks from their diversion points downstream to the confluence with the Williams Fork mainstem. The tributaries to the Williams Fork mainstem are Rosgen Type A streams. The mainstem of the Williams Fork below the Steelman Creek confluence includes both Rosgen Type B (49%) and Type C (51%) streams. The following sections describe the vegetation communities within the segment and at the two sample sites:

CPW Mapping

The mapping of CPW riparian vegetation categories along the upper Williams Fork River segment covers approximately 336 acres (Table 3.8-7). The following bullets describe the vegetation communities within the river segment and at the sample sites.

- *Riparian Evergreen (RE)* – The riparian evergreen category is mapped on 126 acres or 37.5% of the Williams Fork. This category is mapped primarily along the Rosgen Type A streams and portions of Type B streams along the upper Williams Fork mainstem. The riparian evergreen category along Rosgen Type A streams is fairly narrow and is primarily confined to the margins of the streams. The riparian evergreen category along Rosgen Type B and C streams is generally mapped on broad, gently sloping terraces or landforms in the valley bottom.
- *Riparian Deciduous Tree (RT)* – No riparian deciduous tree vegetation was mapped on the affected Williams Fork segment.
- *Riparian Shrub (RS)* – The riparian shrub category is mapped on 164 acres or 48.8% of the Williams Fork primarily along the Rosgen Type C streams at the downstream end of the study reach. The riparian shrub category is the dominant CPW riparian vegetation type on this reach.
- *Riparian Herbaceous (RH)* – The riparian herbaceous category is mapped on 46 acres or 13.7% of the Williams Fork. It is distributed primarily in the uppermost reaches of Steelman Creek but is also mapped in scattered locations throughout the river segment.

WF1 – Williams Fork River Near Sugarloaf Campground

The WF1 site is located approximately 0.5 mile upstream of the Sugarloaf Campground on the mainstem of the Williams Fork River; the study reach length at this sample site was 1,157 feet. The stream at the sample site is classified as a Rosgen Type C stream. The bed is primarily cobble and gravel but has a number of sand bars along inside bends of the stream and various gravel-cobble bars that extend along the shoreline throughout much of the sample site. Many of the sand bars have been colonized by wetland plants. Within the active channel, alluvial habitats with potential to support colonization by riparian plant

species were mapped on 0.37 acre at sample site WF1. Much of the mapped alluvial habitat had been colonized by riparian herbaceous species and willow seedlings. Gravel bars ranged from -0.1 to 0.37 feet above the water surface elevation at WF1.

There was some evidence of aggradation with sand observed behind boulders and cobble throughout the reach. The banks above the gravel bar are generally steeply cut or overhanging. On the right side of the river (facing downstream), extensive stands of willow occur along the banks and extend well beyond the river on a broad relatively flat terrace. A beaver pond is located on the terrace and has connecting wet swales that extend and branch upstream. These swales may be the only flood-prone portion of the terrace. The swales, pond, and generally high water table associated with the terrace create a rich mosaic of riparian vegetation types supporting Engelmann spruce, lodgepole pine, and willow, sedge, and grass species. The left bank generally has a continuous band of willow-dominated riparian vegetation. At the downstream end of the sample site, a fairly large, old side channel appears cut off from the present active channel. The old channel is heavily colonized with young conifer species and a few willow species. At the upstream end of the sample site, a large wetland supports lush and dense wetland vegetation comprised primarily of willow, sedge, and grass species. The water source for this wetland appears to be seasonal flows in the Middle Fork Williams Fork, as well as ground-penetrating flows from the Middle Fork. This wetland was dry in September 2010 and does not appear to be related to groundwater discharge. The acres of CNHP groups/plant associations mapped at sample site WF1 are provided in Table 3.8-12.

Table 3.8-12
Acreage of CNHP Groups/Plant Associations:
Sampling Site WF1 on the Williams Fork River

CNHP Group/Association	Acres	Percent
Evergreen Riparian Forest (RE-CPW)		
Lodgepole pine/bluejoint reedgrass	0.4	7
Subalpine fir-Engelmann spruce/Drummond's willow	0.3	6
Subalpine fir-Engelmann spruce/tall fringed bluebells	3.0	55
Evergreen Riparian Forest Total	***3.7***	***68***
Tall Willow Shrubland (RS-CPW)		
Drummond's willow/bluejoint reedgrass	1.3	24
Drummond's willow/mesic forb	0.3	6
Tall Willow Shrubland Total	***1.6***	***30***
Herbaceous Vegetation (RH-CPW)		
Beaked sedge	0.1	2
Total Acres Mapped	**5.4**	**100**

Notes:
All footnotes listed for Table 3.8-9 apply. Totals may not equal 100% due to rounding.
CNHP = Colorado Natural Heritage Program
CPW = Colorado Parks and Wildlife
RE = riparian evergreen
RH = riparian herbaceous
RS = riparian shrub

There are two CNHP plant associations and one other unclassified riparian conifer stand that represent the Evergreen Riparian Forest group at the WF1 sample site. These plant associations occupy the majority (68%) of the 5.4-acre sample site. The two CNHP plant associations are dominated by Engelmann spruce along with lesser amounts of subalpine fir and lodgepole pine. Shrub layer species formed an open cover and included Drummond's willow (and probably some Geyer's willow), twinberry honeysuckle, whortleberry (*Vaccinium myrtillus*), Woods' rose (*Rosa woodsii*), and whitestem gooseberry (*Ribes inerme*). The herb layer included, in wetter areas, bluejoint reedgrass and beaked sedge and, in less wet areas, arrowleaf ragwort, tall fringed bluebells, field horsetail, and sidebells wintergreen (*Orthilia secunda*). The two associations actually commingle on the site as willow in the understory varies throughout the site. These stands occur within a complex of overflow areas comprised of swales including a beaver pond and a wide valley bottom with a very shallow water table. Elevations for the Evergreen Riparian Forest group at this site ranged approximately from 2.2 to 3.5 feet above the water surface elevation on the day of field sampling. The unclassified stand is dominated by lodgepole pine and has an understory of bluejoint reedgrass. Information on these associations from the CNHP descriptions was previously described in Section 3.8.5.1.

The Shrub-dominated Riparian group is represented by two CNHP plant associations in the Tall Willow Shrubland group, which occupied approximately 1.6 acres or 30% of the site. Drummond's willow was the dominant willow at the site; however Geyer's willow and planeleaf willow were also present. The associated willow shrub species was most often bluejoint reedgrass but also includes thinleaf alder (*Alnus incana* ssp. *tenuifoila*), blue wildrye (*Elymus glaucus*), Richardson's geranium, Fendler's cowbane (*Oxypolis fendleri*), fringed brome (*Bromus ciliatus*), common cowparsnip, and tall fringed bluebells. The distribution of these associations was primarily along the river edge, in areas affected by seepage from the beaver pond, in swales that extended upriver on river right and, at the most downstream end of the site, in areas influenced by lateral groundwater seepage from the adjacent hillslope on river right. The elevation of these associations ranged from 0.8 to 3.3 feet above the water surface. CNHP information on the hydrologic regime and other relevant data from on the predominant shrub association is excerpted below.

> The Drummond's willow/Bluejoint reedgrass plant association occurs as small, isolated patches in forest and shrubland openings along channels in narrow valley bottoms and is often an early colonizer of first-order, boulder-strewn, steep streams. Drummond's willow usually occurs along steep, narrow stream margins. This association appears to be limited to saturated wetland environments and is often associated with beaver activity and can occasionally occur along low-gradient streams (Carsey et al. 2003).

Herbaceous Vegetation at the WF1 sample site was represented by the beaked sedge association, which covered 0.12 acre or 2% of the site. This association was previously described and is associated with the beaver pond and the lowest, wettest portions of the adjoining swales. Elevations for the group ranged from -1.6 to 4.88 feet above the water surface.

Additional field observations were conducted in September 2010 to evaluate presence of wetlands, sources of hydrology, and presence of fens. Areas mapped as beaked sedge herbaceous vegetation and Drummond's willow/bluejoint reedgrass shrubland were

wetlands, along with some portions of the Drummond's sedge/mesic forb and subalpine fir – Engelmann spruce/tall fringed bluebells associations. Groundwater seepage and wetlands occurred adjacent to and upslope of about half of the northern edge of the study area, and probably contributes to the shallow water table in parts of the site. Surface flows appear to also contribute to alluvial groundwater.

WF2 – Williams Fork below Steelman Creek

The 1.09-acre WF2 sample site is also located on the Williams Fork mainstem just below the confluence with Steelman Creek; the study reach length at this sample site was 590 feet. The stream at the WF2 site is a Rosgen Type B stream. The bed is largely cobble and small boulders exposed throughout the length of the site. Substantial deposits of coarse sand were observed in several locations although no consistent signs of aggradation or degradation were apparent throughout the reach. The only substantial area of exposed alluvium on the day of field sampling was a gravel-cobble bar located along the right bank at the downstream end of the sample site. The banks were generally steep to overhanging with few exceptions and typically had a very narrow fringe of mesic forb, willow and alder. The WF2 sample site contained approximately 0.5 acre of alluvial habitat that did not support riparian plants and another 0.01 acre that had a high enough vegetation cover to be included in the Riparian Herbaceous Vegetation group. Gravel bars ranged 0.4 to 1.0 feet above the water surface elevation. The acres of CNHP groups/plant associations mapped at sample site WF2 are provided in Table 3.8-13.

Table 3.8-13
Acreage of CNHP Groups/Plant Associations:
Sampling Site WF2 on the Williams Fork River

CNHP Group/Association	Acres	Percent
Evergreen Riparian Forest (RE-CPW)		
Subalpine fir -Engelmann spruce/currant	0.88	81
Subalpine fir-Engelmann spruce/Drummond's willow	0.04	4
Subalpine fir-Engelmann spruce/tall fringed bluebells	0.11	10
Evergreen Riparian Forest Total	***1.03***	***95***
Non-willow Shrubland (RS-CPW)		
Bog birch/mesic forb-mesic graminoid	0.02	2
Herbaceous Vegetation (RH-CPW)		
Fowl mannagrass-seep monkeyflower-milkflower willowherb	0.02	2
Heartleaf bittercress- tall fringed bluebells- arrowleaf ragwort	0.02	2
Herbaceous Vegetation Total	***0.04***	***4***
Total Acres Mapped	**1.09**	**100**

Notes:
All footnotes listed for Table 3.8-9 apply. Acres may not equal 100% due to rounding.
CNHP = Colorado Natural Heritage Program
CPW = Colorado Parks and Wildlife
RE = riparian evergreen
RH = riparian herbaceous
RS = riparian shrub

The three Evergreen Riparian Forest plant associations mapped at sample site WF2 are also dominated by Engelmann spruce and to a lesser degree, subalpine fir. This group occupies approximately 94% of the sample site. The stands with Drummond's willow and tall fringed bluebells as dominant understory species are primarily restricted to a narrow fringe along the river and the narrow, poorly formed channel that extends along the outside edge of the wide valley bottom on the right bank. These three stands represent Evergreen Riparian Forest stands along Rosgen Type A and some Type B streams in the river segment. The large mapped stand representing the subalpine fir-Engelmann spruce/currant (*Ribes* spp.) association occupies a wide valley bottom landform similar to that described for the WF1 sample site that supports Evergreen Riparian Forest. The hydrophytic understory species in this stand are restricted primarily to low-lying areas or depressions where access to shallow groundwater is available. Elevations for the Evergreen Riparian Forest at the WF2 site ranged approximately from 1.9 to 3.5 feet above the water surface elevation on the day of field sampling.

There was one plant association in the Non-willow Shrubland group mapped at sample site WF2. The 0.02-acre stand was associated with a fen that extended upslope away from the river. The dominant shrub was bog birch although hydric graminoid species were very abundant including bluejoint reedgrass, beaked sedge and some water sedge. The bog birch association was documented at elevations from 2.2 to 4.4 feet above the water surface along the edge of the river although the fen extends upslope to higher elevations further away from the river. Potential willow shrubland at the sample site grew along the stream margin and was closely associated with coniferous species rooted at the stream edge.

There were two plant associations in the Herbaceous Vegetation group at sample site WF2. These associations were mapped on 0.04 acre or approximately 4% of WF2 primarily along the river's edge, but also within low-lying areas of the riparian conifer stands located on the broad flat valley bottom on river right. These associations supported a variety of forb species including heartleaf bittercress, tall fringed bluebells, arrowleaf ragwort, brook saxifrage, claspleaf twistedstalk, Fendler's cowbane, milkflower willowherb (*Epilobium lactiflorum*), and redpod stonecrop (*Rhodiola rhodantha*). Elevations for these associations ranged from 0.5 to 2.2 feet above the water surface.

On the right bank, the valley bottom or terrace extends up to 100 feet back from the river. There was no evidence that this terrace is flood-prone. Coniferous forest with Engelmann spruce, subalpine fir and lodgepole pine dominate the terrace although the understory species with upland and wetland affinities commingle in most parts of these stands.

All of the important CNHP plant associations at this site have been previously described.

Site WF2 has a large fen on the southwest side that had both saturated soils and ponded water in mid-September. The fen generally parallels the river for a thousand feet or more, and appears to be supported by groundwater discharge and at least one tributary stream. No active seepage or drainage into river was observed where it paralleled the river during the September 2010 field visit. Other wetlands in and near the study site were limited to the edge of the river and appear to be supported by surface flows.

3.8.5.3 Colorado River

The characterization of existing riparian and wetland acres focused on the Colorado River segment that extends from the confluence with the Fraser River to its confluence with the Williams Fork. This potentially affected portion is 15.5 miles long and is classified as a Rosgen Type C stream over its entire length. Elevations in this segment range from approximately 7,500 feet to 7,800 feet. The following sections describe the vegetation communities within this segment and at sample site CR1.

CPW Mapping

The mapping of CPW riparian vegetation categories along the river segment covers approximately 1,446 acres (Table 3.8-7). The following bullets describe the vegetation communities within the river segment:

- *Riparian Evergreen (RE)* – The riparian evergreen category is mapped on 4 acres or 0.3% of the Colorado River segment.
- *Riparian Deciduous Tree (RT)* – The riparian deciduous tree category is mapped on 314 acres or 21.7% of the Colorado River segment. Large stands of narrowleaf cottonwood were observed at many, often widely spaced, locations within the affected basin.
- *Riparian Shrub (RS)* – The riparian shrub category is mapped on 295 acres or 20.4% of the Colorado River segment. The distribution of the riparian shrub category is similar to the riparian deciduous tree category in that shrub stands are widely but consistently distributed throughout the segment.
- *Riparian Herbaceous (RH)* – The riparian herbaceous category is mapped on 833 acres or 57.6% of the Colorado River; the riparian herbaceous category is the dominant CPW riparian vegetation type on this reach. The majority of the riparian herbaceous category is mapped along the very wide valley bottoms above and below Hot Sulphur Springs and Byers Canyon and is used for hay and livestock production.

The segment of the Colorado River from the Williams Fork to the confluence with the Blue River is about 13.5 miles long and has about 3,285 acres of riparian vegetation, including 2,874 acres of riparian herbaceous (87.5% of the total), 276 acres of riparian deciduous tree (8.4%), and 135 acres of riparian shrub (4.1%). Areas mapped as riparian herbaceous occupy much of the valley floor between the Williams Fork and Kremmling and are associated with agriculture. Cottonwoods and riparian shrub occur along portions of the river and on old channels.

Grand County Stream Management Plan

The Grand County Stream Management Plan includes data for three reaches of the Colorado River from Windy Gap to the Blue River confluence (Table 3.8-8; Grand County 2010). Three sites were sampled in the reach from Windy Gap to Williams Fork (CR4), and one each in the reaches from Williams Fork to the Blue River (CR5 and CR6). Riparian cover and width was rated as poor at the site in Byers Canyon in CR4, and riparian width was rated as marginal in CR6. Other sites were rated as suboptimal.

CR1 – Colorado River above Parshall

The 2.2-acre sample site CR1 is located between the towns of Parshall and Hot Sulphur Springs within the Hot Sulphur Springs SWA; the study reach length at this sample site was 953 feet. The wide, cobble-bottom river at the sample site is classified as a Rosgen Type F3 stream. The floodplain supports large stands of reed canarygrass (*Phalaris arundinacea*), willow shrubland, and narrowleaf cottonwood (*Populus angustifolia*) stands. A large irrigation canal runs along most of the right bank on the outer edge of the primary floodplain and appears to support the largest, oldest cottonwood trees at the sample site. Significant portions of the stream had exposed cobble during field sampling and some islands were colonized by willow, sedges, and grasses. The active channel alluvial habitats with potential to support colonization by riparian plant species were mapped on 0.14 acre at sample site CR1. There were several small islands within the active channel that support willow, reed canarygrass, and small amounts of common spikerush. The gravel bar elevations at the sample site ranged from approximately -0.19 to 0.12 feet above the water surface. The acres of CNHP groups/plant associations mapped sample site CR1 are provided in Table 3.8-14.

Table 3.8-14
Acreage of CNHP Groups/Plant Associations:
Sampling Site CR1 on the Colorado River

CNHP Group/Association	Acres	Percent
Deciduous Dominated Forests and Woodlands (RT-CPW)		
Narrowleaf cottonwood/redosier dogwood (rose)	1.12	51
Non-willow Shrubland (RS-CPW)		
Thinleaf alder - mixed willow	0.67	30
Herbaceous Vegetation (RH-CPW)		
Beaked sedge	0.12	5
Reed canarygrass	0.26	12
Woolly sedge	0.03	1
Herbaceous Vegetation Total	***0.41***	***18***
Total Acres Mapped	**2.20**	**100**

Notes:
All footnotes listed for Table 3.8-9 apply. Acres may not equal 100% due to rounding.
CNHP = Colorado Natural Heritage Program
CPW = Colorado Parks and Wildlife
RH = riparian herbaceous
RS = riparian shrub
RT = riparian deciduous tree

One CNHP plant association within the Deciduous Dominated Forests and Woodland group was mapped on 1.12 acres or 51% of the CR1 sample site. The deciduous stand at the sample site is dominated by narrowleaf cottonwood and has a dense understory of Woods' rose along with lesser amounts of redtop (*Agrostis gigantea*), woolly sedge (*Carex pellita*), starry false lily of the valley (*Smilacina stellata*), Kentucky bluegrass (*Poa pratensis*), Canada goldenrod (*Solidago canadensis*), American red raspberry (*Rubus idaeus*), fringed brome, Bebb's willow (*Salix bebbiana*), and Drummond's willow. This association was difficult to classify due to the dominance of rose in the understory. Based on CNHP's description of the narrowleaf cottonwood/redosier dogwood (*Cornus sericea*) association,

this stand may be a disturbed, transitional stage of this association or possibly the narrowleaf cottonwood/river hawthorn (*Crataegus rivularis*) association. The most decadent and probably also the oldest cottonwood trees on the site appear to be closely associated with an irrigation canal that runs along river right. Other, possibly younger, cottonwood trees occur in the floodplain away from the canal and closer to the river where they are associated with more hydrophytic herbaceous and willow species and less Woods' rose. There were no signs of cottonwood regeneration on the sample site. The elevation of this stand ranges approximately from 4.7 to 6.4 feet above the water surface on the day of field sampling. CNHP information on the hydrologic regime and other relevant data from the descriptions of this plant association is excerpted below:

> The narrowleaf cottonwood/redosier dogwood plant association usually occurs 2 to 6 feet (0.5 to 2 meters) above the stream channel. A seasonally high water table is required to maintain a vigorous redosier dogwood layer (Carsey et al. 2003).

Thinleaf alder and a variety of willow species dominate the Non-willow Shrubland stands observed at the sample site. The willow species observed and identified in these stands includes Bebb's willow, Drummond's willow, shining willow (*Salix lucida*), and sandbar willow (*Salix exigua*). Fowl bluegrass (*Poa palustris*), bluejoint reedgrass, Woods' rose, whitestem gooseberry, Kentucky bluegrass, twinflower honeysuckle and reed canarygrass were the most frequently observed species in the understory. The elevation range for this plant association ranged from 1.8 to 2.9 feet above the water surface in stands mapped on both sides of the river. The thin leaf alder/mixed willow association is described by CNHP as:

> The thinleaf alder/mixed willow species plant association is a more general type than other thinleaf alder types. If the water table lowers, this plant association may succeed to a more stable, drier community dominated by Geyer's willow or quaking aspen (*Populus tremuloides*) (Carsey et al. 2003).

There were three CNHP plant associations in the Herbaceous Vegetation group that occupy 0.41 acre or 19% of the CR1 sample site. The two plant associations dominated almost exclusively by reed canarygrass and by beaked sedge generally occur near the river at elevations ranging from 1.1 to 1.5 feet and 0.23 to 0.58 feet above the water surface, respectively.

The third plant association included one stand located in a low-lying area approximately 100 feet from the right bank near the access road to the site. The stand was dominated by woolly sedge with lesser amounts of mountain rush and bluejoint reedgrass. The woolly sedge meadow is approximately 7 feet above the water surface elevation and the broad flat valley bottom extends gradually hundreds of feet beyond the meadow to the toe of slope at the far side of the river valley. The elevation measurements and mapping of CNHP plant associations did not include this portion of the valley floor which was extremely dry and dominated primarily by pasture grass species. However, the elevations of this portion of the valley floor were estimated to be similar to those on the left bank at the downstream end of the sample site which supported upland sagebrush vegetation.

3.8.5.4 Blue River

The Blue River Basin extends from its confluence with the Colorado River near the Town of Kremmling approximately 55 miles south to its headwaters south of the Town of Breckenridge. The characterization of existing riparian and wetland acres concentrated on the river segment which is 21.8 miles long and extends from the dam at Dillon Reservoir downstream to Green Mountain Reservoir. Elevations in this segment range from approximately 7,900 to 8,800 feet. The entire reach is classified as a Rosgen Type C stream. The following sections describe the vegetation communities within the segment and at the one sample site.

CPW Mapping

The mapping of CPW riparian vegetation categories along the river segment within the Blue River Basin covers approximately 891 acres (Table 3.8-7). The following bullets describe the vegetation communities within the river segment:

- *Riparian Evergreen (RE)* – The riparian evergreen category is mapped on 53 acres or 5.9% of the Blue River.
- *Riparian Deciduous Tree (RT)* – The riparian deciduous tree category is mapped on 346 acres or 38.8% of the Blue River; the riparian deciduous tree category is the dominant CPW riparian vegetation type on this reach. Large stands of narrowleaf cottonwood were observed at several locations within the affected basin along this Rosgen Type C stream.
- *Riparian Shrub (RS)* – The riparian shrub category is mapped on 223 acres or 25% of the Blue River. This category was mapped throughout the river segment.
- *Riparian Herbaceous (RH)* – The riparian herbaceous category is mapped on 269 acres or 30.2% of the Blue River. This category was mapped in a few, but relatively large areas along the river where old floodplain terraces have been converted to other land uses.

Grand County Stream Management Plan

The Grand County Stream Management Plan includes data for the Blue River from the county line to the Colorado River (Table 3.8-11; Grand County 2010). Riparian cover and width were rated as optimal.

BR1 – Blue River below Confluence with Boulder Creek

The 1.33-acre sample site (BR1) is located midway between Dillon Reservoir and Blue Mountain Reservoir. The river bed is predominately cobble with large boulders spaced throughout the sample reach. The bank along river right is generally gently sloping with narrow gravel-cobble bars along the shoreline. Above these bars, a relatively narrow but dense band of willow and alder grows along most of the study reach. The bank then rises steeply approximately 25 feet to the relatively flat valley bottom. The steep slope above the riparian shrubland supports a mix of blue spruce and aspen with an understory of upland and wetland species. The shoreline along the left bank is covered primarily with cobble and some boulders and supports a narrow band of willow and alder in most places. The banks rise

steeply for a few feet then level off to a fairly wide terrace that tapers narrowly at the up- and downstream ends of the sample site. The vegetation on the terrace is variously influenced by groundwater seepage. One inundated area supports a sedge community. Most of the terrace supports a mixture of coniferous and deciduous trees, willow shrubs and herbaceous wetland species. The outer portions of the terrace abut a steep slope that rises approximately 15 feet before it levels off at the valley floor. The active channel alluvial habitats with potential to support colonization by riparian plant species were mapped on 0.24 acre at sample site BR1. Approximately 0.23 acre of the mapped alluvial habitat had been colonized by at least a small amount of riparian herb species and willow seedlings. One small mid-channel island supported several mature willow shrubs. However, most alluvial habitats or gravel bars were low gradient portions of the shoreline between open water and the willow-alder shrubland. The non-vegetated gravel bars were recorded in areas -0.15 to 0.72 feet above the water surface, while the bars with more significant vegetation growth extended from 0.52 to 1.34 feet above the water surface. The acres of CNHP groups/plant associations mapped at sample site BR1 are provided in Table 3.8-15.

Table 3.8-15
Acreage of CNHP Groups/Plant Associations:
Sampling Site BR1 on the Blue River

CNHP Group/Association	Acres	Percent
Evergreen Riparian Forest (RE-CPW)		
Blue spruce/thinleaf alder	0.82	62
Non-willow Shrubland (RS-CPW)		
Thinleaf alder-mixed willow	0.33	25
Herbaceous Vegetation (RH-CPW)		
Beaked sedge	0.18	14
Total Acres Mapped	**1.33**	**100**

Notes:
All footnotes listed for Table 3.8-9 apply. Acres may not equal 100% due to rounding.
CNHP = Colorado Natural Heritage Program
CPW = Colorado Parks and Wildlife
RE = riparian evergreen
RH = riparian herbaceous
RS = riparian shrub

One CNHP plant association within the Evergreen Riparian Forest group was mapped on 0.82 acre or 62% of the BR1 sample site in an area that receives groundwater seepage. This association was dominated by blue spruce and narrowleaf cottonwood and had a mesic understory of thinleaf alder, Bebb's willow, bluejoint reedgrass, beaked sedge, redtop, and Canada thistle (*Cirsium arvense*). The elevation of this stand ranged from approximately 4.2 to 5.6 feet above the water surface. This stand did not key well in the CNHP classification key and may not actually represent the narrowleaf cottonwood–blue spruce/thinleaf alder association.

Another conifer/deciduous tree-dominated stand occurred on the right bank that was mapped as upland but may represent an undescribed riparian association. This stand had a relatively open tree layer with blue spruce, ponderosa pine (*Pinus ponderosa*), quaking aspen, and a few narrowleaf cottonwood. The understory consisted of Woods' rose and a dominant cover of species observed growing on the upland valley floor. The potential

undescribed riparian association was recorded at elevations from 3.6 to 6.7 feet above the water surface. Including this "upland" stand, the total conifer-deciduous tree-dominated vegetation would cover 2.3 acres.

Overall, the tree-dominated riparian stands at the study site appear to represent an intermediate version of the types of tree-dominated riparian vegetation in the segment with stands ranging from those dominated by conifers to those dominated by deciduous trees. The combined CPW categories of riparian evergreen and riparian deciduous tree account for 44.7% of all mapped riparian vegetation compared to 62% mapped at the sample site.

> The blue spruce/thinleaf alder plant association occurs in deep, shaded canyons and narrow valleys and appears to be a climax riparian species in this setting that will remain until removed or damaged by a catastrophic flood. In Colorado, the closely related blue spruce/field horsetail plant association is considered an indicator of frequent flooding. With less frequent flooding, this association may gradually change to a blue spruce/thinleaf alder plant association (Carsey et al. 2003).

There is one plant association in the Non-willow Shrubland group CNHP mapped at the BR1 sample site. Willow and alder are the dominant shrub layer species in these stands. Approximately 0.33 acre (25%) of the association are mapped as a nearly continuous narrow band along both banks of the sample reach. These narrow bands of riparian shrubland were recorded at elevations ranging from 1.9 to 2.6 feet above the water surface and do not appear to be mapped in many portions of the river segment based on the CPW mapping. The CPW mapping of shrubland throughout the river segment appears to catch the majority of riparian shrubland but only the larger stands. Hence, the CPW mapping may under-represent riparian shrubland in the river segment.

At the sample site, the Herbaceous Vegetation group included only 0.18 acre (14%) of beaked sedge association mapped in an area where groundwater pools on the broad, left bank terrace approximately 7 feet above the river within the larger tree-dominated stand. The terrace at the sample site represents the types of habitats that have been converted to other land uses in other parts of the river segment and which now support the herb-dominated riparian vegetation mapped as the CPW riparian herbaceous category. This scenario may explain why the sample site has a relatively high percentage of tree-dominated stands and relatively low percentage of herb-dominated stands compared to the respective CPW categories mapped in the river segment.

Relevant information on CNHP plant associations has been previously described.

3.8.5.5 South Boulder Creek

The South Boulder Creek Basin drains into Boulder Creek just east of Boulder and extends westward past Gross Reservoir, the Town of Rollinsville, and the East Portal of Moffat Tunnel to its headwaters in the vicinity of Haystack Mountain on the Continental Divide. The characterization of existing riparian and wetland acres focused on the stream reach (river segment), which is 22 miles long and extends from the outlet of Moffat Tunnel to Eldorado Springs near Denver Water's South Boulder Diversion Canal. Elevations in this segment range from approximately 6,000 to 9,200 feet. The following sections describe the vegetation communities within the river segment and at the two sample sites.

CPW Mapping

The mapping of CPW riparian vegetation categories along South Boulder Creek covers approximately 298 acres (refer to Table 3.8-7). The following bullets describe the vegetation communities within the river segment.

- *Riparian Evergreen (RE)* – The riparian evergreen category is mapped on 56 acres or 18.8% of the South Boulder Creek segment.
- *Riparian Deciduous Tree (RT)* – The riparian deciduous tree category is mapped on 37 acres or 12.4% of the South Boulder Creek segment. Most of this category is mapped in the broader valley sections upstream of Rollinsville. The river has been channelized to contain high flows in the valley sections and probably limits the distribution of this category.
- *Riparian Shrub (RS)* – The riparian shrub category is mapped on 93 acres or 31.2% of the South Boulder Creek segment. In many areas upstream of Rollinsville, willow, river birch, and alder are scattered thinly along the channelized portions of the river segment. The relatively narrow Rosgen Type A and B channels in the remaining parts of the river segment provide only narrow habitats along the river that can support riparian species. Many of these habitats are hidden by coniferous forest canopies making them difficult to detect during aerial mapping.
- *Riparian Herbaceous (RH)* – The riparian herbaceous category is mapped on 112 acres or 37.6% of the South Boulder Creek segment; the riparian herbaceous category is the dominant CPW riparian vegetation type on this reach. The category was distributed upstream of Rollinsville primarily on the steep banks of the channelized portions of the river. The riparian herbaceous category was also distributed downstream of Gross Reservoir presumably along wider portions of the valley bottom where tree cover was sparse.

SBC1 – South Boulder Creek above Gross Reservoir

The SBC1 sample site is located above Gross Reservoir approximately 6 miles upstream of Rollinsville at the Jumbo Mountain Picnic area; the study reach length at this sample site was 599 feet. The affected basin above Gross Reservoir consisted of Rosgen Types A, B, and C streams and the basin below Gross Reservoir is a Type A stream. Much of the reach above Gross Reservoir has been highly modified and disturbed by past and/or ongoing land uses. The 0.27-acre SBC1 sample site is a Rosgen Type B stream within a confined valley. The bed is comprised of cobble and boulder with small quantities of stored sand in the bed and bank. No alluvial deposits suitable for colonization were observed within the active channel during field sampling. Riparian vegetation along the main channel is limited to a narrow, inconsistent fringe of mesic herbs and willow shrubs.

The active channel alluvial habitat that supports colonization by riparian plant species was mapped on 0.06 acres at sample site SBC3. These habitats were observed only along the highest edge of the active channel along the left bank where colluvium has helped to create a sliver of habitat suitable for colonization. The elevations associated with these habitats ranged from -0.62 to -0.13 feet below the water surface. The acres of CNHP groups/plant associations mapped at sample site SBC1 are provided in Table 3.8-16.

Table 3.8-16
Acreage of CNHP Groups/Plant Associations:
Sampling Site SBC1 on South Boulder Creek

CNHP Group/Association	Acres	Percent
Tall Willow Shrubland (RS-CPW)		
Drummond's willow/mesic forb	0.17	29
Non-willow Shrubland (RS-CPW)		
Thinleaf alder-Drummond's willow	0.42	71
Shrub-dominated Riparian Total	***0.59***	***100***
Total Acres Mapped	**0.59**	**100**

Notes:
All footnotes listed for Table 3.8-9 apply. Totals may not equal 100% due to rounding.
CNHP = Colorado Natural Heritage Program
CPW = Colorado Parks and Wildlife
RS = riparian shrub

There are no CNHP plant associations that fall within the Evergreen Riparian Forest group mapped at this sample site. However, one stand of upland conifer dominated by lodgepole pine was mapped on 0.44 acre adjacent to the sample site. The understory species included a few hydrophytic species and several aspen trees. This stand is positioned as high as 11.7 feet above the river on top of the right bank levy but extends to lower elevations on the steep cutbank hillslope downstream.

Two Shrub-dominated Riparian plant associations were mapped at sample site SBC1, one association each in the Tall Willow Shrubland group and the Non-willow Shrubland group. These two associations collectively occupy 0.59 acre or 100% of the sample site. These shrub-dominated stands supported Drummond's willow, thinleaf alder, and river birch to varying degrees and were located primarily along the overflow channel along river right but also in scattered locations along the main channel and the tall left bank slope. The Tall Willow Shrubland association mapped along the main channel was poorly defined with clumps of willow scattered along the steep boulder-cobble shoreline. At higher elevations on the steep left bank, groundwater provided essential moisture to support patches of willows and mesic forbs. The elevation of these stands was generally from 1.6 to 3.0 feet with maximum elevation on the left bank of 14.3 feet above the water surface. On the high banks, the hydrophytic understory species were limited to seepage areas and often grew next to species with stronger upland affinities. Associated understory species included Woods' rose, fireweed (*Epilobium angustifolium*), field horsetail, fringed brome, American red raspberry, stinging nettle (*Urtica dioica*), whitestem gooseberry, and wax currant (*Ribes cereum*). The association in the overflow channel was primarily dominated by Drummond's willow and thinleaf alder but also supported some river birch, narrowleaf cottonwood, and aspen. This community also supported a lush understory that included fowl bluegrass, twinflower honeysuckle, tall fringed bluebells, and bluejoint reedgrass. The elevations measured within the overflow channel ranged from 7.9 to 11.7 feet above the water surface which may, to some degree, indicate how much the main channel has degraded due to channelization.

The Shrub-dominated Riparian group mapped at the SBC1 sample site best represents the more channelized portions of the river segment generally found upstream of Rollinsville.

There was no CNHP association in the Herbaceous Vegetation group mapped at the SBC1 sample site. However, an upland grass vegetation type was mapped near the sample site. This upland grass type had a relatively low herb cover on a steep gravelly bank. It was not strictly dominated by grass species, but included low-growing prairie sagewort (*Artemisia frigida*), fringed brome, fireweed, timothy, Canada thistle, sulphur-flower buckwheat (*Eriogonum umbellatum*), and ox-eye daisy (*Chrysanthemum leucanthemum*). Hydrophytic herbaceous species were common in areas influenced by groundwater seepage. The elevation of the upland grass category occurred as high as 12 feet above the river although elevations generally ranged from 3.0 to 4.4 feet above the water surface. This type of tall, steep bank is common along the channelized portions of the river segment and likely would be interpreted as riparian herbaceous using the CPW mapping techniques. An example of riparian herbaceous-dominated vegetation that included a substantial proportion of hydrophytic species at sample site SBC1 occurred only as part of the understory associated with Shrub-dominated Riparian group.

The upland grass vegetation documented at the SBC1 sample site best represents the more channelized portions of the river segment generally upstream of Rollinsville. The Herbaceous Vegetation group mapped at the SBC3 is more typical of the less disturbed Rosgen Type A and Type B streams downstream of the channelized portions of the affected South Boulder Creek reach.

Redtop is a facultative wetland species that grows in mesic to semi-hydric conditions and is tolerant of some flooding. The association is typically found in or near irrigated hay meadows or along streams and ditches. Typically cultivated as a hay crop, this species readily escapes cultivation and can be found in many wet meadows in the western U.S., including those that are no longer cultivated or have never been cultivated (Carsey et al. 2003).

SBC3 – South Boulder Creek below Gross Reservoir

The SBC3 sample site is located downstream of Gross Reservoir; the study reach length at this sample site is 446 feet. The basin below Gross Reservoir downstream to Eldorado Springs is generally classified as a Rosgen Type A stream. The 0.59-acre SBC3 sample site is classified as a Rosgen Type B stream. The SBC3 site was considered an excellent choice for sampling although its Rosgen Type B classification differs from the generally Type A stream classification below Gross Reservoir. The river has a predominately cobble and boulder bed with various bedrock outcrops and stored sand and gravel. There was a significant amount of in-channel alluvium exposed during field sampling, most of which supported colonizing riparian herbs and willow seedlings. Most of the riparian vegetation is restricted to a relatively narrow margin along the main channel because the stream banks are generally steep and transition to upland habitat over a relatively short distance. The banks are steep or V-shaped.

The SBC3 sample site contained approximately 0.16 acre of alluvial habitat within the active channel. Colonizing species including seedlings of sandbar willow and another unidentified willow as well as scouringrush horsetail (*Equisetum hyemale*), were observed in these habitats. The elevations ranged from -0.29 to 2.0 feet above the mean water surface elevation on the day of field sampling. The uncolonized portions of the gravel bar were not distinguished from colonized portions due to their small size and difficulty

associated with mapping them. The acres of CNHP groups/plant associations mapped at sample site SBC1 are provided in Table 3.8-17.

Table 3.8-17
Acreage of CNHP Groups/Plant Associations:
Sampling Site SBC3 on South Boulder Creek

CNHP Group/Association	Acres	Percent
Evergreen Riparian Forest (RE-CPW)		
Blue spruce/field horsetail	0.03	11
Non-willow Shrubland (RS-CPW)		
River birch/mesic forb	0.04	15
River birch/mesic graminoid	0.02	7
Non-willow Shrubland Total	***0.06***	***22***
Herbaceous Vegetation (RH-CPW)		
Blue joint reedgrass	0	0
Beaked sedge	0.01	4
Redtop	0.17	63
Herbaceous Vegetation Total	***0.18***	***67***
SBC3 Total Acres Mapped	**0.27**	**100**

Notes:
All footnotes listed for Table 3.8-9 apply. Totals may not equal 100% due to rounding.
CNHP = Colorado Natural Heritage Program
CPW = Colorado Parks and Wildlife
RE = riparian evergreen
RH = riparian herbaceous
RS = riparian shrub

The sample site included one Evergreen Riparian Forest group plant association mapped on 0.03 acre or 11% of the sample site. This stand occurred on a narrow bench along the right bank where it commingled with the more abundant upland conifer forest. The upland stand may be an Evergreen Riparian Forest stand. The upland forest at this site was highly disturbed by recreation access which may have destroyed the hydrophytic understory. The two stands have similar elevations with Evergreen Riparian Forest ranging from -0.32 to 6.04 feet above the water surface, and the upland conifer forest ranging from 3.2 to 4.0 feet above the water surface. Combined, the two stands occupy 0.33 acre.

The dominant tree species in these stands were blue spruce but several ponderosa pines were also observed. The more mesic understory species included field horsetail, common cowparsnip, Canada goldenrod, Woods' rose, and snowberry (*Symphoricarpos* sp.).

The mapping of the Shrub-dominated Riparian at the SBC3 sample site included two associations in the Non-willow Shrubland group. The two associations were mapped on 0.06 acre or 22% of sample site SBC1. The stands were dominated by river birch, but also included significant amounts of thinleaf alder, Bebb's willow, sandbar willow, and two other unidentified species of willow that made classification of these stands very difficult. One relatively large stand of river birch and alder were associated with a large meadow and had a mesic graminoid understory comprised of redtop, bluejoint reedgrass, fowl mannagrass (*Glyceria elata*), common cowparsnip, Canada thistle, and field horsetail. The other Shrub-dominated Riparian association had a sparse mesic forb understory and occurred along the river edge. The associated species in these stands included starry false

lily of the valley, field mint (*Mentha arvensis*), common cowparsnip, Porter's aster (*Aster porteri*), darkthroat shootingstar (*Dodecatheon pulchellum*), and bluejoint reedgrass. The elevations associated with the two plant associations were similar and ranged from approximately 1.4 to 3.0 feet above the mean water surface elevation on the day of field sampling.

The Herbaceous Vegetation group at sample site SBC1 included three CNHP plant associations mapped on 0.18 acre or 67% of the sample site. The majority of this group was mapped in one meadow dominated by redtop although a number of other abundant herbaceous species were also present; these included mountain rush, beaked sedge, saltspring checkerbloom (*Sidalcea neomexicana*), western aster (*Aster ascendens*), panicled bulrush (*Scirpus microcarpus*), Canada thistle, fowl bluegrass, and Kentucky bluegrass. This meadow ranged in elevation from 1.8 to 2.4 feet above the water surface. The two other associations dominated either by beaked sedge or by bluejoint reedgrass were located along the edge of the active channel; these associations ranged from 0.7 to 1.7 feet above the water surface.

Relevant information on CNHP plant associations has been previously described.

3.8.5.6 North Fork South Platte River

The North Fork South Platte River (North Fork) Basin drains into the South Platte River at the Town of South Platte and extends generally westward passing consecutively near the towns of Estabrook and Pine, and then along US 285 to its headwaters in the vicinity of Whale Peak on the Continental Divide. The affected section of the North Fork South Platte River Basin is 39.7 miles in length and extends from the outlet of the Roberts Tunnel near the Town of Grant to the confluence with the South Platte River. Elevations in this segment range from approximately 6,100 to 8,700 feet. The entire river segment is classified as a Rosgen Type C stream.

There are two representative sample sites (NF1 and NF2) located within the affected river reach. The NF1 and NF2 sample sites are located near the towns of Shawnee and Pine, respectively, along the mainstem of the South Platte River. The following sections describe the vegetation communities within the river segment and at the two sample sites.

CPW Mapping

The mapping of CPW riparian vegetation categories along the North Fork South Platte River covers approximately 1,141 acres (Table 3.8-7). The following bullets describe the vegetation communities within the river segment:

- *Riparian Evergreen (RE)* – The riparian evergreen category is mapped on 131 acres or 11.5% of the North Fork South Platte River segment. This category is distributed throughout the broad valley portions of the reach with Rosgen Type C streams.
- *Riparian Deciduous Tree (RT)* – The riparian deciduous tree category is mapped on 31 acres or 2.7% of the North Fork South Platte River segment. This category is sparsely but well distributed in this reach.

- *Riparian Shrub (RS)* – The riparian shrub category is mapped on 395 acres or 34.6% of the North Fork South Platte River segment. This category is distributed throughout the segment.
- *Riparian Herbaceous (RH)* – The riparian herbaceous category is mapped on 584 acres or 51.2% of the North Fork South Platte River segment; the riparian herbaceous category is the dominant CPW riparian vegetation type on this reach. The category was distributed within the broader valley bottom floodplains that have been used to raise livestock either presently or in the past.

NF1 – North Fork South Platte River Near Shawnee

The study reach at the 0.83-acre NF1 sample site supports a Rosgen Type C stream and has a largely cobble and gravel bed with small amounts of coarse sand stored in the bed and bank; the study reach length at this sample site is 300 feet. The only alluvial materials exposed within the channel during field sampling were located just upstream of the sample site. The right bank was steep and more or less vertical except at the upstream end where a small portion of floodplain supported deciduous trees and shrubs. A terrace positioned above the floodplain extends downstream the length of the study site and supports dense willow, cottonwood and disturbed mesic riparian grassland. The dense willow on this terrace is supported almost exclusively by a wet ditch that receives water from a diverted upstream tributary. The ditch ends on the site and appears to percolate into the terrace. Along the steep bank there is a narrow strip of old, decadent narrowleaf cottonwood. The left bank has a much gentler slope which extends up to 75 feet from the river forming a wide floodplain supporting large old cottonwood but also a distinctly younger class of young trees. It also supports willow, river birch, and mesic meadow. At the downstream end of the lower left bank there is a small stand of blue spruce with an understory of hydrophytic grasses. A steep bank at the outer edge of this floodplain transitions into a higher terrace supporting upland vegetation. The were no alluvial habitats or gravel bars observed within the active channel at the NF1 samples site although one small gravel cobble bar was observed just upstream of the site. The acres of CNHP groups/plant associations mapped at sample site NF1 are provided in Table 3.8-18.

Table 3.8-18
Acreage of CNHP Groups/Plant Associations: Sampling Site NF1 on the North Fork South Platte River

CNHP Group/Association	Acres	Percent
Evergreen Riparian Forest (RE-CPW)		
Blue spruce/river birch	0.02	2
Deciduous Dominated Forests and Woodlands (RT-CPW)		
Narrowleaf cottonwood/redosier dogwood (rose)	0.26	31
Tall Willow Shrubland (RS-CPW)		
Shining willow	0.23	28
Non-willow Shrubland (RS-CPW)		
Chokecherry	0.09	11
River birch/mesic graminoid	0.01	1
Non-willow Shrubland Total	***0.10***	***12***
Shrub-dominated Riparian Total	***0.33***	***40***
Herbaceous Vegetation (RH-CPW)		
Redtop	0.22	27
Total Acres Mapped	**0.83**	**100**

Notes:
All footnotes listed for Table 3.8-9 apply. Totals may not equal 100% due to rounding.
CNHP = Colorado Natural Heritage Program
CPW = Colorado Parks and Wildlife
RE = riparian evergreen
RH = riparian herbaceous
RS = riparian shrub
RT = riparian deciduous tree

There is one plant association in the Evergreen Riparian Forest group at sample site NF1 on just 0.02 acre comprising 2% of the sample site. This stand is dominated by blue spruce and supported river birch, willow, bluejoint reedgrass and beaked sedge in the understory. Blue spruce is a common, but not very abundant, component of other plant associations at sample site NF1. This association was observed growing at elevations ranging from -0.4 to 2.1 feet above the water surface.

The Evergreen Riparian Forest group mapped at both sample sites is less well represented than in the CPW mapping of the riparian evergreen category within the river segment. The NF1 sample site may offer some indication as to why this may be true. Conifer trees are obvious in aerial photography and would tend to be emphasized when delineating polygons for the CPW classification map. The blue spruce in other plant associations at sample site NF1 would likely get lumped into the riparian evergreen category even though they were not the dominant species in the tree layer when assessed in the field. This would be particularly true along the North Fork South Platte River where conifer stands tend to be fragmented in their distribution and obvious in aerial photography.

There is one plant association within the Deciduous Dominated Forest and Woodlands group mapped at sample site NF1 on 0.26 acre or 31% of the sample site. This stand is dominated by narrowleaf cottonwood with Woods' rose as the most abundant understory component. The understory of the stand is considered to be transitional to redosier

dogwood although closer to wetter sites near the river it may actually be transitional to river birch. Other understory species included common cowparsnip, cutleaf coneflower (*Rudbeckia laciniata*), Kentucky bluegrass, redtop, Canada thistle, Canada goldenrod, and chokecherry (*Prunus virginiana*). The elevations of this association ranged from 1.5 to 2.0 feet above the water surface.

The Shrub-dominated Riparian group was represented by one plant association in the Tall Willow Shrubland group and two plant associations within the Non-willow Shrubland group. The stands representing these groups were mapped on 0.33 acre or 40% of the sample site. The Tall Willow Shrubland plant association was dominated by shining willow although Bebb's willow, dewystem willow (*Salix irrorata*), thinleaf alder and river birch were also present in the shrub layer. This association grew along an old, partially inundated, irrigation ditch 2.2 to 4.1 feet above the water surface. One of the plant associations in the Non-willow Shrubland group was dominated by chokecherry growing along the steep bank separating the two large terraces on river left. This association grew well back from the river and approximately 4.9 to 10.5 feet above the water surface. The second plant association in the Non-willow Shrubland group was dominated by river birch and had the same associated shrub layer species as the Tall Willow Shrubland group association. This association grew on the lower of the two left bank terraces approximately 1.1 to 1.5 feet above the water surface. Bluejoint reedgrass and beaked sedge are among the most abundant herb layer species in the wettest portions of the Shrub-dominated Riparian stands.

The Herbaceous Vegetation group at sample site NF1 included one CNHP plant association mapped on 0.22 acre or 27% of the sample site. This association was more or less dominated by redtop but had an abundant component of other pasture grass species, including Kentucky bluegrass, timothy and red fescue (*Festuca rubra*), but also mountain rush, largeleaf avens (*Geum macrophyllum*), Canada thistle and common yarrow (*Achillea millefolium*). This type occurred on the left bank lower terrace where it occurred at slightly lower elevations than stands observed on the left bank. The left bank stands had a more abundant component of hydrophytic herb species than the right bank stands which supported a larger proportion of pasture grass species. Elevations for both stands dominated by redtop ranged from 2.6 to 3.7 feet above the water surface. Both stands appeared to have been lightly grazed earlier in the year.

NF2 – North Fork South Platte River Near Pine

The study reach at the 3.47-acre NF2 sample site supports a Rosgen Type C stream that lies within a wide valley with a broad floodplain, particularly on river right; the study reach length at this sample site is 778 feet. The sample reach has a bed with predominately large gravel with some cobble and moderate amounts of sand stored along the banks and bed. There were several small alluvial bar habitats exposed within the active channel during field sampling, some of which had a few colonizing herbaceous species. The right bank rises vertically several feet in most areas and supports a willow, alder, and river birch at the top edge of the bank. Near the downstream end of the right bank is a concrete wall and headgate structure. In the middle portion of the reach at the highest point along the bank is a single line of blue spruce trees. Further back from the river, a broad band of sandbar willow extends nearly the full length of the sample site. Beyond the sandbar willow is a very wide, gently sloping floodplain supporting pasture grass species. On river left, a short

vertical cutbank at the downstream end of the sample site transitions to a fairly wide terrace supporting a large stand of sandbar willow and mesic grassland comprised largely of pasture grass species. A road/recreation trail runs along the left bank between the toe of the hillslope and the river. The left bank river edge/road fill slope rises steeply approximately 15 feet to meet the road. Patches of willow and disturbed, eroded areas occupy the steep road bank. Several small, subtle seepage areas were observed in several locations along the road bank. The active channel alluvial habitats that support colonization by riparian plant species were mapped on 0.05 acre at sample site NF2. Approximately 0.01 acre of the mapped active channel was mapped as gravel bar or alluvial habitat but had not been colonized by riparian species. The alluvial habitats at the NF2 sample site ranged from approximately 0.12 to 1.2 feet above the water surface. The acres of CNHP groups/plant associations mapped at sample site NF2 are provided in Table 3.8-19.

Table 3.8-19
Acreage of CNHP Groups/Plant Associations:
Sampling Site NF2 on the North Fork

CNHP Group/Association	Acres	Percent
Evergreen Riparian Forest (RE-CPW)		
Blue Spruce/thinleaf alder	0.23	7
Tall Willow Shrubland (RS-CPW)		
Sandbar willow/mesic graminoid	1.08	31
Strapleaf willow	0.09	3
Tall Willow Shrubland Total	***1.17***	***34***
Herbaceous Vegetation (RH-CPW)		
Pasture-meadow[1]	2.07	60
NF2 Total Acres Mapped	**3.47**	**100**

Notes:
All footnotes listed for Table 3.8-9 apply. Acres may not equal 100% due to rounding.
[1]Not a designated CNHP plant/group association.
CPW = Colorado Parks and Wildlife RH = riparian herbaceous
RE = riparian evergreen RS = riparian shrub

There is one Evergreen Riparian Forest plant association mapped at sample site NF2 on just 0.23 acre or 7% of the sample site. This stand is dominated by blue spruce and supported thinleaf alder, bluejoint reedgrass, common cowparsnip, and American red raspberry in the understory. Blue spruce is restricted to this plant association at sample site NF2 and grows at elevations ranging from 3.0 to 3.7 feet above the water surface. The Evergreen Riparian Forest plant associations occurring at this site were previously described.

There were no CNHP plant associations within the Deciduous Dominated Forest and Woodlands group observed at the NF2 sample site. This sample site may be more representative of the riparian deciduous tree category mapped within the affected North Fork South Platte River reach. The narrowleaf cottonwood stand, similar to the one sampled at the NF1 sample site, was not often observed in the river segment.

The mapping of the Shrub-dominated Riparian group at the NF2 sample site included two associations in the Tall Willow Shrubland group. The two associations were mapped on 1.17 acres or 34% of sample site NF2. Most stands were dominated almost exclusively by

sandbar willow. These stands form large patches that extend well away from the river and, on river right, are spreading clonally into the broad floodplain dominated by pasture grass species. The elevation of these stands ranges from 3.3 to 4.3 feet above the water surface. The other Tall Willow Shrubland association is dominated by a willow species tentatively identified as strapleaf willow (*Salix ligulifolia*). However, this stand has several abundant, sometime co-dominant, shrub species including shining willow, sandbar willow, Bebb's willow, and thinleaf alder which makes it difficult to classify. This stand is located on the left bank river edge at elevations approximately 1.7 to 2.6 feet above the water surface. CNHP describes the tall willow shrubland group as:

> The shining willow plant association is a tall willow community often found within a mosaic of several other riparian communities. It is generally a small patch type on large floodplain ecosystems that occurs in saturated areas, usually adjacent to the channel flow. It is found on low point bars and islands, as well as on low stream banks and overflow channels of larger rivers. It is often associated with abandoned beaver ponds or occurs along steeper reaches below beaver ponds. The shining willow plant association establishes on deep alluvial materials and is considered to be early-seral. It appears to colonize areas that have been or are currently filling in with silt. This association will eventually be replaced by slightly drier-site willow species (Carsey et al. 2003).
>
> Sandbar willow is one of the most common willow species in Colorado, generally occurring along backwater channels and other perennially wet, but less scoured sites. This plant association usually occurs within 3 feet (1 meter) vertical distance of the stream channel on point bars, low floodplains, terraces and along overflow channels. It can also occur away from the stream channel in mesic swales or along the margins of beaver ponds. This plant association is typical of recent floodplains and highly disturbed, low, wet areas and is considered early-seral (Carsey et al. 2003).

No CNHP associations in the Herbaceous Vegetation group were mapped at the NF2 sample site although large areas of fallow pasture are mapped in the valley bottom floodplain. These former pastures were mapped on 2.07 acres or 60% of the sample site on both sides of the river. One small stand of little blue stem (*Schizachyrium scoparium*), was included on river right within the pasture/floodplain. The elevation of the pasture-meadow group ranged from approximately 2.3 to 6.1 feet above the water surface.

3.8.5.7 South Platte River

Detailed studies of riparian vegetation were not conducted for the South Platte River between Antero Reservoir and the Henderson gage because average annual and monthly flow changes would be less than 10% in almost all months of the 45 year study period. Riparian vegetation occurs along much of the river, but generally in relatively narrow areas along each bank especially in the mountainous areas and in the Denver urban area. About 30 miles of the river are located in South Park, including two large reservoirs, Spinney and Eleven Mile Canyon. Riparian vegetation occupies about 1,937 acres of the river valley between the reservoirs. Nearly all of the riparian area (1935 acres, 99.9%) is riparian herbaceous, and the remainder is riparian shrub. In addition, there are hundreds of acres of sparsely vegetated salt flats below Antero Reservoir.

From Eleven Mile Canyon Reservoir to the mouth of Waterton Canyon, the South Platte River passes through mountainous terrain, and riparian vegetation is limited and generally dominated by shrubs. Only about 375 acres of riparian occurs along about 60 miles of river valley, of which 337 acres (90%) is riparian shrub. The South Platte River emerges from the mountains at Waterton, flow for several miles to Chatfield Reservoir, and then goes north through the Denver Metropolitan area. Above and below Chatfield Reservoir, there are larger patches of riparian woodland and shrubland associated with the South Platte River, canals and ponds.

Riparian vegetation in the Denver urban area is limited and is generally dominated by a mix of native and non-native tree species. More developed areas of riparian woodland occur along the South Platte River north of Denver, along with numerous reservoirs and gravel pit ponds north of I-270. Overall, the approximately 43 miles of the South Platte River from Waterton to Henderson has about 825 acres of riparian vegetation, including 415 acres of riparian deciduous tree (50.3%), 218 acres of riparian shrub (26.5%), and 191 acres of riparian herbaceous (23.2%).

3.9 WILDLIFE

3.9.0 Overview

This section discusses the wildlife potentially present in the Moffat Collection System Project (Moffat Project or Project) area. Information on species distribution was obtained from habitat assessments using aerial photography during 2005-2006 field visits, the Natural Diversity Information Source (NDIS), previous studies conducted in the Project area and reports, and literature searches. Identification of species likely to occur was based primarily on habitats present and reported ranges. Figures 3.9-1 through 3.9-5 present wildlife habitat areas.

3.9.1 Reservoirs

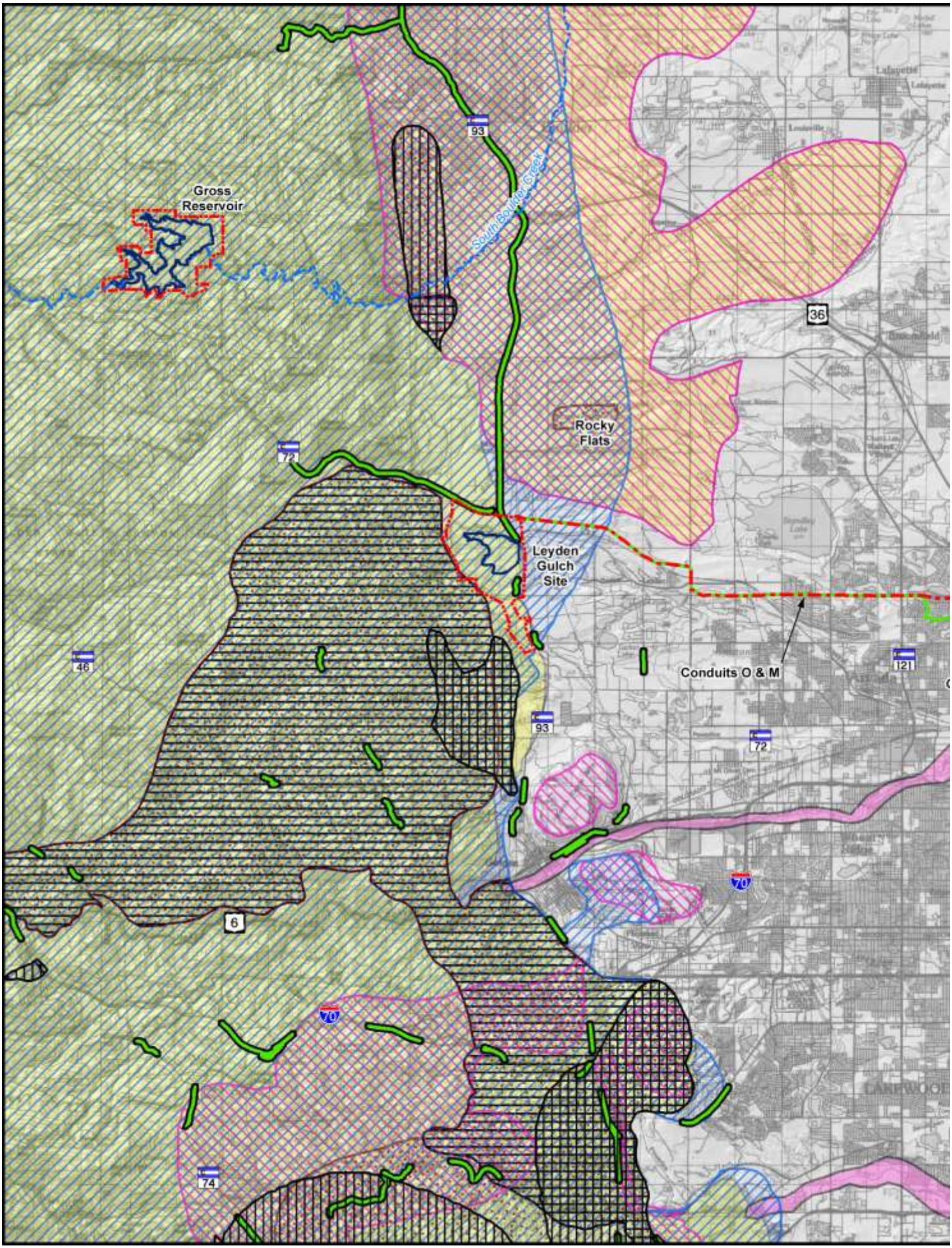
3.9.1.1 Gross Reservoir

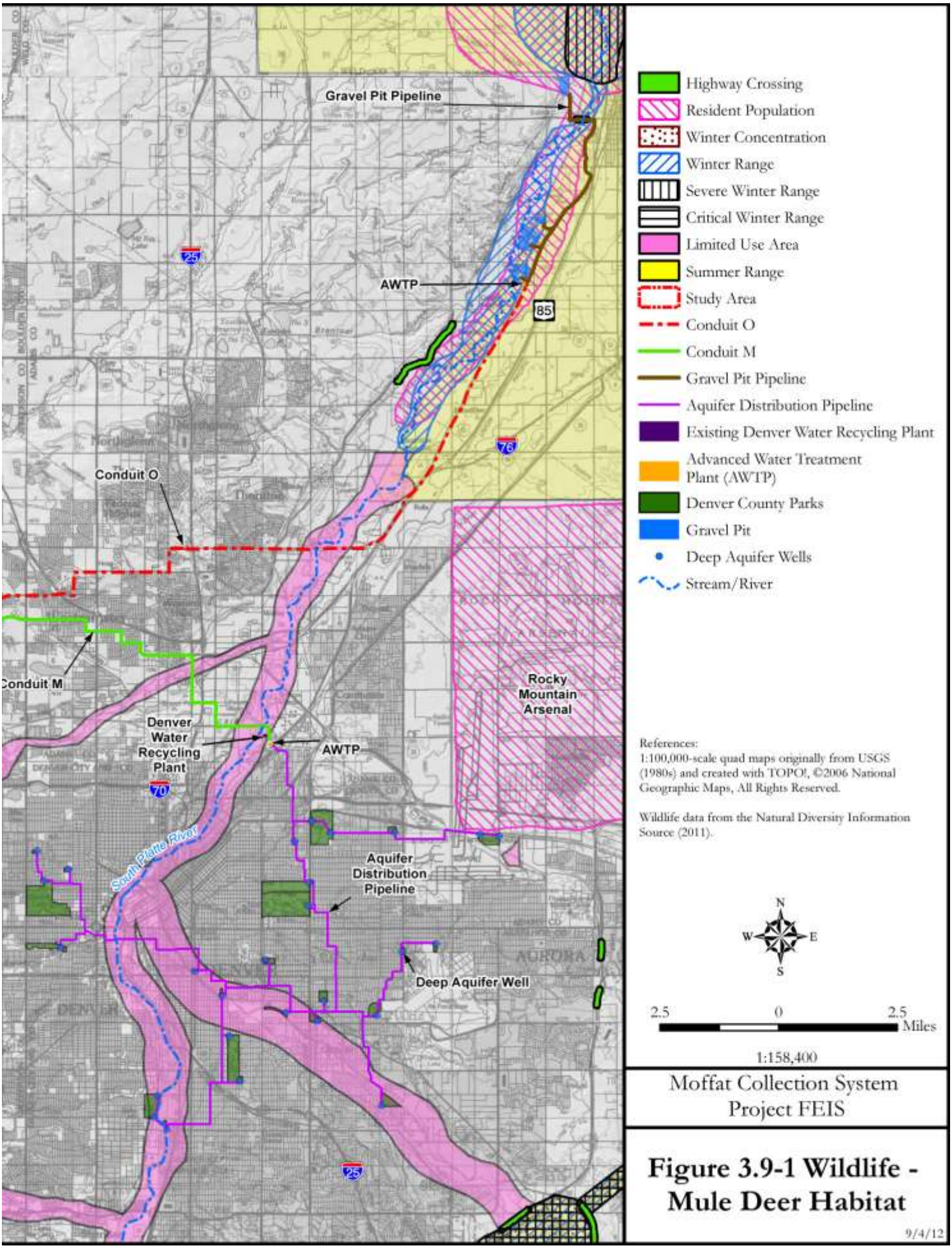
The Gross Reservoir study area is comprised of several wildlife habitat types including ponderosa pine (*Pinus ponderosa*) woodland, mixed conifer forest consisting of Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine, mountain grassland, wetlands and riparian areas, and disturbed or bare ground. The wetland and riparian habitats in the Gross Reservoir study area are primarily located in Winiger Gulch, South Boulder Creek, and Forsythe Canyon.

Montane forest provides wildlife with food and shelter. The understory in the forested habitats is comprised of grasses, forbs, and patches of bare ground (refer to Section 3.7). Insect infestations (mountain pine beetle [*Dendroctonus ponderosea*] and western spruce budworm [*Choristoneura occidentalis*]) have killed large patches of ponderosa pines and Douglas-fir on the west side of Gross Reservoir. These dead trees provide good habitat for cavity nesting birds. Wildlife known or likely to occur in the Gross Reservoir study area is discussed by group in the following sections.

Big Game

Mule deer (*Odocoileus hemionus*) are common, non-migratory, year-round residents of the Gross Reservoir study area (NDIS 2011). Colorado Parks and Wildlife (CPW) (previously called Colorado Division of Wildlife) divides the State into data analysis units (DAU) that are again divided into game management units (GMU). DAUs encompass a herd's entire range throughout the year; GMUs are smaller areas to manage big game hunting by geographic area. The herd inhabiting the area around Gross Reservoir is part of DAU 27 and GMUs 29 and 38, which encompass an area that is bounded on the north by Left Hand Canyon and to the south by Interstate (I-) 70 (NDIS 2011). In 1994, the DAU 27 mule deer population was estimated at 6,646 animals; the herd size increased until 2001, then the population declined. In 2004, the herd size was estimated at 7,000 individuals with a buck-to-doe ratio of 46:100 (Denver Water 1998b; Huwer 2005), and the 2009 post-hunt population was estimated at 7,260 (CDOW 2011a). No migration corridors, winter concentration, or severe winter range is located in the vicinity of Gross Reservoir (NDIS 2011, Figure 3.9-1).


Gross
Reservoir
South Boulder Creek
Rocky
Flats
Leyden
Gulch
Site
Conduits O & M
93
72
46
36
121
6
70
74
Lafayette
Louisville
Broomfield
LAKEWOOD



Moffat Collection System Project FEIS

Figure 3.9-1 Wildlife - Mule Deer Habitat

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American elk (*Cervus elaphus*) generally inhabit semi-open forests or forest edges adjacent to meadows (Fitzgerald et al. 1994). The elk inhabiting the Gross Reservoir study area are part of the Clear Creek elk herd located in GMUs 29 and 38 (Huwer 2005). As of 2004, herd size was estimated to be 1,150 individuals, which is CPW's goal for this herd (Huwer 2005). The 2009 post-hunt population was estimated to be 1,170 (CDOW 2011a). The herd size increased between 1994 and 1998, but decreased after CPW implemented a management strategy of increased hunting licenses (Huwer 2005).

Severe winter range is present all around the reservoir and a winter concentration area around the northern two-thirds of the reservoir (NDIS 2011, Figure 3.9-2). A *winter concentration area* is defined as the part of the winter range where densities are at least 200 percent (%) greater than the surrounding winter range density during the same period used to define winter range in the average of five winters out of ten (NDIS 2011). *Severe winter range* is the part of the overall range where 90% of the individuals are located when the annual snowpack is at its maximum and/or temperatures are at a minimum in the two worst winters out of ten (NDIS 2011). A migration corridor extends about 9 miles from south of Nederland to Gross Reservoir and includes the entire shoreline.

Mountain lions (*Felis concolor*) are another big game species known to inhabit the Gross Reservoir study area. Mountain lions are present at Gross Reservoir year-round and inhabit montane forest and shrubland in rough, broken foothill and canyon areas. Mountain lions primarily prey on deer. Home range size varies by sex, reproductive condition, and age of the individual but is generally 15 to 27 square miles for females and 40 to 320 square miles for males (Fitzgerald et al. 1994).

Black bear (*Ursus americanus*), the largest carnivore in Colorado, inhabits the Gross Reservoir study area especially in montane forest and shrubland, and areas with berry-producing shrubs. The diet of black bears primarily consists of seasonally available vegetation such as grasses and forbs in the spring and berries and acorns in the fall. Black bears also opportunistically eat insects, rodents, rabbits, ungulates, and carrion (Fitzgerald et al. 1994). Winter denning begins in early October through late December. Home range varies from 1 to 73 square miles, depending on topography, food availability, and the sex and age of the individual.

Carnivores

Bobcats (*Lynx rufus*) inhabit similar habitats as mountain lions. They primarily prey on cottontails, but also rodents, small birds, deer, and amphibians (Fitzgerald et al. 1994). Home range sizes for males are 8 to 30 square miles and 3 to 10 square miles for females.

Coyote (*Canis latrans*) inhabit most habitats in Colorado and are opportunistic hunters. Red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), long-tailed weasel (*Mustela frenata*), and American (pine) marten (*Martes americana*), discussed in Section 3.10 are also common inhabitants of the study area (Denver Water 1998b; Fitzgerald et al. 1994).

Small and Medium-sized Mammals

A variety of small mammals are present in the study area. Lagomorphs (rabbits and hares) common in the study area include mountain cottontail (*Sylvilagus nuttalii*) and white-tailed jackrabbit (*Lepus townsendii*) (Fitzgerald et al. 1994).

Golden-mantled ground squirrels (*Spermophilus lateralis*) were observed and other species known to occur include least chipmunk (*Eutamias minimus*), Colorado chipmunk (*Tamias quadrivittatus*), rock squirrel (*Spermophilus variegatus*), Abert's squirrel (*Sciurus aberti*), which inhabits ponderosa pine stands, and porcupine (*Erethizon dorsatum*) (Fitzgerald et al. 1994).

Other small sized rodents include northern pocket gophers (*Thomomys talpoides*), which may be present in the grassland areas. Deer mice (*Peromyscus maniculatus*) occur in almost all habitats in Colorado, while Mexican woodrat (*Neotoma mexicana*), southern red-backed vole (*Clethrionomys gapperi*), long-tailed vole (*Microtus longicaudus*), and montane vole (*M. montanus*) can be found in moist areas (Fitzgerald et al. 1994).

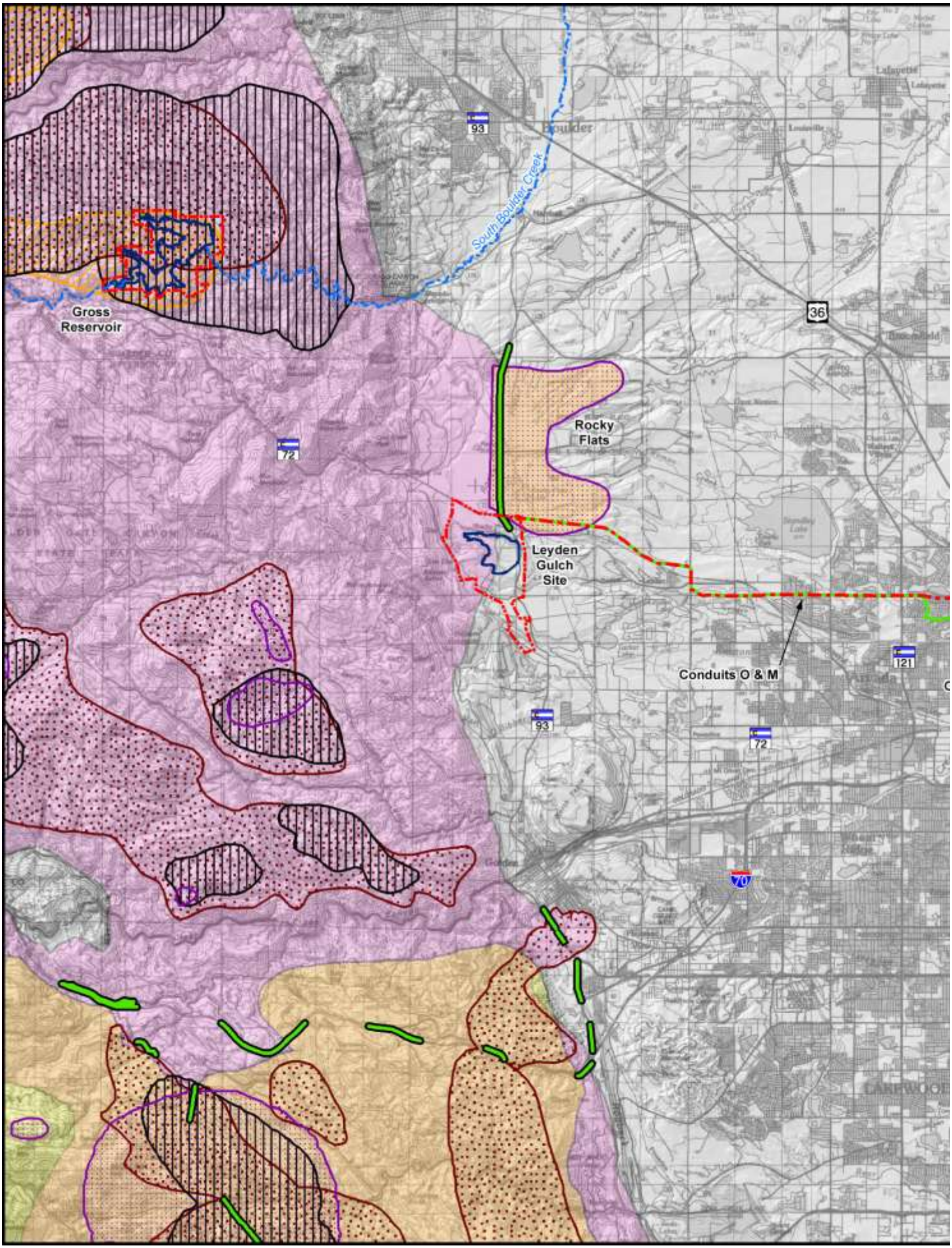
Montane shrew (*Sorex monticolus*) and masked shrew (*S. cinereus*) occur in moist habitats such as willow carrs along streams and drainages. Additionally, dwarf shrews (*Sorex nanus*) may occur in coniferous forests and open woodlands (Fitzgerald et al. 1994).

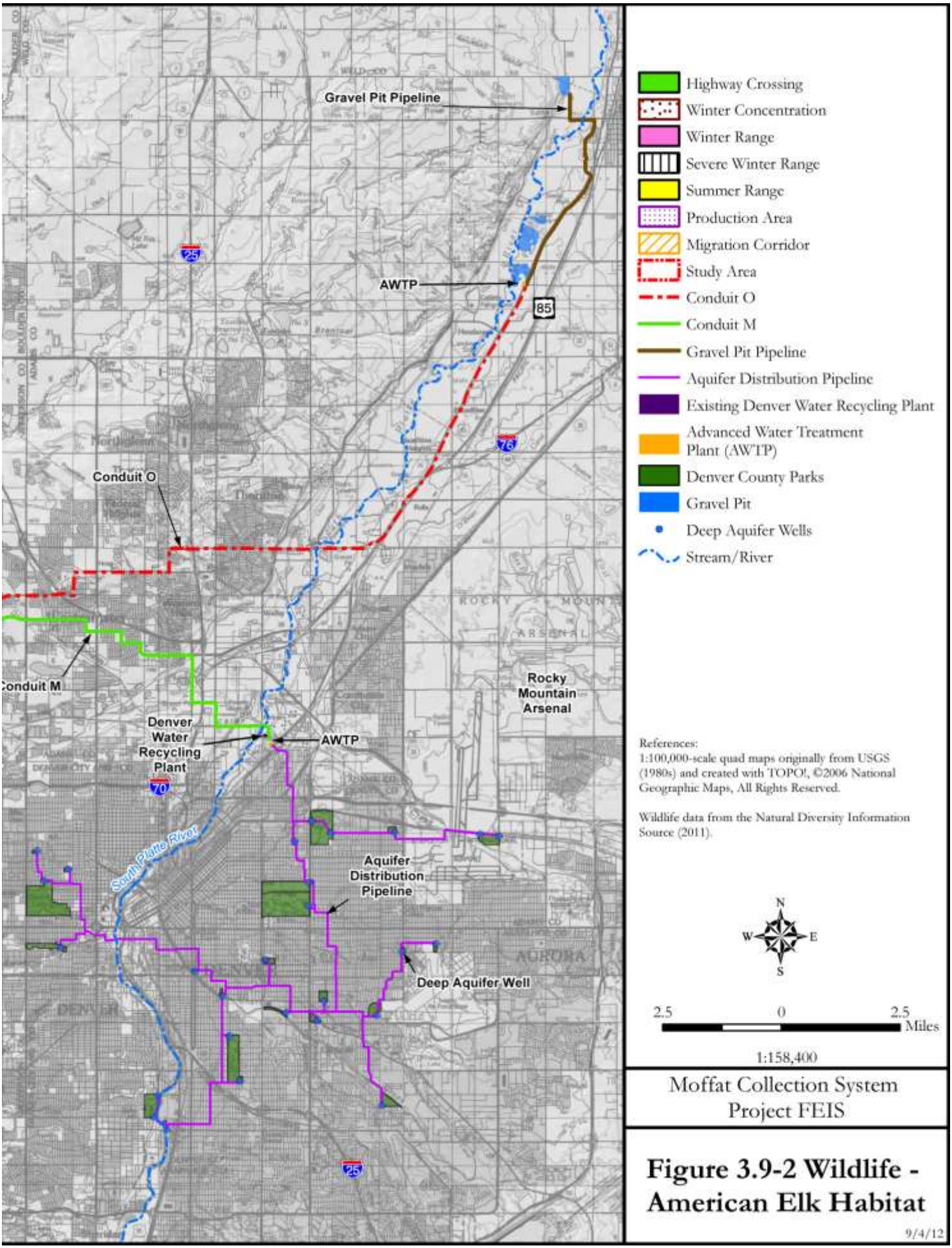
A variety of bat species are known to inhabit the mixed conifer and/or ponderosa pine woodlands in the vicinity of the Gross Reservoir study area and may forage over open water or other areas and may roost in tree cavities or under bark (Adams 2003). These species include:

- Western small-footed myotis (*Myotis ciliolabrum*)
- Long-eared myotis (*M. evotis*)
- Little brown myotis (*M. lucifugus*)
- Fringed myotis (*M. thysanodes*)
- Long-legged myotis (*M. volans*)
- Hoary bat (*Lasiurus cinereus*)
- Big brown bat (*Eptesicus fuscus*)
- Townsend's big-eared bat (*Corynorhinus townsendii*; discussed in Section 3.10)

Raptors

Numerous raptors forage over or nest in the mixed coniferous or rocky habitat in the vicinity of the Gross Reservoir study area. Golden eagles (*Aquilla chrysaetos*) are known to nest at Forsythe Rock, west of the study area (Denver Water 1998b). Various species including red-tailed hawk and northern goshawk have the potential to nest at Gross Reservoir, but no raptor nests are currently known and none were observed during biological field studies conducted in 2005 and 2010. The U.S. Forest Service (USFS) installed two osprey nesting platforms in 1993 and nesting has been attempted although no successful nesting has been observed. Ospreys from other nearby nesting areas forage at Gross Reservoir. Peregrine falcons are not known to nest in the study area, but may occur during foraging. The following raptor species are known to occur in the Gross Reservoir study area (Table 3.9-1).


Gross
Reservoir
South Boulder Creek
Boulder
Rocky
Flats
Leyden
Gulch
Site
Conduits O & M
93
72
36
121
70



Moffat Collection System Project FEIS

Figure 3.9-2 Wildlife - American Elk Habitat

9/4/12

Table 3.9-1
Raptors Likely or Known to Occur in the Gross Reservoir Study Area

Common Name	Scientific Name
Golden eagle	*Aquilla chrysaetos*
Bald eagle	*Haliaeetus leucocephalus*
Osprey	*Pandion haliaetus*
Prairie falcon	*Falco mexicanus*
Sharp-shinned hawk	*Accipiter striatus*
Cooper's hawk	*Accipiter cooperii*
Northern goshawk	*Accipiter gentilis*
Red-tailed hawk	*Buteo jamaicensis*
American kestrel	*Falco sparverius*
Peregrine falcon	*Falco peregrinus*
Turkey vulture	*Cathartes aura*
Flammulated owl	*Psiloscops (Otus) flammeolus*
Great-horned owl	*Bubo virginianus*
Northern pygmy owl	*Glaucidium gnoma*
Northern saw-whet owl	*Aegolius acadicus*

Source: Kingery, 1998; Jones, 2003.

Other Birds

In Colorado, the diversity and numbers of birds are highest in summer months, especially in the ponderosa pine/mixed conifer forest. Dusky grouse (*Dendragapus obscurus*), common ravens (*Corvus corax*), and American crows (*C. brachyrhynchos*) occur and possibly nest in the study area. The Gross Reservoir study area is within the overall range of wild turkeys (*Meleagris galloparvo*) and therefore they can be expected to occur around the existing reservoir. Winter Range for the species is east of Gross Reservoir therefore, no wild turkeys are expected to occur on the western side of Gross Reservoir in the winter (Huwer 2005).

Birds that may forage over the open water of the reservoir or its banks include common nighthawk (*Chordeiles minor*), tree swallow (*Tachycineta bicolor*), and spotted sandpiper (*Actitis macularia*) (Kingery 1998).

Songbirds known or likely present in the ponderosa pine/Douglas-fir forest, wetland and riparian areas, and mountain grassland habitats are shown in Table 3.9-2. Several of these species, including pygmy nuthatch, warbling vireo and mountain bluebird, are USFS Management Indicator Species (MIS) (see Table 3.9-3).

Table 3.9-2
Common Songbirds in the Gross Reservoir Study Area by Habitat Type

Habitat Type	Common Species in Habitat	Habitat Type	Common Species in Habitat
Ponderosa Pine/ Douglas-fir	Chipping sparrow (*Spizella passerina*)	**Wetland/ Riparian**	Mourning dove (*Zenaida macroura*)
	Mountain chickadee (*Poecile gambeli*)		Olive-sided flycatcher (*Contopus cooperi*)
	Northern flicker (*Colaptes auratus*)		Warbling vireo (*Vireo gilvus*)
	Pygmy nuthatch (*Sitta pygmaea*)		Yellow-rumped warbler (*Dendroica coronata*)
	Steller's jay (*Cyanocitta stelleri*)		MacGillivray's warbler (*Oporornis tolmiei*)
	Western tanager (*Piranga ludoviciana*)		Yellow warbler (*Dendroica petechial*)
	Western wood-pewee (*Contopus sordidulus*)		American dipper (*Cinclus mexicanus*)
	Williamson's sapsucker (*Sphyrapicus thyroides*)		
	Western bluebird (*Sialia mexicana*)	**Mountain Grassland**	Horned lark (*Eremophila alpestris*)
	White-breasted nuthatch (*Sitta carolinensis*)		Vesper sparrow (*Pooecetes gramineus*)
	Hermit thrush (*Catharus guttatus*)		Chipping sparrow (*Spizella passerine*)
	Pine siskin (*Carduelis pinus*)		Mountain bluebird (*Sialia currucoides*)
	Townsend's solitaire (*Myadestes townsendi*)		Brewer's blackbird (*Euphagus cyanocephalus*)
	Red-breasted nuthatch (*Sitta canadensis*)		

Source: Andrews and Righter, 1992; Kingery, 1998.

Reptiles and Amphibians

Several species of reptiles and amphibians may occur in the moist, riparian areas within the Gross Reservoir study area. These species include tiger salamander (*Ambystoma tigrinum*), northern leopard frog (*Lithobates pipiens*), and western terrestrial garter snake (*Thamnophis elegans*) (Denver Water 1998b; Hammerson 1999). Bullsnakes (*Pituophis catenifer*) and western rattlesnakes (*Crotalus viridus*) inhabit the woodland and grassland areas, while milk snakes (*Lampropeltis triangulum*) may be present in ponderosa pine woodland areas (Hammerson 1999).

USFS Management Indicator Species

MIS are used by the USFS to monitor the efficacy of management practices in meeting habitat objectives. Table 3.9-3 provides the list of MIS that are designated by the Arapaho & Roosevelt National Forests (ARNF) and the habitats they represent. For further discussion on special status species, refer to Section 3.10.

Table 3.9-3
Management Indicator Species for the Arapaho & Roosevelt National Forests

Management Indictor Species	Scientific Name	Habitat	Occurrence in Gross Reservoir Study Area
Mammals			
Rocky Mountain bighorn sheep	*Ovis canadensis*	Openings	Does not occur
Elk	*Cervus elaphus*	Young to mature forest and openings	Known to occur
Mule deer	*Odocoileus hemionus*	Young to mature forest and openings	Known to occur
Birds			
Golden-crowned kinglet	*Regulus satrapa*	Interior forest	May occur
Hairy woodpecker	*Picoides villosus*	Young to mature forest	Known to occur
Mountain bluebird	*Sialia cucrucoides*	Openings	Known to occur
Pygmy nuthatch	*Sitta pygmaea*	Old growth	Known to occur
Warbling vireo	*Vireo gilvus*	Aspen forest	Known to occur
Wilson's warbler	*Cardellina pusilla*	Montane riparian and wetlands	Likely to occur
Amphibians			
Boreal toad	*Anaxyrus boreas boreas*	Montane riparian and wetland	Does not occur; special status species

Source: USFS, 2010.

Forest Service Wildlife Habitats

The 1997 Revision of the Land and Resource Management Plan (RMP) (USFS 1997a) evaluated several key elements of biological diversity, including old growth forests, travel corridors for terrestrial wildlife, habitat effectiveness, and interior forests. Each of these is described below.

Areas of existing old growth were identified by the USFS based on surveys. All of the old growth in the Gross Reservoir study area occurs at lower elevation sites dominated by ponderosa pine. Key characteristics of low elevation old growth on the ARNF include: large trees of 18+ inches diameter at breast height (dbh), including 15 or more trees per acre of 12+ inches dbh; large snags including 2 or more snags per acre of 12+ inches dbh; large fallen trees; multi-storied canopy; overhead canopy closure of more than 20%; and presence of large, old, declining live trees (Appendix B, Description of the Analysis Process, in USFS 1997b). Existing old growth occurs only on 21.5 acres, a small portion of the Gross Reservoir study area, along the west edge of the study area near Winiger Gulch and South Boulder Creek. About 12% of the major forest types on the ARNF are existing old growth. Most of the old growth is spruce-fir, one-third is lodgepole pine, and only 1% is ponderosa pine (USFS 1997b).

Old growth development areas are mature forests that are relatively close to becoming old growth (USFS 1997b). Areas designated by ARNF as old growth development occupy 450 acres above the existing reservoir, about half of the terrestrial habitat on USFS lands, and are located in the southwestern quarter of the study area. Areas used for recreational

activities including Winiger Gulch, Forsythe Canyon and the boat launch area are not designated for old-growth development.

Two types of travel corridors were analyzed by the USFS, forested corridors and open corridors. Forested corridors maintain the connectedness of areas with relatively dense conifers. They include forested areas with a medium to dense canopy, a minimum width of 100 meters, minimum area of 20 acres, and gaps or interruptions no wider than 100 meters (Appendix B, Description of the Analysis Process, in USFS 1997b). Open corridors maintain the connectedness of non-forested and non-vegetated areas (except water). They consist of shrublands, grasslands, and rock, with the same size restrictions. Forested corridors occupy most of the terrestrial habitat on USFS lands in the Gross Reservoir study area (696 acres), while open corridors are restricted to a portion of Winiger Ridge and occupy about 32 acres. Forested corridors occur on 60% of the ARNF and are generally well-connected throughout the Forest (USFS 1997b). Open corridors occupy 21% of the ARNF.

Habitat effectiveness represents areas that are generally undisturbed by human presence, by being buffered from regularly used roads and trails. Wildlife disturbance distances vary with intensity of human use, vegetation type, vegetation density, terrain and location of the travelway. The ARNF modeled distances within which wildlife would be affected based on elk and deer disturbance distances, with the results ranging from 0 to 500 meters depending on vegetation screening and topography. Areas within the buffer distances of roads and trails were considered to be ineffective habitat. The Gross Reservoir study area is located within the ARNF Thorodin Geographic Area, for which about 59% of the habitat is effective and the total road and trail density is 1.9 miles per square mile. In the Gross Reservoir study area, effective habitat occurs on about 539 acres of land above the reservoir, about 56% of the terrestrial habitat on USFS land. Areas used by recreationists were considered to be none-effective, including Forsythe Canyon, Winiger Ridge, Winiger Gulch, and the boat launch area.

Interior forests are contiguous areas of relatively dense and large trees that are buffered from sizeable openings in the forest and from regular human disturbance along roads and trails. All interior forest occurs within effective habitat. Within the Gross Reservoir study area, interior forest is limited to a few areas on the western side of the reservoir and occupies a total of 133 acres, about 14% of the USFS terrestrial habitat. Interior forests occur on about 15% of the ARNF (USFS 1997b).

Sensitive Areas

Potential Conservation Areas

The Colorado Natural Heritage Program (CNHP) designates Potential Conservation Areas (PCAs) based on habitats and ecological processes upon which a species or community depends for its continued existence. CNHP ranks PCAs according to their biodiversity significance: outstanding significance (B1), very high significance (B2), high significance (B3), moderate significance (B4), and general significance (B5). PCA boundaries have no legal status, but should be used for planning and management decisions. PCAs located in the Gross Reservoir study area are shown in Figure 3.9-3 and are discussed below (CNHP 2005a, 2009).

- **Winiger Gulch (B3)** – The Winiger Gulch PCA, as defined in the most recent version of CNHP's review of conservation resources in Boulder County (CNHP 2009), includes both Winiger Gulch and a portion of South Boulder Creek above Gross Reservoir. These two areas were identified as separate PCAs in the Draft Environmental Impact Statement, based on CNHP 2005a, but have subsequently been combined. Winiger Gulch includes a good occurrence of thinleaf alder/mesic forb riparian shrubland along Winiger Gulch, and good occurrence of foothills riparian shrubland (*Betula occidentalis*/*Maianthemum stellaum*), and an excellent occurrence of Sprengle's sedge (*Carex sprengelii*), a CNHP and USFS sensitive species. More information about the two plant communities is provided in Section 3.7 and more information about Sprengle's sedge in Section 3.10.
- **Boulder Foothills (B2)** – The Boulder Foothills PCA is located east and northeast of the Gross Reservoir study area and overlaps a small portion of the study area (<80 acres). It also contains a segment of the South Boulder Creek watershed downstream of Gross Reservoir. It includes numerous occurrences of multiple CNHP-ranked birds, insects, natural communities, and plant species (CNHP 2009). Moist drainages within this area have a long list of plant species that are primarily associated with eastern North America, including several species also found at Gross Reservoir (refer to Section 3.10).

Boulder County Environmental Conservation Areas

The Boulder County Comprehensive Plan (Boulder County 1986) depicts Environmental Conservation Areas (ECAs) - individual sites that are critical wildlife habitats, rare plant sites, plant communities of special concern, and wetlands that Boulder County considers important for protection. Two ECAs are present in the vicinity of the Gross Reservoir study area.

- **Winiger Ridge ECA** – The Winiger Ridge ECA consists of 3,000 acres of montane forest bordering the west side of Gross Reservoir. This ECA was designated for high wildlife and environmental value because it is an important wildlife corridor for seasonal wildlife movement between higher and lower elevations. The ECA is critical range and a seasonal migration route for elk, as well as mule deer winter range (Boulder County 1986). The habitat is montane forest dominated by Douglas-fir, lodgepole pine, and ponderosa pine; blue and Engelmann spruce occur on the north slopes and along Forsythe Creek.
- **Hawkin Gulch/Walker Ranch/Upper Eldorado Canyon ECA** – This ECA is comprised of 9,500 acres forested and grassland habitat. This ECA encompasses South Boulder Creek below Gross Reservoir.

USFS Managed Areas

Approximately 10,000 acres on the west side of Gross Reservoir is managed by the USFS Roosevelt National Forest. The USFS management goals for the area are to maintain and enhance the flora and fauna in the Winiger Ridge critical elk winter range by implementing prescribed burns, while managing recreation in the area (Denver Water 1998b).

3.9.1.2 Leyden Gulch Reservoir Site

The Leyden Gulch site is primarily composed of short to mid-height grass and forb habitat with a few wetland areas, deciduous shrubland (skunkbush sumac [*Rhus trilobata*]), and scattered trees. Cattle grazing is evident throughout much of the site. Riparian woodland occurs along Ralston Creek, and dense riparian and foothills shrub occurs along one drainage. Foothills shrub (primarily skunkbush sumac) is also present along the hogback, east of State Highway (SH) 93. Skunkbush sumac fruit is an important winter food source for birds, including songbirds and wild turkeys; the fruit is also eaten by black bears and browsed by mule deer (FERC and USDA 1999).

Big Game

The Leyden Gulch study area is summer and winter range for mule deer. The mule deer that inhabit this area are also part of DAU 27, which is the same unit as the DAU that contains the Gross Reservoir study area. Areas west of the proposed Leyden Gulch site are winter concentration areas for mule deer (NDIS 2011) (Figure 3.9-1). Elk occur in the Leyden Gulch site during winter.

Mountain lions and black bears also occur in the site. The western portion of the Leyden Gulch site is within the overall range of black bears, though they are concentrated along Ralston Creek, west of Ralston Reservoir and southwest of the site in fall and summer (NDIS 2011). The Leyden Gulch study area is within the overall range of mountain lions.

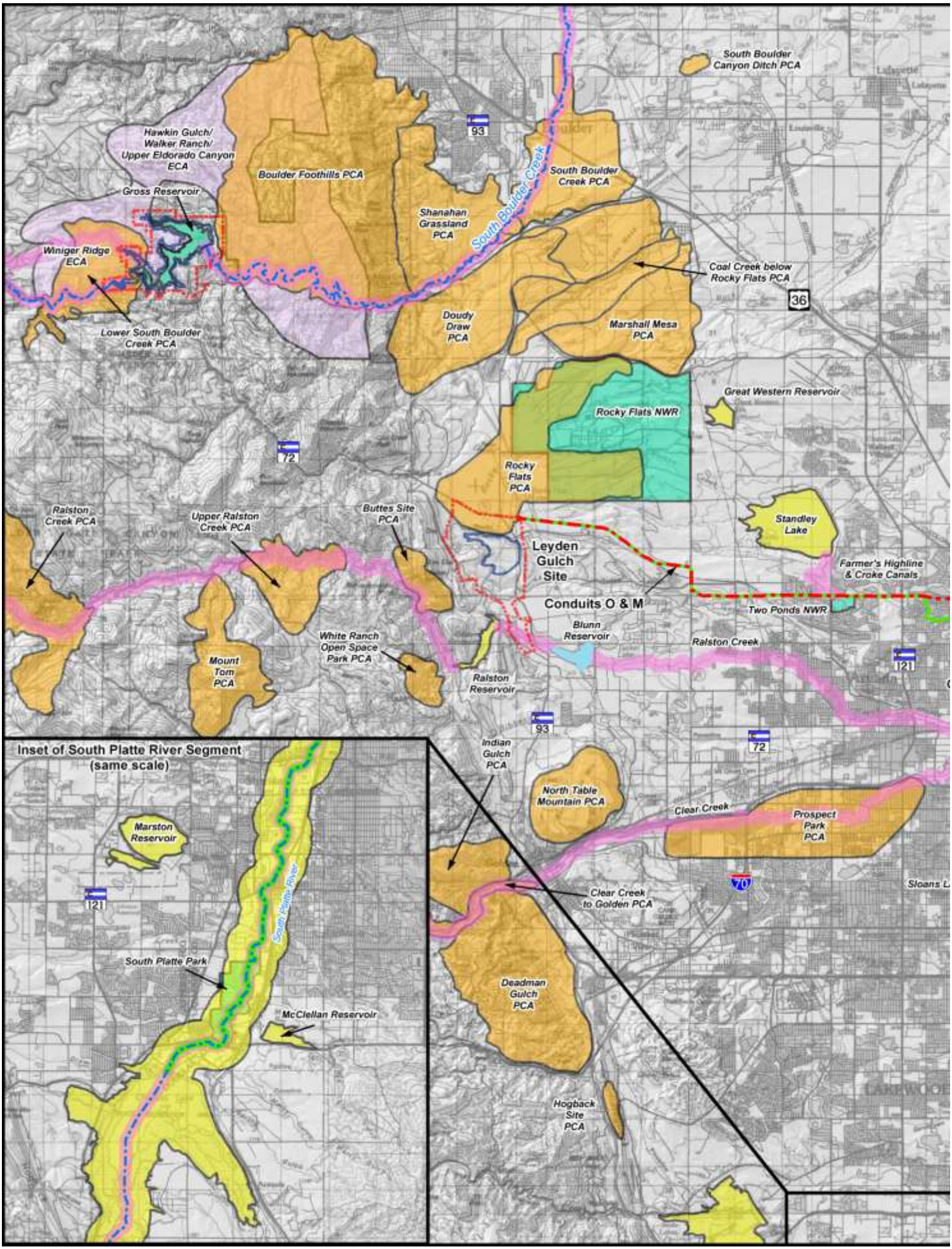
Carnivores

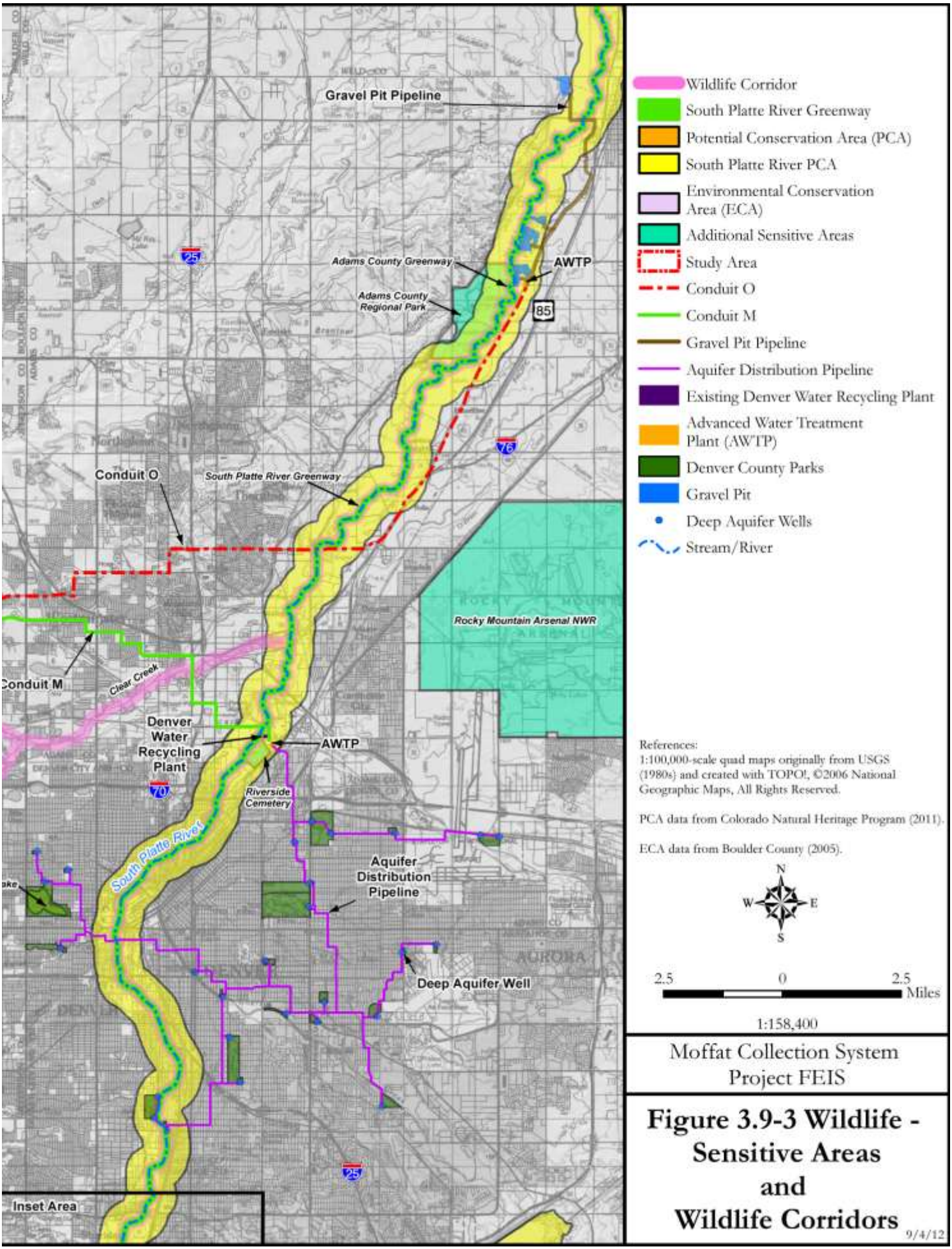
Coyotes, gray foxes (*Urocyon cinereoargenteus*), long-tailed weasels (*Mustela frenata*), and striped skunks (*Mephitis mephitis*) are the carnivore species likely to occur in the Leyden Gulch site. These species are all habitat generalists and could occur throughout the site (Fitzgerald et al. 1994).

Small and Medium-sized Animals

Lagomorphs present in the Leyden Gulch site include mountain cottontail (*Sylvilagus nuttallii*) and white-tailed jackrabbit (*Lepus townsendii*) (Fitzgerald et al. 1994).

Black-tailed prairie dogs (*Cynomys ludovicianus*) are large, colonial burrowing rodents that occupy the grassland habitats in the site (Figure 3.9-4). Numerous black-tailed prairie dog burrows were observed in the study area; however, the lack of individuals observed indicates recent eradication efforts. Black-tailed prairie dogs are a “keystone species” of the short- and mid-grass prairie ecosystem, which means that many other wildlife species depend on prairie dogs for food and shelter and their colonies support a higher diversity of plants and wildlife. Bald eagles, ferruginous hawks, red-tailed hawks, and golden eagles prey on prairie dogs, especially in winter months. Burrowing owls, mice, snakes, and toads use abandoned prairie dog burrows to nest or den. Black-tailed prairie dogs were a candidate species for Federal threatened or endangered species status, but were removed from consideration for Federal status in August 2004. The species is still considered by CPW and CNHP as a species of concern.

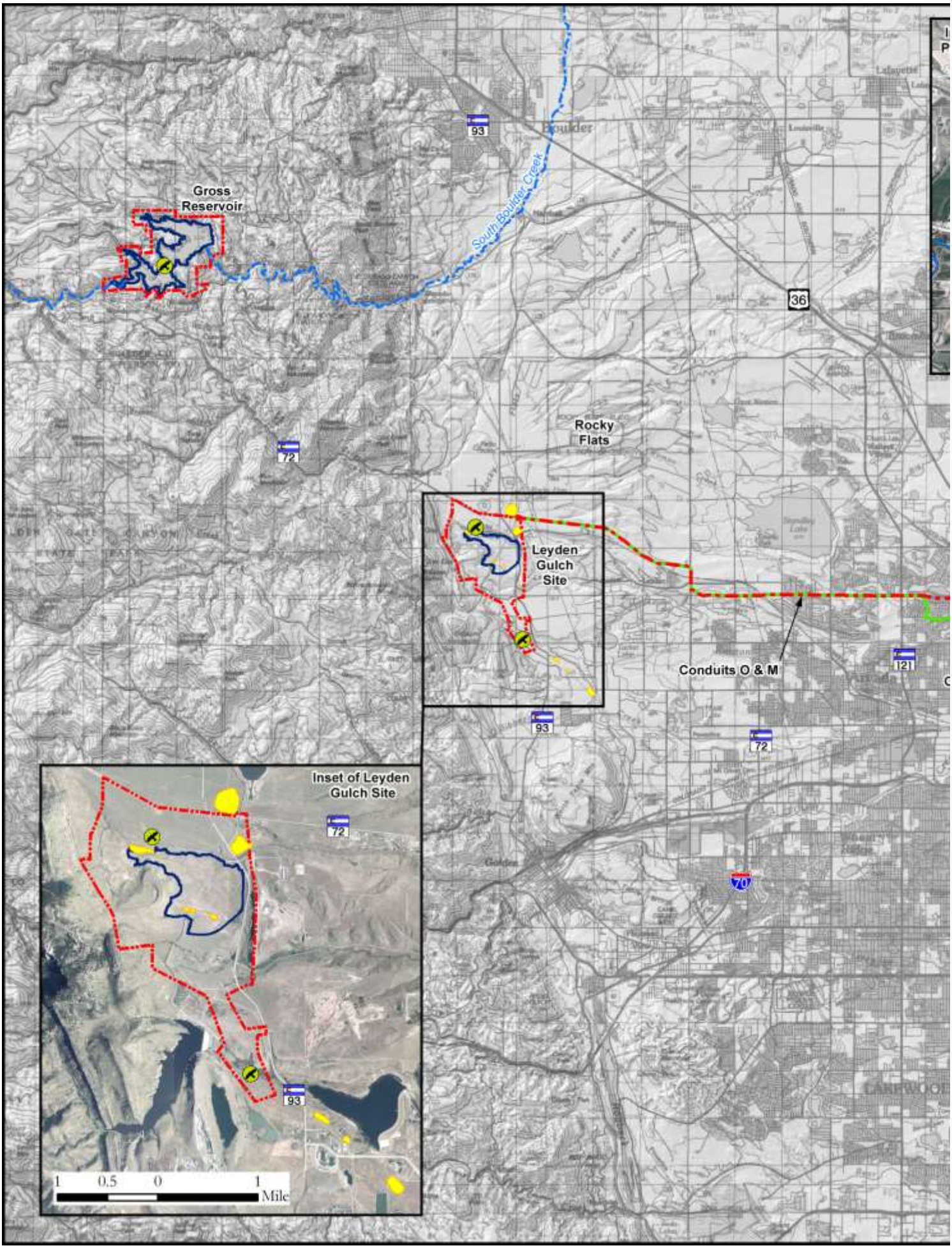

South Boulder Canyon Ditch PCA
Hawkin Gulch/ Walker Ranch/ Upper Eldorado Canyon ECA
Boulder Foothills PCA
Gross Reservoir
South Boulder Creek PCA
Shanahan Grassland PCA
South Boulder Creek
Winiger Ridge ECA
Coal Creek below Rocky Flats PCA
Lower South Boulder Creek PCA
Doudy Draw PCA
Marshall Mesa PCA
Great Western Reservoir
Rocky Flats NWR
Rocky Flats PCA
Ralston Creek PCA
Upper Ralston Creek PCA
Buttes Site PCA
Standley Lake
Leyden Gulch Site
Farmer's Highline & Croke Canals
Conduits O & M
Two Ponds NWR
Blunn Reservoir
Ralston Creek
White Ranch Open Space Park PCA
Mount Tom PCA
Ralston Reservoir
Inset of South Platte River Segment (same scale)
Indian Gulch PCA
North Table Mountain PCA
Clear Creek
Prospect Park PCA
Marston Reservoir
South Platte River
Clear Creek to Golden PCA
South Platte Park
McClellan Reservoir
Deadman Gulch PCA
Hogback Site PCA

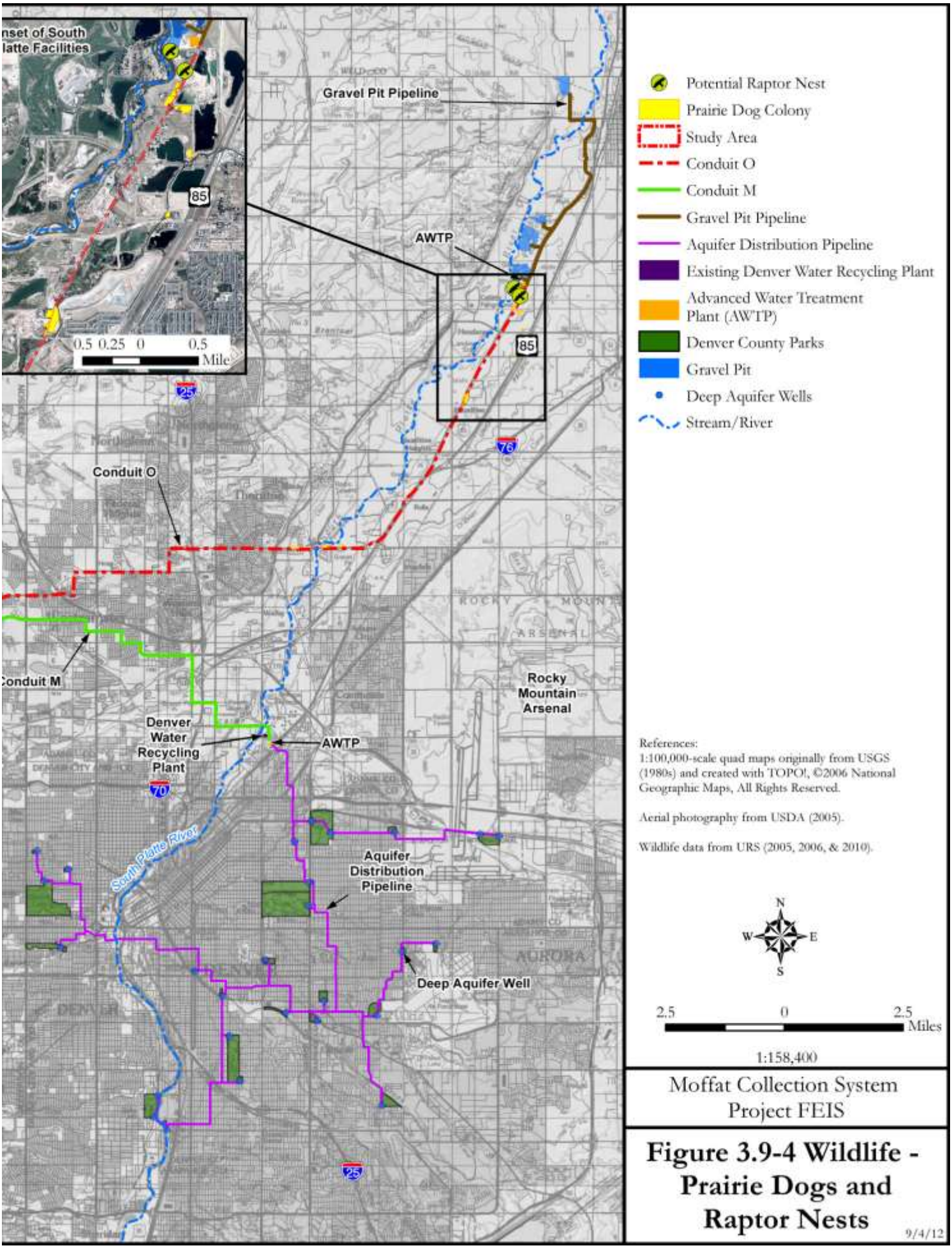


Moffat Collection System Project FEIS

Figure 3.9-3 Wildlife - Sensitive Areas and Wildlife Corridors

9/4/12

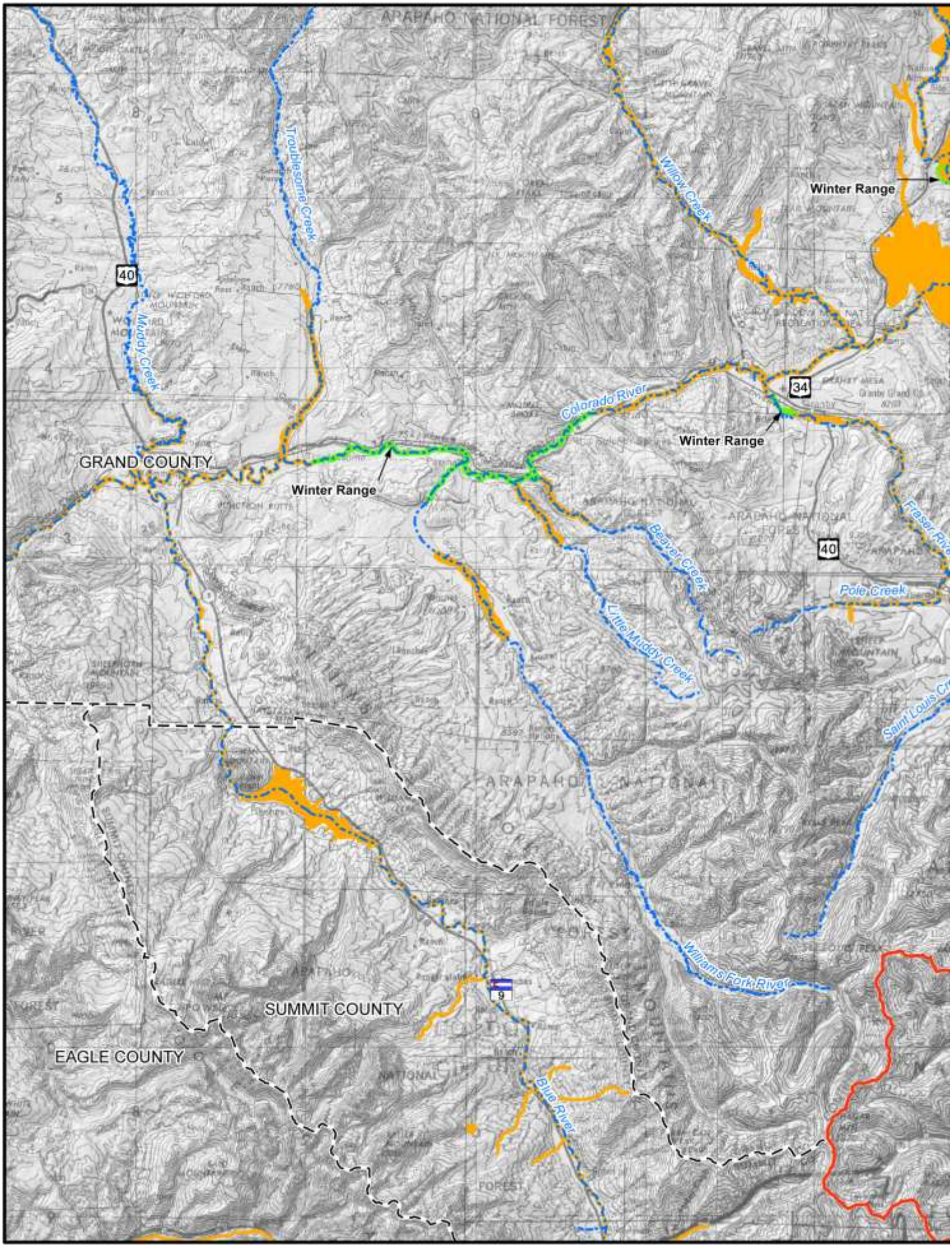

Gross Reservoir
South Boulder Creek
Boulder
Rocky Flats
Leyden Gulch Site
Conduits O & M
Inset of Leyden Gulch Site
1 0.5 0 1 Mile
93
36
72
121
70

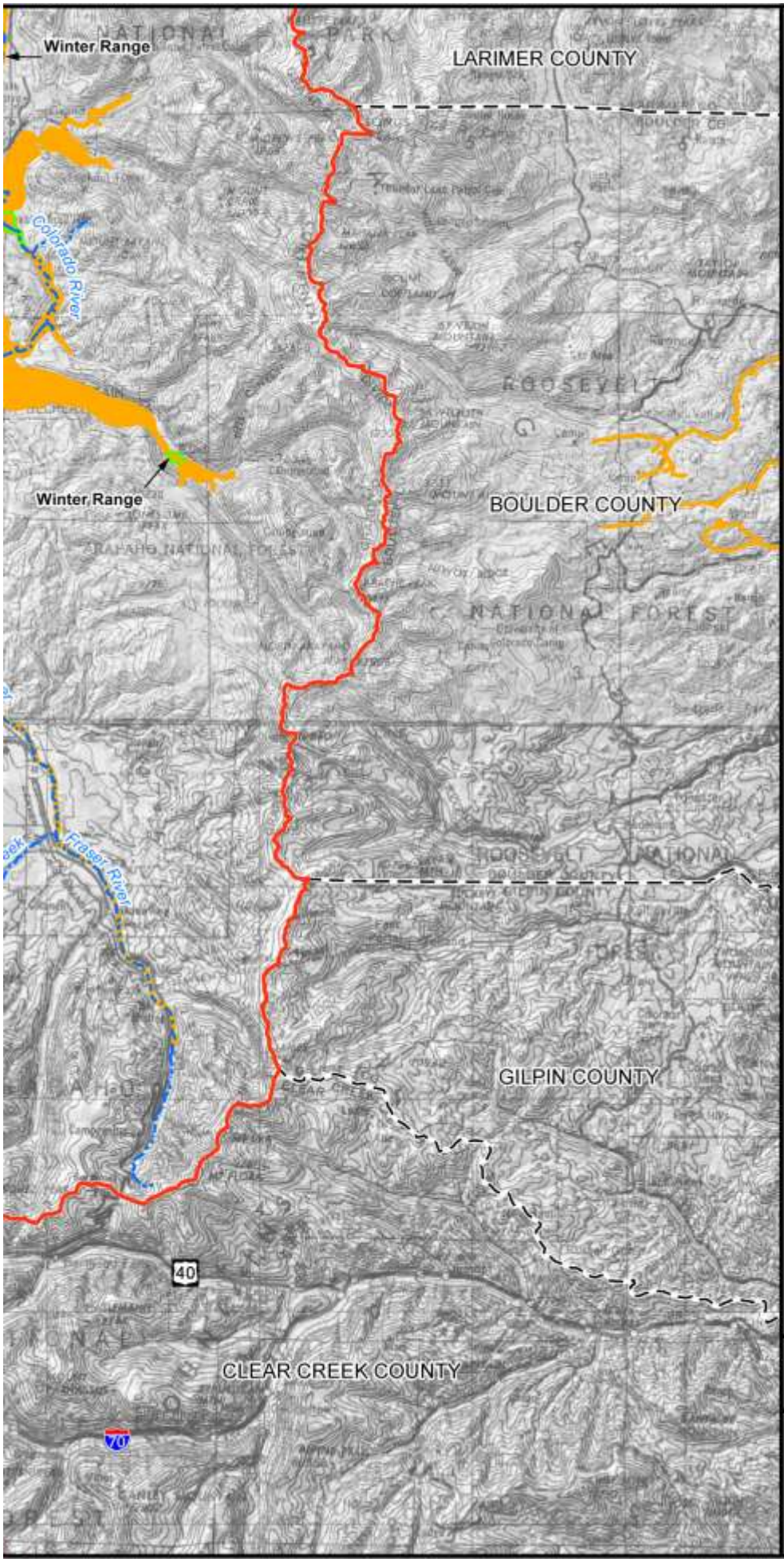


Moffat Collection System Project FEIS

Figure 3.9-4 Wildlife - Prairie Dogs and Raptor Nests

9/4/12


ARAPAHO NATIONAL FOREST
Troublesome Creek
Willow Creek
Winter Range
40
Muddy Creek
34
Colorado River
Winter Range
GRAND COUNTY
Winter Range
Beaver Creek
40
Fraser River
Pole Creek
Little Muddy Creek
Saint Louis Cr
ARAPAHO NATIONAL
Williams Fork River
9
SUMMIT COUNTY
EAGLE COUNTY
Blue River



Winter Range
Overall Range
Counties
Continental Divide
Stream/River

References:
1:250,000-scale quad maps from USGS (1980s).

Wildlife data from the Natural Diversity Information Source (2010).

N
W E
S

4 0 4 Miles

1:275,000

Moffat Collection System Project FEIS

Figure 3.9-5 Wildlife - River Otter Habitat

9/4/12

Other rodents that potentially occur in the Leyden Gulch site include plains pocket mouse (*Perognathus flavescens*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), hispid pocket mouse (*Chaeotodipus hispidus*), and western harvest mouse (*Reithrodontomys megalotis*) (Fitzgerald et al. 1994). During small mammal trapping surveys conducted in 2005 for Preble's meadow jumping mouse (Preble's), deer mouse (*Peromyscus maniculatus*), Mexican woodrat (*Neotoma mexicana*), prairie vole (*Microtus ochrogaster*), and meadow vole (*Microtus pennsylvanicus*) were captured in Leyden Gulch (Ensight 2005a). Mexican wood rats were captured in association with the rip-rapped section of the access road over the gulch. In addition, northern rock mouse (*Peromyscus nasutus*) may occur in the rocky hogback habitat on the east side of SH 93.

Raptors

Several raptor species forage over the Leyden Gulch site (Figure 3.9-4). A red-tailed hawk nest was observed in riparian woodland along Ralston Creek during 2006 field surveys. Large trees are scarce in the majority of the site; however, adjacent habitats, such as ponderosa pine woodland and cliffs, provide nesting habitats for raptors. American kestrels may nest in the large trees located in the center of the site. Additionally, the prairie dogs and other rodent species provide prey for foraging raptors. Species observed or likely to occur during foraging include: Swainson's hawk (*Buteo swainsoni*), red-tailed hawk, golden eagle, prairie falcon, and potentially ferruginous hawks (*Buteo regalis*).

Other Birds

The Leyden Gulch site is considered within the overall range of wild turkey. Additionally, wild turkey winter range is present northwest of and outside of the site (NDIS 2011).

During 2005 site visits, the following species were observed: vesper sparrow (*Pooecetes gramineus*), sage thrasher (likely in migration), American kestrel, western meadowlark, horned lark, black-billed magpie, and European starling (*Sturnus vulgaris*). Additional species expected to occur in the Leyden Gulch site are presented in Table 3.9-4 by habitat type.

Table 3.9-4
Birds Observed or Likely Present in the Leyden Gulch Site

Habitat Type	Common Species in Habitat
Grassland	Mourning dove (*Zenaida macroura*)
	Common nighthawk (*Chordeiles minor*)
	Black-billed magpie (*Pica pica*)
	Crow (*Corvus brachyrhynchos*)
	Common raven (*Corvus corax*)
	Horned lark (*Eremophila alpestris*)
	Mountain bluebird (*Sialia currucoides*)
	Lark sparrow (*Chondestes grammacus*)
	Western meadowlark (*Sturnella neglecta*)
	Brewer's blackbird (*Euphagus cyanocephalus*)
	Brown-headed cowbird (*Molothrus ater*)
Riparian Woodland	Red-winged blackbird, American goldfinch (*Carduleis tristis*)
	Black-capped chickadee (*Parus atricapillus*)
	Song sparrow (*Melospiza melodia*)
	Chipping sparrow (*Spizella passerine*)
	Downy woodpecker (*Picoides pubescens*)
	Bullock's oriole (*Icterus bullockii)*
	Belted kingfisher (*Ceryle alcyon*)
	Red-tailed hawk (*Buteo jamaicensis*)
	Cooper's hawk (*Accipiter cooperi*)
	Great horned owl (*Bubo virginianus*)
	Eastern screech owl (*Psiloscops asio*)
Foothills Shrub	Virginia's warbler (*Vermivora virginiae*)
	Green-tailed towee (*Pipilo chlorurus*)
	Common nighthawk (*Chordeiles minor*)
	Vesper sparrow (*Pooecetes gramineus*)
	Wild turkey (*Meleagris gallopavo*)

Source: Andrews and Righter, 1992; Kingery, 1998.

Amphibians and Reptiles

A northern leopard frog (*Lithobates pipiens*) was observed at the study area during field visits conducted in 2005. This species is found typically in wet meadows and banks and shallows of ponds, marshes, and irrigation ditches. The species goes into winter dormancy in October or November through March (Hammerson 1999).

Prairie and plateau lizard (*Sceloporus undulatus*) may occur in the rock outcropping habitat on the eastern side of SH 93. Snakes emerge from hibernation generally in April and go into hibernation in September to October, depending on weather conditions (Hammerson 1999). Western rattlesnakes and a racer (*Coluber constrictor*) were observed at the site during field visits. Bullsnakes and milksnakes may also occur in the grass-forb or foothills

shrub communities present in the Leyden Gulch site. Garter snakes (*Thamnophis* sp.) are likely present in the vicinity of the wetlands.

Sensitive Areas

The Rocky Flats (B2) PCA overlaps with the northwestern portion of the Leyden Gulch site and was designated primarily for the presence of xeric tallgrass prairie and Preble's. No tallgrass prairie or Preble's habitat were observed in this portion of the site during 2006 site visits. Two rare and imperiled butterflies, Arogos skipper (*Atrytone arogos*) and hops azure (*Celastrina humulus*), have been observed at the Rocky Flats PCA (CNHP 2005a). Common breeding birds within the PCA include song sparrow (*Melospiza melodia*), red-winged blackbird (*Agelaius phoeniceus*), loggerhead shrike (*Lanius ludovicianus*), and grasshopper sparrow (*Ammodramus savannarum*). The PCA is also an important migratory stopover habitat for many bird species, including lark bunting (*Calamospiza melanocorys*), ferruginous hawk, MacGillivray's warbler (*Opornis tolmiei*), and Brewer's sparrow (*Spizella brewerii*) (CNHP 2005a).

3.9.2 Conveyance Systems

Important wildlife habitats along the conduits include riparian and wetland areas, prairie dog colonies, and native prairie. Table 3.9-5 lists wildlife that commonly inhabit urban and rural habitats representative of those crossed by the conduits. Information specific to Conduits M and O will be discussed following the table.

Table 3.9-5
Common Wildlife Species that Occur in the Conveyance System Study Areas

Habitat	Mammals	Birds	Reptiles and Amphibians
All habitats (except water)	Red fox (*Vulpes vulpes*) Mule deer (*Odocoileus hemionus*) Little brown bat (*Myotis lucifugus*) Big brown bat (*Eptescicus fuscus*)	Mourning dove (*Zenaida macroura*) American robin (*Turdus migratorius*) American crow (*Corvus brachyrhnchos*) Black-billed magpie (*Pica pica*) American kestrel (*Falco sparverius*)	N/A
Urban/ Developed	Raccoon (*Procyon lotor*) Fox squirrel (*Sciurus niger*) House mouse (*Mus musculus*) Norway rat (*Rattus norvegicus*)	Black-capped chickadee (*Parus atricapillus*) House finch (*Carpodacus mexicanus*) House sparrow (*Passer domesticus*) European starling (*Sturnus vulgaris*) Rock dove (*Columba livia*) Northern flicker (*Colaptes auratus*) Canada goose (*Branta canadensis*)	N/A

Table 3.9-5 (continued)
Common Wildlife Species that Occur in the Conveyance System Study Areas

Habitat	Mammals	Birds	Reptiles and Amphibians
Grassland (includes native prairie, pastures, agricultural fields, and open space)	Coyote (*Canis latrans*) Striped skunk (*Mephitis mephitis*) Long-tailed weasel (*Mustela frenata*) American badger (*Taxidea taxus*) Cottontail (*Sylvilagus* sp.) Jackrabbit (*Lepus* sp.) Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) Northern pocket gopher (*Thomomys talpoides rostralis*) Plains pocket gopher (*Geomys bursarius*) Deer mouse (*Peromyscus maniculatus*) Prairie vole (*Microtus ochrogaster*)	Horned lark (*Eremophila alpestris*) Western meadowlark (*Sturnella neglecta*) Red-winged blackbird (*Agelaius phoeniceus*) Killdeer (*Charadrius vociferous*) Common grackle (*Quiscalus quiscula*) Barn swallow (*Hirundo rustica*) European starling (*Sturnus vulgaris*) Western kingbird (*Tyrannus verticalus*) Rock dove, Swainson's hawk (*Buteo swainsoni*) Rough-legged hawk (*Buteo lagopus*; winter) Northern harrier (*Circus cyaneus*) Red-tailed hawk (*Buteo jamaicensis*)	Tiger salamander (*Ambystoma tigrinum*) Plains spadefoot (*Spea bombifrons*) Woodhouse's toad (*Anaxyrus woodhousii*) Six-lined racerunner (*Cnemidophorus sexlineatus*) Bullsnake (*Pituophis catenifer*) Western rattlesnake (*Crotalus viridis*)
Prairie dog colonies	Same as grassland species, plus: Black-tailed prairie dog (*Cynomys ludovicianus*)	Same as grassland species, plus: Burrowing owl (*Athene cunicularia*) Ferruginous hawk (winter) Bald eagle (*Haliaeetus leucocephalus*; winter) Golden eagle (*Aquila chrysaetos*; winter)	Same as grassland species, except tiger salamander not present

Table 3.9-5 (continued)
Common Wildlife Species that Occur in the Conveyance System Study Areas

Habitat	Mammals	Birds	Reptiles and Amphibians
Riparian and wetland	Raccoon Long-tailed weasel Coyote White-tailed deer (*Odocoileus virginianus*) Eastern cottontail Fox squirrel (*Sciurus niger*) Beaver (*Castor canadensis*) Muskrat (*Ondatra zibethicus*) Meadow vole (*Microtus pennsylvanicus*) Preble's meadow jumping mouse [(*Zapus hudsonius preblei*) – limited areas, see Section 3.10] Western harvest mouse (*Reithrodontomys megalotis*) Deer mouse Porcupine (*Erethizon dorsatum*)	Red-winged blackbird American goldfinch (*Carduelis tristis*) Black-capped chickadee Song sparrow (*Melospiza melodia*) Chipping sparrow (*Spizella passerine*) Downy woodpecker (*Picoides pubescens*) Bullock's oriole (*Icterus bullockii*) Belted kingfisher (*Ceryle alcyon*) Red-tailed hawk Cooper's hawk (*Accipiter cooperi*) Great horned owl (*Bubo virginianus*) Eastern screech owl (*Psiloscops asio*)	Northern leopard frog (*Lithobates pipiens*) Western chorus frog (*Pseudacris triseriata*) Bullsnake Northern water snake (*Nerodia sipedon*) Garter snakes (*Thamnophis* sp.) Tiger salamander Woodhouse's toad Bullfrog (*Lithobates catesbeiana*)
Open water: lakes, ponds, rivers (includes South Platte River and Clear Creek corridors)	Muskrat Beaver	American avocet (*Recurvirostra americana*) Spotted sandpiper (*Actitis macularia*) Killdeer Great blue heron (*Ardea herodias*) Double-crested cormorant (*Phalacrocorax auritus*) Canada goose White pelican (*Pelecanus erythrorhynchos*) Mallard Cinnamon teal (*Anas cynoptera*) Blue-winged teal (*Anas discors*) Ring-necked duck (*Athya collaris*; winter) Northern shoveler (*Anas clypeata*; winter) Gadwall (*Anas strepera*; winter) Common goldeneye (*Bucephalus clangula*; winter)	Snapping turtle (*Chelydra serpentina*) Yellow mud turtle (*Kinosternon flavescens*) Garter snakes Northern water snake

Table 3.9-5 (continued)
Common Wildlife Species that Occur in the Conveyance System Study Areas

Habitat	Mammals	Birds	Reptiles and Amphibians
Foothills habitats (xeric shrub and grassland) and rocky habitat	Grey fox (*Urocyon cinereoargenteus*) Coyote Bobcat (*Lynx rufus*) Mountain lion (*Felis concolor*) Black bear (*Ursus americana*) American elk (*Cervus elaphus*) Golden-mantled ground squirrel (*Spermophilus lateralis*) Colorado chipmunk (*Tamias quadrivittatus*) Rock squirrel (*Spermophilus variegatus*) Deer mouse Fringed myotis (*Myotis thysanoides*) Long-legged myotis (*Myotis volans*)	Stellar's jay (*Cyanocitta stellari*) Mountain chickadee (*Parus gambeli*) Pygmy nuthatch (*Sitta pygmaea*) Pine siskin (*Carduelis pinus*) Evening grosbeak (*Cocothraustes vespertinus*) Black-headed grosbeak (*Pheucticus melanocephalus*) Brown creeper (*Certhia americana*) Canyon wren (*Catherpes mexicanus*) Common raven (*Corvus corax*) Dark-eyed junco (*Junco hyemalis*)	Plateau lizard (*Sceloporus undulatus*) Milk snake Bullsnake Western terrestrial garter snake Western rattlesnake Tiger salamander

Source:
General: NDIS, 2011.
Mammals: Adams, 2003; Fitzgerald et al., 1994.
Birds: Andrews and Righter, 1992; Kingery, 1998.
Amphibians and Reptiles: Hammerson, 1999.
Note:
N/A = not applicable

3.9.2.1 Conduit M

Areas of interest are discussed from the western end to the eastern end of the conduit. From the western end of Conduit M, the first 4 miles are mostly bordered by grassland, while the remainder is primarily rural residential, urban, or industrial land uses. Conduit M crosses several riparian habitats including the South Platte River and Clear Creek as well as the Farmers Highline and Croke canals just east of Kipling Street on the northern boundary of the Two Ponds National Wildlife Refuge (NWR). Habitat at these crossings is riparian woodland with a mix of cottonwoods and Russian olive. South of Conduit M at this location, these canals flow through Two Ponds NWR, which Conduit M borders on the north. Standley Lake is located approximately 0.75 mile to the north of Conduit M.

Clear Creek provides important riparian habitat in the Conduit M study corridor and consists of riparian woodland/shrub with dense sandbar willow stands and scattered cottonwoods and Russian olive. Wetlands dominated by cattails and teasel also occur along Clear Creek and around the pond located adjacent to and south of the creek. Clear Creek provides habitat and movement corridors for migrating and nesting birds, beavers, and red fox. Small mammal populations are likely to be of low diversity where Conduit M crosses Clear Creek due to the presence of non-native species such as house mice, Norway rats, and

domestic cats associated with the surrounding residential neighborhoods and industrial land uses.

Conduit M crosses the South Platte River in an area that consists of highly disturbed and altered habitat surrounded by industrial land use; a refinery is located on the east side of the South Platte River. The surrounding land use in this area is rural residential, industrial, grassland, and pastureland. The South Platte River is an important wildlife corridor for species that otherwise would not have contiguously connected habitat within heavily developed areas of Denver. Additionally, existing gravel pit storage areas occur along the South Platte River that support migrating and nesting waterfowl and shorebirds.

Big Game

The western end of the Conduit M study area to Kipling Boulevard is within the overall range of white-tailed deer (NDIS 2011). The first 2 miles of Conduit M is also elk winter range (NDIS 2011). The western two miles are mule deer winter range, and areas north of Conduit M (Rocky Flats NWR) are year-round mule deer habitat. The Clear Creek corridor is within the overall range of white-tailed deer and is a limited use area for mule deer (NDIS 2011). The portion of Conduit M crossing the South Platte River is within a mule deer limited use area.

Birds

Standley Lake, which is located approximately 0.75 mile to the north of Conduit M and connects to the Farmers Highline and Croke canals, supports bald eagles and variety of waterfowl.

The South Platte River corridor is important nesting habitat for waterfowl and shorebirds and supports large numbers of wintering ducks. In a recent survey of year-round use, 65 avian species were documented along the South Platte River though the dominant bird species are common birds adapted to urban habitats (Jones et al. 2003). Common species that are known to nest or have suitable nesting habitat along the South Platte River corridor include:

- Double-crested cormorant (*Phalacrocorx auritus*)
- Great blue heron (*Ardea herodias*)
- Black-crowned night heron (*Nycticorax nycticorax*)
- Canada goose (*Branta canadensis*)
- Wood duck (*Aix sponsa*)
- Mallard (*Anas platyrhynchos*)
- Killdeer (*Charadrius vociferus*)
- Red-winged blackbird (*Agelaius phoeniceus*)
- Belted kingfisher (*Ceryle alcyon*)
- Common grackle (*Quiscalus quiscula*)

During winter, spring, and fall migrations, many species of waterfowl or shorebirds use the river or occur in the riparian/wetland habitat in the South Platte River corridor. These species are identified in Table 3.9-6 below.

Table 3.9-6
Waterfowl and Shorebirds Dependent on South Platte River Corridor during Winter or Migration

Common Name	Scientific Name
Canada goose	*Branta canadensis*
Mallard	*Anas platyrhynchos*
Pied-billed grebe	*Podilymbus podiceps*
Eared grebe	*Podiceps nigricollis*
American bittern	*Botaurus lentiginosus*
Snowy egret	*Egretta thula*
Northern pintail	*Anas acuta*
Blue-winged teal	*Anas discors*
Green-winged teal	*Anas crecca*
Cinnamon teal	*Anas cyanoptera*
Northern shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
American wigeon	*Anas americana*
Common goldeneye	*Bucephala clangula*
Barrow's goldeneye	*Bucephala islandica*
Hooded merganser	*Lophodytes cucullatus*
Common merganser	*Mergus merganser*
American white pelican	*Pelecanus erythrorhynchos*
Solitary sandpiper	*Tringa solitaria*
Spotted sandpiper	*Actitis macularia*
Common snipe	*Gallinago gallinago*
Ring-billed gull	*Larus delawarensis*

Source: Andrews and Righter, 1992; Jones et al., 2003; Kingery, 1998.

Sensitive Areas

National Wildlife Refuges

Rocky Flats NWR and Rocky Flats PCA (B2; refer to PCA description in Section 3.9.1.2) are located north of Conduit M at its western end near SH 93. The refuge consists of 6,266 acres surrounded by an additional 50,000 acres of Jefferson County open space. Habitats within the refuge include xeric tallgrass prairies, the Walnut Creek riparian corridor, wetlands, and mixed grass prairies. Walnut Creek, located approximately 2 miles north of the Conduit M study area, contains known occurrences for Preble's.

Conduit M borders the Two Ponds NWR on the south, which is located off of 80th Avenue within the City of Arvada. Two Ponds NWR is a satellite of the Rocky Mountain Arsenal NWR. It occupies 72 acres that are managed for wetlands and native wildlife, and contains ponds, wetland, riparian woodland, and prairie grassland habitats (USFWS 2004a). Many birds are observed at the refuge during summer and spring/fall migration. Ten bird species

nest at the refuge including Swainson's hawk and western meadowlark. Mammals known to inhabit the refuge include mule deer, raccoons, muskrats, beavers, and red fox. Ponds and riparian areas provide habitat for leopard frog, painted and snapping turtles (USFWS 2004a).

Potential Conservation Areas

As shown in Figure 3.9-3, the South Platte River (B5) PCA includes the open water and shorelines of the mainstem South Platte River and surrounding large lakes and reservoirs, including Ralston Reservoir and Standley Lake (CNHP 2005a). Mature cottonwood trees along the South Platte River support roosting bald eagles and nesting red-tailed hawks and Swainson's hawks, while the open water habitat support snowy egret, white pelican, and Preble's in southern portions of the PCA (refer to Section 3.10).

Wildlife Corridors

Wildlife corridors connect areas of fragmented wildlife habitat surrounded by developed or human inhabited areas. In small patches of habitat, corridors are essential for survival of populations since they provide a means for animals to disperse or survive when resources are scarce in their core home range. Without corridors to access adjacent areas of habitat, wildlife populations become isolated and susceptible to local extinctions through inbreeding, lack of resources, and disease. Important habitats and corridors are discussed below by Project segment. Wildlife corridors in the Project area are mapped in Figure 3.9-3.

Habitats along the South Platte River in urban Denver are highly disturbed and altered, and are often bordered by industrial areas. Downstream areas near existing gravel pit storage sites provide higher quality wildlife habitat since riparian cottonwood forest grows along the South Platte River, providing cover and habitat for birds. Additionally, the South Platte River serves as an important corridor for species that would otherwise not have connected habitat within this highly developed area. The 1999-2000 Christmas Bird Count recorded 56 bird species and 8,896 individuals along the river. Of these, 50% were Canada geese and European starlings (Jones et al. 2003).

Clear Creek is a major riparian corridor connecting the foothills near Golden with the South Platte River. Relatively large areas of riparian woodland and shrubland occur along the creek in some areas, while other portions contain gravel pits and disturbed habitats. Where Conduit M crosses Clear Creek, the habitat is cottonwood/willow riparian forest with adjacent ponds and wetlands. The Clear Creek corridor provides habitat for birds and some raptors that are more tolerant of human disturbance, such as red-tailed hawks and American kestrels.

Wildlife Viewing Areas

Wildlife viewing areas were chosen from a joint cooperative effort of various government and non-profit organizations in Colorado (Taylor Young 2000). Two wildlife viewing areas occur in the Conduit M study corridor:

- **South Platte River Greenway/Adams County Greenway** – This greenway is an urban wildlife corridor comprised of 30 miles of paved pedestrian trail extending through the study area. The Adams County Greenway links Barr Lake to the South Platte River corridor and to Clear Creek, which links the foothills in Jefferson County.

While the Greenway is primarily surrounded by developed areas, suburban parks and open space are located adjacent to the greenway. Numerous waterfowl, wading birds, and songbirds may be observed on the water or in cottonwood/willow riparian habitat. Beavers, muskrats, red foxes, raccoons, skunks, and deer may be observed at night (Taylor Young 2000).

- **Riverside Cemetery** – Riverside Cemetery is located east of Conduit M at Brighton Boulevard and York Street and is adjacent to the South Platte River. This riparian habitat is dominated by sandbar willow, smooth brome, and sand dropseed with hawthorn, Siberian elm, and cottonwood trees. The area adjacent to the river was part of a 1993 wetland restoration project. At least 40 species of birds have been recorded at the South Platte River adjacent to the cemetery (Jones et al. 2003). Prairie dogs, red fox, white-tailed deer, and muskrats may also be observed at Riverside Cemetery (Taylor Young 2000). In a recent survey of wildlife use of the South Platte River corridor in Denver County, Riverside Cemetery had the second highest number of species occurrence out of six sites (Jones et al. 2003).

3.9.2.2 Conduit O

The western portion of Conduit O (west of 80th Avenue at Pierce Street) is the same as described for Conduit M in Section 3.9.2.1.

The eastern portion of Conduit O crosses the South Platte River at 88th Avenue and Colorado Boulevard and parallels the river to its northern end. The habitat at the river crossing is primarily sandbar willow with upland areas dominated by grassland. The north side of the South Platte River is lined with riparian woodland. The majority of the habitat in the surrounding area of the South Platte River is residential, rural/agricultural, and open water gravel pit ponds; wildlife expected in these areas is listed in Table 3.9-5 under all habitats, urban habitat, and riparian woodlands. During a 2006 site visit, a Swainson's hawk nest was observed and a pair of red-tailed hawks were perched on a communications tower, indicating a nest is likely to occur nearby.

The portion of Conduit O along the South Platte River supports mule deer resident population and migration corridor, and is also within white-tailed deer winter range, overall range and concentration area (NDIS 2011).

Numerous prairie dog colonies are present on Conduit O along 88th Avenue and 120th Avenue. Just east of the South Platte River crossing is an Adams County Parks and Recreation property that is a prairie dog relocation site. Prairie dog colony locations are shown in Figure 3.9-4. Wetlands are present at various ditch crossings and roadside ditches along 88th Avenue between Colorado Boulevard and SH 85.

Sensitive Areas

As described in Section 3.9.2.2, Conduit O is located on the southern boundary of Rocky Flats NWR and the northern boundary of Two Ponds NWR.

Conduit O crosses and parallels the South Platte River from 88th Avenue and Colorado Boulevard to its northern terminus. The South Platte River Greenway/Adams County Greenway and South Platte River PCA is the same as described for Conduit M in Section 3.9.2.1.

3.9.3 South Platte River Facilities

3.9.3.1 Gravel Pits

Three of the storage pit lakes are existing and are bordered by the South Platte River to the east: Worthing Pit, South Tower Pit, and North Tower Pit. In 2006, the Challenger Pit site was being gravel-mined. Habitats present in the study area include grasslands, black-tailed prairie dog colonies, open water, riparian, and wetland. Table 3.9-5 lists species common to these habitats. Common cormorants and American white pelicans were observed at Worthing Pit during field visits.

A variety of waterfowl occur on the existing gravel pit ponds during migration and winter. American white pelicans were observed during a June 2006 site visit. In addition, several raptor nests, likely great-horned owl nests, were observed in deciduous trees on the south side of the study area in the summer of 2005. Several areas along the shores of the gravel pit lakes provide suitable nesting habitat for birds including mallards, Canada geese, and red-winged blackbirds. However, due to the high levels of recreational activity (i.e., watersports and camping), nesting opportunities may be limited. The patches of riparian forest are nesting habitat for great-horned owl, red-tailed hawk, Swainson's hawk, Bullock's oriole, and various songbirds. The South Platte River corridor is also a production area for wild turkey (NDIS 2011).

Diversion

The diversion structure would be constructed in the South Platte River near Worthing Pit. The area has a resident population of mule deer, is a mule deer migration corridor and white-tailed deer winter range and concentration area (NDIS 2011). Deer would be expected to occur at the site since it is adjacent to the South Platte River. A prairie dog colony occurs in the proposed diversion construction staging area. Birds associated with the diversion area are described in Table 3.9-6. An unknown raptor nest was identified in the trees adjacent to the proposed pipeline connecting the South Platte River Diversion to Worthing Pit.

Conveyance

Habitats present along the gravel pit pipelines are riparian, wetland, open water, grassland, and prairie dog colonies. Table 3.9-5 lists those species commonly occurring in these habitats. The pipeline corridor is year-round mule deer range and migration corridor, white-tailed deer winter range, overall range, and concentration area, and wild turkey winter range and production area (NDIS 2011). Black-tailed prairie dog colonies are present in the areas along and adjacent to the corridor, as shown in Figure 3.9-4. Riparian areas provide nesting habitat for orioles, great-horned owls, red-tailed hawks, and other birds. Mule deer and white-tailed deer would also be expected to occur in the portions of the corridor adjacent to the South Platte River.

The gravel pit pipeline would cross the South Platte River along Bridge Street. The western side of the river is lined with sandbar willow and the eastern bank is sandy with scattered cottonwoods and upland grassland areas. Further north, the pipeline would cross a canal with wetlands.

The lateral pipelines would follow existing roads surrounded by sand dropseed dominated grassland with scattered cottonwood, elm, Russian olive, and agricultural land. Prairie dog colonies are scattered throughout this area.

Treatment

The proposed 4-acre Advanced Water Treatment Plant (AWTP) would be located adjacent to Worthing Pit. This area is part of a gravel pit that has been heavily disturbed and is not considered important wildlife habitat due to the lack of vegetation. Shorebirds and swallows may utilize the open water in the gravel pit. No suitable nesting habitat is present on the site as only one tree is present.

Sensitive Areas

The South Platte River Greenway/Adams County Greenway is described for Conduit M in Section 3.9.2.1. This greenway connects to the Adams County Regional Park, which is located directly west of the Worthing Pit study area, across the South Platte River. The greenway includes a nature preserve at the north end of the Adams County Regional Park, near 124th Street.

3.9.4 Denver Basin Aquifer Facilities

The parks where wells would be placed mostly consist of landscaped areas with lawns, trees, and horticultural plantings, and support wildlife typical of urban and developed areas (Table 3.9-5). Distribution pipelines would follow streets and urban utility corridors, but would cross several areas of riparian and aquatic habitat, including the South Platte River in two locations, Cherry Creek in three locations, Lakewood Gulch at one location, and Sand Creek in one location. Because these crossings are in urban areas and adjacent to city streets, the wildlife species present are generally typical of urban and developed areas rather than the riparian and wetland species listed in Table 3.9-5.

The proposed AWTP would be a 7-acre site located near the South Platte River and the Board of Water Commissioners (Denver Water) Recycled Water Treatment Plant (WTP), northeast of Riverside Cemetery. Although this site is adjacent to Riverside Cemetery (across York Street) and the South Platte River, it provides minimal wildlife habitat as it has been previously disturbed and mostly lacks vegetation.

3.9.5 River Segments

Flow changes in the river segments have the potential to affect wildlife species dependent on wetlands, riparian habitats, or open water habitats. The potentially affected rivers where stream flow depletions or additions may result from the Moffat Project, include segments of the: Fraser River, Williams Fork River, Colorado River, Blue River, South Boulder Creek, North Fork South Platte River, and the South Platte River. The characterization of wildlife species dependent on wetlands, riparian habitats, or open water habitats was focused on those reaches that would experience a flow increase or decrease of greater than 10% (average annual, normal year, reference hydrology section) as a result of the Moffat Project, as determined from PACSM results (refer to Section 5.1). Using the criterion of a 10% flow change, approximately 208 miles of river segments were identified along the

mainstems and adjoining tributaries of the drainage basins listed above. The locations of these river segments are shown in Figures 3.0-2 through 3.0-4.

Species associated with upland habitats would not be affected and thus are not addressed in this section. The classification of habitat associations by flow changes is based on methods used to collect data for riparian and wetlands for the river segments, which is discussed in Section 3.8. Fish are discussed in Section 3.11. This section addresses the focus river segments shown in Figures 3.0-2 through 3.0-4 and the South Platte River more generally because flow changes along the mainstem are expected to be relatively minor.

Birds

Table 3.9-7 lists bird species that are dependent on the riparian habitats within the river segment study areas.

Table 3.9-7
Bird Species Breeding in Riparian and Wetland Habitats along the River Segments

Species	Riparian Evergreen	Riparian Deciduous	Riparian Shrub	Riparian Herbaceous	Stream and Pond
Ruby-crowned kinglet *Regulus calendula*	✓				
Golden-crowned kinglet *Regulus satrapa*	✓				
Mountain chickadee *Poecile gambeli*	✓				
Yellow-rumped warbler *Dendroica cornata*	✓				
Western tanager *Piranga ludoviciana*	✓				
Cordilleran flycatcher *Empidonax occidentalis*	✓	✓			
American robin *Turdus migratorius*	✓	✓			
Broad-tailed hummingbird *Selasphorus platycercus*	✓	✓	✓		
Swainson's thrush *Catharus ustulatus*	✓	✓	✓		
Western wood-pewee *Contopus sordidulus*		✓			
Northern flicker *Colaptes auratus*		✓			
House wren *Troglodytes aedon*		✓			
Warbling vireo *Vireo gilvus*		✓			
American kestrel *Falco sparverius*		✓			
Violet-green swallow *Tachycineta thalassina*		✓			

Table 3.9-7 (continued)
Bird Species Breeding in Riparian and Wetland Habitats along the River Segments

Species	Riparian Evergreen	Riparian Deciduous	Riparian Shrub	Riparian Herbaceous	Stream and Pond
Yellow warbler *Dendroica petechia*		✓	✓		
MacGillivrays warbler *Oporornis tolmiei*		✓	✓		
Song sparrow *Melospiza melodia*		✓	✓	✓	
Dusky flycatcher *Empidonax oberholseri*			✓		
Wilson's warbler *Cardellina pusilla*			✓		
Lincoln's sparrow *Melospiza lincolnii*			✓		
White-crowned sparrow *Zonotrichia leucophyrs*			✓		
Fox sparrow *Paserella iliaca*			✓		
Red-winged blackbird *Agelaius phoeniceu*				✓	
Brewers blackbird *Euphagus cyanocephalus*				✓	
Common snipe *Gallinago gallinago*				✓	
Killdeer *Charadrius vociferous*				✓	✓
Spotted sandpiper *Actitis macularia*				✓	✓
Mallard *Anas platyrhynchos*				✓	✓
Green-winged teal *Anas crecca*				✓	✓
American dipper *Cinclus mexicanus*					✓
Belted kingfisher *Ceryle alcyon*					✓

Source: Andrews and Righter, 1992; Kingery, 1998.

Mammals

Mammals associated with riparian and wetland habitats along the river segments are presented in Table 3.9-8. These include two game species, moose and elk, which are discussed in more detail in the individual river segments.

Table 3.9-8
Mammal Species Likely or Known to Occur in
Riparian and Wetland Habitats along the River Segments

Species	Riparian Evergreen	Riparian Deciduous	Riparian Shrub	Riparian Herbaceous	Stream and Pond
Masked shrew *Sorex cinereus*			✓	✓	
Montane shrew *Sorex monticolus*	✓	✓	✓	✓	
Dwarf shrew *Sorex nanus*	✓	✓	✓	✓	
Water shrew *Sorex palustris*	✓	✓	✓	✓	✓
Little brown myotis *Myotis lucifugus*	✓				✓
Long-legged myotis *Myotis volans*	✓				✓
Snowshoe hare *Lepus americanus*			✓		
Beaver *Castor canadensis*		✓	✓		✓
Deer mouse *Peromyscus maniculatus*	✓	✓	✓	✓	
Southern red backed vole *Clethrionomys gapperi*	✓		✓		
Long-tailed vole *Microtus longicaudus*		✓	✓	✓	
Montane vole *Microtus montanus*		✓		✓	
Meadow vole *Microtus pennsylvanicus*				✓	
Common muskrat *Ondatra zibethicus*				✓	✓
Western jumping mouse *Zapus princeps*		✓	✓	✓	
Common porcupine *Erethizon dorsatum*	✓	✓	✓	✓	
Red fox *Vulpes vulpes*	✓			✓	
Raccoon *Procyon lotor*			✓	✓	
Long-tailed weasel *Mustela frenata*	✓	✓	✓	✓	
Mink *Mustela vison*	✓	✓	✓	✓	✓
Northern river otter *Lontra canadensis*					✓

Table 3.9-8 (continued)
Mammal Species Likely or Known to Occur in
Riparian and Wetland Habitats along the River Segments

Species	Riparian Evergreen	Riparian Deciduous	Riparian Shrub	Riparian Herbaceous	Stream and Pond
Moose *Alces alces*	✓		✓	✓	✓
American elk *Cervus elephus*			✓	✓	

Source: Andrews and Righter, 1992; Kingery, 1998.

Amphibians and Reptiles

Amphibians that would be likely to occur in the riparian habitats of the river segments include tiger salamander, western chorus frog (*Pseudacris triseriata*), and potentially northern leopard frog. Boreal toad (*Anaxyrus boreas boreas*) is discussed in Section 3.10. Reptiles are less common in mountainous environments due to the higher elevations and colder temperatures; however, western terrestrial garter snake is likely to be associated with the river segments because it occurs in almost any terrestrial or wetland habitat near flowing water (Hammerson 1999; CDOW 2011b).

Habitats and Sensitive Areas

Wildlife habitats and sensitive areas present along other river segments in the Project area are discussed below.

3.9.5.1 Fraser River

The focus river segments in the Fraser River Basin include the mainstem below Denver Water's diversion points downstream to its confluence with the Colorado River below Granby, and approximately 30 tributaries to the mainstem. The dominant riparian vegetation type along the Fraser River is riparian herbaceous, but it also supports evergreen forest and riparian shrub.

The entire Fraser Valley is summer range for moose, and concentration areas are present along the Fraser River above the Town of Fraser, and along a number of tributaries including Jim Creek, Vasquez Creek, Elk Creek, St. Louis Creek, and Ranch Creek (NDIS 2011). Winter range occurs along Jim Creek and lower Ranch Creek. Most of the Fraser Valley, except for developed areas along U.S. Highway 40 (US 40), is elk summer range. There are no areas mapped as production area or summer concentration areas along the Fraser River or its tributaries (NDIS 2011); however, elk use higher elevation willow complexes as nursery areas.

USFS MIS present along the Fraser River and its tributaries include two indicators of montane riparian and wetland communities – Wilson's warbler and boreal toad.

The Fraser River at Granby PCA (B3) has a good occurrence of the globally vulnerable plant community of narrowleaf cottonwood/mixed willows montane riparian forest. The vegetation is dominated by narrowleaf cottonwood and a shrub layer of mountain willow,

Geyer's willow, greenleaf willow, and sandbar willow. The boundary includes approximately 4 miles of the Fraser River (CNHP 2006a).

About 2 miles of Vasquez Creek, a tributary of the Fraser River, is in the Vasquez Creek PCA (B3). This PCA includes a good occurrence of the globally vulnerable plant community, lower montane willow carrs (*Salix drummondiana*)/*Calamagrostis canadensis*) shrubland, an excellent occurrence of a globally secure plant community *Salix planifolia/ Carex aquatilis* shrubland, and two rare moonwort species (CNHP 2006a).

St. Louis Creek, a tributary of the Fraser River just east of the Town of Fraser, is a designated PCA, St. Louis Creek at Fraser PCA (B4). This PCA has a good occurrence of the globally apparently secure plant community of Wolf's willow (*Salix wolfii*)/water sedge (*Carex aquatilis*) subalpine riparian willow carr. West St. Louis Creek PCA (B4) is designated for a good occurrence of a State rare community (G4/S2) of Englemann spruce (*Picea engelmannii*)/field horsetail (*Equisetum arvense*) coniferous wetland forests (CNHP 2006a).

3.9.5.2 Williams Fork River

The characterization of wildlife species concentrated on the focus river segment, which includes the Williams Fork River mainstem from its confluence with the South Fork Williams Fork near the South Fork Campground upstream to its confluence with Steelman Creek. The focus river segment also includes Steelman, Bobtail, Jones, and McQueary creeks from their diversion points downstream to the confluence with the Williams Fork mainstem. This 12.3 mile segment of the Williams Fork River is located at elevations ranging from 8,900 to 11,200 feet. Riparian shrub is the dominant vegetation type in the river segment, but riparian evergreen and riparian herbaceous are also present.

The upper Williams Fork is moose summer range and concentration area (NDIS 2011), including riparian areas and surrounding uplands. Moose winter range is more closely confined to the riparian area and occurs along most of the upper Williams Fork below Steelman Creek. The entire valley is also elk summer range. There are no areas mapped as production area or summer concentration areas along the Fraser River or its tributaries (NDIS 2011); however, elk use higher elevation willow complexes as nursery areas.

USFS MIS present along the Fraser River and its tributaries include two indicators of montane riparian and wetland communities – Wilson's warbler and boreal toad.

The northern portion of the Williams Fork River segment is within the South Fork Williams Fork PCA (B3), which was designated for the occurrence of vulnerable plant communities, including montane willow carrs, subalpine riparian willow carr, reflected moonwort, Mingan's moonwort, and western moonwort. The boundary includes 10 miles of the upper reaches of the Williams Fork River and its southern fork (CNHP 2006a).

The southern portion of the river segment is in the upper Williams Fork PCA (B3), designated to support populations of Colorado River cutthroat trout and boreal toad. The boundary includes the upper Williams Fork, South Fork Williams Fork, McQueary, Steelman, and Bobtail creeks. More information about these species is provided in Section 3.10.5.2.

3.9.5.3 Colorado River

The characterization of wildlife species focused on the affected Colorado River segment, which extends from the confluence with the Fraser River near Granby to its confluence with the Blue River near Kremmling. This 27-mile segment of the Colorado River is located at elevations ranging from 7,400 to 7,800 feet. Vegetation is dominated by riparian herbaceous, but also supports riparian deciduous trees, riparian shrub, and riparian evergreen types.

The entire Colorado River segment is moose summer range, and there is a small area of winter range mapped near Troublesome. Elk severe winter range and winter concentrations occur in uplands adjacent to the river valley. The Hot Sulphur Springs State Wildlife Area (SWA) is located along the river about 3 miles west of the Town of Hot Sulphur Springs. Pioneer Park in the Town of Hot Sulphur Springs also provides fishing access and is a unit of the Hot Sulphur Springs SWA.

3.9.5.4 Blue River

The Blue River segment extends from the dam at Dillon Reservoir downstream to the confluence with the Colorado River, while the focus segment extends from the dam at Dillon Reservoir downstream to Green Mountain Reservoir. The 21.8-mile focus segment of the Blue River is located at elevations ranging from 7,900 to 8,800 feet. The dominant vegetation types are riparian deciduous tree, riparian herbaceous, and riparian shrub; a small portion of the habitat is riparian evergreen.

The Blue River valley is summer range for moose. A moose concentration area is located west of the upper portion of the Blue River. The Blue River above Green Mountain Reservoir is also elk summer range.

Blue River SWA consists of three parcels along the Blue River between Silverthorne and Green Mountain Reservoir at approximately 9,000 feet in elevation: Sutton, Eagle's Nest, and Blue River. The Blue River parcel has an interpretive trail for wildlife viewing. All of the parcels are located between 7 and 17 miles north of Silverthorne. The parcels consist of montane riparian habitat along the Blue River and its tributary creeks, with surrounding upland areas characterized by sagebrush shrubland, irrigated hay meadows, and mixed conifer-aspen forest on steep slopes (Taylor Young 2000).

The Blue River SWA supports nesting bald eagles (refer to Section 3.10). Additionally, numerous songbirds such as American dippers and warblers occur along the river. Shorebirds and waterfowl present on the water include great blue herons, sandpipers, mallards, teals, mergansers, Canada geese, and goldeneyes in winter. Mammals likely to occur include long-tailed weasels, raccoons, foxes, river otters, and beaver (Taylor Young 2000).

The Blue River-North of Silverthorne PCA (B4) is also located on the Blue River, 1.5 miles north of the Town of Silverthorne at the I-70 interchange. The site consists of several gravel ponds with a small occurrence of a montane riparian willow carr (*Salix geyeriana-Salix monticola/Calamagrostis canadensis*) and a subalpine riparian shrubland (*Betula glandulosa*/mesic forb-mesic graminoid) located in the boggy areas of the Blue

River (Culver and Sanderson 1997). The area is approximately 600 acres at an elevation of 8,600 feet. The site also supports a pair of nesting osprey.

3.9.5.5 South Boulder Creek

The potentially affected portion of South Boulder Creek is 22 miles long and extends from the outlet of Moffat Tunnel to Eldorado Springs near Denver Water's South Boulder Diversion Canal. Elevations in the affected river segment range from 6,000 to 9,200 feet. The vegetation along the segment of the creek is dominantly riparian herbaceous and shrub, but also supports riparian deciduous (mostly upstream of the Town of Rollinsville) and evergreen.

The segment of South Boulder Creek east of Gross Reservoir is within the Hawkin Gulch/ Walker Ranch/upper Eldorado Canyon ECA, which is 17,500 acres (Boulder County 1986). It is also mostly within the Boulder Foothills PCA, an area of very high biodiversity significance, previously described for Gross Reservoir (Section 3.9.1).

3.9.5.6 North Fork South Platte River

The segment of the North Fork South Platte River potentially affected by the Moffat Project is 39.7 miles long and extends from the Roberts Tunnel near the Town of Grant in Park County at 8,700 feet in elevation, east to the confluence with the South Platte River at 6,100 feet in elevation. Dominant vegetation is riparian herbaceous and riparian shrub with smaller areas of riparian evergreen and riparian deciduous trees. The North Fork South Platte River from Grant to the South Platte River is a major fishing stream (Class I) (NPWRC 2006).

The North Fork South Platte River from the Roberts Tunnel to Buffalo Creek has a moderately decreasing slope and flows through a combination of montane meadow and canyon habitat. The stream is channelized to downstream of Bailey. From Buffalo Creek to the confluence with the South Platte River, the slope increases and the channel straightens, flowing through narrow foothill canyon habitat (NPWRC 2006). The segment of the North Fork South Platte River from Pine, downstream (east) to the confluence with the South Platte River is bald eagle winter range (NDIS 2006).

3.9.5.7 South Platte River

The overall study area for the South Platte River extends from Antero Reservoir in Park County to the Henderson gage in Weld County. The South Platte River from Antero Reservoir to Henderson in Adams County passes through three landscapes, open mountain park in South Park, mid-elevation canyons from Eleven Mile Canyon Reservoir to Chatfield Reservoir, and low elevation riparian woodland, developed and disturbed areas through the Denver Metropolitan area.

The section through South Park includes three large reservoirs that are State parks and wildlife viewing areas: Antero Reservoir, Spinney Mountain Reservoir, and Eleven Mile Canyon Reservoir. These reservoirs provide both deepwater and mudflat habitat for waterfowl and shorebirds. Antero Reservoir has one of three pelican breeding colonies in Colorado. The South Platte River between the reservoirs has large areas of willow carr and wetlands bordered by dry montane grasslands. One PCA is located along this reach of the

South Platte River. Antero Reservoir PCA (B2) is located on the south side of Antero Reservoir and along Salt Creek, and includes alkaline marshes and salt springs. Antero Reservoir is a playa lake that was enhanced for water storage. The Antero Reservoir PCA was designated based on presence of a good occurrence of a globally imperiled salt meadow community, excellent and good occurrences of globally imperiled plant species, and fair occurrences of several rare plant species and communities (Spackman et al. 2001).

The section from Eleven Mile Canyon Reservoir to Chatfield Reservoir includes mostly forested canyons to the confluence with the North Fork South Platte River, and foothill canyon from there to the mouth of Waterton Canyon. Riparian areas are mostly narrow and consist of a mix of forest, shrub, and herbaceous communities. The Eleven Mile Canyon PCA is located along the South Platte River between Eleven Mile Canyon Reservoir and Lake George. It includes a blue spruce/river birch (*Picea pungens/Betula occidentalis*) riparian community within a steep canyon. Waterton Canyon is a wildlife viewing area located along the South Platte River between Cheesman and Chatfield reservoirs. The habitat along this segment of the South Platte River is riparian woodland consisting of cottonwood, willow, and box elder changing to Douglas-fir at higher elevations. Many songbirds and American dippers may be observed at Waterton Canyon, as well as foraging bald eagles that winter roost at Cheesman Reservoir (CNHP 2005a).

Industrial land use in Denver and Adams counties, as well as water-management projects such as Chatfield Reservoir have altered water flow and habitat of the South Platte River through the Denver Metropolitan area. The primary habitat along the river is riparian woodland composed of cottonwood, willows, elms, native and non-native grasses, and weeds (Jones et al. 2003). However, the corridor is fragmented by channelization, bank stabilization with riprap, and other alterations. The land uses along the South Platte River are industrial, residential, open space, and suburban parks, with the majority of the open space occurring close to Chatfield Reservoir. Species present in this segment of the South Platte River are those listed in Table 3.9-6.

The portion of the South Platte River between SH 88 and south to Chatfield Reservoir is an important urban wildlife corridor and is part of the South Platte River (B5) PCA and greenway. Cottonwoods and willow riparian habitat are present along most of the river. Additionally, 16 municipal parks are located along the river, one of which is South Platte Park that contains 2.5 miles of unchannelized river and over 85 acres of wetlands. Chatfield State Park is located at the mouth of Waterton Canyon and supports grassland, wetland, riparian woodland, and open water habitats. Many migrant birds and raptors travel through this area during spring and fall migrations (Taylor Young 2000).

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3.10 SPECIAL STATUS SPECIES

3.10.0 Overview

This section discusses the special status species present in the Moffat Collection System Project (Moffat Project or Project) area. Special status species include Federal and State listed threatened, endangered, and candidate species; U.S. Forest Service (USFS) Region 2 sensitive species; Bureau of Land Management (BLM) sensitive species, and Colorado Natural Heritage Program (CNHP) listed species.

Information was obtained from field visits, CNHP element occurrence data, the Natural Diversity Information Source (NDIS) website of species' ranges, USFS data, previous studies and reports, and literature searches. Habitats that support special status species were further identified using Geographic Information System (GIS) to overlay aerial photographs on study area boundaries.

Federally listed species are protected under the Endangered Species Act (ESA) while State listed species are protected under Colorado State law. Information about the potential recurrence of Federal and State listed endangered and threatened species is presented below by Project component. Lists of the special status species are presented in Appendix G-1. Table G-1 and Table G-2 present the Federal and State listed species that may occur in the Project area, along with their status, and habitat affiliation. Table G-1 presents only those species that are expected to occur at the East Slope alternative components. Table G-2 lists species expected to occur in river segments on the East and West Slope river segments, as well as species that depend on the riparian habitats downstream from the Project area (such as South Platte River in Nebraska). More detailed information for those species with potential to occur in the Project area is provided in Sections 3.10.1 through 3.10.5.

Other Special Status Species include USFS Region 2 sensitive species (USFS 2011), Arapaho & Roosevelt National Forests (ARNF) plant species of local concern (USFS 2010), and CNHP listed species (CNHP 2013). Tables G-3, G-4, and G-5 in Appendix G present these species, their status, habitat, and potential to occur in each of the Project component study areas. Table G-5 includes only those species inhabiting aquatic or riparian environments associated with the river segments.

3.10.1 Reservoirs

Preble's meadow jumping mouse (Preble's) (*Zapus hudsonius preblei*), burrowing owl, greenback cutthroat trout (*Onchorhynchus clarki stomias*), Ute ladies'-tresses orchid (*Spiranthes diluvialis*), and Colorado butterfly plant (*Gaura neomexicana* ssp. *coloradensis*) have been documented to occur, or have potential habitat at Gross Reservoir and the Leyden Gulch site. A number of other species status species, including USFS Region 2 sensitive species and ARNF plant species of local concern, are also known or likely to occur. Bald eagle (*Haliaeetus leucocephalus*), which was discussed in the Draft Environmental Impact Statement (EIS) as a State listed species, has been down-listed to a State species of special concern and is discussed under Other Special Species.

3.10.1.1 Gross Reservoir

Preble's Meadow Jumping Mouse

Preble's inhabit well-developed plains riparian vegetation with adjacent, undisturbed upland grassland communities and nearby water sources (Figure 3.10-2). Suitable Preble's habitat is typically a dense combination of grasses, forbs, and shrubs, though a taller shrub and tree canopy may be present. The species hibernates near riparian zones, usually from September or October to May (CNHP 1999).

Preble's is native only to the Rocky Mountains-Great Plains interface of eastern Colorado and southeastern Wyoming. The western boundary of Preble's distribution is limited to below 7,600 feet in elevation. Preble's has been extirpated from the Denver Metropolitan area, which separates the northern and southern extents of their range (CNHP 1999). In Colorado, Preble's is known to occur in seven counties: Weld, Larimer, Boulder, Jefferson, Douglas, Elbert, and El Paso.

In September 2005, three areas of potential habitat were evaluated as potentially suitable for Preble's: Forsythe Canyon, Winiger Gulch, and the Gross Reservoir inlet on South Boulder Creek (Ensight 2005b). Forsythe Canyon and South Boulder Creek did not have suitable Preble's habitat. The steep, narrow profile and rocky terrain at Forsythe Canyon does not have suitable vegetation to support Preble's and the South Boulder Creek inlet does not have enough riparian vegetation to support the species (Ensight 2005b).

Of the three areas evaluated, only Winiger Gulch has suitable habitat to support Preble's; however, the affected areas at Winiger Gulch are near the upper elevational limit of Preble's distribution in Colorado (Ensight 2005b). Furthermore, a population of Preble's in Winiger Gulch has been isolated from the known downstream population by Gross Reservoir for more than 50 years. Therefore, if Preble's did inhabit upper Winiger Gulch prior to the construction of Gross Reservoir, the population is now likely to be extinct (Ensight 2005b). U.S. Fish and Wildlife Service (USFWS) concurred that populations of Preble's are not likely to be present in the Gross Reservoir study area (Appendix G). A population of Preble's is present downstream from Gross Reservoir along South Boulder Creek (USFWS 2006). There is no designated critical habitat in the Gross Reservoir study area.

Greenback Cutthroat Trout

Greenback cutthroat trout are found primarily in headwater streams in the Arkansas River and South Platte River drainages. Suitable habitat consists of clear, swift-flowing, gravelly headwater mountain streams and lakes with cover such as overhanging banks and vegetation. They historically occurred throughout the mountain and foothill areas of these drainages, but today exist only in about 5 percent (%) of their native range (CDOW 2008a). Greenback cutthroat trout occur in 62 sites, of which 20 populations are believed to be stable and self-sustaining (Rogers 2012). The most stable populations are within the South Platte drainage in Rocky Mountain National Park. Additional information about occurrence of greenback cutthroat trout on the West Slope (Fraser and Williams Fork drainages) is provided in Section 3.10.5.

Colorado Parks and Wildlife (CPW) (previously called Colorado Division of Wildlife) stocked greenback cutthroat trout in Gross Reservoir in 2002 and 2004. Net sampling in 2007 did not find any greenback cutthroat trout and they appear to be relatively rare if still present. After the 2002 and 2004 stocking events, problems were discovered with the genetic purity of a number of greenback cutthroat trout populations (Metcalf et al. 2007) and the cutthroat trout stocked at Gross Reservoir are likely to have been hybrids of greenback and Colorado River cutthroat trout (*Oncorhynchus clarkii pleuriticus*) (Swigle 2008). Gross Reservoir is not considered to be a recovery water for this species, and a number of other fish species and hybrids are regularly stocked at Gross Reservoir.

Other Special Status Species

Several other special status animal species are likely to occur at Gross Reservoir (Table G-3 and below). These species are mostly USFS Region 2 sensitive species. Four species, including northern leopard frog, American peregrine falcon, Townsend's big-eared bat, and bald eagle are also Colorado State species of special concern. USFS Management Indicator Species are addressed in Section 3.9. Additional information on the occurrence of USFS sensitive and local concern species is presented in the Special Status Species Technical Report in Appendix G.

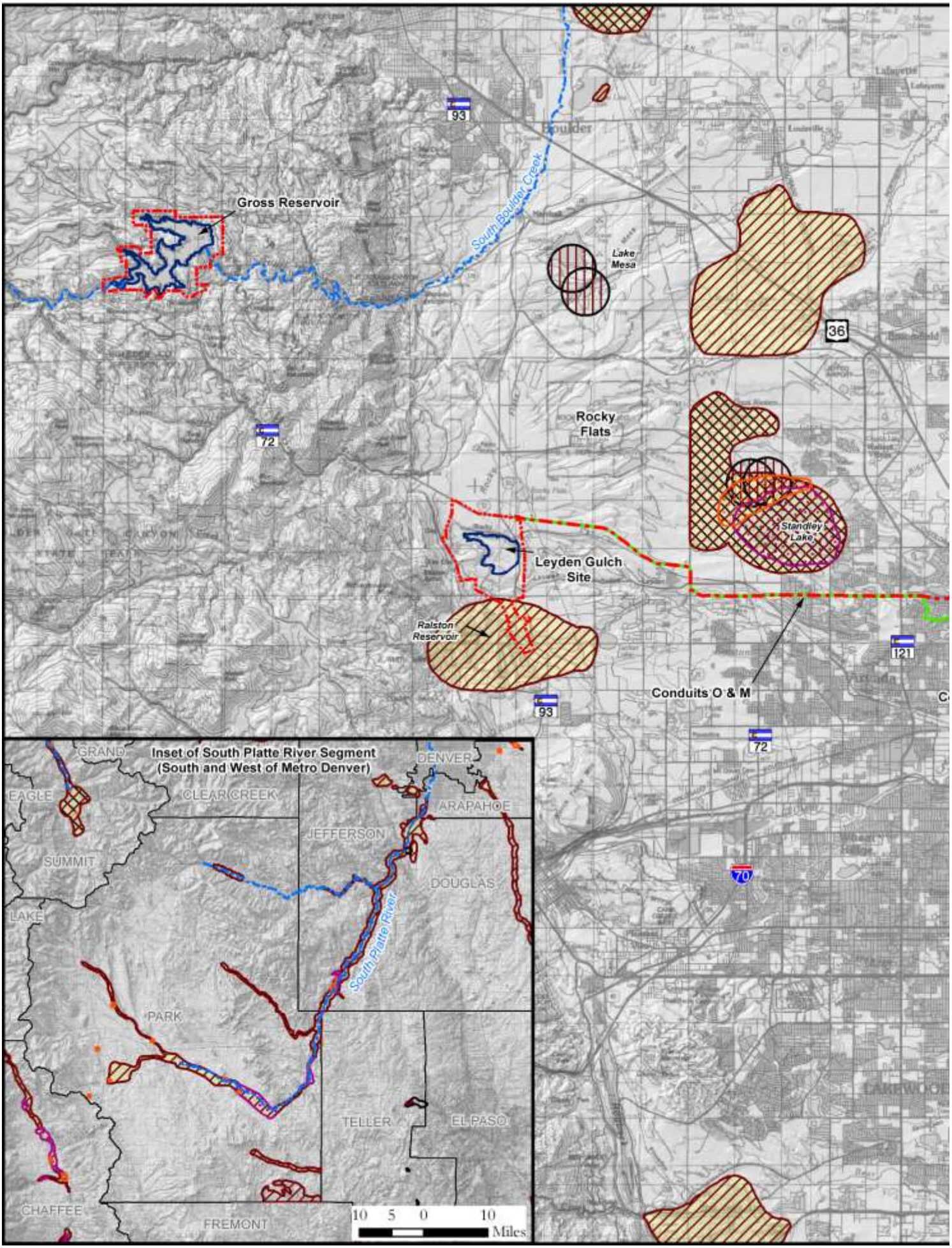
- Northern goshawk (*Accipiter gentilis*). Surveys conducted in 2010 indicated that the study area around Gross Reservoir is used by the species, at least on Winiger Ridge. The Gross Reservoir area seems to be limited in its potential as breeding habitat, largely because of the lack of tree stands with dense canopy cover that also occur on moderate terrain. Dense stands of forest around Gross Reservoir typically are limited to steep, north-facing slopes, which are not typically used as nesting habitat by the northern goshawk. The study area likely provides suitable foraging or post-fledgling habitat, but the extent of use could not be confirmed by 2010 field surveys.
- Northern leopard frog (*Lithobates pipiens*). Surveys for this species were conducted in 2010. The surveys found no northern leopard frogs or suitable breeding habitat and only limited areas of marginally suitable habitat for adult frogs.
- American peregrine falcon (*Falco peregrinus anatum*). Peregrine falcons may occur during foraging or migration but are unlikely to occur regularly. There are no prominent cliffs that appear to be suitable for nesting peregrine falcons, and no nest sites have been identified. Known nesting sites are located about 3 miles away.
- Flammulated owl (*Psiloscops [Otus] flammeolus*). Surveys for flammulated owl were conducted at Gross Reservoir in 1997 and no flammulated owls were observed (FERC and USDA 1999). However, the ponderosa pine forests in the Gross Reservoir study area provide suitable habitat for flammulated owls and they are likely to occur.
- Townsend's big-eared bat (*Plectotus townsendii pallescens*). Roosting habitat (caves, mines) is not known to be present in the Gross Reservoir study area, but suitable foraging habitat, including forested and riparian habitats, is present. There is a good potential for occurrence, because this species has been reported at several locations in western Boulder County.

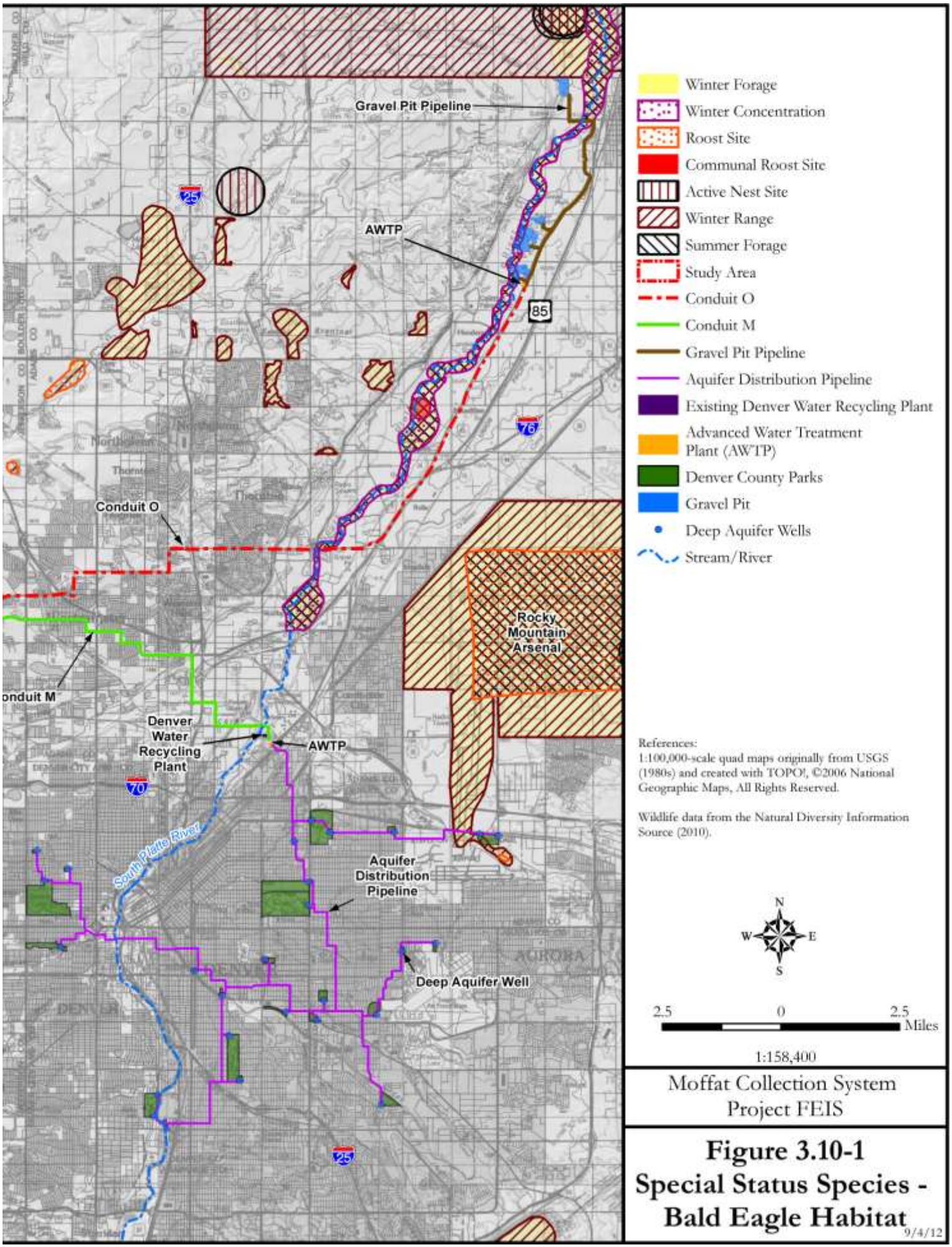
- Fringed myotis (*Myotis thysanodes*). The study area does not include any known caves or mines that could be used as maternity roosts or hibernacula by this bat species, but suitable foraging and day roosting habitat is present. The study area has a large amount of potential day and night roosting habitat in the form of rock crevices and scattered ponderosa pine and Douglas-fir snags.
- American three-toed woodpecker (*Picoides dorsalis*). This species may occur at Gross Reservoir, although typical habitat (dead or burned forest) is limited. This species was observed about a mile west of the Gross Reservoir study area in 1999 where a prescribed burn had been conducted the previous year (FERC and USDA 1999).
- Black swift (*Cypseloides niger*). There are no reports of black swift nesting at Gross Reservoir, but they may occasionally forage over the Gross Reservoir study area.
- Dwarf shrew (*Sorex nanus*). Dwarf shrew is not a USFS sensitive species, but is considered to be rare and imperiled (S2) by the CNHP. This species is reported from a wide variety of habitats in the mountains of Colorado above 5,800 feet and may occur in the study area, although it has not been reported in Boulder County (NDIS 2011).
- Olive-sided flycatcher (*Contopus cooperi*). The Gross Reservoir study area is within the general range of this species, and the forests adjacent to the Project area provide potential habitat.
- Bald Eagle. The bald eagle is Federally protected by the Bald and Golden Eagle Protection Act, in addition to being a State special concern species and a USFS sensitive species. It was a State threatened species at the time that the Draft EIS was prepared in 2009. In Colorado, nest trees are located in various forest types from old growth ponderosa pine to linear groups of riparian woodland. Nests and roosts are usually located in tall trees near water in areas free of human activity and development. Roost sites are trees that provide diurnal and/or nocturnal perches for less than 15 wintering bald eagles and includes a 0.25-mile buffer zone (NDIS 2011). Figure 3.10-1 shows bald eagle habitat within the Project area. A bald eagle was observed flying over Gross Reservoir during site visits conducted in September 2005. In addition, commenters on the Draft EIS mentioned seeing bald eagles at Gross Reservoir. Bald eagles occur occasionally, but are not known to nest or roost in the Gross Reservoir study area.

In its comments on the Draft EIS, USFS identified a number of USFS sensitive and local concern plant species that were known to occur or could be present in the Gross Reservoir study area. Surveys for USFS Region 2 sensitive plant species and ARNF plant species of local concern were conducted during the summer of 2010 and the results are summarized below and provided in Appendix G. A previous survey was conducted by Rick Brune in 2001 for the Board of Water Commissioners' (Denver Water's) Recreation Management Plan and power line relocation associated with the FERC relicensing (Shapins Associates 2002). The 2001 survey did not include all areas of anticipated disturbance for the proposed reservoir enlargement, and extended outside of the Gross Reservoir study area along Forsythe Canyon. Surveys were conducted in June, July, and August 2001 (Shapins Associates 2002). One additional special status plant species, Sprengel's sedge, was first found by CNHP in 2007 (CNHP 2009). The 2010 surveys found more occurrences of most of the previously reported species, but did not find any new plant species of concern. All of

the observed species are associated with riparian areas and adjacent lower slopes along Forsythe Creek, Winiger Creek, and other drainages. One species (dwarf raspberry) is a USFS Region 2 sensitive species, and the other species are ARNF plant species of local concern.

- Wild Sarsaparilla (*Aralia nudicaulis*). This species was reported to be present at several locations in 2001 (Shapins Associates 2002), with more than 3,200 plants observed. During surveys conducted in 2010, wild sarsaparilla was found to be a regular component of riparian habitat and shaded mesic areas in the Gross Reservoir study area. More than 5,000 individuals were observed in 2010, in five populations located in Winiger Gulch, Forsythe Canyon, along the South Platte River, and along two unnamed drainages on the south side of the reservoir.
- Dewey sedge (*Carex deweyana*). Surveys in 2001 (Shapins Associates 2002) found about 50 of this species in Forsythe Canyon and a few plants in one of the drainages on the south side of Gross Reservoir. Surveys in 2010 confirmed the presence of this species at those locations and additional locations, and about 260 individuals in four populations in Forsythe Canyon, Winiger Gulch, and two drainages on the south side of Gross Reservoir.
- Sprengel's sedge (*Carex sprengelii*). CNHP found this species during surveys in 2007, near the junction of Winiger Gulch and its south fork. This population was found again along with additional occurrences in other portions of Winiger Gulch and in Forsythe Canyon. An estimated 650 individuals of this species were observed. Sprengel's sedge was most common in open areas in the valley bottom. The largest numbers were found at the confluence of Winiger Gulch and its south fork, at the site where they were originally reported by CNHP.
- Enchantress's nightshade (*Circaea alpina*). More than 900 individuals of this species were observed in Winiger Gulch and one of the tributaries on the south side of the reservoir. This is likely an underestimate because of the diminutive size of the plant. In Gross Reservoir, *C. alpina* occurs on unvegetated, heavily shaded stream banks, growing to the water's edge. Due to the dense shade it prefers, the species was always observed with little or no other associated herbaceous vegetation.
- Tall blue lettuce (*Lactuca biennis*). One individual of this species was found in Forsythe Canyon in 2001 (Shapins Associates 2002). About 150 plants of this species were found at several locations along both Forsythe Canyon and Winiger Gulch. It is a tall herbaceous plant and grows in areas of dense herbaceous vegetation in relatively unshaded areas on mesic terraces.
- Maryland sanicle (*Sanicula marilandica*). Several plants of this species were found in 2001 (Shapins Associates 2002) in one of the drainages on the south side of Gross Reservoir. About 32 individuals of this species were found in the same drainage again in 2011. They occurred in areas of moderate shade along the edges of the creek. It appears that none of this population is located on USFS land.


Gross Reservoir
South Boulder Creek
Lake Mesa
Rocky Flats
Standley Lake
Leyden Gulch Site
Ralston Reservoir
Conduits O & M
Inset of South Platte River Segment (South and West of Metro Denver)
GRAND
EAGLE
CLEAR CREEK
DENVER
ARAPAHOE
JEFFERSON
SUMMIT
DOUGLAS
LAKE
South Platte River
PARK
TELLER
EL PASO
CHAFFEE
FREMONT
10 5 0 10
Miles



Moffat Collection System Project FEIS

Figure 3.10-1
Special Status Species - Bald Eagle Habitat

9/4/12

- Dwarf raspberry *(Rubus arcticus* var. *acaulis, Cylactis arctica* ssp. *acaulis*). An occurrence of this species was found in Forsythe Canyon in 2001 (Shapins Associates 2002), with about 10 plants. This population was not found again in 2010; however, the survey was conducted later in the season when the species may have been dormant. The location that was searched, based on a Global Positioning System point, was a mesic riparian area with mineral soils, and not typical of the habitats in which this species generally occurs.
- False melic (*Schizachne purpurascens*). This species was found during surveys of the Gross Reservoir area in 2001 (Shapins Associates 2002), with about 20-30 individuals at a location in Forsythe Canyon. It was found in three additional locations in 2010, but the number of individuals observed at those locations was not recorded. This species appears to be a regular though uncommon constituent of riparian areas, and was also observed in aspen communities on the north side of Gross Reservoir. This species was observed in lower Forsythe Canyon, one of the drainages on the south side of Gross Reservoir, and along the north shore of the reservoir.
- Wood lily (*Lilium philadelphicum*). This species was mentioned as present, but not affected by activities at Gross Reservoir (FERC and USDA 1999). The location of the population is not known and is likely not to be within the Gross Reservoir study area. Wood lily were not observed during the 2010 survey.
- Ferns. All species except brittle bladderfern (*Cystopteris fragilis*) are considered to be plant species of local concern for the ARNF. Six species of ferns were found during surveys at Gross Reservoir in 2010, including forked spleenwort (*Asplenium septentrionale*), brittle bladderfern, male fern (*Dryopteris felix–mas*), Rocky Mountain polypody (*Polypodium saximontanum*), western brackenfern (*Pteridium aquilinum*), and Oregon cliff fern (*Woodsia oregana* ssp. *cathcartiana*). The numbers of individuals were not recorded.

3.10.1.2 Leyden Gulch Reservoir Site

Burrowing Owl

Burrowing owls (*Athene cunicularia*) are small, terrestrial raptors that nest in grassland habitats in close association with active or inactive black-tailed prairie dog colonies. They nest in abandoned black-tailed prairie dog or ground squirrel burrows as well as in native prairie, pasture, hayland, fallow fields, and along road ROWs. Burrowing owls are present in eastern Colorado between March 1 and October 1, and nest between April 1 and July 31.

Black-tailed prairie dogs are the best indication of the potential presence of burrowing owls; several black-tailed prairie dog colonies occur at the Leyden Gulch site. No burrowing owls were recorded in the site; however, site visits were conducted late in the season and burrowing owl presence could not be verified. Burrowing owls may be present at Leyden Gulch in summer where prairie dog burrows occur (Figure 3.9-4). Furthermore, due to Denver Water's ongoing prairie dog eradication efforts, many burrows are abandoned, which makes them highly suitable for nesting burrowing owls.

Preble's Meadow Jumping Mouse

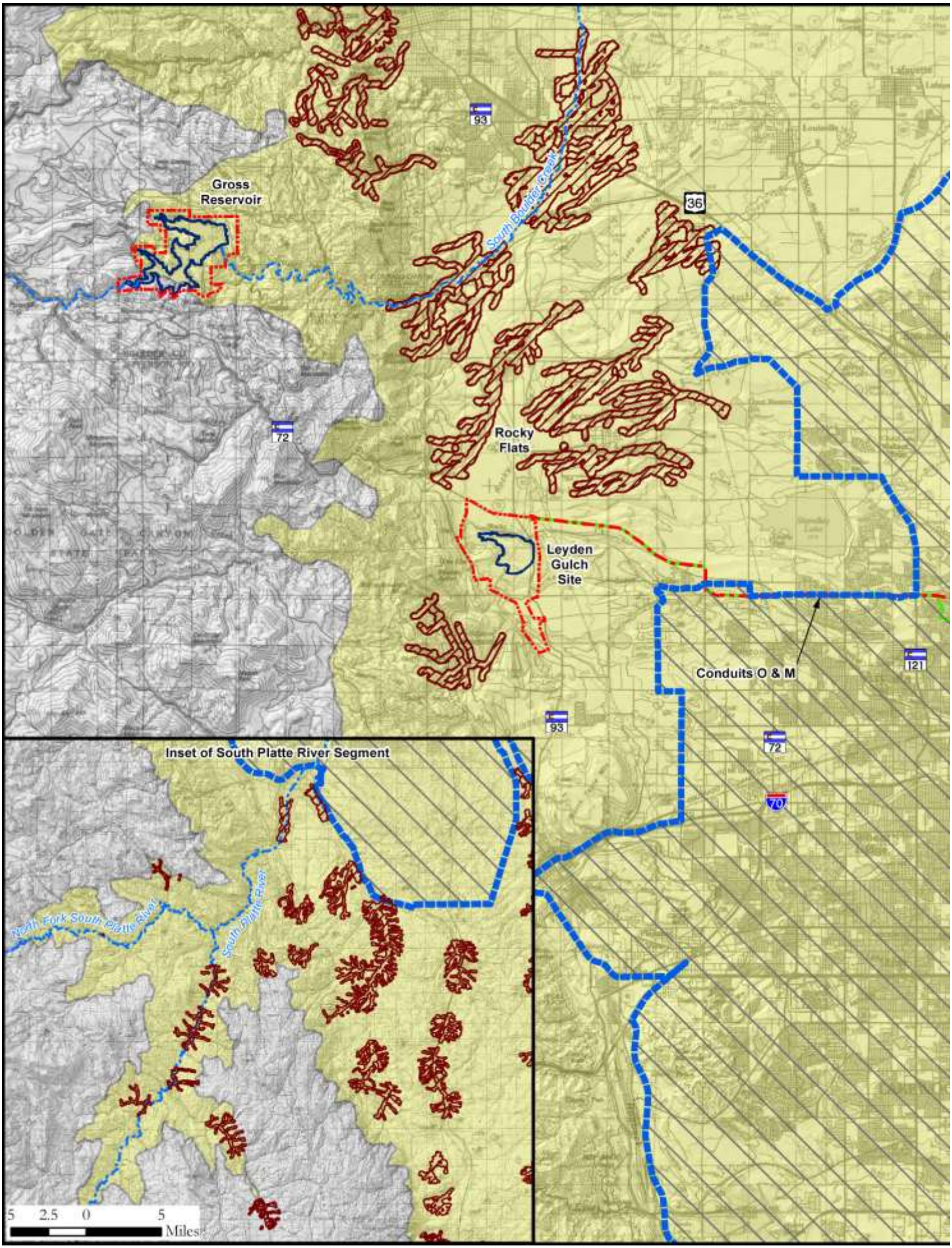
The Leyden Gulch site has potential habitat for the Preble's; however, Leyden Gulch is isolated from nearby drainages that are known to support Preble's populations, including Coal and Ralston creeks upstream of Ralston Reservoir (Figure 3.10-2). While Leyden Gulch does connect with Ralston Creek approximately 8 miles east of the Leyden Gulch site, Preble's has not been captured on Ralston Creek east of State Highway (SH) 93—a location that is within the Denver Metropolitan Block Clearance Zone (BCZ). Additionally, the known Ralston Creek Preble's population is located above the Ralston Creek dam, which is west of the site. USFWS designated the BCZ as an area that Preble's are unlikely to occur and would not be suitable for future recovery of the species.

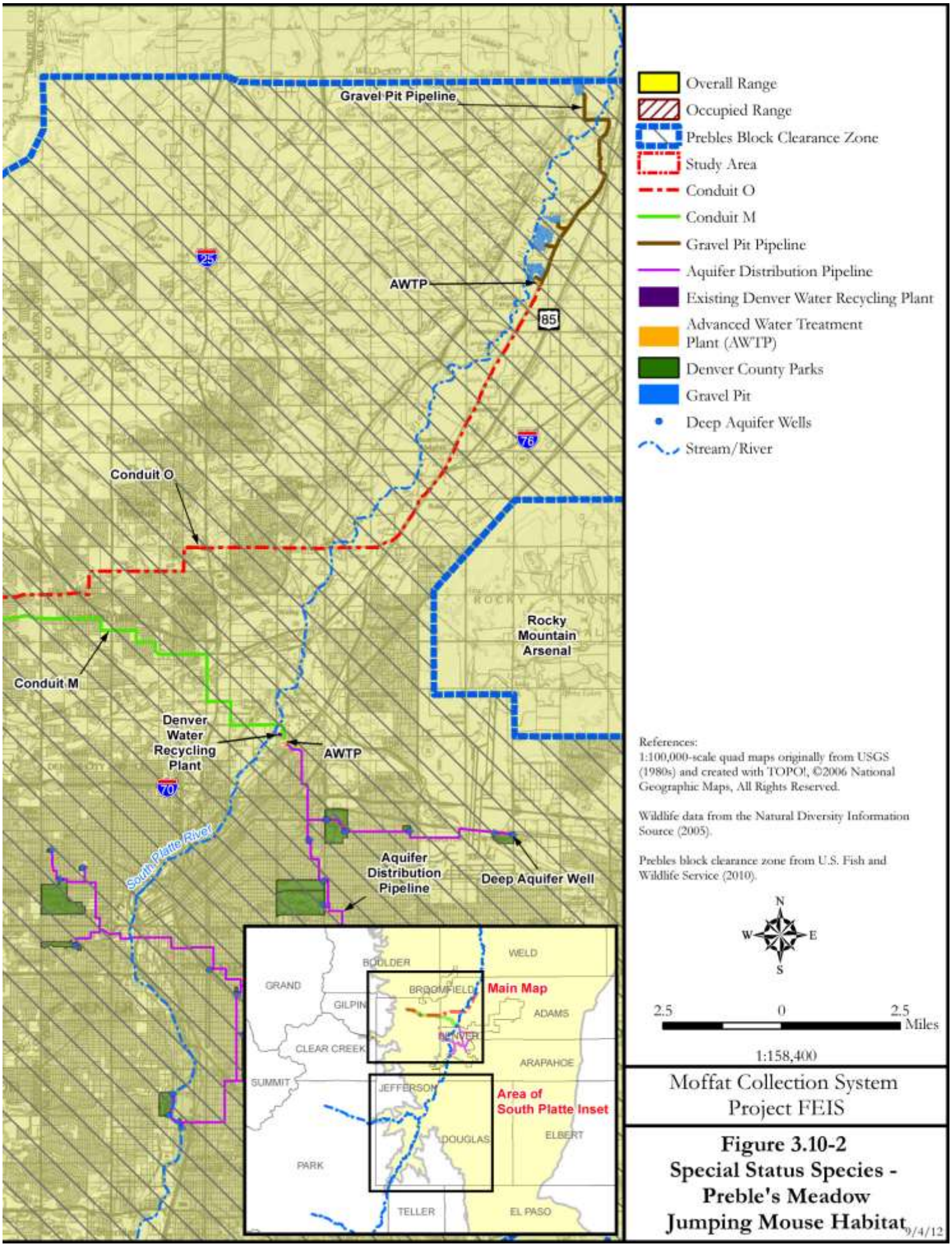
The portion of the Leyden Gulch site north of Ralston Creek was trapped in 1997 for a previous Denver Water project, in conjunction with the straightening and relocation of SH 93 by the Colorado Department of Transportation (CDOT). Although no Preble's were captured in the 1997 survey, the Denver Water Habitat Conservation Plan for Preble's Meadow Jumping Mouse specifies that new surveys would be required for future projects (Denver Water 2003g). A more recent Preble's survey was conducted on Leyden Gulch, 0.5 mile east of SH 93, with negative results (Ensight 2005a). The 2005 survey substantiates past survey results, which indicate that Leyden Gulch does not support a population of Preble's, likely due to the degradation of potential Preble's habitat since the 1997 survey (Ensight 2005a). USFWS concurred that a population of Preble's is unlikely to be present in the Leyden Gulch study area (Appendix G). Furthermore, downstream habitat (east of the site) is unlikely to support Preble's since no individuals have been captured east of SH 93 and this habitat is generally unsuitable to support the species.

The 2005 trapping survey at the Leyden Gulch site did not include the portion of Ralston Creek in the site. Upper Ralston Creek above Ralston Reservoir is occupied habitat and is designated critical habitat. However, Ralston Creek downstream of Ralston Reservoir was trapped from the base of the dam east to SH 93 with negative results (Ensight 1997). The habitat in lower Ralston Creek is considered marginally suitable to support a population of Preble's based on 2005 and 2006 habitat evaluations. Furthermore, the Preble's population in upper Ralston Creek is isolated from the lower Ralston Creek habitat by the reservoir, making a barrier for individuals to move to the lower reaches of Ralston Creek.

Ute Ladies'-tresses Orchid

Ute ladies'-tresses orchids are perennial, terrestrial orchids that flower from mid-July through August (Spackman et al. 1997). The plant may remain dormant underground for at least one growing season before leaves emerge aboveground (USFWS 1995). The species usually occurs in small, scattered populations in moist soils in mesic or wet meadows near springs, lakes, or perennial streams in the western United States (U.S.) (Heidel 1998). Ute ladies'-tresses orchids are often found in association with floodplain areas where the water table is near the surface throughout the growing season and into late summer or early fall (USFWS 1995). The plant is categorized as Facultative Wet, meaning that populations usually occur in wetlands but are occasionally found in non-wetlands (USFWS 1996). In Colorado, Ute ladies'-tresses orchids occur along the eastern slope of the Front Range between 4,300 and 7,400 feet in elevation (Spackman et al. 1997).


Gross Reservoir
South Boulder Creek
93
36
72
Rocky Flats
Leyden Gulch Site
Conduits O & M
121
93
72
70
Inset of South Platte River Segment
North Fork South Platte River
South Platte River
5 2.5 0 5
Miles



Moffat Collection System Project FEIS

Figure 3.10-2
Special Status Species - Preble's Meadow Jumping Mouse Habitat

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A field survey of the northern part of the Leyden Gulch site was conducted on August 12, 2005 and of the Ralston Creek corridor on August 29, 2006; no Ute ladies'-tresses orchids were observed in the site. A previous survey conducted in 1997 also concluded no Ute ladies'-tresses orchids were present within the site. The 1997 survey included portions of Leyden Gulch above the railroad tracks and east of SH 93, as well as Barbara Gulch, which were not included in the URS Corporation 2005 survey.

Because emergent populations of Ute ladies'-tresses orchid may fluctuate from year to year, assessing population status and distribution is difficult. Additional presence/absence surveys would be conducted prior to construction in accordance with the ESA.

Colorado Butterfly Plant

The Colorado butterfly plant is a short-lived perennial herb that grows in sub-irrigated fields and/or alluvial soils on level or slightly sloped floodplains and drainage bottoms within mixed grass prairies in northeast Colorado. It typically grows at elevations of 5,800 to 6,200 feet (Spackman et al. 1997). Colorado butterfly plant occurs in the same habitat as Ute ladies'-tresses orchid. The Leyden Gulch site contains some areas of suitable habitat for Colorado butterfly plant at some riparian and wetlands crossings such as Leyden Gulch and Ralston Creek. Surveys were conducted on August 12, 2005 along Leyden Gulch and on August 29, 2006 at Ralston Creek to document habitat and/or presence/ absence of the species; no Colorado butterfly plants were found. Additional presence/ absence surveys would be conducted prior to construction in accordance with the ESA.

In 2000, Colorado butterfly plant was listed as threatened due to population declines from periodic flooding within the plants' riparian habitat, herbicides, and land conversion to agricultural uses and urban development. Additionally, the species declines from competition by dense growths of willows, grasses, and noxious weeds, such as Canada thistle (*Cirsium arvense*) and leafy spurge (*Euphorbia esula*). USFWS has designated critical habitat for Colorado butterfly plant, but no critical habitat occurs within the Project area. The critical habitat is located along 113-stream miles in Platte and Larimer counties in Wyoming, Nebraska, and Weld County, Colorado (USFWS 2004b).

Other Special Status Species

Other special status species that are known or likely to occur at the Leyden Gulch site include bald eagle, American peregrine falcon, ferruginous hawk (*Buteo regalis*), black-tailed prairie dog (*Cynomys ludovicianus*), and northern leopard frog (Table G-3). Both black-tailed prairie dogs and northern leopard frog were observed during field surveys and are resident. Ferruginous hawk and peregrine falcon may forage over the site but do not nest. No suitable nesting habitat for bald eagle is present at the Leyden Gulch Reservoir site. However, the southern portion of the site, including Ralston Creek, is used for winter foraging while the east side of SH 93 at Ralston Creek is a winter concentration area (NDIS 2011). Since prairie dogs are present at the Leyden Gulch site, bald eagles may potentially forage there in winter months (Figure 3.10-1). Winter foraging areas are areas where bald eagles are common from November 15 to March 15, and winter concentration areas are areas where eagles concentrate between November 15 and April 1 (NDIS 2011).

3.10.2 Conveyance Systems

Of the species presented in Table G-1, the following are known to occur within or have suitable habitat near the conduit corridors. These species include: bald eagle, burrowing owl, interior least tern (*Sterna antillarum athalassos*), Preble's, Ute ladies'-tresses orchid, and Colorado butterfly plant. The potential for these species to occur in the conveyance system study areas are discussed below.

3.10.2.1 Conduit M

Of the species listed in Table G-1, bald eagle, Ute ladies'-tresses orchid, and Colorado butterfly plant have the potential to occur along Conduit M. Species considered not present in these areas are not discussed.

Bald Eagle

A pair of bald eagles, nest at Standley Lake, 1 mile north of Conduit M (Figure 3.10-1). Standley Lake is year-round foraging habitat, a winter concentration area, and a winter roost site for bald eagles (NDIS 2011). Bald eagles may occasionally forage over Conduit M in the western end of the conduit, especially in winter where prairie dog colonies are present, such as the intersection of SH 93 and SH 72. The South Platte River corridor where Conduit M crosses is also a winter concentration area as well as a year-round foraging area for bald eagles (NDIS 2011). Bald eagles may also forage along the Conduit M corridor near Clear Creek. However, due to the industrial land uses where Conduit M crosses the South Platte River and Clear Creek, bald eagle use is likely to be infrequent.

Ute Ladies'-tresses Orchid and Colorado Butterfly Plant

There are no known occurrences of Ute ladies'-tresses orchid along Conduit M, but suitable habitat may be present at some riparian and wetland crossings such as Clear Creek. A population of Colorado butterfly plant was found in 2011 within one-half mile of the Conduit M crossing of Clear Creek and suitable habitat may be present at other stream crossings. The South Platte River is within the BCZ for Ute ladies'-tresses orchid and Colorado butterfly plant (USFWS 2008). Habitat suitability and/or presence/absence would be documented at Clear Creek and other drainages prior to construction in accordance with the ESA.

Other Special Status Species

Other special status species that are likely to occur along Conduit M (Table G-3) include American peregrine falcon, ferruginous hawk, and snowy egret (*Egretta thula*).

3.10.2.2 Conduit O

Of the species listed in Table G-1, bald eagle, burrowing owl, interior least tern, piping plover (*Charadrius melodus*), Ute ladies'-tresses orchid, and Colorado butterfly plant have the potential to occur along Conduit O.

Bald Eagle

Bald eagles nest at Standley Lake, as described for Conduit M in Section 3.10.2.1. Additionally, bald eagles roost and forage year-round along the South Platte River corridor, including where Conduit O parallels and crosses the river (Figure 3.10-1). Bald eagles may forage over Conduit O where prairie dogs are present, including the extreme western end near SH 93 and throughout the eastern half of the conduit.

Burrowing Owl

Burrowing owls are known to nest in the Rocky Mountain Arsenal NWR and surrounding areas. Therefore, the species may be present between March and October in the habitat adjacent to Conduit O where prairie dog colonies are present (Figure 3.9-4).

Interior Least Tern

The South Platte River has suitable habitat for migrant interior least terns, however, the species is considered a casual to very rare spring and fall migrant (seven records from spring and 11 records from fall; Andrews and Righter 1992). Migrants occur at reservoirs, lakes, and rivers with bare sandy shorelines. The species may potentially occur where Conduit O crosses the South Platte River from late April to September.

Piping Plover

Piping plovers are very rare migrants in the Denver area (Andrews and Righter 1992). Migrating individuals would likely occur on mudflats and shorelines of reservoirs and lakes.

Ute Ladies'-tresses Orchid and Colorado Butterfly Plant

The Conduit O crossing of the South Platte River and the portion of the river that Conduit O parallels are within the BCZ for Ute ladies'-tresses orchid and Colorado butterfly plant (USFWS 2008). Surveys to determine the presence or absence of these species are not expected to be required.

Other Special Status Species

Other special status species that are likely to occur along Conduit O (Table G-3) include American peregrine falcon, ferruginous hawk, snowy egret, black-tailed prairie dog, and common garter snake (*Thamnophis sirtalis*).

3.10.3 South Platte River Facilities

Of the species presented in Table G-1, bald eagle, piping plover and interior least tern are considered to have potential to occur within the South Platte River Facilities study area. The South Platte River provides suitable habitat for migrant interior least terns and piping plovers, and bald eagle may occur along the South Platte corridor during foraging or roosting (Figure 3.10-1).

Bald Eagle

The South Platte River corridor is a winter concentration area and a year-round foraging area for bald eagles (NDIS 2011) and bald eagles prey on waterfowl at the gravel pit lakes. The South Platte River is located west of and immediately adjacent to the diversion structure, the Advanced Water Treatment Plant (AWTP), and the gravel pits. In 2006, the Challenger Pit was a gravel quarry and did not have suitable habitat for bald eagle; however, the pit would be suitable bald eagle foraging habitat when it is converted to a pond. No known bald eagle nests are present in the vicinity of the diversion structure; the nearest nest is located at Barr Lake, approximately 4 miles east of the diversion structure.

Interior Least Tern

The South Platte River has suitable habitat for migrant interior least terns, though the gravel pits are not considered preferred year-round habitat for the species. Therefore, least terns may potentially occur at the gravel pits during spring and fall migration. Interior least terns may occur at the diversion structure and AWTP due to their location on the South Platte River.

Piping Plover

Migrating piping plovers may occur along shorelines of the gravel pit lakes during migration stopovers between April and September. No known breeding habitat is present in the South Platte River Facilities study area.

Other Federal or State Listed Species

The South Platte River is within the BCZ for Ute ladies'-tresses orchid and Colorado butterfly plant (USFWS 2008). These species are not expected to be present and surveys would not be needed prior to construction.

Burrowing owl may occur near the gravel pit pipeline corridors where prairie dog colonies are located (Figure 3.9-4).

Other Special Status Species

Other special status species that are likely to occur at one or more of the South Platte River Facilities (Table G-4) include snowy egret, black-tailed prairie dog, northern leopard frog, and common garter snake.

3.10.4 Denver Basin Aquifer Facilities

The Denver Basin Aquifer Facilities would be located within urbanized areas of the Denver Metropolitan area. None of the proposed aquifer well sites support habitat or occur within the known range of any of the threatened or endangered species listed in Table G-1 in Appendix G.

The AWTP would be surrounded by industrial land uses, but would support numerous urban adapted wildlife species. However, most of the threatened and endangered species are not likely to occur at this location due to lack of suitable habitat. The only species that

may occur based on range are bald eagles, migrating interior least tern, and piping plover. No other special status species (Table G-4) are known or likely to occur.

3.10.5 River Segments

Table G-2 presents Federal and State listed threatened and endangered species and their potential to occur in the river segments, or habitats downstream from the Project area (such as the South Platte River in Nebraska). Special status species that are known to occur or have potential to occur in the rivers or adjacent habitat or those species that may be affected by downstream water depletions are discussed in this section.

3.10.5.1 Fraser River

Special status species were characterized at the mainstem below Denver Water's diversion points downstream to its confluence with the Colorado River below Granby, and at approximately 30 tributaries to the mainstem. Greenback cutthroat trout, Canada lynx, river otter (*Lontra canadensis*) and boreal toad (*Anaxyrus boreas boreas*) have range or potential habitat in this river segment.

Canada Lynx

Canada lynx is a Federally listed threatened species. They inhabit northern coniferous forests that are characterized by uneven-aged tree stands with relatively open canopies and well-developed understories. Ideal habitat is high-elevation spruce-fir forests with deep snow, and good populations of their principal prey, snowshoe hare. They use rock ledges, trees, fallen logs, and sometimes caves for denning. Throughout the year they mostly occur in Engelmann spruce-subalpine fir and Engelmann spruce-subalpine fir-aspen forests. Riparian and riparian mix areas are the third most commonly used type, with usage of this habitat greatest in July through November. CPW began a reintroduction program in 1997, and 218 wild-caught lynx from Canada and Alaska were released in southwestern Colorado from 1999 through 2006 (Shenk 2009). There are currently two core areas for lynx in Colorado, the release core area in the San Juan Mountains, and a lynx established core area in Taylor Park and the Collegiate Peaks area. Although Grand County is not a core area, lynx have been tracked at a number of locations. According to a map of satellite locations (Shenk 2009), the highest use density in Grand County occurs west of Winter Park including the St. Louis and Vasquez Creek drainages. The Fraser River and its tributaries that are east of U.S. Highway 40 have low to moderate use density.

Greenback Cutthroat Trout and Colorado River Cutthroat Trout

The greenback cutthroat trout was previously discussed in Section 3.10.1.1 for Gross Reservoir. Greenback cutthroat trout, a listed threatened species, are considered native to the headwaters of the South Platte and Arkansas River drainages in eastern Colorado and a small part of Wyoming, while Colorado River cutthroat trout, a State species of concern and USFS and BLM sensitive species, occurs in the Colorado and Green River drainages. Colorado River cutthroat trout was petitioned for listing as threatened, but a 12-month finding by the USFWS in 2007 determined that listing was not warranted at that time (USFWS 2007). There are several lineages of cutthroat trout that are native and still present in Colorado (Metcalf et al. 2012). The prevailing view was that there were three

lineages still present: Colorado River cutthroat trout, greenback cutthroat trout, and Rio Grande cutthroat trout (*Oncorhynchus clarkia virginialis*) (Behnke 2002), although this has been modified by the recent information. Recent genetic studies on the relationship between these subspecies have identified two divergent lineages within the ranges of the greenback cutthroat trout and the Colorado River cutthroat trout. However, sampling and analysis has found that many assumed greenback or Colorado River cutthroat populations belong to the other lineage. It is not known if this distribution is natural, the result of moving fish across river drainages, or the result of a close genetic relationship between the two subspecies and insufficient time to evolve separate physical characteristics. The Greenback Recovery Group is conducting ongoing research to help resolve this issue. The presence of greenback cutthroat trout on the West Slope (Fraser and Williams Fork drainages) was not addressed in the 2009 Biological Assessment and Biological Opinion, and a Supplemental Biological Assessment will be prepared to address Project impacts in these areas.

Populations of cutthroat trout are present in several of the Fraser River tributaries above the Denver Water diversions. The range-wide status review for Colorado River cutthroat trout (Hirsch et al. 2006) classified populations as "core conservation populations" or "conservation populations" depending on genetic purity. Populations in Iron Creek (tributary to St. Louis Creek), Hamilton, Jim, Ranch (Middle, North and South Forks), and Little Vasquez creeks were considered to be genetically pure (i.e., core conservation populations), while populations in Vasquez and Cabin creeks, and the Fraser River were identified as hybridized with either rainbow trout or other cutthroat trout subspecies (i.e., conservation populations). The populations in Little Vasquez Creek and Hamilton Creek have subsequently been identified as lineage greenback, which may result in them being reclassified as greenback cutthroat trout.

Cutthroat trout have also been reported to be present above Denver Water's diversion on St. Louis Creek, and downstream of the diversions on Fraser River, Vasquez Creek, Little Vasquez Creek, North Fork Ranch, South Fork Ranch, and Cabin Creek.

River Otter

River otter is a State threatened and USFS sensitive species. River otters inhabit high-quality, perennial rivers that support abundant fish or crustaceans within many habitats ranging from semidesert shrublands to montane and subalpine forests. Minimum estimated water flows are 10 cubic feet per second (cfs). Other habitat features that may be important include the presence of ice-free reaches of stream in winter, water depth, stream width, and suitable access to shoreline (Fitzgerald et al. 1994). River otters' overall range includes the entire length of the Fraser River below Denver Water's diversion, and winter range occur downstream of Granby (NDIS 2011; Figure 3.9-5). CPW has collected numerous road kills near Tabernash. The Fraser River tributaries that are diverted by Denver Water are not mapped by NDIS as being within the overall range of river otter. CPW conducts annual river otter surveys along the Fraser River, Williams Fork, Colorado River, and Blue River.

Boreal Toad

Boreal toads are listed as endangered by the State of Colorado and are a USFS sensitive species. They have greatly decreased in Colorado in the last 20 years and many former

breeding sites have not had activity in recent years (Jackson 2008). Three of seven known sites in Grand County are located on tributaries of the Fraser River, including Jim Creek, upper Vasquez Creek, and Pole Creek. No breeding activity has been observed at Jim Creek since 1996 and at Vasquez Creek since 2000, although single toads were observed in the Vasquez Creek area in a couple of year. Monitoring of the Pole Creek site found adults and egg masses every year and recruitment most years since 1993 (Jackson 2008). Surveys for the Fraser Valley Parkway in 2005 did not find any boreal toads in the area between Fraser and Tabernash (CNHP 2005b), and surveys for the Fraser River Enhancement Project (Horstman 2004) along portions of the Fraser River and Vasquez Creek did not find this species except for one adult female in atypical habitat. CNHP records show recent occurrences along Pole Creek, its tributary Skunk Creek, and Crooked Creek (CNHP 2005b).

There does not appear to be recent documentation of boreal toad presence along the Fraser River and its tributaries below the diversions, but there are relatively large areas of habitat suitable for adult toads and dispersing juveniles (riparian and wetland areas and adjacent uplands), as well as potential breeding habitat (shallow, abandoned, or active beaver ponds and other areas of still, shallow warm water). Recent observations and breeding sites in the Pole Creek area occur within dispersal distance, and there is enough habitat connectivity to support colonization of the Fraser River (CNHP 2005b). Boreal toad recovery activities have occurred along Crooked and Pole creeks since 2000, including creation of toad-specific breeding ponds and overwintering hibernacula. It is possible that toads from the Pole Creek population or other nearby sites will persist, reproduce successfully, and disperse to the Fraser River.

Bald Eagle

The lower 4 miles of the Fraser River is winter foraging habitat for bald eagles (NDIS 2011).

Other Special Status Species

Additional special status species that may occur along the Fraser River and its tributaries include northern leopard frog and several rare plant species (Table G-5 in Appendix G).

3.10.5.2 Williams Fork River

The characterization of special status species included the entire Williams Fork to its confluence with the Colorado River. Analysis of Project impacts focused on the river segment along the Williams Fork River mainstem from its confluence with Steelman Creek downstream to its confluence with the South Fork Williams Fork near the South Fork Campground. It also includes Steelman, Bobtail, Jones, and McQueary creeks from Denver Water's diversion points downstream to the confluence with the Williams Fork mainstem. Most of the species discussed for the Fraser River also occur in this segment.

Canada Lynx

Suitable habitat for lynx occurs along the upper Williams Fork. This is not a core area for lynx, but lynx have been recorded at a number of locations. According to a map of satellite locations (Shenk 2009), the highest use density in Grand County occurs west of Winter

Park including the St. Louis and Vasquez Creek drainages. Habitat in the upper Williams Fork River has low to moderate use density.

Greenback Cutthroat Trout and Colorado River Cutthroat Trout

Populations of cutthroat trout are present in three of the Williams Fork tributaries above the Denver Water diversions, McQueary Creek, Steelman Creek, and Bobtail Creek. In McQueary Creek, the diversion apparently isolates cutthroat trout upstream from brook trout downstream. However, the isolated cutthroat trout are apparently not a pure population of native greenback cutthroat trout, since non-native Trappers Lake-strain cutthroat trout were stocked in McQueary Lake (Chadwick and Associates 1986). In Bobtail and Steelman creeks, the cutthroat trout have apparently been genetically isolated and are considered to be genetically pure (Chadwick and Associates 1986; Young et al. 1996), and are assumed by USFWS to be greenback cutthroat trout. However, brook trout are present and have been increasing in proportion over the last few decades.

River Otter

The lower Williams Fork River includes areas occupied by river otter (Figure 3.9-5). According to Colorado Department of Natural Resources (CDNR 2010), river otter occur upstream to Kinney Creek and numerous road kill otter are collected along CR3. The focus segment above South Fork does not appear to be occupied by river otter.

Boreal Toad

Three known boreal toad sites are located along the Williams Fork River (Jackson 2008), including a known breeding site on the upper Williams Fork downstream of Bobtail, Steelman, and McQueary creeks, one at McQueary Lake, and an observation of boreal toad at South Fork in 2007. The upper Williams Fork site is located in an abandoned beaver pond, and small numbers of adults and egg masses have been were observed each year through 2007. Tadpoles were observed in this pond in the fall of 2010. Another breeding site is located less than one mile from the affected segment of Williams Fork River at McQueary Lake (Keinath and McGee 2005). Suitable habitat for adults and dispersing young occurs along most of the upper Williams Fork. CPW monitors and surveys boreal toads in Colorado, and the CPW and USFS are responsible for monitoring in the Fraser and Williams Fork drainages.

Bald Eagle

The lower 9 miles of the Williams Fork, below the focus segment, contains winter range and foraging habitat and about 2 miles of winter concentration area. The lower 5 miles is also summer foraging habitat, and nest sites are located near the confluence of the Colorado River and Williams Fork River. Summer foraging habitat is areas where bald eagles are common from March 15 to July 30. No bald eagle habitats are located within the focus segment on the upper portions of the Williams Fork.

Other Special Status Species

Additional special status species that may occur along the Williams Fork River and its tributaries include northern leopard frog and several rare plant species (Table G-5).

3.10.5.3 Colorado River

The characterization of special status species included the length from the confluence from the Fraser River near Granby to the confluence with the Blue River near Kremmling. Bald eagle and river otter have range or potential habitat in this river segment.

River Otter

The Colorado River segment is within the overall range of river otters (Figure 3.9-5). An approximately 0.5-mile reach of the river, 2 miles east of the Town of Hot Sulphur Springs is a river otter concentration area, and Windy Gap Reservoir is another concentration area. Concentration areas are where otter sightings and signs of otter activity are higher than in the overall range (NDIS 2011). Winter range occurs along a large portion of the Colorado River segment. CDNR (2010) has collected numerous road kill river otter near the Town of Hot Sulphur Springs.

Bald Eagle

Nearly all of the Colorado River from Granby to Kremmling is winter and summer foraging habitat (NDIS 2011). Winter concentration areas occur at several locations along about 7 miles of the river, and a number of roost sites are present. Active bald eagle nests are located between Windy Gap and Hot Sulphur Springs, and west of the Town of Parshall.

Other Special Status Species

Northern leopard frog have been reported recently in wetlands along the Colorado River near Kremmling (CDOW 2011b) and are likely to occur in the focus segment. American peregrine falcon have been are known to breed and forage along the Colorado River near the Town of Hot Sulphur Springs. Other special status species that may occur in aquatic or riparian habitat are listed in Table G-5 of Appendix G.

3.10.5.4 Blue River

The characterization of special status species focused on the river segment which extends from the dam at Dillon Reservoir downstream to Green Mountain Reservoir. Bald eagle, boreal toad, and river otter have range or potential habitat in this river segment.

Canada Lynx

Canada lynx may occur in riparian habitats along the Blue River. According to a map of lynx satellite locations (Shenk 2009), the Blue River in Summit County has low use density.

Boreal Toad

Boreal toads have been recorded at the Blue River watershed (Keinath and McGee 2005); however, the habitat conditions along the river in the study area are only marginally suitable to support the species. Known breeding sites (Jackson 2008) occur on tributaries mostly above Dillon Reservoir, and not near the Blue River.

River Otter

The entire length of the Blue River is considered to be occupied by river otter (Figure 3.9-5, NDIS 2011, Figure 3.9-5).

Bald Eagle

Bald eagle summer and winter foraging areas are located along the entire length of the Blue River, including the focus segment. Three active nests and several bald eagle roost sites are located along the Blue River above Green Mountain Reservoir. Two active nests, roost sites, and about 9 miles of winter concentration area are located along the river below Green Mountain Reservoir.

Other Special Status Species

A known peregrine falcon nesting area is present near Green Mountain Reservoir (NDIS 2011). Other special status species that may occur in aquatic or riparian habitat are listed in Table G-5 of Appendix G.

3.10.5.5 South Boulder Creek

The characterization of special status species focused on the river segment of South Boulder Creek, which extends from the outlet of Moffat Tunnel to Eldorado Springs near Denver Water's South Boulder Diversion Canal. The study area for special status species was also extended further downstream to the confluence with Boulder Creek. The vegetation along this segment of the creek is dominantly riparian herbaceous and shrub, but also supports riparian deciduous (mostly upstream of the Town of Rollinsville) and evergreen. Downstream from Eldorado Springs, numerous ditches divert water from the creek, and the landscape consists of mesic and wet meadows mixed with corridors of riparian trees and shrubs along the creek and major ditches. Preble's, boreal toad, Ute ladies'-tresses orchid, and Colorado butterfly plant have range or potential habitat in this river segment.

Preble's Meadow Jumping Mouse

The east portion of South Boulder Creek from Gross Reservoir to the South Boulder Diversion Canal is within the elevational range for Preble's. The habitat in this area consists of mature forest with scattered shrubs, but Preble's may occur and this area is considered to be Potential Habitat (Denver Water 2003g). No surveys have been conducted on South Boulder Creek upstream of Eldorado Canyon; however, Preble's have been captured downstream of the study area along South Boulder Creek. A large area of occupied habitat occurs along South Boulder Creek and irrigation ditches on City of Boulder open space.

Canada Lynx

Canada lynx may occur in riparian habitats along South Boulder Creek upstream of Gross Reservoir. According to a map of lynx satellite locations (Shenk 2009), this portion of South Boulder Creek in Gilpin and on the edge of Gilpin and Boulder counties has low use density.

Boreal Toad

Marginally suitable boreal toad habitat is present along South Boulder Creek. Surveys were conducted for boreal toad on South Boulder Creek just south of the Boulder-Gilpin county line with no toads detected (Denver Water 1998b). Subsequent surveys have not located boreal toads along South Boulder Creek (Keinath and McGee 2005). There are no known breeding sites along South Boulder Creek that are monitored for boreal toad.

Ute Ladies'-tresses Orchid and Colorado Butterfly Plant

Ute ladies'-tresses orchid and Colorado butterfly plant occur in the same types of habitats. The east portion of South Boulder Creek below Gross Reservoir is within the elevational range of Ute-ladies'-tresses orchid. However, habitat evaluations conducted in 1998 concluded no potential habitat was present. As of 2004, 29 known sites were located on South Boulder Creek within City of Boulder Open Space and Mountain Parks property or private property, downstream of the potentially affected segment of South Boulder Creek (Fertig et al. 2005). Ute ladies'-tresses orchid do not emerge in all 29 of these sites in each year so assessing population status can be difficult. The Colorado butterfly plant are not known to occur anywhere along South Boulder Creek, although suitable habitat occurs at many of the same locations occupied by Ute ladies'-tresses orchid.

Other Special Status Species

American peregrine falcon may forage along South Boulder Creek both above and below Gross Reservoir. A known nesting area is located downstream, and another nesting area is located within several miles of the creek above the reservoir. Other special status species that may occur in aquatic or riparian habitat are listed in Table G-5 of Appendix G.

3.10.5.6 North Fork South Platte River

The characterization of special status species focused on the river segment of the North Fork South Platte River, which extends from the outlet of the Roberts Tunnel east to the confluence with the South Platte River. Dominant vegetation in this segment is riparian herbaceous and riparian shrub with smaller acreage of riparian evergreen and riparian deciduous trees. Bald eagle and Preble's are known to occur in this river segment.

Preble's Meadow Jumping Mouse

The portion of the North Fork South Platte River within Jefferson County is considered within the overall range of Preble's. They have only been found at one location along the North Fork, and on a tributary, Kennedy Gulch. They also occur along the South Platte River, approximately 2 miles south of the confluence (NDIS 2011).

Bald Eagle

The upper 5 miles below Grant is winter foraging habitat, and the lower 10 miles of the North Fork South Platte River in Jefferson County is bald eagle winter range (NDIS 2011). No nests or roost sites are known to occur.

Other Special Status Species

A known American peregrine falcon nesting area is located along a portion of the North Fork (NDIS 2011), and peregrine falcons may forage along the river. Other special status species that may occur in aquatic or riparian habitat are listed in Table G-5.

3.10.5.7 South Platte River

The overall study area segment extends from Antero Reservoir in Park County to the Henderson gage in Weld County. Three reservoirs are present along the South Platte River in Park County: Antero, Spinney Mountain, and Eleven Mile Canyon. Cheesman and Chatfield reservoirs are located in Jefferson County. The industrial land use in Denver and Adams counties, as well as water-management projects such as Chatfield Reservoir have altered water flow and habitat of the South Platte River within the Denver Metropolitan area. Seven species have potential to occur in the overall South Platte River segment or adjacent riparian habitat.

Interior Least Tern

The South Platte River has suitable habitat for migrant interior least terns; therefore, least terns may potentially occur at the river in spring and fall.

Piping Plover

Piping plovers are migrants and are present in Colorado between April and May. Migrating individuals may occur in the South Platte River drainage.

Preble's Meadow Jumping Mouse

Occupied habitat occurs along several portions of the South Platte River between Cheesman Reservoir and Chatfield Reservoir, including a large area on the south end of Chatfield Reservoir (Figure 3.10-2). Except for a few miles below Chatfield Reservoir, all of the lower South Platte River to the Henderson gage is within the Denver Metropolitan BCZ, where Preble's are not expected to occur. Designated critical habitat is present on the South Platte River on Corps property above Chatfield Reservoir and on two reaches of USFS land between Deckers and Nighthawk.

Common Shiner

This species is reported to occur in the South Platte River between Chatfield Reservoir and northern Adams County (Hanophy 2006). It occurs in moderate gradient streams with cool, clear water, gravel bottoms, and shaded by brush or trees. However, occurrences of the species are rare. One common shiner was captured during sampling surveys in the South Platte River in Denver in 1981 (Woodling 1985), but even then were considered extremely rare in the South Platte River.

Ute Ladies'-tresses Orchid and Colorado Butterfly Plant

Suitable habitat for Ute ladies'-tresses orchid and Colorado butterfly plant may be present along the South Platte River. However, no individuals of these species are known to occur along the South Platte River segment potentially affected by the Moffat Project.

Bald Eagle

The entire South Platte River segment, except for the Denver urban area from about Bowles Avenue to Interstate (I-) 76, is winter foraging habitat for bald eagle. Winter concentration areas are located in eastern Park County around Lake George (near SH 24), at Elevenmile Canyon Reservoir, at Cheesman Reservoir, and from I-76 to the Henderson gage. The portion of the South Platte River north of I-76 is also a summer foraging area (NDIS 2011).

Other Special Status Species

Known and potential American peregrine falcon nesting areas are located in the general vicinity of the South Platte River in several locations, and the falcons may forage along the river. Several other special status species are likely to occur in aquatic or riparian habitat along the river (Table G-5), mostly downstream of Waterton Canyon. These species include American white pelican, snowy egret, white-faced ibis (*Plegadis chihi*), common garter snake, and Iowa darter (*Etheostema exile*).

3.10.5.8 Downstream Colorado River

Water depletions to West Slope tributaries of the Colorado River may affect four endangered fish species where they occur downstream in the Colorado River. These species include bonytail chub, Colorado pikeminnow (*Ptychocheilus lucius*), humpback chub (*Gila cypha*), and razorback sucker (*Xyrauchen texanus*). The decline of these fish species throughout the Colorado Basin is a result of extensive loss, fragmentation, modification of habitat, and barriers to fish movement associated with dam construction and operations. Major dams were constructed in the upper Colorado Basin in the 1960s, including Flaming Gorge Dam on the Green River, Navajo Dam on the San Juan River, the Aspinall Units on the Gunnison River, and Glen Canyon Dam on the Colorado River (USFWS 2002a). Glen Canyon Dam approximately divides the lower from the upper basin and is also a barrier to fish movement.

Bonytail Chub

Bonytail chubs were historically found throughout the Colorado River drainage. Wild adult bonytail have been captured in Powell, Mohave, and Havasu lakes, and in rivers within the upper Colorado River Basin, including the Green River in Colorado and Utah and in the Colorado River, west of Grand Junction near the Colorado-Utah border. Since 1977, only 11 wild adults have been reported from the upper basin. No self-sustaining populations of bonytail chub exist in the wild (USFWS 2002a). CPW has been stocking some bonytail chub in the river near Grand Junction.

Colorado Pikeminnow

Colorado pikeminnow occur primarily in the Green River below the confluence with the Yampa River, the lower Duchesne River in Utah, the Yampa River below the Town of Craig in Colorado, the White River from Taylor Draw dam near the Town of Rangely downstream to the confluence with the Green River, the Gunnison River in Colorado, and the Colorado River from Palisade, Colorado, downstream to Lake Powell (USFWS 2002b).

Humpback Chub

Historically, humpback chubs occurred in Colorado, Green, Yampa, White, and Little Colorado rivers. Currently, humpback chub populations are found in canyon portions of the Colorado River near the Colorado-Utah border at Westwater Canyon in Utah and Black Rocks in Colorado. Smaller populations inhabit the Yampa and Green rivers in Dinosaur National Monument in Colorado, Desolation and Gray canyons on the Green River in Utah, Cataract Canyon on the Colorado River in Utah, and the Colorado River and Little Colorado River in the Grand Canyon in Arizona.

Razorback Sucker

In the upper Colorado River Basin, reproducing razorback suckers are only found in the upper Green River in Utah and in an off-channel pond of the Colorado River near Grand Junction. Razorback suckers also occur in the lower Yampa River in Colorado and Lake Powell at the mouths of the Dirty Devil, San Juan, and Colorado rivers. Approximately 500 wild razorback suckers are thought to occur in the upper Colorado River Basin. Most of these individuals are adults likely more than 25 years old, and are reproducing, but few young are surviving. Razorback suckers are being stocked in the Green, Colorado, Gunnison, and San Juan rivers to develop and augment adult populations (CDOW 2006b).

3.10.5.9 Platte River (Central Nebraska)

The Platte River Basin includes three States: the North and South Platte rivers originate in Colorado, the North Platte flows through Wyoming and Nebraska, and the central and lower Platte River flows in Nebraska. Six special status species are known or expected to occur downstream. These species include interior least tern, piping plover, whooping crane (*Grus Americana*), pallid sturgeon (*Scaphirhynchus albus*), Eskimo curlew (*Numenius borealis*), and Western prairie fringed orchid (*Platanthera praeclara*). In addition, Western prairie fringed orchid is known from one extant population along the Platte River and Eskimo curlew formerly occurred, but has not been observed for many years and may be extinct.

Interior Least Tern

Interior least terns nest on bare sandbars in the Middle Platte region in Nebraska. The breeding distribution of interior least terns in the Platte River Basin includes the Platte River from its mouth west to North Platte River and some isolated sites along the South Platte River. In addition, breeding occurs along the Niobrara, Loup and Elkhorn, and Missouri rivers outside of the area of influence for the Moffat Project (NGPC 2006).

Piping Plover

Piping plovers nest on riverine sandbars of the Platte, Niobrara, and Missouri rivers. Approximately 440 miles of the Platte, Loup, and Niobrara rivers have been designated as critical habitat for piping plover. The designated critical habitat is comprised of sparsely vegetated riverine sandbars, sand and gravel beaches on riverine islands used for nesting, temporary pools on riverine sandbars and islands, and moist sand areas used for foraging (Sidle and Faanes 1997).

Whooping Crane

Whooping cranes generally migrate through the Platte River valley in Nebraska in April and October. A 56-mile long, 3-mile wide reach of the Platte River between Lexington and Shelton, Nebraska, was designated by USFWS as critical habitat for whooping cranes. The critical habitat that may be affected by water depletions includes migration areas along the Platte River bottoms between Lexington and Denman, Nebraska (USFWS 2005a).

Whooping cranes night roosting occurs in areas of shallow, submerged sand and gravel bars in rivers and lakes. This habitat condition is dependent on the right flow conditions and is likely to be one of the major factors determining whooping crane use of these habitats as roosting sites. Whooping cranes observed during migration are most often found within short flight distances of these wetland areas (Sidle and Faanes 1997).

Pallid Sturgeon

The pallid sturgeon historically ranged the entire length of the Missouri River, into the Mississippi River south to New Orleans, Louisiana. The main part of the pallid sturgeon range is the Missouri River from its confluence with the Mississippi River upstream to Fort Benton, Montana. The Pallid sturgeon are also found in downstream reaches of several major tributaries of the Missouri River, including the lower Platte River (Sidle and Faanes 1997).

Eskimo Curlew

Although once abundant throughout its range, the Eskimo curlew is now among the rarest bird species in the western hemisphere, with probably fewer than 500 individuals. They nest on the Canadian arctic tundra, and winter in southern South America. Fall migration is along the east coast and Atlantic Ocean, while spring migration passes through the middle of the continental U.S. including the central Platte River valley. Northward-migrating birds arrive on the Gulf Coast in early March, and then move northward toward their nesting grounds. They make extensive use of wet meadow habitat during migration, and historic records indicate that wet meadows in several counties along the South Platte River were of special importance to this species (Sidle and Faanes 1997).

Western Prairie Fringed Orchid

This species occurs in marshes and wet meadows within the North American tallgrass prairie biome, and is most often found on unplowed prairies and sedge meadows. Historic records exist from more than 200 sites in 109 counties in eight States and one Canadian Province. Extant populations occur in 175 sites in 6 States and Manitoba. It is known from eight counties in Nebraska, with only one population along the Platte River in Hall County. Historical records are lacking, because the Platte River floodplain was the first large area of Nebraska to be converted to agriculture. Drainage, decreased river flows, and intensive agriculture in former wet prairies have eliminated most areas of suitable habitat along the Platte River (Sidle and Faanes 1997).

3.11 AQUATIC BIOLOGICAL RESOURCES

3.11.0 Overview

This section describes the affected environment for aquatic biological resources in the Moffat Collection System Project (Moffat Project or Project) area including fish, benthic macroinvertebrates, and aquatic habitat. The Project area includes reservoirs and streams in the South Platte and Colorado River drainages potentially affected by the action alternatives through changes in hydrology. This section summarizes the more detailed information in the Aquatic Biological Resources Technical Report (GEI 2013). Refer also to Section 3.15 for a description of the existing recreational fishing conditions in the Project area.

Much of the information in this section was obtained from existing agency sources. During scoping and initial Project plan development, several data gaps were identified that required supplemental data collection for this Environmental Impact Statement (EIS).

Existing data were available as far back as 1970 for some portions of the Project area and as recent as 2010 for others. None of the sections of stream or reservoirs have continuous data over this entire period. For most stream sections, the available data are the result of one or more short-term studies. In most cases, the available data are presented from the 1980s through 2010.

3.11.0.1 Habitat

Available qualitative habitat data were summarized for individual streams when available. Montane streams can include the following habitat-forming stream morphologies: step-pool complexes, cascades, plane beds, and pool-riffle complexes. Pool-riffle complexes are common in fish bearing streams and tributaries (Montgomery and Buffington 1997).

Fish habitat simulations were available for some of the mainstem river sections in the Project area from the Metropolitan Denver Water Supply EIS, also referred to as Two Forks EIS (Corps 1988). Habitat was simulated with Physical Habitat Simulation (PHABSIM) system by Colorado Parks and Wildlife (CPW) (previously called Colorado Division of Wildlife) or Chadwick Ecological Consultants, Inc. ([CEC], formerly Chadwick & Associates, Inc.) in the 1980s. Fish habitat simulations were also available from the Grand County Stream Management Plan (Grand County 2008, 2010) for several stream sections in the Project area. The PHABSIM habitat relationships were used to assess the effects of the Moffat Collection System Project EIS alternatives as described in Section 5.11. Habitat simulations are not available for most tributaries. In many of the tributaries, the limited or complete lack of flowing water makes habitat simulations unnecessary; there is assumed to be no habitat available with no flow.

In some of the mainstem and tributary streams in the Fraser and Williams Fork river basins, CPW has collected data to be used with the R-2-Cross method. This method does not model fish habitat, but simulates width, depth, and velocity conditions across a single stream transect over a range of flows. This method is used in Colorado to evaluate the suitability of low flows to maintain habitat conditions for fish and invertebrates. Much of the collected R-2-Cross information is simply raw field data and has not been evaluated by

CPW, except for two sites on the lower Fraser River. The information at the two sites was used to assess the impacts of the alternatives in tributary streams.

Quantitative descriptions or simulations of habitat features were not available for the lakes and reservoirs in the Project area. Measurements of basic features of the reservoirs, such as surface area and maximum depth, are presented as available.

3.11.0.2 Fish

The description of the fish populations concentrates on data relating to species composition and data on relative abundance, usually including density and/or biomass of each species, when available. Distribution of fish species throughout the Project area is described. A total of 49 different varieties of fish including 43 fish species, four hybrids, and fish designated only as cutthroat trout and unidentified warmwater species have been collected or stocked within the Project area (Table 3.11-1) including 43 fish species, four hybrids, and fish designated only as cutthroat trout.

Table 3.11-1
Fish Species Collected and Stocked in the Moffat Collection System Project Area

Common Name	Scientific Name
Arctic char	*Salvelinus alpinus*
Bigmouth shiner	*Notropis dorsalis*
Black bullhead	*Ameuirus melas*
Black crappie	*Pomoxis nigromaculatus*
Bluegill sunfish	*Lepomis macrochirus*
Bluehead sucker	*Catostomus discobolus*
Brook stickleback	*Culaea inconstans*
Brook trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Bullhead	*Ameiurus* sp.
Channel catfish	*Ictalurus punctatus*
Colorado River cutthroat trout	*Oncorhynchus clarkii pleuriticus*
Common carp	*Cyprinus carpio*
Common shiner	*Luxilus cornutus*
Creek chub	*Semotilus atromaculatus*
Cutbow (rainbow/cutthroat trout hybrid)	*Oncorhynchus clarkii* x *O. mykiss*
Cutthroat trout (other subspecies)	*Oncorhynchus clarkii* ssp.
Dace (unidentified)	*Rhinichthys* spp.
Fathead minnow	*Pimephales promelas*
Flannelmouth sucker	*Catostomus latipinnis*
Green sunfish	*Lepomis cyanellus*
Greenback cutthroat trout	*Oncorhynchus clarkii stomias*
Iowa darter	*Etheostoma exile*
Johnny darter	*Etheostoma nigrum*
Kokanee salmon	*Oncorhynchus nerka*
Lake trout	*Salvelinus namaycush*
Largemouth bass	*Micropterus salmoides*

Table 3.11-1 (continued)
Fish Species Collected and Stocked in the Moffat Collection System Project Area

Common Name	Scientific Name
Longnose dace	*Rhinichthys cataractae*
Longnose sucker	*Catostomus catostomus*
Mosquitofish	*Gambusia affinis*
Mottled sculpin	*Cottus bairdi*
Northern pike	*Esox lucius*
Paiute sculpin	*Cottus beldingii*
Pike's Peak cutthroat trout	*Oncorhynchus clarkii stomias*
Plains topminnow	*Fundulus sciadicus*
Rainbow trout/steelhead	*Oncorhynchus mykiss*
Razorback sucker	*Xyrauchen texanus*
Sand shiner	*Notropis stramineus*
Sculpin (unidentified)	*Cottus* sp.
Smallmouth bass	*Micropterus dolomieu*
Speckled dace	*Rhinichthys osculus*
Splake (brook/lake trout hybrid)	*Salvelinus fontinalis* x *S. namaycush*
Spottail shiner	*Notropis hudsonius*
Sucker, unidentified	*Catostomus* spp.
Tiger muskie (pike/muskellunge hybrid)	*Esox lucius* x *E. masquinongy*
Unidentified warmwater species	Not applicable
White sucker	*Catostomus commersoni*
White/longnose sucker (hybrid)	*C. commersoni* x *C. catostomus*
Yellow perch	*Perca flavescens*

Of these fish species, the greenback cutthroat trout, is Federally and State listed as a threatened species. Previous studies (Metcalf et al. 2007) indicate that populations of greenback cutthroat trout are still at a high risk of extinction. Colorado River cutthroat trout are listed within the State of Colorado as a species of concern. Previous studies of cutthroat trout genetics have shown that both greenback and Colorado River lineages of cutthroat trout inhabit the Project area on both sides of the Continental Divide (Metcalf et al. 2007; Rogers 2010, 2012). Efforts to resolve the genetic lineages of native cutthroat trout populations and the historic ranges of the greenback and Colorado River lineages are ongoing. The most recent genetic study (Metcalf et al. 2012) identified greenback cutthroat trout from only one location near Colorado Springs, suggesting that this species of cutthroat trout is not present in the Project area. The cutthroat trout in West Slope streams in the Project area appear to be an undetermined lineage of native West Slope cutthroat trout.

However, because the genetic lineage data for individual streams is provisional in nature, the lineages of the cutthroat trout (i.e., greenback or some lineage of native West Slope Colorado River cutthroat) in the Project area are not identified in this report because both lineages face the same conservation threats and are managed in a similar manner. Instead of citing provisional and/or unpublished data in the EIS from the agencies working to resolve the genetic issues surrounding Colorado's cutthroat trout, all of the cutthroat trout in the Project area are referred to as "cutthroat trout." Data from Hirsch et al. (2006) are

presented, because they separate genetically pure cutthroat trout populations from those that are hybridized with rainbow trout (*Oncorhynchus mykiss*) or other cutthroat trout subspecies, such as Snake River or Yellowstone cutthroat trout. One additional species, the Iowa darter, is listed within the State of Colorado as a species of concern.

Most fish population data presented in this report were collected by the CPW, CEC, or by GEI Consultants, Inc. (GEI [formerly CEC]) coupled with data from the U.S. Forest Service (USFS) from some Fraser River tributaries. In 2005, CEC sampled fish and benthic macroinvertebrate populations in several Fraser River tributaries to provide supplemental data to fill in data gaps identified during the preliminary stages of EIS preparation. In 2010, GEI sampled fish in many Fraser River and Gross Reservoir tributaries in response to comments on the Draft EIS.

3.11.0.3 Benthic Macroinvertebrates

Benthic invertebrate populations are described in terms of upper-level taxonomic composition (usually class or order), with estimated densities and number of taxa present. A total of 16 classes/orders of invertebrates have been collected within the Project area (Table 3.11-2).

Table 3.11-2
Invertebrate Classes/Orders Collected in the Moffat Collection System Project Area

Common Name	Scientific Name
Mayflies	*Ephemeroptera*
Dragonflies/Damselflies	*Odonata*
Stoneflies	*Plecoptera*
Beetles	*Coleoptera*
Caddisflies	*Trichoptera*
True flies	*Diptera*
Water mites	*Hydracarina*
Scuds	*Amphipoda*
Aquatic sow bugs	*Isopoda*
Hydras	*Coelenterata*
Flatworms	*Turbellaria*
Leeches	*Hirudinea*
Round worms	*Nematoda*
Oligochaete worms	*Oligochaeta*
Snails	*Gastropoda*
Clams	*Pelecypoda*

Benthic invertebrate population data were collected, including supplemental data collection conducted in 2005, to fill in data gaps identified during the early stages of EIS preparation. In streams, both qualitative and replicate, quantitative sampling techniques were used to estimate total densities (number of individuals/square meter [m^2]) and total number of taxa. Benthic macroinvertebrate population data were not available for reservoirs or the South Platte River Facilities.

The New Zealand mud snail (*Potamopyrgus antipodarum*) has recently been introduced to Colorado, apparently by accidental introductions by anglers. This species is very invasive and is known to completely dominate the invertebrate community where it becomes established. Watersheds in which New Zealand mud snails have been found include South Boulder Creek and the upper South Platte River.

In this EIS, the macroinvertebrate data are summarized using density, total number of taxa, total number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa, and Shannon-Weaver Diversity Index (H'), although the analysis of the data also includes species composition, including taxonomic and functional diversity. The presence of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), collectively referred to as the EPT taxa, is used as an indicator of water quality. EPT taxa are also sensitive to water diversion and increasing the proportion of the flow that is removed from a stream increases the risk of eliminating rheophilic species (i.e., species that prefer or need faster currents). Another metric that these studies identified as potentially impacted by flow diversion is richness and abundance of erosional taxa, in the Project area, these families include Blephariceridae, Deuterophlebiidae, Simuliidae, Isonychiidae, Perlidae, Perlodidae, Apataniidae, Brachycentridae, Glossosomatidae, Helicopsychidae, Hydropsychidae, Philopotamidae, Rhyacophilidae, and Uenoidae (Poff et al. 2006; McCarthy 2008).

The Colorado Macroinvertebrate Multimetric Index (MMI) was also calculated by the Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division (WQCD) for the existing macroinvertebrate information that was provided by CDPHE WQCD. This index was developed for and is used by the CDPHE to determine aquatic life use attainment in streams (Jessup 2010; CDPHE 2010e). This bioassessment tool incorporates scores from five or six individual metrics that were selected to represent various invertebrate community characteristics that respond to environmental stressors (Jessup 2010). MMI scores were not calculated for samples from other sources, since the methods utilized to collect and process these samples differed from the methods recommended for collection of samples for MMI calculation.

3.11.1 Aquatic Ecological Context

3.11.1.1 Ecological Processes in Streams

Aquatic biological communities are a product of their environment. Environmental factors at large scales (e.g., elevation and stream size) and local scales (e.g., instream physical habitat) interact with biological factors to determine the number and type of species that can survive in a stream (Quist et al. 2005). These environmental factors are not fixed; they change over space, time, or both and interact with factors in adjacent communities. These changing environmental constraints can be referred to as ecological processes.

Ecological processes can also be affected by the Project in ways that are less obvious than changes in the number of fish or the species of macroinvertebrates in a stream. Ecological processes are complex and function on a number of different scales. Some ecological processes that are relevant to the Project area are discussed below.

Streams are categorized and linked by large-scale factors such as seasonal runoff patterns and morphology (Poole 2002; Vannote et al. 1980), but spatial variation in stream ecological processes across multiple scales creates a patchy mosaic of stream morphologies and habitat types. Streams do not change according to a smooth continuum—instead, physical characteristics change in "fits and starts" over the longitudinal profile of the stream. For example, ecologically relevant habitat features such as temperature, stream morphology, water quality, and sediment can change dramatically at tributary inputs (Poole 2002). Although the river continuum concept (Vannote et al. 1980), which describes the expected transition of streams along their length from small headwater streams to large rivers, is a useful conceptual model, the "river discontinuum" or "hierarchical patch dynamics" concepts better describe spatial changes in streams by incorporating local variations (Poole 2002).

The hierarchical patch dynamics concept stresses the fact that ecological processes and responses to disturbance in a stream depend heavily upon the location in the stream network. The factors structuring aquatic communities in headwater streams are different from those shaping aquatic communities lower in the watershed (Brown and Swan 2010). The effects of fragmentation can also depend on the location of the migration barrier (Fagan 2002). This is of particular interest in the Project area, which contains diversions in headwater or tributary streams and in mainstem rivers. Therefore, connectivity and the ability for stream organisms to move upstream and/or downstream between different sections of stream is one ecological process that has already been affected in the Project area.

Stream and river food webs are fueled by a complex mixture of allochthonous (i.e., carbon inputs from outside of the stream, such as leaf input and terrestrial insects) and autochthonous (i.e., energy produced from internal processes such as photosynthesis from algae) sources (Allan and Castillo 2008). Allochthonous input often exceeds autochthonous energy production, especially in headwater streams where plant litter, coarse debris, fine particulates, and dissolved organic matter are the base of the food web (Allan and Castillo 2008). Larger mainstem rivers receive allochthonous input from tributary and riparian inputs and through floodplain inundation, and these sources often are more important than autochthonous energy production, especially because scouring high flows and riparian shade tend to limit primary production from algae (Dodds 2002). Therefore, the connections between the stream environment and the adjacent riparian environment are another ecological process that has already been affected in the Project area.

Stream productivity tends to increase in a downstream direction according to the river continuum concept (Vannote et al. 1980). Although some energy is transported upstream by fish and aerial dispersal of macroinvertebrates (Ward 1989), allochthonous carbon sources (such as leaf litter) are exported and flow downstream from small streams before they are fully incorporated into the food web (Ward 1989). This represents another ecological process, the delivery of energy from upstream stream sections to downstream sections. This upstream subsidy increases productivity of downstream systems (Meyer et al. 2007; Freeman et al. 2007). As systems become wider and allochthonous input is reduced (canopy becomes more open), the system relies more on internal nutrient cycling and primary production (Vannote et al. 1980). However, sudden changes in morphology, productivity, and chemistry occur at tributary junctions (Poole 2002).

3.11.1.2 Fish Life Histories

Several fish species are common in the Project area or are important for management or recreational purposes. The life histories of several species are summarized below.

Cutthroat Trout

There are several lineages of cutthroat trout (*Oncorhynchus clarkii*) that are native and still present in Colorado (Metcalf et al. 2012). The prevailing view was that there were three lineages still present: Colorado River cutthroat trout (*O. c. pleuriticus*), greenback cutthroat trout (*O. c. stomias*), and Rio Grande cutthroat trout (*O. c. virginialis*) (Behnke 2002) although this has been modified by the recent information (refer to Section 3.11.0.2). Cutthroat trout lineages have experienced significant declines because they are readily displaced by brown trout and brook trout, and they hybridize with introduced rainbow trout (Behnke 2002). They are also sensitive to habitat disturbances and alterations (Behnke 2002). As a result, they are largely restricted to high-mountain streams (Young 2008) and in Colorado commonly occur upstream of barriers where they are isolated from other species.

Although the genetic distribution of the different lineages of cutthroat trout is still uncertain, greenback cutthroat trout are currently managed under the Greenback Cutthroat Trout Recovery Plan (USFWS 1998). Colorado River cutthroat trout are currently managed under the Colorado River Cutthroat Trout Conservation Strategy (CRCT Coordination Team 2006), which includes assessment and protection of existing populations, reestablishment of extirpated populations, and removal of potential stressors contributing to population declines.

Cutthroat trout can inhabit lakes and streams, but they require streams for successful spawning (Young 2008). Like other salmonids, cutthroat trout build redds or nests excavated in gravel by the female fish to incubate their eggs; they spawn at peak flows or on the descending limb of the hydrograph to prevent destruction of eggs by scouring floods (Young 2008). Spawning begins when water temperatures are between 7 and 10 degrees Celsius (°C), and is stimulated by increased day length in spring (Young 2008; Behnke 2002). Cutthroat trout become sexually mature between ages two and six, depending upon stream size and elevation, but males mature earlier than females. The average lifespan of this fish ranges from seven to 11 years (Young 2008). Cutthroat trout longer than 250 millimeters (mm) are rare (Behnke 2002). Cutthroat trout consume zooplankton, aquatic and terrestrial invertebrates, small fish, and other small vertebrates (Young 2008).

Sculpins

Paiute and mottled sculpins are native to the upper Colorado River Basin and both species are found in the Project area. Sculpins inhabit pools, runs, and riffles in streams (Quist et al. 2004). Although they tend to be habitat generalists, sculpin have a strong preference for unembedded cobble (Haro and Brusven 1994; Quist et al. 2004). Both species are considered coolwater fishes. In the Salt River Drainage of Wyoming, the average summer (July-August) temperature at sites supporting mottled sculpin was 12.9ºC (Quist et al. 2004). A study of 10 Michigan streams showed that sites supporting mottled sculpin had average summer temperatures ranging from 13º to 23ºC (Lessard and Hayes 2003). Mottled sculpin inhabit streams with average summer temperatures of approximately 16ºC

in Canada (Scott and Crossman 1973). The broad temperature tolerances of adult mottled sculpin are in contrast with the specific thermal requirements during the spawning season. Spring water temperatures of approximately 10ºC are required during spawning season (Scott and Crossman 1973).

Mottled sculpin spawn in April and May. A male establishes a single spawning site, a collection of cobbles with interstitial spaces, and females deposit their eggs in hemispherical masses on the ceiling of the space (Downhower et al. 1983). Males guard fertilized eggs until they hatch, and they guard the fry until absorption of yolk sacs; fry reach a swim-up stage 4-6 weeks after egg fertilization (Downhower et al. 1983). Mottled sculpin rely heavily on unembedded cobble for spawning success. A 1979 study found that overall reproductive success was directly proportional to the available spawning substrate (Downhower and Brown 1979).

The effects of altered flows on mottled sculpin in Colorado have not been quantitatively evaluated. However a study of streams on Michigan's lower Peninsula showed that mottled sculpin could be found in streams characterized by groundwater contributions at low flows and by flow stability (Zorn et al. 2002). The results of the 2002 study suggest that mottled sculpin can tolerate flow variability but are not generally found in "flashy" streams.

Brook Trout

Brook trout are native to the eastern United States (U.S.), but their range has been greatly expanded by stocking (Behnke 2002). This species is not native to the Project area. Brook trout were introduced to the western U.S. in 1872 (MacCrimmon and Campbell 1969). Brook trout inhabit streams and lakes, and they are the most commonly found species in small Rocky Mountain streams (Behnke 2002). Brook trout spawn in the fall. Like other salmonids, they construct redds, but they prefer spawning sites where groundwater upwelling occurs (Ficke et al. 2009). Brook trout in smaller streams typically live three to four years (Behnke 2002), but brook trout living at higher elevations or in larger bodies of water can live nine to 12 years (Behnke 2002; Ficke et al. 2009). Brook trout over 250 mm are rare in small montane streams (Behnke 2002). Sexual maturity occurs between ages two and five; fish living in low-temperature, high-elevation environments mature later than those in mid-elevation streams (Kennedy et al. 2003). Brook trout are opportunistic predators whose diet includes terrestrial and aquatic invertebrates, crustaceans, and mollusks and changes according to prey availability (Ficke et al. 2009).

Rainbow Trout

The native range of the rainbow trout is the Pacific Coast of North America and streams west of the Rocky Mountains; this range stretches from Baja California north to the Kuskokwim River in Alaska (Scott and Crossman 1973). This species is not native to the Project area, however, rainbow trout have been introduced worldwide and are common in Colorado (Bernstein and Montgomery 2008). They are one of the most common species of fish stocked by CPW in Colorado.

Rainbow trout inhabit small to moderately large streams with gravel substrates and riffle-pool morphology. They also inhabit lakes, but require streams for successful reproduction (Scott and Crossman 1973; Bernstein and Montgomery 2008). Rainbow trout spawn when water temperatures exceed 6-7°C, so timing is variable; in coastal areas,

spawning occurs in January or February, but in colder regions, it occurs as late as June (Behnke 2002). Fertilized eggs are buried in redds (Scott and Crossman 1973; Bernstein and Montgomery 2008). Female rainbow trout reach sexual maturity between two and six years of age, and an average adult length for resident stream rainbow trout is 12-18 inches (Behnke 2002; Bernstein and Montgomery 2008). Rainbow trout mainly consume drifting invertebrates, but larger individuals will also eat small fish, eggs, and an occasional rodent (Scott and Crossman 1973; Bernstein and Montgomery 2008).

3.11.1.3 Temperature

Temperature exceedances of coldwater standards in the Fraser River and some tributaries have the potential to harm coldwater fishes. Therefore, current knowledge of thermal tolerances of brown trout and rainbow trout, the two most common coldwater game fishes in the lower mainstem of the Fraser River, is summarized below. A combination of field and laboratory studies has determined optimal temperatures, lethal temperatures, and the effects of temperature on stress response and competitive ability.

Laboratory experiments on eight populations of brown trout from thermally diverse habitats in Norway and Sweden showed that optimal temperatures for growth were always below 20ºC and that growth ceased at 23ºC (Forseth et al. 2009). A 2007 field study highlighted the role of duration in determining lethal temperatures. Brown trout held in cages in Michigan and Wisconsin rivers could tolerate a mean daily temperature of 25.3ºC for one day and 21.0ºC over 63 days. Maximum daily temperatures tolerated were 27.6ºC for one day and 24.6ºC for 63 days (Wehrly et al. 2007).

Laboratory tests of rainbow trout temperature tolerance are extensive. Rainbow trout can survive at 25ºC, but they exhibit slow growth and depressed appetite. The optimal temperature for adult rainbow trout appears to be between 14ºC and 19ºC (Myrick and Cech 2000). Thermal tolerances of rainbow trout that were selectively bred to withstand higher temperatures for 14 generations were compared to those of a native California strain. The temperature that led to a 50 percent (%) mortality rate (LT50) at 96 hours was 25.8ºC and 24.3ºC, respectively (Ineno et al. 2005). A naturalized population of rainbow trout in the Firehole River in Wyoming regularly experiences summer water temperatures of 25ºC. However, laboratory tests showed that these fish did not have a significantly higher temperature tolerance than two strains of hatchery rainbow trout. The 7-day LT50 was approximately 26ºC for all three strains (Kaya 1978).

Although both brown trout and rainbow trout can tolerate temperatures of approximately 25ºC under laboratory conditions, temperatures approaching 20ºC may affect food demand, stress response, and disease susceptibility. Trout held at higher temperatures require more food than those held at lower temperatures. For example, the optimum temperature (i.e., where growth was greatest) for brown trout fed maximum rations was 14ºC, but brown trout fed 50% rations grew fastest at 10ºC (Elliot 1975a, 1975b). Similarly, food consumption rates of rainbow trout held at five temperatures between 10 and 25ºC were highest at 19ºC (Myrick and Cech 2000). Rainbow trout feeding rates are suppressed at 25ºC (Myrick and Cech 2000), and brown trout feeding rates are suppressed at 26ºC. This decrease in feeding, in combination with increased energy demands will result in eventual starvation (Kitchell et al. 1977).

A 2008 study demonstrated that temperatures below lethal limits can affect survival of trout in recreational catch-and-release fisheries. At water temperatures over 23ºC there was an increase of 16% and 4% in 72-hour mortality for rainbow and brown trout, respectively, compared to fish caught and released at 20ºC. Mortality of fish caught and released between 20ºC and 22.9ºC was 9% for rainbow trout and 0% for brown trout. No mortality was observed for either species for fish caught and released at temperatures below 20ºC (Boyd et al. 2010).

Laboratory and field experiments have shown that trout are generally more susceptible to infection as temperatures increase. Rainbow trout exposed to a bacterial pathogen show increased disease severity and shorter time to mortality at 20ºC than at 10ºC (Kocan et al. 2009). Infection severity and mortality rates in brown trout exposed to a number of bacterial diseases also increase over a similar range of temperatures (Jonsson and Jonsson 2009). Field experiments in the upper Colorado River have shown that the density and species richness of gill parasites found on juvenile rainbow trout and brown trout increase with low flows and high temperatures (Schisler et al. 1999). Field experiments have also demonstrated that the infection severity of whirling disease in rainbow trout is positively correlated with water temperature (Hiner and Moffitt 2001).

Coldwater fish that encounter high temperatures experience physiological stress that can increase the probability of angling or disease-related mortality. However, fish can avoid or reduce temperature-related stress through behavioral thermoregulation, or the selection of cooler areas of the stream. For example, coldwater fish avoid high summer water temperatures by utilizing cool tributaries or springs; this has been documented for rainbow trout, brown trout, and brook trout (Keefer et al. 2009; Meisner et al. 1988). Behavioral thermoregulation can be very effective: in a 2003 study in a New York river, body temperatures of brook and rainbow trout implanted with temperature-sensitive radiotransmitters were 4.0ºC and 2.3ºC lower than ambient water temperatures, respectively (Baird and Krueger 2003). Although behavioral thermoregulation allows fish to avoid stressful temperatures, it cannot eliminate the temperature dependence of food demand, stress responses, and competitive ability. Furthermore, cold water refuges can be rare in some streams. Therefore, in some years, seasonally high summer temperatures may be stressful to brown trout and rainbow trout that cannot find thermal refuges.

As a result of these studies, temperatures that are less than 19ºC can be considered optimal for rainbow and brown trout. Temperatures between 19ºC and 24ºC can be considered stressful because of studies demonstrating increased food demand and increases angling and disease-related mortality within this range. Temperatures above 24ºC are increasingly lethal if sustained for periods of hours to days. Long-term exposure (i.e., days to weeks) to stressful temperatures can increase mortality rates through the mechanisms discussed above. Although temperatures above 24ºC are potentially lethal, mortality resulting from occasional short-term exposure (i.e., minutes to hours) is not likely.

3.11.1.4 Flushing Flows

One important aspect of managed flow regimes is “flushing flows” (Poff et al. 1997) such as those recommended in Phase 3 of the Grand County Stream Management Plan (see Section 3.2.5.1). Flushing flows are periodic high flows that maintain the bottom substrate of streams (Whiting 2002; O’Neill and Kuhns 1994; Nelson et al. 1987). These flows can

remove fine sediments that decrease the spawning success of species such as trout which spawn in gravel and cobble substrates (Milhous 1998; Wu and Chou 2004). For the streams in the Project area, natural or managed flushing flows are necessary to remove fine sediment (silt and sand) from the coarser gravel, cobble, and boulder substrate typical of mountain streams in Colorado. Since the Project would reduce peak high flows during runoff in many of the study streams in the Project area, flushing flows are examined in detail.

Flow regime profoundly affects the aquatic biological community in streams (Albano 2006; Lytle and Poff 2004; McCarthy 2008; Poff and Allan 1995; Poff et al. 1997; Poff et al. 2007). Although minimum flow requirements and bypass agreements keep water in streams, they are often inadequate in maintaining ecological processes (Richter et al. 1997). Flow variability is essential to the function of aquatic systems—the duration, frequency, magnitude, timing, and rate of change of low flows and high flows are all essential in shaping aquatic communities (Poff et al. 1997). Aquatic and riparian communities are more likely to adjust to changes in flow regime if as many aspects of the flow regime are preserved as possible. For example, when reduced flows in a British Columbia river were managed to mimic a scaled-down version of the historic flow regime, recruitment of native riparian vegetation was greatly increased.

It is often difficult to determine the amount of flow needed to produce desired physical stream changes and their associated ecological benefits (Kondolf and Wilcock 1996). Flushing flows are most often identified for channel maintenance, but the recommended flow and duration will vary depending upon the methods used to calculate them, and each method contains considerable uncertainty (Kondolf et al. 1987). Channel maintenance also contains multiple, potentially conflicting goals. For example, flows that result in the removal of fine sediments from riffles and pools often result in loss of spawning gravels (Kondolf and Wilcock 1996; Wu and Chou 2004) and can result in short-term reductions in habitat availability for some species and life stages. Therefore, the need for flushing flows must be determined before they are prescribed (Simons and Simons 1997), and the identified flows must be determined through careful analysis and subsequent validation. For example, Rocky Mountain streams are often supply-limited in terms of fine sediment availability (Schmidt and Potyondy 2004) and sediment does not tend to accumulate, so typical high flows (i.e., the historic peak flow) may not be necessary in all years to remove fine sediment from gravel or cobble substrate. Both the beneficial and detrimental effects of flushing flows were evaluated in the characterization of the Current Conditions and the evaluation of environmental effects based on information from the Channel Morphology sections of this EIS (Sections 3.3, 4.6.3, and 5.3).

High flows during runoff can result in low habitat availability for fish and macroinvertebrates. Based on the results of the PHABSIM for fish in the streams in the Project area for brook, brown, and rainbow trout, normal high runoff flows in average years in all of the reaches examined in more detail in the upper Colorado River Basin are substantially higher than optimum flows. In most cases, runoff flows in average years result in approximately 50% lower habitat availability than the more moderate flows at other times of the year. In wet years, peak runoff flows may result in a small fraction of the habitat available at optimum flows.

High flows can also be a disturbance that reduces populations of fish and invertebrates. These disturbances can cause the displacement of aquatic fauna (Poff 1992), especially small or young fish (Wesche 1991), and stress trout populations in Colorado (Milhous 2007). The abundance of young fish is inversely correlated to the magnitude of peak snowmelt flows in some streams in Colorado (Latterell et al. 1998), the western U.S. (Chadwick et al. 2004; Nehring and Anderson 1993; Seegrist and Gard 1972), and other areas (Cattanéo et al. 2002; Grossman et al. 1998)—high flow years are often characterized by low recruitment. However, trout have behavioral mechanisms that allow them to weather high flows. Although high flows can scour gravel and destroy redds, trout fry are only vulnerable to displacement from high flows for a few days after emergence (Ficke et al. 2009).

Invertebrate abundance can also be inversely related to high flows (Robinson et al. 2003; Jakob et al. 2003). However, these high flows can also result in increased species richness (Rader et al. 2008) and increased richness of EPT taxa (McCarthy 2008). Also, macroinvertebrates can recolonize flood-affected areas rapidly enough to suggest the presence of behavioral traits that allow them to weather flow-related disturbances (Robinson et al. 2004). For example, the hyporheic zone below the stream bottom can provide a refuge from high flows (Ward 1989).

Aquatic organisms are adapted to predictable, low-intensity disturbances such as seasonal high and low flows. These disturbances can increase the seasonal variability in fish and macroinvertebrate abundance, but they do not have the catastrophic effects of major floods or forest fires (Bilby et al. 2003). Furthermore, transport rates of nutrients and materials are dependent upon flow regimes (Dodds 2002; Stewardson and Gippel 2003). Thus, despite the fact that they are stressful to fish and macroinvertebrates, high seasonal flows may maintain stream productivity over the long term. However, the effects of flow alteration on stream productivity are not well-quantified (Freeman et al. 2007; Poff and Zimmerman 2010). In the absence of a method for modeling the effects of flow alteration on stream productivity, fish and macroinvertebrate abundances can be used as a surrogate for stream productivity to some extent. Potential effects of altered flows on stream productivity were qualitatively examined in the evaluation of environmental effects of the Project in Section 5.11.

3.11.1.5 Tipping Points

Although the concept of an ecological “tipping point” or the point beyond which environmental change will lead to non-linear and potentially irreversible effects is intuitive, it is difficult to define. Tipping points have been studied in semi-arid rangelands and in shallow lakes, but these dramatic assemblage shifts are most commonly identified only after they have occurred (Strange 2007). There are likely multiple tipping points for different aspects and processes for a stream. The replacement of native cutthroat trout with nonnative salmonids represents a “tipping point” that has already occurred in the majority of the stream sections in the Project area. The introduction of brook trout, brown trout, and rainbow trout and of eastern slope sucker species to the western slope within the Project area predate quantitative fish survey data—no “baseline” or “pre-introduction” data exist for this system to judge the extent of the change although it is obvious that the point has

been crossed. Also, the incidence of whirling disease has caused the collapse of the rainbow trout fishery in many areas of Colorado and represents another tipping point.

Dramatic changes to the biota in the Project area and streams going past the tipping point is a possibility for this Project, given the existing and proposed alterations to the flow regime. However, the discussion of potential flow-mediated tipping points in the Project area is complicated by several factors. Trout populations experience multiple environmental stresses including winter habitat limitations (Harig and Fausch 2002; Chisolm et al. 1987), high spring runoff flows (Nehring and Anderson 1993; Latterell et al. 1998), food limitation, and high temperatures at base flows (Meisner et al. 1988). Trout populations have adapted to these stressors in natural and altered streams, and they continue to persist in the Project area. Determining a tipping point for a single factor, such as peak flow diversion, does not take into account the other relevant factors.

Unfortunately, pre-diversion data are unavailable for streams in the Project area, so estimates of the population-level effects of current water diversions cannot be calculated for the Project area. Also, natural populations exhibit large variations in density over time (Hilborn et al. 2003). Fish readily recolonize stream sections defaunated by floods or desiccation when conditions return to a more favorable state (Roghair and Doloff 2005, brook trout). Macroinvertebrates readily recolonize empty stream habitat. There are four primary colonization methods: drift from upstream sources, upstream migration, aerial dispersal of egg-laying adults, and migration up from the hyporheic zone (Williams and Hynes 1976). Large, long-term datasets are needed to quantitatively identify temporal trends (Collins et al. 2000). Most of the streams in the Project area lack sufficient data to detect trends in fish density. However, a qualitative trend assessment was made for streams in the Project area as described in Section 5.11.

Recent studies of macroinvertebrate response to flow regime change have produced equivocal results. This was also reported by Dewson et al. (2007) and Poff and Zimmerman (2010), which reviewed literature reports of quantitative responses of macroinvertebrate abundance and diversity in response to alteration of four flow metrics: mean annual flow, annual peak flow, annual base flow, and short-term (i.e., hourly) flow. Their reviews found that macroinvertebrate abundance and diversity generally declined in response to alteration of one of these flow metrics, but that there were also increases in abundance and diversity, even at severe (i.e., greater than 70%) changes to another metric. Poff and Zimmerman (2010) also indicated that it was not possible to extract any robust statistical relationships between the size of the flow alteration and changes in the invertebrate assemblage, nor could they identify ecological thresholds, due to the lack of data where changes in these four flow metrics were less than 50%.

Recently, Walters (2011) studied macroinvertebrate assemblages upstream and downstream of experimentally diverted streams in Connecticut. Walter's study showed that community traits and number of species did not change as expected in response to reduced flows. For invertebrates with the most expected traits (e.g., desiccation resistance and burrowing habit), the natural seasonal change was larger than the changes observed as a result of diversion of 40% to 80% of stream flow.

A study in the St. Louis Creek watershed also showed that macroinvertebrate density and richness was not reduced until nearly 100% of the water was removed from the stream

(Rader and Belish 1999). Likewise, Albano (2006) used a site on St. Louis Creek among 13 other streams in an analysis of flow reduction at existing diversions on the invertebrate community. This study found that although density in diverted streams increased, overall abundance only increased in approximately half of the study streams, due to the loss in available habitat area. Community shifts, such as the loss of some rheophilic species, varied by season and were more pronounced when diversions exceeded 90%.

McCarthy (2008) studied recovery of several streams downstream of diversions in the Fraser River watershed, finding that most invertebrate metrics (compositional and functional) responded positively to increased flow downstream of the diversions as flow accumulated due to groundwater, tributary, or wetland inputs. Streams that McCarthy (2008) studied, however, were those that were nearly 100% diverted, and sustained flow recovery was evident in all sampled streams within 0.4 kilometer (km) of the diversion. The results of that study indicated that recovery of benthic macroinvertebrate communities is related to increased flow from zero flow just downstream of the diversions, but did not address the quantitative response of the benthic macroinvertebrate communities to incremental decreases in flow. However, some tributaries may not recover substantial groundwater flow downstream of the diversion and are dry or nearly dry until the confluence with the next major tributary downstream.

In general, the amount and diversity of macroinvertebrate habitat is reduced, temperature and fine sediments may increase, and water quality may change with water diversion (Dewson et al. 2007; Albano 2006). However, the quantitative relationships between flow alteration and macroinvertebrate community response remain difficult to characterize.

Studies of these small streams in the Fraser River Basin also suggest that EPT taxa are sensitive to water diversion (Albano 2006; McCarthy 2008; Rader and Belish 1999) and that increasing the proportion of the flow that is removed from a stream increases the risk of eliminating rheophilic (species that prefer or need faster currents) including a wide range of stoneflies, mayflies, caddisflies, and true flies, such as Simuliidae, Perlodidae, Rhyacophilidae, *Doddsia*, *Baetis*, *Drunella*, *Epeorus*, *Rhithrogena*, and *Neothremma* (Albano 2006; McCarthy 2008; Rader and Belish 1999). However, there is considerable uncertainty associated with using these results to construct general conclusions about the effects of flow diversion on EPT taxa richness. The studies above found few statistically significant relationships between flows and EPT metrics, even though they focused on small streams where nearly 100% of flow was diverted for multiple months. Also, the effects of "mild" diversion (not diverted 100%) on the macroinvertebrate assemblage in one study stream appeared to be negligible (Rader and Belish 1999). A conclusion that can be reached from analysis of these studies plus the many others on recolonization of streams that have undergone either total drying or extensively scouring flash floods (e.g., Williams and Hynes 1976; Williams 1977, 2001; Fisher et al. 1982; Molles 1985; Lytle 2000; AWWQRP 2006; Bogan et al. 2013; De Jong and Canton 2013) is that the macroinvertebrate communities opportunistically colonize headwater streams to persist in whatever habitat is afforded them, and that they are extremely resilient, so that when flows do return, even if small, they are still able to colonize the streams.

Some of the aquatic biological resources within the Project area may be near, at, or past ecological thresholds; however, such ecological thresholds have not been empirically determined for any of the stream segments within the Project area, and it is likely that each

stream will have its own threshold level. Each stream segment was evaluated to determine if the proposed flow changes would cause the segment to cross a flow-based threshold. If flow-based thresholds were crossed, there was greater likelihood that an ecological "tipping point" may have been crossed as well. This indicator was consistently used in the description of the affected environment for aquatic biological resources (Section 3.11) and in the impacts analyses for aquatic biological resources (Sections 4.6.11 and 5.11).

The methods used to determine the ecological condition of individual streams as a function of flow were based loosely on the flow node Ecological Limits of Hydrologic Alteration framework (Poff et al. 2010). Flow data were used to evaluate the percent reduction in peak flows as one aspect to evaluate whether a tipping point had been crossed. Fish are adapted to their native flow regimes, and fish assemblages are often shaped by the amount of hydrologic variability in a system (Poff and Allan 1995). Given the uncertainties associated with stream community responses to flow alteration, published relationships were used to determine whether ecological tipping points had been crossed or were imminent in individual study streams.

Two flow-based thresholds were used. The first was based on the 2010 study by Carlisle et al., where the risk of fish community impairment increased after a 60% reduction in maximum flows. However, there was considerable variability among the individual streams. This threshold is noted throughout the aquatic biological resource sections of this EIS because historic flow data were available for some streams in the Project area.

The second flow-based threshold was based on the 1995 study by Baran et al. This study showed that a 60% reduction in average annual weighted useable area produced threshold effects on fish populations (Baran et al. 1995). However, the relationships between flow changes, habitat availability changes, and changes in fish populations are complex, and a 60% reduction in average annual flows does not necessarily create an equivalent reduction in habitat. Because this study showed the effects of a 60% reduction in a measure of average annual available habitat, not a 60% reduction in average annual flows, the use of this threshold assumes a 1:1 relationship between percent flow change and percent habitat loss. Because this is most often not the case, this threshold is conservative.

Both thresholds were used because Project effects could result in one or both of these thresholds being crossed. Under the Ecological Limits of Hydrologic Alteration (ELOHA) concept, crossing both of these thresholds would result in increased risk of a stream segment crossing an ecological tipping point. The possibility of these thresholds points being crossed was considered in the effects analysis and the estimation of impact type and intensity. A determination of crossing an ecological tipping point was made using the available ecological information as well as the flow information.

Fish data from the individual streams in the Project area were compared to a regional range of densities to evaluate historical changes to determine whether the individual streams had crossed an ecological tipping point. Average densities and ranges of density from the available data were compared to published density values from Platts and McHenry (1988) for streams outside of the upper Colorado River drainage. Upper Colorado River drainage values for streams in Platts and McHenry (1988) were excluded from this analysis because pre-diversion data are not available for these streams. Therefore, a reference condition was established using streams in other areas.

With the Platts and McHenry (1988) data and based on past experience, there apparently is a pattern of higher fish density in small streams and generally lower density in larger streams and rivers. Using density and width data from 17 streams in Colorado at sites between 6,000 feet and 9,500 feet, similar to the elevations of streams in the study area, there was a correlation with lower density at wider stream sites. Further analysis indicated that stream sites with widths of 10 meters or more tended to have lower density and sites narrower than 10 meters tended to have higher density. Therefore, separate ranges of density were calculated for stream sites greater than and less than approximately 10 meters.

Median densities of trout were calculated for small unimpacted Rocky Mountain streams by using the data in Platts and McHenry (1988). For larger streams, data from 248 sampling events on 78 sites from 13 Colorado streams was used. Because variability in average density estimates spanned two orders of magnitude, both the medians and ranges of variability were compared between these estimates of reference condition and the data from the Project area. For small streams less than 10 meters in width, median fish density was 1,700 fish per hectare (fish/ha) with a 25th percentile of 700 fish/ha and a 75th percentile of 3,500 fish/ha. This includes most streams in the Project area. For larger streams greater than 10 meters in width, median fish density was 668 fish/ha, with a 25th percentile of 382 fish/ha and a 75th percentile of 980 fish/ha. This includes the Colorado River and the Blue River in the Project area. Platts and McHenry (1988) also report mean biomass in Rocky Mountain streams of 77 kilograms per hectare (kg/ha). Benthic macroinvertebrate data were also considered qualitatively in the EIS. Classifications were assigned to the small tributary streams in the Project area as described below.

- **Healthy, not past the tipping point:** The fish data ranges in all years fall between the 25th and 75th percentiles of density estimates of Platts and McHenry (1988) or for larger streams. The mean density estimates are greater than or equal to 50th percentile estimates of Platts and McHenry at least 50% of the time. The macroinvertebrate data indicate the presence of a healthy community.
- **Sustaining, not past the tipping point:** The fish data ranges fall between the 25th and 75th percentiles of density estimates in more than half of the years. The mean density estimates are greater than or equal to the 50th percentile estimates 25% to 50% of the time. Macroinvertebrate data indicate the presence of a healthy community. The term "sustaining" refers to a population that is not as robust as a healthy population but has adjusted to existing disturbances and exhibits no upward or downward density trends.
- **Near collapse, near a tipping point:** The fish data ranges fall between the 25th and 75th percentiles of density estimates of Platts and McHenry in less than half of the years. The mean density estimates are greater than or equal to the 50th percentile estimates of Platts and McHenry less than 25% of the time. The macroinvertebrate data indicate a community that is degraded to some extent. There are no natural circumstances, such as naturally intermittent flows or unsuitable small stream size that would preclude the presence of fish. For example, trout are unlikely to overwinter successfully in streams with wetted widths of 1 meter or less with few deep pools (Harig and Fausch 2002).
- **Collapsed, past a tipping point:** Few to no fish present and degraded macroinvertebrate communities. The exception to this would occur in the case of extremely small streams that may not support fish year-round, even if water were not diverted.

In the absence of published relationships or sufficient density data, professional judgment was used to generate the best estimate of Current Conditions. The assessment of individual streams was based on the assumption that current water management practices would continue.

3.11.1.6 Mercury in Fish Tissue

Mercury bioaccumulation by fish is a concern in reservoirs in Colorado. Many reservoirs in Colorado have consumption advisories based on fish with high levels of mercury including Cheesman Reservoir, Carter Lake, and Horsetooth Reservoir near the Project area. Gross Reservoir has no consumption advisory although initial testing in fish resulted in some samples with elevated levels of mercury and it is on the Monitoring and Evaluation List for Aquatic Life Use due to mercury in fish tissue (see Section 3.2.1.1).

A concern in Gross Reservoir enlargement is the resulting incorporation of bioavailable mercury into the food web. The environmental fate of mercury in lakes is complex (Mast and Krabbenhoft 2010), and the amount of mercury that ultimately accumulates in fish tissue depends on a number of factors such as reservoir productivity, pH, fish diet and growth rate, temperature, watershed-to-basin area ratio, and dissolved organic carbon (Mailman et al. 2006). As a result, the amount of mercury in fish tissue is ecosystem-specific (EPA 2010g) and it depends heavily on the factors described below.

Fish life histories are important in determining how much mercury is incorporated into the food web. Because most mercury in fish tissue comes from the food web (EPA 2010g; Hrenchuk et al. 1999), the diet of the predatory fish is important (e.g., Burgess and Hobson 2006), and fish that prey on items lower in the food web may have lower body burdens (Goodchild and Gerstenberger 2011). Slow growth rates and exposure to high levels of dietary mercury lead to high tissue concentrations of mercury (Brinkmann and Rasmussen 2010). For example, a 2012 study of two Colorado East Slope reservoirs found that female walleye consumed stocked rainbow trout, as well as fish prey produced in the lake, whereas male walleye only consumed prey produced in the lake. As a result, females had lower levels of mercury in their muscle tissue (Lepak et al. 2012).

The inundation of terrestrial vegetation, whether by the creation of a new reservoir or the enlargement of an existing one, invariably results in increased body burdens of mercury in fish (Hecky et al. 1991; Mailman et al. 2006; Goodchild and Gerstenberger 2011). This is exacerbated if large areas of warm, shallow water are created (Mailman et al. 2006) or if the flooded vegetation contain large amounts of material (e.g., peatlands or wetlands) (Brinkmann and Rasmussen 2010; St. Louis et al. 2004). Upon reservoir enlargement, a spike in fish tissue methylmercury (MeHg) concentrations occurs shortly after construction and can take decades to attenuate (Brinkmann and Rasmussen 2010; Weiner et al. 2003).

Water level fluctuations can also increase MeHg formation (Selch et al. 2009; Sorensen et al. 2005; St. Louis et al. 2004), particularly in reservoirs with gently sloping sides due to the large surface area of the exposed lake bottom zone at low water (Mast and Krabbenhoft 2010). While hypolimnetic discharge can remove some mercury from reservoirs, they can also cause contamination of downstream areas (Brinkmann and Rasmussen 2010).

MeHg can be formed as a byproduct of the metabolism of sulfate-reducing bacteria; because these organisms are anaerobic, anoxic conditions in the hypolimnion can increase MeHg levels (Mast and Krabbenhoft 2010; Weiner et al. 2003). The amount of sulfate available in the system is also important, likely because it stimulates methylation by sulfate-reducing bacteria (Sorensen et al. 2005; Weiner et al. 2003).

3.11.1.7 Nuisance Species

Whirling Disease

Several nuisance species have raised concerns in the Project area. These species are described briefly below and the impacts of the Project and its alternatives are evaluated in Section 5.11.

Whirling disease was introduced to Colorado in 1987 and has spread throughout the State of Colorado (Nehring et al. 2003; CDOW 2007a). The causative agent of whirling disease (*Myxobolus cerebralis*), requires Tubifex worms (*Tubifex tubifex*) to complete its life cycle (Markiw and Wolf 1983). Tubifex worms lives in fine sediments in the bottoms of streams and lakes, and fine sediment is crucial in the production of triactinomyxons (TAMs), the infective form of *M. cerebralis* (Nehring 2006). Because increasing Tubifex worm habitat can increase the incidence and severity of whirling disease (Hallett and Bartholomew 2008), conditions that result in more sedimentation may result in an adverse impact.

Unlike brown trout, which can carry and expel viable myxospores (Nehring et al. 2002), many North American salmonids have little to no resistance to whirling disease (Gilbert and Granath 2003). In a 1999 study, 85 to 89% of brook trout, rainbow trout, and Colorado River cutthroat trout fry held in net pens in the Colorado River in Middle Park died within four weeks (Thompson et al. 1999). This explains the low abundances of rainbow trout in the Colorado River in recent samples, and it has implications for naturalized brook trout and native cutthroat trout populations in the Project area. The timing of brook trout emergence, which is earlier in the spring than for other trout species, may partially protect them from the disease—population-level effects of the disease are partially related to timing of emergence in relation to seasonal densities of TAMs (TAMs, the phase of the *M. cerebralis* life cycle that attacks trout, Pierce et al. 2009). Rainbow trout and cutthroat trout emergence later in the spring tends to coincide with high levels of TAM production.

Whirling disease has profoundly affected the salmonid populations in the Colorado River Basin and other areas of Colorado by eliminating natural reproduction of rainbow trout. Large die-offs of young rainbow trout were first observed in 1993 and 1994, and by 2000, the naturalized rainbow trout population in the Colorado River was near collapse (Nehring 2006). However, brown trout populations remained largely unaffected (Nehring 2006).

Research to recover Colorado's rainbow trout fishery continues. The Hofer rainbow trout, a whirling disease-resistant, highly domesticated strain of rainbow trout from Germany, has been bred with Colorado River rainbow trout, the naturalized strain present in Colorado; offspring of the two strains show decreased mortality and infection when exposed to whirling disease (Schisler et al. 2006). Current research involves selective breeding to balance the whirling disease resistance of the German strain of rainbow trout with the Colorado River rainbow trout's ability to survive well in the wild in Colorado.

All watersheds within the Project area have tested positive for whirling disease, although particular streams within these watersheds may still be negative (CDOW 2007a). Whirling disease is already present throughout the Project area where conditions are good for sustaining this parasite, especially the cool water temperatures normally found in the streams which are near optimum condition for the parasite (Nehring and Thompson 2001). Windy Gap Reservoir, with its high proportion of fine sediments, has been a major source of TAMs to downstream reaches of the Colorado River (Nehring 2006). However, TAM production from Windy Gap has been variable over time due to changes in the dominant lineage of Tubifex worms in the reservoir. Some genetic lineages of Tubifex worms are less susceptible to infection by myxospores and therefore inhibit TAM production. Population-level effects of the disease in fish are reduced in Colorado streams that have a predominance of the resistant lineage of Tubifex worms (Beauchamp et al. 2005).

There is also evidence that the parasite is inhibited at water temperatures above 20ºC (Blazer et al. 2003; Nehring and Thompson 2001). Therefore, conditions that result in elevated temperatures above 20ºC may have a beneficial impact on the incidence of whirling disease. However, higher temperatures also tend to increase the infection severity of whirling disease.

New Zealand Mud Snails

New Zealand mud snails were found in Colorado in 2004 (USGS 2011). Although the ecological consequences of New Zealand mud snail introductions are poorly understood, this species may inhibit substrate colonization by native macroinvertebrates (Kerans et al. 2005). New Zealand mud snails also appear to be a lower-quality prey than native macroinvertebrates. Rainbow trout fed New Zealand mud snails in a laboratory experiment grew poorly, and 54% of the ingested New Zealand mud snails passed through the gut without being digested (i.e., trout were defecating live snails, Vinson and Baker 2008).

New Zealand mud snails have been found downstream of the Project area in Boulder Creek. However, it is highly unlikely that they would be able to access the Project area. New Zealand mud snails survive poorly at elevations above about 1,500 meters (5,000 feet, reviewed in Stockton 2011), the current upstream edge of their range in Boulder Creek. Although increased stream flows can stimulate upstream movement of New Zealand mud snails, water velocities greater than 1 meter per second severely inhibit survival (Stockton 2011). Furthermore, laboratory experiments showed that crawling distances of New Zealand mud snails may decrease when velocities increase from 0 to 0.33 meter per second (Hoyer 2011). The upstream movement of New Zealand mud snails through fish movements is also unlikely—despite ongoing mitigation efforts by the City of Boulder, South Boulder Creek is still fragmented by barriers to upstream fish movements such as agricultural diversions and by the dam at Gross Reservoir. New Zealand mud snails also occur in Eleven Mile Canyon and the Charlie Meyer State Wildlife Area in the upper South Platte River in the Project area. The snails spread by passive means, such as attaching to boots, fishing equipment, animals, etc.

Zebra and Quagga Mussels

Zebra mussels were first found in North America (in the Great Lakes) in the mid-1980s (Carlton 2008), but they were not introduced into the western U.S. until the mid-2000s (Stokstad 2007). Both of these species can form dense colonies of up to 700,000 individuals per square meter (Stokstad 2007). Because these filter-feeding organisms consume zooplankton, high densities of either or both species can dramatically affect the nutrient load, planktonic community, and water clarity of lake environments (WRPANS 2009; Strayer 2009). Zebra mussels have also been collected in streams, where they can outcompete native mussels (e.g., Martel et al. 2001).

Quagga mussel veligers were found in the upper Colorado River Basin in Grand Lake, Shadow Mountain Reservoir, Granby Reservoir, and Willow Creek Reservoir in 2008, and zebra mussel veligers were found in Grand Lake in 2008. However, neither species was found after intensive sampling in 2009 or 2010 (Brown 2011). It is possible that the water chemistry in the area prevents survival of veligers, which require much higher calcium levels than are found in any of these lakes. However, because their primary means of introduction into new waters in the western U.S. is by transfer of boats from one body of water to another (WRPANS 2009; Strayer 2009), future accidental introduction of these species is possible. Risk of further introduction of these mollusks has been reduced by monitoring and decontamination stations at boat ramps throughout the State of Colorado (Brown 2011).

Didymo

Didymo or "rock snot" (*Didymosphenia geminata*) is an invasive species of algae that has recently become a nuisance in Colorado and in the Project area (Kumar et al. 2009). This stalked diatom that can form thick, blooms that can affect the ecological function and aesthetic appeal of rivers (Spaulding and Elwell 2007). Several studies have documented the response of macroinvertebrate communities to didymo blooms, but the effects on higher trophic levels (i.e., fish communities) have not been intensively studied. Macroinvertebrate community changes may include increases in oligochaetes and chironomids and decreases in EPT taxa (Gillis and Chalifour 2009; Kilroy et al. 2009). However, species richness response was varied between and within studies, suggesting that macroinvertebrate community response to didymo blooms is complex (Gillis and Chalifour 2009; Kilroy et al. 2009; Spaulding and Elwell 2007).

A study of didymo in two rivers in Alberta showed that it prefers oligotrophic conditions and increases in response to stabilized flows typical of regulated rivers (Kirkwood et al. 2007). A study of six Alberta rivers compared periphyton communities between paired upstream reference sites and sites below dams. Despite high seasonal and interannual variability, didymo cell density was higher and nuisance blooms were more frequent downstream of dams. Mean discharge and didymo presence were negatively related (Kirkwood et al. 2007), probably because scouring flows that move cobbles are required to dislodge the dense stalks that alter stream ecology (Miller et al. 2009; Larned et al. 2006). Didymo apparently prefers cool temperatures and moderate to fast waters with relatively high base flows during the low flow part of the year (Kumar et al. 2009). Reduced flows or higher temperatures may discourage didymo.

3.11.2 Reservoirs

3.11.2.1 Gross Reservoir, Forsythe Canyon, and Winiger Gulch

Gross Reservoir is located on the mainstem of South Boulder Creek, approximately 22 miles (34.7 km) upstream of the confluence with Boulder Creek. Forsythe Canyon and Winiger Gulch are two small tributary streams to Gross Reservoir and portions of these streams would be inundated with an expanded reservoir.

Habitat

Gross Reservoir is a steep-sided reservoir, with limited shallow-water areas near the shoreline. At bankfull (surface elevation of 7,282 feet), the depth of the reservoir is approximately 330 feet, with a surface area of 169 hectares (418 acres) (Miller Ecological Consultants, Inc. 1997). The elevation of the reservoir fluctuates approximately 48 feet within a year as drawdowns use stored water. The deep water, small size, and seasonal fluctuation limit the available habitat for aquatic biological resources in Gross Reservoir (Miller Ecological Consultants, Inc. 1997).

Gross Reservoir is classified as Aquatic Life Cold 2 for aquatic life uses (refer to Section 3.2). It has moderate water clarity, low to moderate levels of chlorophyll *a*, and meets CDPHE WQCD standards for temperature, dissolved oxygen, and pH (refer to Section 3.2). Gross Reservoir is on Colorado's Monitoring and Evaluation List for aquatic life use because of elevated levels of mercury in fish tissue, like many other Front Range reservoirs in Colorado.

Fish

CPW commonly sampled Gross Reservoir with experimental gill nets which have a variety of mesh sizes and collected fish over a wide range of sizes. This is a typical sampling method for reservoirs in Colorado that is adequate to collect the variety of species that are present. Gill net data collected in 1982 through 1996 revealed a diverse fish community present in Gross Reservoir (Table 3.11-3). Twelve species and two hybrid varieties have been collected over this period including both coldwater and warmwater fishes. CPW stocks the reservoir annually with a variety of species. Rainbow trout and splake are stocked nearly every year. Kokanee salmon were stocked in 2001, 2003, and 2004. Greenback cutthroat trout were stocked in 2002 and 2004, and cutthroat/rainbow trout hybrids were stocked in 2003 and 2004. All of the stocked fish were small, usually less than 4 inches.

Longnose and white suckers and rainbow trout have dominated the gill net catch, with the three species combined consistently averaging over 70% of the total catch. Other fish species comprised smaller proportions of the fish community (Table 3.11-3).

Table 3.11-3
Gross Reservoir Fish Population Data, Percent of Total Catch (1982 to 2010)

Species	1982-1983	1986-1987	1989-1992	1994-1995	1996	2000	2007	2008	2010
Brook trout	<1%	0%	0%	0%	0%	0%	0%	1%	0%
Brown trout	<1%	<1%	<1%	<1%	0%	1%	2%	4%	4%
Black Bullhead	<1%	0%	0%	0%	0%	0%	0%	0%	0%
Channel Catfish	0%	0%	1%	0%	0%	0%	0%	0%	0%
Cutthroat trout	0%	0%	0%	<1%	3%	0%	0%	0%	0%
Kokanee salmon	3%	16.5%	<1%	1%	0%	0%	0%	0%	3%
Lake trout	3.5%	1.5%	1%	12.5%	6%	11%	2%	1%	3%
Longnose dace	<1%	0%	0%	0%	0%	5%	0%	0%	0%
Longnose sucker	44.5%	47%	36.5%	11%	14%	3%	26%	33%	37%
Rainbow trout	6%	1%	9%	13.5%	29%	18%	10%	23%	20%
Snake River cutthroat trout	0%	0%	0%	0%	0%	0%	0%	0%	3%
Splake	0%	0%	0%	0%	<1%	0%	27%	5%	1%
Tiger muskie	0%	0%	4.5%	14%	4%	0%	1%	1%	0%
White sucker	41%	33.5%	47%	47.5%	44%	62%	32%	32%	29%

Source: Chadwick and Associates, 1986; Miller Ecological Consultants, 1997; CDOW, 2011b.
Notes:
< = less than
% = percent

Lake trout, longnose sucker, and white sucker probably maintain self-sustaining, naturally reproducing populations in Gross Reservoir. Several species were represented by only a few individuals and are not maintained in the reservoir by natural reproduction or stocking by CPW. Only a few brook and brown trout have been collected and probably migrated downstream into the reservoir from stream populations in South Boulder Creek and tributaries to the reservoir. Likewise, one longnose dace was present in only two years. This species prefers stream habitat but can occasionally be found in lakes. Black bullheads and channel catfish are normally found only in warm waters and the presence in Gross Reservoir of a single fish of each of these two species only in one year was probably the result of an illegal introduction. The diverse fish community and the suitability for sustaining stocked fish over the years indicate that Gross Reservoir is currently supporting a healthy fishery and has not reached a tipping point.

Fish surveys were conducted in the two inlet streams to Gross Reservoir, Forsythe Canyon and Winiger Gulch. Forsythe Canyon was sampled in 1985 and 2010, and fish were absent. Forsythe Canyon is likely too small with insufficient flow to support fish. During sampling in 2010, there was just a trickle of water with some dry sections between pools. There is also a waterfall approximately 150 feet upstream of the reservoir that would prevent fish from moving from the reservoir past this point on the stream. Winiger Gulch is also a small stream but apparently has more permanent flow and can support fish. Winiger Gulch was also sampled in 1985 and 2010, and brook trout, brown trout, and rainbow trout were present in both years. Total fish density was estimated to be 3,647 fish/ha in 1985 and 2,200 fish/ha in 2010. In 1985, most of the fish were small, either young-of-the-year (YOY) or juvenile fish, and in 2010 all fish were YOY. All three species inhabit Gross

Reservoir and likely Winiger Gulch is used for spawning and rearing young fish for the reservoir populations of these species. Five other tributaries enter Gross Reservoir, but they are ephemeral and dry for much of the year and do not support fish.

Benthic Macroinvertebrates

Sampling data for Gross Reservoir are not available. However, the Rocky Mountain capshell snail (*Acroloxus coloradensis*) is a species of limpet that has isolated populations in the United States and Canada (Anderson 2005). Currently this species is only known from one location in Montana and six locations in Colorado, specifically the Routt and Roosevelt National Forests, Rocky Mountain National Park, and one private lake in Boulder County (Riebesell et al. 2001). This mollusk is likely not present in Gross Reservoir. The Rocky Mountain capshell snail is designated as a species of concern by CPW.

Much of the basic ecology of the species is unknown (Anderson 2005). Rocky Mountain capshell snail habitat preferences include cold mountain streams, but this species has also been found in slow-moving streams in Canada. This species is not found above 9,394 feet. Rocky Mountain capshell snails tend to prefer high water calcium concentrations and high conductivity (Riebesell et al. 2001). A study of several lakes in British Columbia showed that the Rocky Mountain capshell snail inhabits a variety of substrates, including woody debris, rocks, decaying cattail leaves, and submerged leaf packs (Lee and Ackerman 2000).

3.11.2.2 Leyden Gulch Reservoir Site

The proposed Leyden Gulch Reservoir would inundate portions of Leyden Gulch upstream of SH 93. Leyden Creek is an ephemeral stream in this section and apparently only has water after precipitation events. During field studies conducted in August 2005, the channel was dry and overgrown with terrestrial vegetation. There was no aquatic life present. Leyden Gulch is classified as Aquatic Life Warm Class 2 (refer to Section 3.2).

A short, south branch of Leyden Gulch contains a spring pool near the railroad tracks. This spring allowed a trickle of water to flow in the channel for less than 50 feet downstream of the spring. These areas provide no habitat for fish, although a limited community of benthic invertebrates is probably present within the spring.

The proposed outlet pipe from the proposed Leyden Gulch Reservoir would cross under Ralston Creek to connect to Conduits 16 and 22. Based on sampling in 1990, Ralston Creek contains three species of fish (creek chub, longnose dace, and longnose sucker) with total density up to 1,935 fish/ha. Benthic macroinvertebrates are represented by up to 46 taxa at total densities ranging from 3,054 to 5,403 individuals/m^2 (Chadwick and Associates 1991).

3.11.3 Conveyance Systems

3.11.3.1 Conduit M

Conduit M crosses the following streams going from west to east:

- Little Dry Creek – three crossings

- Clear Creek and its tributary
- South Platte River

Little Dry Creek, Clear Creek, and the South Platte River near the crossings contain communities of warmwater fish and invertebrates. The tributary to Clear Creek is a small stream that periodically may be dry. This stream may support a very limited community of warmwater fish and invertebrates.

3.11.3.2 Conduit O

The first 9 miles of Conduit O (from west to east) overlaps with the Conduit M corridor. Refer to Section 3.11.3.1 for a discussion regarding those streams. The stream crossings that are unique to Conduit O (not shared with Conduit M) include:

- Tributary to Little Dry Creek
- Tributary to Niver Creek

These two small streams probably support limited communities of warmwater fish and invertebrates. Conduit O also crosses the South Platte River similar to Conduit M, but in a different location.

3.11.4 South Platte River Facilities

Gravel Pits

The Board of Water Commissioners (Denver Water) will purchase gravel pit lakes for storage. At this time, the specific pits have not been identified. However, for the purposes of this EIS, four existing pits have been chosen as examples of gravel pit lakes that could be purchased for storage, including the Worthing Pit, the North Tower and South Tower pits, and the Challenger Pit. The existing gravel pits are adjacent to the South Platte River near Brighton. The pits all contained water in 2006 except for the Challenger Pit, which was actively being mined. No sampling data exist for the gravel pit lakes. However, the three pits with water probably contain communities of benthic macroinvertebrates, phytoplankton, and zooplankton. Fish may also be present.

The gravel pit lakes would be transferred to Denver Water without water stored in them, and apparently with no existing aquatic resources. The future aquatic communities of the gravel pit lakes would depend upon their operation and management. They would probably be suitable to support warmwater fish, invertebrates, and other aquatic organisms.

Diversion

The proposed diversion structure crosses the South Platte River near the Worthing Pit. The South Platte River in this section contains a warmwater community of fish and invertebrates.

3.11.5 Denver Basin Aquifer Facilities

The distribution pipelines for the Denver Basin Aquifer Facilities cross the following waterways:

- South Platte River – two crossings
- Lakewood Gulch
- Cherry Creek – three crossings
- Sand Creek

These four waterways are perennial at the locations of the crossings. They sustain communities of many species of warmwater fish and invertebrates.

3.11.6 River Segments

The characterization of existing aquatic biological resources was conducted for the overall study area, however, more detailed descriptions were provided for river segments that would experience the greatest flow change as shown in Table 3.11-4. Annual and monthly hydrology was used for summaries of Current Conditions (refer to Sections 3.0 and 3.1). However, daily hydrology was used in PHABSIM for fish and impact evaluation for aquatic biological resources in Section 4.6.11 and Section 5.11.

Overall Study Area

Within the overall study area the characterization of existing aquatic biological resources focused on those affected river segments that would experience an average annual flow increase or decrease of greater than 10% as a result of the Moffat Project. Streams with expected changes in average annual flow of 10% or greater with one or more alternatives are shown in Table 3.11-4. These river segments include:

- Fraser River and its tributaries with Denver Water diversions (Figure 3.0-2)
- Upper Williams Fork River upstream of the confluence with the South Fork of Williams Fork River and its tributaries with diversions (Figure 3.0-2)
- Blue River between Dillon Reservoir and Green Mountain Reservoir (Figure 3.0-2)
- South Boulder Creek downstream to Gross Reservoir (Figure 3.0-3)

No other stream sections in the Denver Water system would be expected to experience changes in average annual flow of greater than 10%.

The geographic scope of the overall study area also includes streams where the annual change in flow is minimal, but the changes in several months of an average year are greater than 10% (Table 3.11-4). This includes:

- Colorado River between the confluences with the Fraser River and the Blue River
- Blue River downstream of Green Mountain Reservoir
- South Boulder Creek from Gross Reservoir downstream to the South Boulder Diversion Canal (Figure 3.0-3)

- North Fork South Platte River from Roberts Tunnel downstream to the confluence with the South Platte River (Figure 3.0-4)
- South Platte River between Strontia Springs Reservoir and Chatfield Reservoir
- South Platte River from Chatfield Reservoir downstream to Bear Creek (Figure 3.0-4)

Aquatic resources for these streams are also discussed in detail (Table 3.11-4).

Table 3.11-4
Streams and Stream Segments in the Overall Study Area

Expected Change in Annual Flow	>10%	<10%	<10%
Expected Change in Monthly Flow	**>10% in Some Months**	**>10% in Some Months**	**<10% in Most Months**
Water Body/Level of Discussion[1]	**Full Description**	**Full Description**	**Brief Description**
Fraser River			
Mainstem	X		
Tributaries	X		
Williams Fork River			
Upstream of South Fork	X		
South Fork to Colorado River			X
Tributaries	X		
Colorado River			
Fraser River to Blue River		X	
Blue River			
Dillon Reservoir to Green Mountain Reservoir	X		
Green Mountain Reservoir to Colorado River		X	
South Boulder Creek			
Moffat Tunnel to Gross Reservoir	X		
Gross Reservoir to South Boulder Diversion Canal		X	
North Fork South Platte River			
Roberts Tunnel to South Platte River		X	
South Platte River			
Antero Reservoir to North Fork South Platte River			X
North Fork South Platte River to Strontia Springs Reservoir			X
Strontia Springs Reservoir to Chatfield Reservoir		X	
Chatfield Reservoir to Bear Creek		X	
Bear Creek to Henderson Gage			X

Notes:
[1]Level of discussion provided within this section, based on expected change in annual flow with at least one Project alternative.
> = greater than
< = less than
% = percent

For completeness, however, adjacent stream segments in which annual flow changes and flow changes in almost all months are not expected to be greater than 10% are described as well, albeit in much lesser detail than the other segments named above (Table 3.11-4). For

these stream sections, there would be no changes in flow in dry years and changes of much less than 10% in most months of average and wet years (see Appendix H-3). Only in June of some years would flows change by more than 10%. This includes:

- Williams Fork River from the confluence with the South Fork Williams Fork River downstream to the Colorado River
- South Platte River from Antero Reservoir to the confluence with the North Fork South Platte River
- South Platte River from the confluence with the North Fork South Platte River to Strontia Springs Reservoir
- South Platte River downstream of the confluence with Bear Creek (Figure 3.0-4)

The Denver Water reservoirs on the South Platte River (Antero, Spinney Mountain, Eleven Mile Canyon, Cheesman, Strontia Springs, and Chatfield) are not expected to experience substantial changes in operation and are discussed only briefly.

Surface water classifications designated by CDPHE and Gold Medal Waters (i.e., waters managed for high potential for success in catching trophy-size fish) designated by CPW are identified.

3.11.6.1 Fraser River

The Project alternatives include additional diversion of water from tributaries in the Fraser River Basin. This would result in depletions in average annual flows of greater than 10% in the mainstem of the Fraser River. Therefore, biological and habitat conditions are fully described for the length of the Fraser River and all tributaries with Denver Water diversions.

The surface water classification for the Fraser River mainstem and all its tributaries is Aquatic Life Cold Class 1 (refer to Section 3.2). The upper sections of the river and all tributaries have Cold Stream Tier I (CS-I) temperature standards including maximum temperatures of 21.2ºC (daily maximum [DM]) and 17.0ºC (maximum weekly average temperature [MWAT]). The mainstem of the Fraser River downstream of the Rendezvous Bridge near Fraser has Cold Stream Tier II (CS-II) temperature standards of 23.8ºC DM and 18.2ºC MWAT. The Fraser River in the section upstream of Fraser is on the 303(d) List for aquatic life (provisionally listed) due to a few recent samples with low Colorado MMI scores. The section downstream of Fraser is on the 303(d) List for exceedances of maximum water temperatures and has been given a priority rating of "low" (refer to EIS Section 3.2). The Fraser River is also on Colorado's Monitoring and Evaluation List for copper and lead between the towns of Tabernash and Granby.

Fraser River: Mainstem

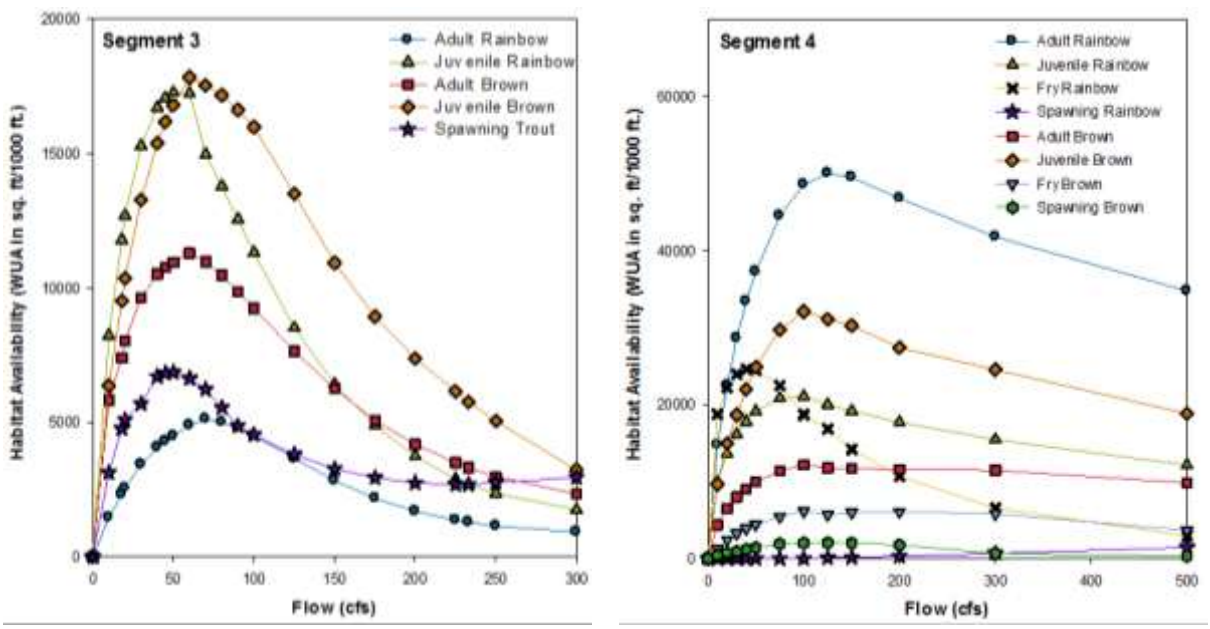
Habitat

PHABSIM habitat relationships are available for five segments of the Fraser River. Habitat for brook trout, rainbow trout, and brown trout was modeled in Segment 1 of the Fraser River from the Winter Park Wastewater Treatment Plant (WWTP) downstream to the Town of Winter Park for the Grand County Stream Management Plan (Grand County 2010). Habitat

for brook trout was modeled and represents Segment 2 of the Fraser River between Vasquez Creek in Winter Park and St. Louis Creek (Chadwick and Associates 1986). A site was established in 2007 for the Grand County Stream Management Plan that simulates habitat for rainbow and brown trout in Segment 3 of the river downstream to Ranch Creek (Grand County 2008). Habitat for rainbow and brown trout was simulated for Segment 4 of the river downstream of Ranch Creek to the mouth of the canyon near Granby (Chadwick and Associates 1986). An additional site from 2007 represents habitat in Segment 5 for rainbow and brown trout in the section from Granby to the Colorado River.

The habitat versus flow relationships for trout in the four modeled segments of the river all have the typical shape, with highest levels of habitat availability at flows in the middle of the range and less suitable habitat at flows on the low end and the high end of the range (Figure 3.11-1). In Segment 1, the relationships for brook trout indicate highest habitat availability at flows of 6 cubic feet per second (cfs) to 13 cfs. In this segment, habitat availability for brown and rainbow trout is highest at flows of approximately 15 to 45 cfs. In Segment 2, the relationship indicates that habitat availability for adult brook trout is relatively high at flows of approximately 20 cfs to 100 cfs, with lower habitat availability at flows higher and lower than this range. In Segment 3, highest habitat availability occurs at flows between 30 cfs and 120 cfs and in Segment 4 the optimum range is slightly higher, 50 cfs to 200 cfs (Figure 3.11-1). In the lower segment (Segment 5), habitat availability for most life stages of rainbow and brown trout is highest at flows ranging from approximately 40 cfs to 150 cfs.

Figure 3.11-1
Habitat Availability (in Weighted Useable Area in Square Feet per 1,000 Feet of Stream) for the Modeled Life Stages of Rainbow and Brown Trout in Segments 3 and 4 of the Fraser River



Source: Grand County, 2008; Chadwick and Associates, 1986.
Notes:
cfs = cubic feet per second
sq. ft. = square feet
WUA = weighted useable area

In addition to PHABSIM habitat data, CPW provided R-2-Cross habitat data for two sites in Segment 5 of the lower Fraser River, which will also be considered in the impacts analysis of the alternatives. The R-2-Cross data from these sites indicate minimum flows to maintain aquatic organisms in winter would need to be approximately 20 cfs and 30 cfs or higher.

Habitat improvement projects, funded through the Fishing Is Fun program, have increased the amount of available adult trout habitat during low flows in the Fraser River. The first project was completed in the 1990s near the Town of Granby. The second, completed in 2005, was a cooperative effort between the CPW, Grand County, and the towns of Fraser and Winter Park. This project involved two miles of stream between Fraser and Winter Park.

Denver Water operates one diversion on the mainstem of the upper Fraser River. Downstream of the diversion there is a minimum bypass requirement of 10 cfs for May 15 through September 15 and 4 cfs for the remainder of the year (refer to Section 3.1.5.1). In addition, there are CWCB minimum instream flows for several different sections of the river from Jim Creek downstream to the Colorado River (refer to EIS Table 3.1-9). Under Current Conditions, approximately 67% of native flows are diverted from the Denver Water diversion on the upper Fraser River (refer to Section 3.1 and Appendix H-12). During the high flow months of May, June, and July, 61-83% of the native flow is diverted. Despite the instream flow rights, by the criteria in Carlisle et al. (2010), and Baran et al. (1995), the Fraser River has been altered enough to have crossed the two flow-based thresholds and the ecological information is evaluated below to determine if an ecological tipping point has been crossed.

Geomorphic evaluations were conducted at three sites on the Fraser River: the first was just downstream of the Denver Water diversion, the second was near the Idlewild Campground, and the third was near Tabernash (refer to EIS Section 3.3). All three sites had habitat complexes of riffles with pools, runs, and glides. The substrate contained cobble throughout, with higher proportions of sand at the sites just downstream of the Denver Water diversion and at Idlewild. The large amount of sand suggests that sediment accumulation may be occurring at this site (refer to Section 3.3), Idlewild Campground, and the third was near Tabernash (refer to EIS Section 3.3). Traction sand applied to roads has the potential to cause aggradation on the Fraser River from Berthoud Pass to the Town of Fraser. However, sediment removal projects are underway on Berthoud Pass (refer to Section 3.2). Downstream sections of the Fraser River show no signs of unusual sediment accumulation. Banks were generally stable and well-vegetated throughout the length of the river.

The water quality of the Fraser River is generally good (refer to Section 3.2). Monthly water quality monitoring data from the Fraser River between the Denver Water diversion and the Winter Park Water and Sanitation District Wastewater Facility indicate possible exceedances of State standards for iron, mercury, copper, and lead. Some algae were observed in the Fraser River between the Town of Winter Park and the Town of Fraser, but current water quality data do not indicate elevated levels of nutrients. The Fraser River from the Town of Fraser to its mouth is on the State Monitoring and Evaluation List for copper, and water quality data show frequent exceedances of the U.S. Environmental Protection Agency (EPA)-recommended levels of phosphorus. Exceedances of State pH

standards also occurred from the Fraser River Sanitation District Facility to the Canyon (refer to Section 3.2).

Only a few water temperature exceedances were observed in the Fraser River from 2005 through 2009. DM temperature exceedances on the Fraser River were infrequent and never reached potentially lethal levels. Though these DM temperatures are considered stressful, they only occurred twice over a four-year period with a maximum of 24.7ºC, and they only occurred at one of 12 temperature monitoring sites. MWATs for the Fraser River were always within the optimal temperature range for trout. No exceedances of MWAT criteria were observed in the Fraser River over the sampling period.

Fish

Fish populations in the mainstem of the Fraser River are typical of a Rocky Mountain alpine coldwater fishery. Several species of trout, suckers, and sculpins have been collected from this river. Small (5 to 12 cm) rainbow trout were stocked by CPW in the section of the Fraser River downstream of Tabernash (CDOW 2006c). The Fraser River has a Denver Water diversion in its headwaters, upstream of most tributaries. Upstream of the diversion, brook trout and cutthroat trout exist, with brook trout dominant. Downstream of the diversion, brook trout are dominant in the upper reaches, with brown trout and rainbow trout becoming more dominant in the lower reaches. Cutthroat trout were present downstream of the diversion in small numbers from 1985 through 2001. Sculpins are abundant throughout (Table 3.11-5), and probably include a mix of Paiute and mottled sculpins present with both species reported. This zonation of fish species is common for Colorado mountain streams (Vincent and Miller 1969).

Fish densities frequently exceed 1,000 fish/ha, but fluctuate considerably between sites and years. The fish data for the mainstem of the Fraser River indicate that the population is healthy to sustaining and has not crossed a tipping point. The average density estimates fell slightly below the 50th percentile for small streams less than 10 meters wide of Platts and McHenry in three of the nine sampling periods, but was within the 25th and 75th percentile estimates in eight of the nine years with data (Table 3.11-5). The observed range of densities often included at least one site that was lower than the 25th percentile estimates of Platts and McHenry. Although this stream has a bypass agreement, the fish populations in the Fraser River are not always judged to be healthy by the prescribed criteria at some sites.

There appears to be no temporal trend in fish abundance. Although there is considerable fluctuation in density among the years, there is no decreasing or increasing pattern. Average density was lowest in 1993-1994 and in 2006, and it was highest in 1985, 2007, 2008, and 2010 (Table 3.11-5). Average density in the last four years with data, 2007-2010, was much higher than the 50th percentile of Platts and McHenry. The fluctuation between years is likely due, at least in part, to differences in site locations and the number of sites. Average fish biomass in the two years when this information was available was nearly twice the average of 77 kg/ha of Platts and McHenry with all six sites in 2007 having average biomass higher than this level.

Table 3.11-5
Fraser River Mainstem, Downstream of Denver Water Diversion, Fish Population Data, Percent of Total Catch, and Summary Parameters (1985 to 2010)

Species/ Date (sites)	1985 (2)	1993-1994 (6)	2000-2001 (3)	2003 (1)	2006 (1)	2007 (6)	2008 (1)	2009 (1)	2010 (4)
Rainbow trout	2.6%	3.4%	0%	0.4%	16%	7.8%	10.1%	4.8%	2.9%
Brook trout	33.7%	42.3%	98.8%	7.2%	14%	8.4%	9.8%	11.7%	5.3%
Brown trout	2.4%	0.7%	0.7%	3.8%	3%	14.9%	9.9%	6.8%	12.8%
Longnose sucker	1.0%	2.1%	0%	16.5%	3%	7.1%	2.0%	0.4%	0%
White-Longnose sucker hybrid	0.0%	0.0%	0.0%	0.0%	0%	1.2%	0%	0%	0%
Fathead minnow	0.0%	0.0%	0.0%	0.0%	0%	0.2%	0%	0%	0%
Sculpin	44.7%	33.9%	0%	67.4%	62%	54.1%	62.2%	74.9%	79.0%
White sucker	15.5%	0.7%	0%	7.6%	2%	1.4%	6.0%	1.4%	0%
Cutthroat trout	<0.1%	1.6%	0.4%	0%	0%	0%	0%	0%	0%
Speckled dace	0%	0.2%	0%	0%	0%	4.9%	0%	0%	0%
Average density (fish/ha)	2,300	456	1,274	1,098	792	2,440	3,309	2,280	3,386
Range	**611-6,989**	**246-717**	**27-2,658**	**N/A**	**315-1,267**	**638-5,096**	**N/A**	**N/A**	**2,102-5,366**
Average biomass (kg/ha)	143.6	N/R	N/R	N/R	N/R	175.9	N/R	N/R	121.8
Range	**42.2-245**	**N/R**	**N/R**	**N/A**	**N/A**	**80.0-253.5**	**N/A**	**N/A**	**73-159**

Source: Chadwick and Associates, 1986; CDOW, 2005a, 2007b, 2010; GEI unpublished data; Nehring et al., 2011.
Notes:
Number of sites represented in each time period are shown in parentheses.
< = less than
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

Whirling disease has been identified as positive within the Fraser River mainstem. The rate of infection is relatively high in the lower Fraser River (Nehring et al. 2003) due to suitable habitat for Tubifex worms.

Data from sampling efforts between 1967 and 2010 show a patchy distribution of mottled sculpin in the Fraser River drainage. They are present in the mainstem of the Fraser River up to 8,750 feet. They have also been collected from the lower reaches of several tributaries. Over the survey period, the distribution of mottled sculpin appears to have remained stable—this species has not disappeared over time from sites that have been sampled more than once. Since 2003 they have accounted for the majority of the fish collected in the Fraser River (Table 3.11-5). The only exception was Meadow Creek at CR 841; mottled sculpin were present in 1993, but not in 2006.

The reasons for the absence of sculpin above 8,800 feet in the Fraser River drainage, approximately the elevation of Winter Park, are not known and probably vary by stream.

Physical habitat features such as large substrates (i.e., boulders), high water velocities, and low temperatures limit upstream sculpin distributions in portions of Wyoming (Quist et al. 2004)—these may also limit sculpin populations in the Fraser River watershed. Fragmentation by road culverts, ditches, and county and Denver Water diversions are possible explanations. Because of their reliance on unembedded cobble, sculpin populations in this drainage may also be negatively impacted by traction sand applied to roads (Ewert 2011a, 2011b).

Benthic Macroinvertebrates

Benthic invertebrate populations were sampled at seven sites in August 2007 along the Fraser River (Table 3.11-6). There were a total of 87 invertebrate taxa collected, ranging from 24 to 38 taxa per sites. Invertebrate groups represented include Ephemeroptera, Plecoptera, Hemiptera, Trichoptera, Coleoptera, Diptera, Hydracarina, Isopoda, Amphipoda, Nematoda, Oligochaeta, Hirudinea, Turbellaria, Gastropoda, and Pelecypoda (GEI 2013). The invertebrate groups present are typical of Colorado mountain streams (Ward 1986, 1994; Ward et al. 2002). At the seven sites, diversity was relatively high, ranging from 2.87 to 3.82, and the species composition contained 24% to 39% EPT taxa. At all sites there were at least several species of sensitive insects and several families of insects that prefer erosional habitats, indicating that habitat and flow conditions were suitable to support sensitive and rheophilic species.

Macroinvertebrate communities were sampled in the Fraser River in 2008 as part of a larger study (Rees 2009). The data indicated the presence of a wide variety macroinvertebrate groups were present including sensitive species. Diversity was 3.02 and there were 62% EPT species. Macroinvertebrate data were evaluated with a Multiple Index Score, a regionally specific index developed by Rees (2009). The Multiple Index Score score indicated that the macroinvertebrate community in the Fraser River was similar to those found in reference streams (Rees 2009).

Macroinvertebrates were sampled at two sites in spring and fall 2010 in Kaibab Park in Granby (Nehring et al. 2011). The samples contained relatively high density and number of taxa (Table 3.11-6). The samples included 63% to 70% EPT species that are generally considered to be sensitive. There were also Coleoptera, Diptera, Hydracarina, Isopoda, Nematoda, Oligochaeta, Hirudinea, Gastropoda, and Pelecypoda.

Numerous sites with CDPHE WQCD macroinvertebrate data were also available for the Fraser River (Table 3.11-6). Samples were collected from sites along the length of the Fraser River from 1997 to 2011. The samples had a wide range of MMI scores. Most of the MMI scores were above the threshold for attainment. Approximately 33% of the MMI scores do not attain the threshold for unimpaired aquatic life use. In some cases, the MMI score is in the gray zone between attainment and impairment but the Hilsenhoff Biotic Index (HBI) and Shannon-Weaver diversity values (H') for these samples were high enough to indicate an unstressed macroinvertebrate community. In other cases, the MMI scores were well below the threshold for attainment of 42. The river in the section upstream of the Town of Fraser is on the Section 303(d) List for aquatic life (provisionally listed) due to the samples with low MMI scores.

Table 3.11-6
Fraser River Mainstem, Downstream of Denver Water Diversion, Macroinvertebrate Population Data Summary Parameters (1985 to 2011)

Reach/Site	Date	Density (#/m²)	Number of Taxa	Number of EPT Taxa (%)	H'	MMI Score	HBI
Headwaters to Vasquez Creek							
Site 1	Spring 1985	3,088	25	12 (48)	2.54	--	--
	Fall 1985	9,310	35	23 (66)	3.14	--	--
At Robber's Roost	September 9, 2004	--	--	--	3.71	63.6	4.60
	November 8, 2000	--	25 36	15 (60) 12 (33)	2.24 3.89	79 81	4.20 3.95
	October 8, 2007	--	--	--	3.88	58.0	3.52
At Winter Park Ski Resort	September 10, 2004	--	--	--	3.15	30.4	2.97
Upstream of Winter Park WWTP	August 2007	--	31	12 (39)	3.66	--	--
Downstream of Winter Park WWTP	August 2007	--	32	11 (34)	3.78	--	--
Fraser River Trail	October 3, 1997	--	26 33	17 (65) 19 (58)	2.51 2.97	66 70	1.87 2.63
	November 8, 2000	--	27 26	14 (52) 18 (69)	2.51 4.14	56 69	1.89 2.37
	October 8, 2007	--	12	5 (42)	3.01	38.0	3.27
Gage at Hwy 40	November 8, 2000	--	42 36	18 (43) 12 (33)	3.70 3.89	69 56.8	4.67 3.95
Below Buck Creek	October 8, 2007	--	22	6 (27)	3.77	27.3	5.38
	September 30, 2010	--	--	--	2.35	23.2	7.27
	September 26, 2011	--	--	--	3.52	30.1	4.04
Vasquez Creek to St. Louis Creek							
Site 2	Spring 1985	1,895	33	19 (58)	3.77	--	--
	Fall 1985	3,862	36	22 (61)	3.56	--	--
Confluence Park	August 2007	--	26	3 (12)	3.82	--	--
Below Vasquez Cr.	October 9, 2007	--	13	3 (23)	3.10	30.4	4.82
"Behind Safeway"	August 2007	--	38	9 (24)	3.57	--	--
Rendezvous Bridge	September 30, 2010	--	21	5 (24)	2.40	32.0	4.44
	September 26, 2011	--	--	--	2.52	18.4	5.22
St. Louis Creek to Ranch Creek							
Below St. Louis Creek	October 9, 2007	--	--	--	2.83	26.2	4.14
Site 3	Spring 1985	3,002	26	13 (50)	3.36	--	--
	Fall 1985	10,629	37	23 (62)	3.56	--	--
Upstream of Fraser WWTP	August 2007	--	27	9 (33)	3.12	--	--
Downstream of Fraser WWTP	August 2007	--	27	8 (30)	2.87	--	--
WGU	2008	10,403	37	23 (62)	3.02	--	--

Table 3.11-6 (continued)
Fraser River Mainstem, Downstream of Denver Water Diversion, Macroinvertebrate Population Data Summary Parameters (1985 to 2011)

Reach/Site	Date	Density (#/m²)	Number of Taxa	Number of EPT Taxa (%)	H'	MMI Score	HBI
At Cty Rd 83 near Tabernash	May 31, 2007	--	--	--	3.70	52.7	3.75
	October 9, 2007	--	--	--	4.08	55.3	3.73
	September 30, 2010	--	--	--	3.76	46.7	3.74
	September 26, 2011	--	--	--	3.66	26.2	3.77
Ranch Creek to Mouth of Canyon							
Site 4	Spring 1985	2,088	35	18 (51)	4.15	--	--
	Fall 1985	5,226	32	20 (63)	3.56	--	--
Strawberry Road	August 2007	--	24	9 (38)	3.24	--	--
Sol Vista	Fall 2010	20,524	42	27 (64)	--	--	--
Mouth of Canyon to the Colorado River							
Site 5	Spring 1985	1,538	30	14 (47)	4.32	--	--
	Fall 1985	5,013	29	19 (66)	3.20	--	--
Kaibab Park	Spring 2010	6,521	30	21 (70)	--	--	--
	Fall 2010	12,538	54	34 (63)	--	--	--
At Granby	March 23, 2003	--	--	--	4.05	56.4	3.50
	November 14, 2003	--	--	--	3.64	76.1	2.42
	November 14, 2004	--	--	--	3.84	58.1	3.57
	November 22, 2005	--	--	--	3.14	65.7	2.94
	November 16, 2007	--	--	--	2.50	55.7	3.31
At CR 57 above WWTF nr Granby	October 15, 2007	--	--	--	3.31	51.6	3.76
	September 30, 2010	--	--	--	3.72	72.4	3.07
	September 26, 2011	--	--	--	3.52	53.6	3.32
WGU	2008	10,403	37	23 (62)	3.02	--	--

Source: CDPHE; GEI, 2013; Nehring et al., 2011.
Notes:
-- = no data
#/m² = number of individuals per square meter
% = percent
Cr. = Creek
CR = County Road
Cty Rd = County Road
EPT = Ephemeroptera, Plecoptera and Trichoptera
H' = Shannon-Weaver Diversity Index
HBI = Hilsenhoff Biotic Index
Hwy = Highway
MMI = Macroinvertebrate Multimetric Index
nr = near
WGU = Windy Gap Upstream
WWTF = Wastewater Treatment Facility
WWTP = Wastewater Treatment Plant

Many of the CDPHE WQCD samples contained high number and percent of EPT taxa, especially the samples with the higher MMI scores (Table 3.11-6). At these sites, over 50% of the taxa were EPT taxa. At sites with low MMI scores, EPT taxa were usually less than 30%. The sites with low MMI scores for the CDPHE WQCD samples generally contained high proportions of chironomid midges and mites. Abundant EPT and other insects were present in the samples with higher scores.

Benthic invertebrate populations were sampled at five sites in spring and fall 1985. Densities ranged from 1,535 to 10,629 organisms per square meter (organisms/m^2),

represented by 25 to 37 taxa at each site, of which 47 to 66% were EPT taxa (Chadwick and Associates 1986). The samples were generally diverse with values ranging from 2.54 to 4.32 (Table 3.11-6). Although the collection methods were different between the two sets of samples, many of the same invertebrate groups present in 2007 were also present in 1985. This suggests there has been no fundamental change in the macroinvertebrate community over this period.

Tipping Point Evaluation

The total amount of average annual and peak flow diverted from the upper Fraser River is over 60%, which suggests that this river may be approaching an ecological tipping point, at least in the upper reaches. However, the fish data for the mainstem of the Fraser River indicate that the population is healthy to sustaining with no trends over time and has not crossed a tipping point. Much of the data for macroinvertebrates also indicates the presence of healthy and diverse community although some recent CDPHE WQCD samples had low MMI scores and the upper reaches of the Fraser River are provisionally listed on the Section 303(d) List for aquatic life. Overall, the available information indicates that the Fraser River has not crossed an ecological tipping point.

Fraser River: Tributaries

A total of 32 tributaries to the Fraser River would be affected by implementation of the Moffat Project alternatives (Table 3.11-7). All of the tributaries have existing Denver Water or Englewood diversions and could potentially be affected by changes in the pattern of flow diversion, except for Trail Creek which has no diversion but is downstream of diversions on North and South Trail creeks. All of the tributaries are classified as Aquatic Life Cold Class 1 (refer to Section 3.2). All tributaries have CS-I temperature standards including maximum temperatures of 21.2ºC (DM) and 17.0ºC (MWAT). Vasquez Creek is provisionally listed on the 303(d) List for aquatic life and Ranch Creek is listed for water temperature.

Table 3.11-7
Fraser River Tributary Streams Data Availability Upstream and Downstream of Existing Denver Water Diversions

Stream	Fish Data		Benthic Macroinvertebrate Data
	Upstream of Diversion	Downstream of Diversion	Downstream of Diversion
St. Louis – Vasquez Creek Section			
West St. Louis Creek	2010	2005 (No fish present)	2005 (Qualitative data only)
Short Creek	2010 (No fish present)	Dry in 2010	No data available
St. Louis Creek	2003	1993, 2000, 2003, 2005	1997, 2000, 2004
Iron Creek	2001	No data available	No data available
Byers Creek	2010 (No fish present)	1980, Dry in 2010	No data available
East St. Louis Creek	2010 (No fish present)	2005 (No fish present)	2005
Fool Creek	1978, 2010 (No fish present)	2005 (No fish present) Dry in 2010	No data available

Table 3.11-7 (continued)
Fraser River Tributary Streams Data Availability Upstream and Downstream of Existing Denver Water Diversions

Stream	Fish Data		Benthic Macroinvertebrate Data
	Upstream of Diversion	Downstream of Diversion	Downstream of Diversion
King Creek	2010 (No fish present)	2005, 2010 (No fish present)	2005
West Elk Creek	2010 (No fish present)	2005	2005
West Fork Main Elk Creek	2010 (No fish present)	2010 (No fish present)	No data available
Main Elk Creek	2010 (No fish present)	2005, 2010 (No fish present)	2000, 2005, 2010
East Elk Creek	2010 (No fish present)	No data available	No data available
Vasquez Creek	1964, 1985, 2001, 2009	1964, 1978, 1984, 1985, 1992, 1993, 2002, 2007, 2009	1985, 2000, 2003, 2010, 2011
Little Vasquez Creek	1996, 1999, 2006	1982, 1983, 1985, 1993, 1997, 2006	No data available
Cooper Creek	2010 (No fish present)	Dry in 2010	No data available
Fraser River – Jim Creek Section			
Jim Creek	2000, 2003	1993, 2005	2005
Ranch Creek Section			
North Fork Ranch Creek	2000 (Headwaters only)	1996, 2005	2005 (No benthic invertebrates present)
Dribble Creek	2010 (No fish present)	Dry in 2010	No data available
Main Ranch Creek	2010	1978, 1985, 1986, 1993, 2005	2005, 2010, 2011
Middle Fork Ranch Creek	2000	1979, 1992, 2005	2005
South Fork Ranch Creek	1999, 2003	1978, 1983, 1992, 2005	2005 (No benthic invertebrates present)
Wolverine Creek	2010 (No fish present)	Dry in 2010	No data available
Cub Creek	2010 (No fish present)	Dry in 2010	No data available
Buck Creek	1983, 2007, 2010 (No fish present)	2010 (No fish present)	No data available
Englewood – Ranch Creek Extension			
Meadow Creek	No data available	1993, 2005, 2006	2005, 2006
Trail Creek	Not sampled (see text)	2005 (No fish present)	2005
South Trail Creek	2010 (No fish present)	Not sampled (see text)	No data available
North Trail Creek	2010 (No fish present)	Not sampled (see text)	No data available
Hurd Creek	2010 (No fish present)	1993, 2005	2005
Hamilton Creek	2000, 2003, 2009	2005	2005
Cabin Creek	2000, 2003	1979, 1983, 1985, 1992, 1996, 1999, 2003, 2005	2005
Little Cabin Creek	2010 (No fish present)	1979, 2005 (No fish present)	2005

Many of these tributaries have minimum flow bypass requirements downstream of the diversions, as described in Section 3.1.5.1 and CWCB minimum instream flows. Native flow depletions in these streams range from 12 to 96% on average and from 19 to 94% during the runoff season under Current Conditions (refer to Appendix H-12). The operation of the diversions is discussed in greater detail in Section 3.1.5.1.

Denver Water diversions can act as barriers to the upstream migration of fish. This allows fish populations upstream of some of the diversions to be isolated from species that are present downstream. In some cases, this allows fish that may be lineages of native cutthroat trout populations to exist upstream of the diversions without competition from or hybridization with non-native trout species. The Moffat Project would not affect flows upstream of the diversions. However, since the diversions can function to isolate trout populations, the description of the existing environment includes descriptions of the fish populations upstream as well as downstream of the diversions. For benthic invertebrates and habitat, the potential effects of the alternatives are only downstream of the diversions, and data from these sections of stream are the focus of the description.

Flow regimes have a great effect on the community of aquatic organisms in a stream (Poff et al. 1997, 2007; Poff and Allan 1995). There has been recent research in some of the Fraser River tributary streams evaluating the effects of the diversions on the aquatic organisms in the downstream sections of streams. These studies indicate that the effects of the diversions are different depending on the conditions in the different streams (McCarthy 2008; Albano 2006; Rader and Belish 1999). One of the findings was that some diverted streams resume flowing at varying distances downstream of the diversions due to groundwater input or leakage past the diversion. Tributaries and wetlands may also contribute flow. Even in diverted streams that were dry below the diversions, there were sometimes communities of benthic macroinvertebrates a short distance downstream as flow resumed. The communities in these streams can be very tolerant to flow removal (Albano 2006). Another finding of the studies was that there were differences in effects depending upon the magnitude of the diversion. In “mildly” diverted streams, with less than 90% of the flow diverted and/or with bypass flows, invertebrate communities were similar upstream and downstream of the diversions and in some cases there was higher density, diversity, and number of taxa downstream of the diversions. This was attributed to the diversions alleviating “hydraulically harsh conditions, enabling a greater diversity of macroinvertebrate taxa to exist” (Albano 2006), to the possibility “that residence time for macroinvertebrates may be increased under the low flow conditions in diverted reaches” (Albano 2006), and to higher temperatures resulting in more favorable conditions for growth and development (Rader and Belish 1999). In streams with bypass flows or when the entire stream is not being diverted, the connectivity with drifting invertebrates from upstream help maintain invertebrate communities downstream of the diversions.

In “severely” diverted streams with flow reductions of more than 90%, there are sections just downstream of the diversion that may be dry or may have some invertebrates finding refuge in the hyporheic zone in the wet areas under the substrate (McCarthy 2008) and fish are probably excluded. However, even in severely diverted streams, groundwater and tributaries usually restore flow to the streams within a few hundred meters of the diversion (McCarthy 2008). In these streams, the low flows result in modified communities of invertebrates. In these sections of stream there are usually fewer rheophilic species

(requiring fast current) and families that prefer erosional habitats, such as several stoneflies (Plecoptera) and caddisflies (Trichoptera), and more taxa that prefer standing water, such as dytiscid beetles (McCarthy 2008; Albano 2006; Rader and Belish 1999). Sections of stream that are dry or have severely reduced flows can quickly recover diverse invertebrate communities as flows increase in a downstream direction due to groundwater inputs or small bypass flows (Rader and Belish 1999).

Habitat

Habitat in most tributaries is described briefly with the best available data. PHABSIMs are available for some tributaries and were incorporated into the description of existing conditions when available. Habitat availability was modeled for brook trout at one site downstream of the Denver Water and Grand County diversions on Vasquez and Little Vasquez creeks based on data from 1985. In both streams, maximum habitat availability for adult brook trout is in the range of 10 cfs to 20 cfs (Chadwick and Associates 1985). A PHABSIM in the Grand County Stream Management Plan for brook trout at a site on Vasquez Creek downstream of the Denver Water diversion and upstream of the Grand County Diversion indicated a similar range of optimum flow (Grand County 2008, 2010). In St. Louis Creek, a PHABSIM site downstream of the Denver Water diversion indicated maximum habitat availability at flows from 5 cfs to approximately 25 cfs (Grand County 2008). In Ranch Creek, a PHABSIM site near Fraser was included in the Grand County Stream Management Plan (Grand County 2010).

R-2-Cross data were collected by CPW for many of the Fraser River tributary streams, including Cabin, Elk, Hamilton, Iron, Jim, Meadow, Middle Fork Ranch, and Main Ranch creeks. However, this information was never evaluated by CPW and is not used in the EIS.

Fish

Upstream of the diversions, brook and Colorado River cutthroat trout are present. Downstream of the diversions, the Fraser River tributary streams contain mostly brook trout, with cutthroat trout, brown trout, and mottled sculpin present in a few streams. No fish are stocked in these streams by CPW, although some streams (Iron, Vasquez, and Jim creeks) have been stocked variously with "cutthroat," Pike's Peak cutthroat, Trapper's Lake cutthroat, brook, and rainbow trout in the past (Young et al. 1996; CDOW 2006c).

Each of the tributary streams in which fish populations were sampled during at least one sample event is discussed below. In 2005 and 2010 during supplemental data collection, some sites were dry downstream of the diversions as all of the water was being diverted at time of sampling, including Short, Fool, Cooper, Dribble, Wolverine, Cub, North Fork Ranch, and South Fork Ranch creeks; therefore, no fish were present. If streams did not contain fish populations, the fact is reflected in Table 3.11-7, and the lack of fish populations of these streams are discussed briefly.

Benthic Macroinvertebrates

Benthic invertebrate population data do not exist for many of the Fraser River tributaries. Historical data existed only for St. Louis Creek and Vasquez Creek. To fill in a large portion of this data gap on the benthic macroinvertebrate communities of the Fraser River tributaries, supplemental data collection was conducted in 2005 by GEI (Table 3.11-8). The sites were downstream of the diversions on these streams and some were fully diverted

and dry and could not be sampled. The data are discussed in more detail in the discussions of the individual tributaries.

Table 3.11-8
Fraser River Tributary Streams in the Project Area with Benthic Macroinvertebrate Population Parameters Downstream of Existing Denver Water Moffat Collection System Diversions (Samples from 2005)

Reach/Site	Date	Density (#/m²)	Number of Taxa	Number of EPT Taxa (%)	H'	MMI Score	HBI
St. Louis – Vasquez Creek Section							
West St. Louis Creek	2005	--	27	7 (26)	--	--	--
East St. Louis Creek	2005	1,994	43	20 (47)	3.66	--	--
King Creek	2005	2,020	53	19 (36)	4.44	--	--
West Elk Creek	2005	6,796	57	17 (30)	4.22	--	--
Main Elk Creek	2005	52,269	42	16 (38)	3.13	--	--
Fraser River – Jim Creek Section							
Jim Creek	2005	1,686	41	16 (39)	3.97	--	--
Ranch Creek Section							
Main Ranch Creek	2005	43,361	46	21 (46)	3.43	--	--
Middle Fork Ranch Creek	2005	6,262	46	20 (44)	4.43	--	--
Englewood – Ranch Creek Section							
Meadow Creek	2005	4,212	53	22 (42)	3.81	--	--
Trail Creek	2005	2,802	51	18 (35)	4.45	--	--
Hurd Creek	2005	3,380	50	23 (46)	3.96	--	--
Hamilton Creek	2005	10,604	47	24 (51)	3.97	--	--
Cabin Creek	2005	6,852	52	23 (44)	3.85	--	--
Little Cabin Creek	2005	3,769	52	20 (39)	3.10	--	--

Source: Chadwick and Associates, 1986; GEI, 2013.
Notes:
-- = no data
#/m² = number of individuals per square meter
% = percent
EPT = Ephemeroptera, Plecoptera and Trichoptera
H' = Shannon-Weaver Diversity Index
HBI = Hilsenhoff Biotic Index
MMI = Macroinvertebrate Multimetric Index

West St. Louis Creek

The reach of West St. Louis Creek from the diversion to the mouth is a small, narrow stream with a width of less than 2 meters at the 2005 and 2010 supplemental fish sampling sites. This stream appears to be a "severely" diverted stream (Rader and Belish 1999). There is no bypass flow for this stream, and it is fully diverted at times. Downstream of the diversion the stream has inputs of water from groundwater, tributaries, and wetlands (McCarthy 2008). Native flow depletions are not available for West St. Louis Creek individually but for the upper St. Louis Creek streams as a whole, diversion rates average 67% annually and range from 51-82% during runoff compared to native flow under Current Conditions (refer to Appendix H-12).

Downstream of the diversion there were no fish in fall 2005. During sampling in 2005 the channel was nearly dry just downstream of the diversion. Most of the water was being diverted with a small amount of water passing through the diversion structure. There was little flowing water but there were standing pools and slow runs. The nearly dry channel limited the sampling of macroinvertebrates to a qualitative sample. A total of 27 different species were present including mostly species with no preference for erosional or depositional habitats, although at least one family preferring erosional habitats, the Hydropsychidae, was present. There were fewer species of invertebrates in this stream compared to other streams sampled at this time.

In 2010, 56 brook trout were collected upstream of the diversion. Average density was estimated to be 2,545 fish/ha, and average biomass was estimated to be 17.31 kg/ha. The average length of the brook trout of 75 mm indicates that there were few larger juveniles and adults present, but abundant YOY fish existed upstream of the diversion.

This stream had no fish below the diversion in 2005, indicating a collapsed population. This is further supported by the fact that fish were collected upstream of the diversion in 2010. The benthic macroinvertebrate community was limited to mostly tolerant species since flow is completely diverted at times. The section of West St. Louis Creek downstream of the diversion has passed an ecological tipping point.

Short Creek

Short Creek is diverted near its confluence with West St. Louis Creek. There is only a short length of stream between the diversion and its mouth, a few hundred meters. There is no bypass flow for this stream and it is fully diverted at times. At the time of sampling in 2010, the stream was fully diverted and the section of stream downstream of the diversion was dry. Upstream of the diversion, the stream was small, less than a meter wide, with low flow, shallow depths, and few pools. No fish were found upstream of the diversion. There is no benthic macroinvertebrate data available for this stream.

It is likely that Short Creek has never supported fish due to its small size, shallow depths, and lack of pools. However, the high rate of diversion resulting in a dry channel downstream indicates that Short Creek is past its ecological tipping point and the short section of stream now likely supports a less abundant and less diverse community of benthic macroinvertebrates.

St. Louis Creek

St. Louis Creek appears to be a “mildly” diverted stream (Rader and Belish 1999) with bypass flows of 10 cfs in summer and 3 cfs in the remainder of the year. The diversions amount to 36% of the native flow on average under Current Conditions with diversion rates of 38 to 52% during the runoff period (refer to Appendix H-12). The criteria from Carlisle et al. (2010) suggest that current diversions on this stream are probably not sufficient to have crossed a flow-based threshold.

St. Louis Creek near Fraser has a moderate slope with an average bankfull width of 11 meters (refer to Section 3.3). Glide and riffle are the predominant habitat types, and woody debris is common in the channel. Cobble and gravel are the most common sediment types, but deposits of coarse sand and small gravels exist on point bars and downstream of

some cobbles, suggesting the potential for sediment accumulation. Banks are stable and vegetated with mosses, and woody vegetation such as willows and conifers. Beaver ponds were common (refer to Section 3.3).

Two temperature exceedances were observed on St. Louis Creek between 2007 and 2009. Both temperatures exceeded the DM temperature. The highest was 21.5ºC compared to the standard of 21.2ºC. Although they exceeded State standards, these temperatures were experienced over the short term (they were 2-hour averages), and they were not high enough to cause physiological stress in trout. No exceedances of the MWAT were observed in St. Louis Creek. No water data exist to document any water quality concerns on St. Louis Creek (refer to Section 3.2).

Fish populations upstream of the Denver Water diversion were sampled in 2003 (GEI 2013). Brook trout and cutthroat trout were collected, with brook trout comprising 95% of the population. No data are available on the genetic lineage of the cutthroat trout in this stream. Total fish density was estimated at 797 fish/ha. Downstream of the diversion, brook trout and mottled sculpin were collected (Table 3.11-9). In each sample event, brook trout dominated the populations, which ranged from 646 to 5,231 fish/ha. No benthic macroinvertebrate data are available for St. Louis Creek.

The fish data are limited for this stream, but they indicate that the fish populations are generally healthy. The average density estimates were below the 50th percentile of Platts and McHenry in two of four sampling periods but were always within the 25th to 50th percentile range of Platts and McHenry. Only one of the samples in 1993 had density that was below the 25th to 50th percentile range. The limited data indicate that the fish population is healthy to sustaining. There are no increasing or decreasing trends between 1993 and 2005.

Table 3.11-9
St. Louis Creek, Downstream of Denver Water Diversion, Fish Population Data, Percent of Total Catch, and Summary Parameters (1993 to 2005)

Species/Date (Sites)	1993 (3)	2000 (1)	2003 (1)	2005 (1)
Brook trout	69%	100%	92%	100%
Mottled sculpin	31%	0%	8%	0%
Average density (fish/ha)	1,079	2,163	5,231	766
Range	**646-1,851**	**N/A**	**N/A**	**N/A**
Average biomass (kg/ha)	N/R	N/R	N/R	24
Range	**N/R**	**N/A**	**N/A**	**N/A**

Source: CDOW, 2003, 2005b.
Notes:
Number of sites represented in each time period in parentheses.
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

Benthic macroinvertebrate data collected by CDPHE WQCD in 1997, 2000, and 2004 are available for five sites (Table 3.11-10). St. Louis Creek was sampled near its confluence with the Fraser River in 1997. A total of 45 taxa were collected among three replicates,

over half of which were EPT taxa. There were six families that prefer erosional habitats, represented by nine distinct taxa. The average Shannon-Weaver Diversity Index (H') of nearly 4.00 indicates that the benthic macroinvertebrate communities are healthy and balanced. MMI scores for these replicates were relatively high indicating attainment of the aquatic life use.

Further upstream, CDPHE WQCD data collected in 2000 are available for two sites bracketing the confluence with West St. Louis Creek (Table 3.11-10). Upstream of the confluence, 48 benthic macroinvertebrate taxa were collected in the two replicate samples including 26 EPT taxa. There were five families that prefer erosional habitats, and the average Shannon-Weaver Diversity Index (H') of 4.16 is indicative of a healthy, balanced community. Downstream of the confluence with West St. Louis Creek, conditions were similar, with 45 benthic macroinvertebrate taxa in the two replicates, 26 EPT taxa, four families that prefer erosional habitats, and an average Shannon-Weaver Diversity Index (H') of 4.27. At both sites, the majority of taxa were from families with no preference for erosional or depositional habitats. At both sites, all replicate samples had relatively high MMI scores. One site at the St. Louis Creek Campground sampled in 2004 had a very low MMI score that indicated non-attainment.

Fish populations are consistently present downstream of the Denver Water diversion. The minimum flows may be protective of the existing fish population. There are several diversions downstream of the Denver Water diversion that can also divert water, and the minimum flows may not be maintained through the entire reach. It does not appear that St. Louis Creek has passed an ecological tipping point.

Table 3.11-10
St. Louis Creek, Downstream of Denver Water Diversion, Macroinvertebrate Population Data Summary Parameters (1997 to 2004)

Reach/Site	Date	Density (#/m²)	Number of Taxa	Number of EPT Taxa (%)	H'	MMI Score	HBI
St. Louis Creek, "u/s of W. St. Louis Creek"	November 8, 2000	--	39 40	20 (51) 23 (58)	3.93 4.39	68 69	4.73 4.21
St. Louis Creek, "d/s of W. St. Louis Creek"	November 8, 2000	--	36 41	20 (56) 25 (61)	4.35 4.18	76 67	3.97 4.60
Above Fraser at St. Louis Creek Campground	September 3, 2004	--	--	--	3.48	35.1	3.49
Downstream of St. Louis Creek Campground	September 10, 1997	--	--	--	3.55	73.2	2.79
Near Fraser	September 10, 1997	--	33 33 40	19 (58) 18 (55) 21 (53)	3.87 3.95 4.18	87 84 88	3.06 3.19 3.21

Source: CDPHE.
Notes:
-- = no data
#/m² = number of individuals per square meter
% = percent
d/s = downstream
EPT = Ephemeroptera, Plecoptera and Trichoptera
H' = Shannon-Weaver Diversity Index
HBI = Hilsenhoff Biotic Index
MMI = Macroinvertebrate Multimetric Index
u/s = upstream
W. = West

Iron Creek

Iron Creek is diverted near its confluence with St. Louis Creek with only a short length of stream of a few hundred meters between the diversion and its mouth. There is no bypass flow for Iron Creek and it is fully diverted at times. Native flow depletions are not available for Iron Creek individually but for the upper St. Louis Creek streams as a whole, diversion rates under Current Conditions average 67% annually and range from 51-82% during runoff compared to native flow (refer to Appendix H-12).

This stream was sampled upstream of the diversion in 2001, and a single cutthroat trout was collected (Ficke et al. 2003). The density of this population is estimated to be between 0 and 50 fish per mile (fish/mile) (Hirsch et al. 2006). The short section of Iron Creek that lies between the diversion and St. Louis Creek was dry in 2001 and in 2010. However, Iron Creek may not support a self-sustaining fish population. Though this stream is large enough to support fish, its steep gradient and cold water temperatures (Ficke et al. 2003) may prevent establishment of fish populations. Iron Creek Lake, a headwater lake, has been stocked by the CPW in the past (Rogers 2001). Iron Lake was last surveyed in 1969, and a total of 28 cutthroat trout was collected during a 12-hour gill net set. The genetic status of these fish is untested, but they are currently classified as unaltered (Hirsch et al. 2006). There is no benthic macroinvertebrate information available for Iron Creek.

It is likely that Iron Creek has never supported fish due to its steep gradient. However, the high rate of diversion resulting in a dry channel downstream indicates that Iron Creek is past an ecological tipping point and the short section of stream now likely supports a less abundant and less diverse community of benthic macroinvertebrates.

Byers Creek

Byers Creek is a steep, narrow stream (refer to Section 3.3) that was less than a meter wide at the 2010 fish sampling site just upstream of the diversion. Byers Creek is diverted near its confluence with St. Louis Creek with only a short length of stream between the diversion and its mouth of only a few hundred meters. There is no bypass flow for Byers Creek, and it is fully diverted at times. Native flow depletions are not available for Byers Creek individually but for the upper St. Louis Creek streams as a whole, diversion rates under Current Conditions average 67% annually and range from 51-82% during runoff compared to native flow (refer to Appendix H-12).

Byers Creek was sampled upstream of the diversion in 2010. No fish were collected from this small, steep stream. Byers Creek is diverted near its confluence with St. Louis Creek. The section of stream between the diversion and the confluence of St. Louis Creek has not been extensively sampled because it is short and usually dry. Fish were absent during a 1980 sample and the stream was not sampled below the diversion in 2010 because it was dry. This indicates that the population in this stream has collapsed. It is possible that fish would use Byers Creek (upstream of the diversion) on a seasonal basis if the diversion did not block upstream migration, but the steep gradient would likely prevent fish from establishing a self-sustaining population. No benthic macroinvertebrate information is available for Byers Creek.

It is likely that Byers Creek has never supported fish due to its steep gradient. However, the high rate of diversion resulting in a dry channel downstream indicates that Byers Creek

is past an ecological tipping point and the short section of stream now likely supports a less abundant and less diverse community of benthic macroinvertebrates.

East St. Louis Creek

East St. Louis Creek is a steep, small stream (refer to Section 3.3). At the 2005 and 2010 fish sampling locations, the stream was approximately one meter wide. At the time of fish sampling in fall 2005 the stream was being fully diverted and was dry for a short section downstream of the diversion. Flow from groundwater added water to the stream a short distance downstream allowing sampling for fish and macroinvertebrates. McCarthy (2008) documented several groundwater inputs a short distance downstream of the diversion. There is no bypass flow for this stream, and it is fully diverted at times. Native flow depletions are not available for East St. Louis Creek individually but for the upper St. Louis Creek streams as a whole, diversion rates under Current Conditions average 67% annually and range from 51-82% during runoff compared to native flow (refer to Appendix H-12). East St. Louis Creek appears to be a "severely" diverted stream (Rader and Belish 1999).

There were no fish at the site in the nearly dry channel sampled downstream of the diversion in 2005 although invertebrate sampling data indicate similar density and number of taxa to other tributaries. The macroinvertebrate community at this site was abundant and diverse with density of 1,994 organisms/m^2 and 43 different taxa present. The community included at least 20 species of EPT taxa, including species that are usually sensitive to degraded water quality and five insect families that prefer erosional habitat conditions. Most of the insect taxa were from families with no preference for erosional or depositional habitats. The Shannon-Weaver Diversity Index (H') was 3.66, indicating a healthy, well-balanced macroinvertebrate community. This stream was sampled upstream of the diversion in 2010, and fish were absent. This stream could possibly support fish on a seasonal basis, but the weir at the gaging station upstream of the diversion would be a barrier to upstream migration.

The amount of flow diverted and the lack of fish in this stream indicate that East St. Louis Creek is past an ecological tipping point. The healthy macroinvertebrate community not far downstream of the diversion indicates that this stream starts to recover quickly with groundwater inputs.

Fool Creek

Fool Creek was dry downstream of the diversion during the sampling periods in fall 2010 and 2005. There is no bypass flow for Fool Creek, and it is fully diverted at times. Fool Creek is steep and narrow (refer to Section 3.3) and was 1.4 meters wide upstream of the diversion at the 2010 fish sampling site with few pools present. There are no native flow depletion data available for Fool Creek but it appears to be a severely depleted stream.

Fool Creek was sampled upstream of the diversion in 1978 and in 2010. Fish were absent during both sampling occasions. Fool Creek was dry downstream of the diversion during the sampling period in fall 2005 as all water was being diverted. Fool Creek may not be large enough to support fish even in the absence of a diversion. A culvert at the Denver Water diversion outlet crosses under the road; this culvert likely would be a fish barrier. However, the high rate of diversion and the dry channel downstream of the diversion indicate that Fool Creek has passed an ecological tipping point.

King Creek

There were no fish at the site sampled downstream of the diversion in 2005 although there was water in the channel. There is no bypass flow for King Creek, and it is fully diverted at times suggesting that this stream has crossed a flow-based threshold. On average, 69% of the native flow is diverted from King Creek under Current Conditions ranging from 52-82% during the high flow months of May through July (refer to Appendix H-12).

King Creek was sampled upstream and downstream of the diversion in 2010, and no fish were collected. There were no fish at the site sampled downstream of the diversion in 2005. However, King Creek is a small steep, narrow stream (refer to Section 3.3) and may be too small to support fish in the absence of a diversion—it was less than 2 feet wide and characterized by low flows. Benthic macroinvertebrates samples were collected in 2005 downstream of the diversion and the results indicate the presence of a healthy and diverse community with a Shannon-Weaver Diversity Index (H') of 4.44. Density was 2,020 organisms/m^2 and there were 53 individual taxa collected, more than at most other sites sampled during that period. The macroinvertebrate community included a wide range of species including numerous species of stoneflies, mayflies, and caddisflies which are usually considered to be intolerant of degraded water quality and flows. Most of the insect taxa were from families with no preference for erosional or depositional habitats, but seven genera in six families that prefer erosional habitats were present. Two genera of Dytiscidae, a depositional habitat-preferring family, were collected only in multihabitat sweep samples, illustrating high habitat heterogeneity.

The high rate of diversion suggests that King Creek is past an ecological tipping point. However, King Creek maintains a robust macroinvertebrate community just downstream of the diversion. Therefore, it is likely that inputs of groundwater not far from the diversion are sufficient to maintain the macroinvertebrate community over time and that King Creek may not yet be past an ecological tipping point.

West Elk Creek

West Elk is a small, steep stream (refer to Section 3.3). At the fish sampling site upstream of the diversion in 2010 the stream width was one meter or less. There is no bypass flow for West Elk Creek. Native flow depletions for West Elk Creek have not been calculated individually but Elk Creek and its tributaries have depletions of 59% on average under Current Conditions (refer to Appendix H-12). However, the peak flows are not diverted to the extent seen in other tributaries. In the peak flow month of June, native depletions are 45% on average and only 13% in wet years. McCarthy (2008) documents inputs of water along West Elk Creek from groundwater, wetlands, and tributaries.

GEI sampled West Elk Creek upstream of the diversion in 2010, and fish were absent. CEC sampled the fish populations in West Elk Creek downstream of the Denver Water diversion in 2005 and brook trout was the only species collected. Total density was 2,400 fish/ha, and biomass was 48 kg/ha. The density in 2005 indicated that the fish population was higher than the small stream 50th percentile of Platts and McHenry. The population contained multiple age classes which is characteristic of a healthy, sustaining population.

Macroinvertebrate samples from 2005 had density of 6,796/m^2, which was higher than most other sites, and a total of 57 taxa, which was higher than all other sites. The macroinvertebrate community contained many different species of EPT taxa, an alderfly, beetles, crustaceans, worms, snails, and clams. There were six families that prefer erosional habitats and none that prefer depositional habitats. Most of the insect taxa were from families with no preference for erosional or depositional habitats. The Shannon-Weaver Diversity Index (H') was 4.22, indicating a healthy, well-balanced macroinvertebrate community.

Native flow depletions calculated from an average of several Elk Creek tributaries do not indicate sufficient flow removal to meet the criteria of Carlisle et al. (2010) for crossing a flow-based threshold. West Elk Creek may or may not be a severely diverted stream, but the presence of a healthy brook trout population with adult, juvenile, and young fish and a healthy and diverse benthic invertebrate community suggests that flow past the diversion as well as groundwater, wetland, and tributary inputs provide sufficient flow at some distance downstream of the diversion to support a healthy community of fish and invertebrates. West Elk Creek likely has not passed an ecological tipping point.

West Fork Main Elk Creek

West Fork Main Elk Creek is a small, steep stream (refer to Section 3.3). The diversion is only a few hundred meters upstream of its confluence with Main Elk Creek. At the fish sampling site upstream of the diversion the stream width was approximately one meter. There is no bypass flow for this stream, and it is fully diverted at times and the stream was dry downstream of the diversion during sampling in 2010. No individual native flow depletion was calculated for this stream but the depletions for Elk Creek and its tributaries average 59% under Current Conditions (refer to Appendix H-12).

The West Fork Main Elk Creek was sampled upstream of the diversion in 2010. Fish were absent. Downstream of the diversion there were no fish; the stream was dry. This stream is probably too small to support fish, even in the absence of a diversion. West Fork Main Elk Creek is narrow and there is little holding water in the stream channel. No benthic macroinvertebrate data are available for this stream.

The dry channel downstream of the diversion indicates that flow is completely diverted at times. This suggests that the short section of stream between the diversion and the confluence with Main Elk Creek is severely diverted and is past an ecological tipping point.

Main Elk Creek

This stream was sampled in 2010 just upstream and downstream of the diversion. There were no fish at either site. In 2005, a site on Main Elk Creek just downstream of the confluence of Main Elk Creek and West Fork Main Elk Creek contained no fish. There is no bypass flow for this stream, and it may be fully diverted at times. Main Elk Creek is steep and narrow (refer to Section 3.3). At the fish sampling sites, the width was less than 2 meters. No native flow depletion estimate is available for this stream, but the Elk Creek Basin as a whole is depleted by 59% on average under Current Conditions (refer to Appendix H-12).

At the 2005 site downstream of the two forks, macroinvertebrate density and number of taxa were relatively high compared to other tributaries in 2005. The density of 52,269 invertebrates/m^2 is an order of magnitude higher than for other sites sampled at this time. The 42 species included a diverse mix of EPT taxa and midges with a few beetles and worms. Although the invertebrate community included many sensitive species and four families that prefer erosional habitats, the majority of the density was midges. These insects may have taken advantage of low flow conditions, as suggested in Albano (2006) and Rader and Belish (1999). Notably, the second most abundant taxon, with a density of 11,223 organisms/m^2 (21% of the total density), was *Pagastia* sp., a midge genus that is very intolerant to perturbations; in Idaho, the closest state for which a broad list of tolerance value data are available, it is assigned a tolerance value of 1 (Barbour et al. 1999). Rather than just a single taxon or a few taxa dominating the assemblage, numerous taxa had high abundances (nine taxa were present with densities over 1,000 organisms/m^2), and there was sufficient taxa richness to maintain a relatively balanced macroinvertebrate community with a Shannon-Weaver Diversity Index (H') score of 3.13. The data indicate that Main Elk Creek has sufficient inflow from groundwater to sustain the invertebrate community a short distance downstream of the diversions on the two forks of the stream.

Two samples have been collected from Elk Creek at a site near Fraser using CDPHE protocols (Table 3.11-11). The sample collected in 2000 had an MMI score of 38.3, which does not meet the threshold for attainment of aquatic life use; however, the sample from 2010 had an MMI score of 53.6, which indicates attainment.

Table 3.11-11
Main Elk Creek, Downstream of Denver Water Diversion, Macroinvertebrate Population Data Summary Parameters (2005 to 2010)

Reach/Site	Date	Density (#/m^2)	Number of Taxa	Number of EPT Taxa (%)	H'	MMI Score	HBI
Below Diversion	October 20, 2005	52,269	42	16 (38)	3.13	--	--
Near Fraser	November 8, 2000	--	--	--	3.29	38.3	3.90
Near Fraser	September 13, 2010	--	--	--	4.13	53.6	4.41

Source: CDPHE; GEI.
Notes:
-- = no data
#/m^2 = number of individuals per square meter
% = percent
EPT = Ephemeroptera, Plecoptera and Trichoptera
H' = Shannon-Weaver Diversity Index
HBI = Hilsenhoff Biotic Index
MMI = Macroinvertebrate Multimetric Index

The absence of fish may be due to the small, steep habitat. However, this stream is wider than other streams in the area with fish and their absence suggests that Main Elk Creek may have passed an ecological tipping point.

East Elk Creek

In 2010, fish were absent upstream of the diversion on East Elk Creek. There were no fish downstream of the diversion during sampling in 2005. Like the West Fork Main Elk Creek and Main Elk Creek, this stream is probably too small and steep (refer to Section 3.3) to support fish—it was less than 1 meter wide and had little to no holding water. No fish or

macroinvertebrate data are available for the section of stream downstream of the diversion but observations in 2010 indicate some flow past the diversion.

No native flow depletion estimate is available for this stream, but the Elk Creek Basin as a whole is depleted by 59% on average under Current Conditions (refer to Appendix H-12). This stream is fully diverted at times and likely has passed an ecological tipping point.

Vasquez Creek

Habitat surveys have been conducted for Vasquez Creek from the Denver Water diversion downstream to the Vasquez tunnel. Stream morphology is typical of mountain streams and predominantly consists of riffle-pool complexes with runs. This stream has a moderately steep channel and an average bankfull width of 7 meters (refer to Section 3.3). Cobble and sand were the most common sediment types. Fine substrates were mostly present on point bars, but they were also present in the active stream channel. Banks were stable and vegetated by grasses and willows. There are no water quality concerns on Vasquez Creek (refer to Section 3.2).

There is a bypass flow of 8 cfs in summer and 3 cfs in the rest of the year at the Denver Water diversion. The native flow depletion is 57% on average and 47-71% during the high flow months of May, June, and July under Current Conditions (refer to Appendix H-12). This does not meet the criteria for crossing a flow-based threshold from Carlisle et al. (2010).

Fish populations upstream and downstream of the Denver Water diversion were sampled in 1964. Brook trout was the only species collected; however, neither density nor biomass estimates were made based on that collection. Subsequent samples were collected downstream of the Denver Water diversion in 1978, 1984, 1985, 1992, 1993, 2002, 2007, and 2009 (Table 3.11-12). Many of these sites, especially the more recent sites, were also downstream of the Grand County Diversion. At sites between the Denver Water and Grand County diversions, only brook trout, cutthroat trout and sculpin were present and densities were variable throughout the study period. At sites downstream of the Grand County Diversion, species composition has changed slightly over time. Brown trout, rainbow trout-cutthroat trout hybrids, and white sucker were first seen in 2007 and 2009 with fewer brook trout. These fish may have moved upstream from the Fraser River and established populations in Vasquez Creek.

Table 3.11-12
Vasquez Creek, Downstream of Denver Water Diversion, Fish Population Data, Percent of Total Catch, and Summary Parameters (1978 to 2009)

Species/Date (Sites)	1978 (1)	1984 (2)	1985 (4)	1992 (1)	1993 (1)	2002 (1)	2007 (1)	2009 (2)
Brook trout	100%	79%	94%	50%	100%	62%*	41%	22%
Brown trout	0%	0%	0%	0%	0%	0%	1%	23%
Cutthroat trout	0%	0%	<1%	50%	0%	38%*	0%	0%
Rainbow trout	0%	18%	<1%	0%	0%	0%	25%	36%
Rainbow trout-cutthroat trout	0%	0%	0%	0%	0%	0%	0%	1%
Paiute sculpin	0%	4%	4%	0%	0%	0%	30%	17%
White sucker	0%	0%	0%	0%	0%	0%	3%	1%
Average density (fish/ha)	2,764	71[1]	1,017	N/R	1,052	21[1]	1,239	361
Range	**N/A**	**60-81**	**842-1,317**	**N/A**	**N/A**	**N/A**	**N/A**	**340-726**
Average biomass (kg/ha)	N/R	5.9	54.3	N/R	N/R	N/R	N/R	N/R
Range	**N/A**	**5.9**	**36.3-88.8**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

Source: Chadwick and Associates, 1985, 1986; CDOW, 1984, 2005b, 2007a, 2011b.
Notes:
[1]Data from 1984 reflect number captured, since insufficient data were included to calculate total density and biomass estimates.
Number of sites represented in each time period are shown in parentheses.
< = less than
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

Seven surveys in Vasquez Creek provided density estimates including sites downstream of the Denver Water diversion and sites downstream of both the Denver Water and Grand County diversions. The average density was well below the 50th percentile reported by Platts and McHenry in five of seven occasions. Two of these occasions had density ranges; the upper end of the range was lower than the small stream 50th percentile of Platts and McHenry in both cases. This leads to the conclusion that the Vasquez Creek fish population is near collapse and may be near a tipping point. Vasquez Creek has a bypass agreement at the Denver Water diversion, but it does not appear to be sufficient to maintain healthy fish populations. However, other environmental or anthropogenic factors could be contributing to low fish densities in this stream. Although the Vasquez Creek trout population is characterized by low densities, it does not appear to be declining further. The highest density estimates in the available data occurred in 1985, but densities were similar again in 1993 and 2007. Benthic invertebrate population data were collected at one site upstream of the diversion in the spring and fall of 1985. The samples contained a wide variety of species including numerous species of mayflies, stoneflies, caddisflies, and true flies. Density was just over 2,000 invertebrates/m^2 in both seasons, with approximately 60% of the taxa being EPT taxa. Diversity was 4.0 and 3.47 in spring and fall, respectively, indicating the presence of healthy populations. Benthic invertebrate population data were also collected at one site downstream of the diversion in both the spring and fall of 1985 in Vasquez Creek, averaging 3,645 organisms/m^2 and 28 taxa per site downstream of the existing diversions. The samples contained a wide variety of species including 55 to 67%

EPT taxa and a low proportion of midges. The data from the sites upstream and downstream of the diversion were similar and indicated healthy populations at both sites in 1985.

Vasquez Creek was also sampled in 2000, 2003, 2010, and 2011 using CDPHE protocols (Table 3.11-13). The MMI value for the 2010 sample was 23, and the MMI value for the 2011 sample was 22.7, neither of which meets the attainment threshold for aquatic life. Vasquez Creek is provisionally listed on Colorado's Section 303(d) List for aquatic life impairment. The 2010 sample contained primarily chironomid midges (72% of total density) and only three EPT taxa, resulting in the low MMI score. A sample from the same site collected by CDPHE WQCD in 2003 had a very different species composition containing a wide variety of invertebrates similar to the 1985 sample. Over half of the taxa were EPT taxa. The samples collected in 2000 and 2003 scored much higher and met the criterion for attainment. In 2003, there were six families present that prefer erosional habitats and the Shannon-Weaver Diversity Index (H') was 4.17; in 2010, there was only one family that prefers erosional habitats and the Shannon-Weaver Diversity Index (H') was 2.81. The reason for the change in species composition between the samples in 2000 and 2003 and those from 2010 and 2011 is not known. For all samples, most of the insect taxa were from families with no preference for erosional or depositional habitats.

Native flow depletions do not indicate sufficient flow removal to meet the criteria of Carlisle et al. (2010) for an impaired fish assemblage. The naturally low density fish populations do not appear to be declining further, and, with the exception of one enigmatic sample event in 2010, the benthic invertebrate community appears to be healthy and balanced. These data suggest that Vasquez Creek has likely not passed an ecological tipping point.

Table 3.11-13
Vasquez Creek, Upstream and Downstream of Denver Water Diversion, Macroinvertebrate Population Data Summary Parameters (1985 to 2011)

Reach/Site	Date	Density (#/m²)	Number of Taxa	Number of EPT Taxa (%)	H'	MMI Score	HBI
Upstream of Diversion							
VC-1	Spring 1985	2,300	29	17 (59)	4.00	--	--
	Fall 1985	2,079	32	20 (63)	3.47	--	--
Downstream of Diversion							
VC-2	Spring 1985	5,514	29	16 (55)	3.32	--	--
	Fall 1985	1,776	27	18 (67)	3.66	--	--
Near Hwy 40	November 8, 2000	--	38 40	20 (53) 22 (55)	4.22 4.40	75 79	3.89 3.43
	March 12, 2003	--	38	20 (53)	4.17	75	3.89
	September 13, 2010	--	21	3 (14)	2.82	23.0	5.01
	September 23, 2011	--	--	--	3.23	22.7	4.69

Source: CDPHE; Chadwick and Associates, 1986.
Notes:
-- = No data
#/m² = number of individuals per square meter
% = percent
H' = Shannon-Weaver Diversity Index
HBI = Hilsenhoff Biotic Index
Hwy = Highway
MMI = Macroinvertebrate Multimetric Index
VC = Vasquez Creek

Little Vasquez Creek

Little Vasquez Creek is a small, steep stream (refer to Section 3.3). There is no bypass flow for Little Vasquez Creek. However, there is an agreement between Denver Water and Grand County Water and Sanitation District to bypass at least 0.5 cfs downstream to the county diversion. The average diversion of native flows under Current Conditions is 83% ranging from 72-92% during the high flow months (refer to Appendix H-12). This suggests that Little Vasquez Creek downstream of the diversion has crossed a flow-based threshold.

The diversion on Little Vasquez Creek acts as a barrier to upstream migration and protects an isolated population of cutthroat trout. Three sites were sampled in 1996, with an average density of 27 fish/ha, ranging from 17 to 44 fish/ha, and an average biomass of 12.1 kg/ha, ranging from 5.5 to 21.5 kg/ha. Little Vasquez Creek was surveyed upstream of the diversion again in 1999, and the estimated cutthroat trout population was 108 ± 57 fish (Horstman 2004, as cited in Ficke et al. 2003). However, high recruitment was observed in 2001, one year after a culvert was modified to allow fish access to spawning habitat (Ficke et al. 2003). The CPW surveyed multiple sites upstream of the diversion in 2006, and fish densities ranged from 109 to 509 fish/ha. Little Vasquez Creek usually contains low densities of fish; a CPW report estimates that the population ranges from 0 to 50 fish/mile (Hirsch et al. 2006). These fish are not genetically altered; as a result, the cutthroat trout in Little Vasquez Creek are considered a "core conservation population" (Hirsch et al. 2006). Furthermore, they are assumed by the U.S. Fish and Wildlife Service (USFWS) to be greenback lineage cutthroat trout given the uncertainty in genetics.

Fish populations were sampled downstream of the Denver Water diversion in 1982, 1983, 1985, 1997, and 2006. Average fish density was variable over time, ranging from 36 to 4,046 fish/ha (Table 3.11-14). Biomass was not reported for all surveys, but values ranged up to 94 kg/ha. Brook trout and cutthroat trout were the only species present during the sampling period, and the proportion of each species in the sample exhibited large fluctuations over time (Table 3.11-14). More recent data collected by the USFS in the last few years apparently also resulted in the collection of cutthroat trout upstream of the diversion and brook trout downstream although this information has not been made available by the USFS and has not been reviewed.

Table 3.11-14
Little Vasquez Creek, Downstream of Denver Water Diversion, Fish Population Data, Percent of Total Catch, and Summary Parameters (1982 to 2006)

Species/Date (Sites)	1982 (1)	1983 (1)	1985 (2)	1997 (1)	2006 (1)
Brook trout	100%	0%	100%	100%	0%
Cutthroat trout	0%	100%	0%	0%	100%
Average density (fish/ha)	2,764	1,480	3,471	359	36
Range	**N/A**	**N/A**	**2,895-4,046**	**N/A**	**N/A**
Average biomass (kg/ha)	N/R	N/R	94	N/R	N/R
Range	**N/A**	**N/A**	**81-108**	**N/A**	**N/A**

Source: CDOW, 2005a, 2005b; Chadwick and Associates, 1985.
Notes:
Number of sites represented in each time period in parentheses.
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

Five surveys in Little Vasquez Creek downstream of the diversion provided density estimates, but only three provided a density range. Three of the five average density estimates were below the small stream 50th percentile reported by Platts and McHenry, but the lower limit of the density range was higher than the 25th percentile of Platts and McHenry. As a result, it can be concluded that the fish populations in Little Vasquez Creek are either healthy or sustaining downstream of the diversion. It is likely that, despite the high diversion rate, the section of Little Vasquez Creek downstream of the diversion has not yet crossed an ecological tipping point. Population densities appear to have declined between the 1980s and the present although sampling has not been at regular intervals and there has been only one site sampled since 1997.

Cooper Creek

Cooper Creek is a small, steep stream (refer to Section 3.3) in the Winter Park Ski Area. It is covered by wood decking or culverts for much of its length through the ski area. At the fish sampling site upstream of the diversion in 2010 the average width was just less than 1 meter. On average, 73% of the native flow is diverted and 84-96% of the spring runoff flow is diverted under Current Conditions (refer to Appendix H-12). It has no bypass flow, and it is fully diverted at times. This stream has likely crossed flow-based thresholds. However, during periods of flow in the spring, there likely are a few species of insects that can live in this stream for short periods.

In 2010, fish were absent upstream of the collection system, and Cooper Creek was being fully diverted and was dry downstream of the collection system. However, given its small size and extremely steep gradient, Cooper Creek probably could not support a fish population along its length. There are no data on macroinvertebrates for this stream. The dry sections downstream of the collection system likely do not support healthy populations of macroinvertebrates and are past an ecological tipping point. However, during periods of flow in the spring, there are likely a few species of insects that can live in this stream for short periods.

Jim Creek

Jim Creek is a small to mid-sized stream with moderate gradient with an average width of approximately 4 meters (refer to Section 3.3). At the fish sampling site downstream of the diversion in 2005 the width was on 2 meters. Step-pool morphology was the predominant habitat type, and the bed material was predominantly cobble, but boulders, gravel, and sand were also present; fine sediments were mostly present behind boulders or debris jams (refer to Section 3.3). The banks were stable, and alder and willow were the predominant types of vegetation. No water quality data are available for Jim Creek, but widespread rock staining suggests that the water in this stream has high iron concentrations (refer to Section 3.2).

There is no bypass flow for Jim Creek. The native flow depletions under Current Conditions average 89% annually and range from 78-94% during high flows (refer to Appendix H-12) and this stream meets the criteria of Carlisle et al. (2010) for a flow-based threshold. This stream is apparently fully diverted at times. McCarthy (2008) indicates that there are inputs of water from groundwater and wetlands not far downstream of the diversion.

Upstream of the Denver Water diversion, fish populations sampled in 2003 contained brook and Colorado River cutthroat trout. Brook trout comprised over 90% of the population both in terms of density and biomass. Total estimated fish density was 259 fish/ha, and total estimated biomass was 30 kg/ha.

Downstream of the diversion, fish populations were sampled in 1993 and 2005 (Table 3.11-15), with brook and rainbow trout collected in 1993 and only brook trout collected in 2005. Densities ranged from 588 to 1,688 fish/ha, and biomass estimates ranged from 10.1 to 24.3 kg/ha. In one of two sampling occasions, estimated densities were lower than the 50th percentile of Platts and McHenry by an order of magnitude, and the second was nearly identical to the 50th percentile. These limited data indicate that fish populations in Jim Creek are sustaining. Fish densities are also low in Jim Creek upstream of the diversion, indicating that water diversion is not the only factor affecting populations in this stream.

Although a remnant population of cutthroat trout persists upstream of the Denver Water diversion, it is threatened by invading brook and rainbow trout. The Denver Water diversion dam on Jim Creek is downstream of the collection system, so nonnative fish can easily access the upper reaches of the stream. A 2000 USFS survey resulted in the capture of 5 brook trout and 10 cutthroat trout in a 4,600 meter reach between the diversion dam and the headwaters—the population estimate for Jim Creek was only 102 ± 50 cutthroat trout (Ficke et al. 2003). Fish populations sampled by the CPW in 2003 were composed of brook trout and cutthroat trout. Brook trout comprised over 90% of the population both in terms of density and biomass. Total estimated fish density was 259 fish/ha, and total estimated biomass was 30 kg/ha. Jim Creek continues to support a low density (0-50 fish/mile) of cutthroat trout per mile (trout/mile) that appear to be genetically unaltered (Hirsch et al. 2006).

Benthic macroinvertebrates were sampled downstream of the diversion in 2005 as part of supplemental data collection. There were 1,686 organisms/m^2 and 41 taxa collected. These values are somewhat lower than at other sites sampled during the same period. However, the invertebrate community contained a wide variety of species, including 16 EPT taxa and many genera of midges. Most of the insect taxa were from families with no preference for erosional or depositional habitats, but three families that prefer erosional habitats were present. The Shannon-Weaver Diversity Index (H') was 3.97, indicating a healthy, well-balanced community. The community composition does not indicate signs of impairment.

The limited fish and macroinvertebrate data suggest that flow-based habitat changes in Jim Creek are sufficient to negatively affect stream biota but not severe enough to cause population collapses. The groundwater and wetland inputs likely aid in the recovery of the fish and invertebrates. The populations of fish and invertebrates appear to be sustaining at moderate levels. The stream does not appear to have crossed a tipping point. With only two fish samples, it is not possible to determine trends, but the sample from 2005 had two to three times the density and biomass of the sample from 1993 (Table 3.11-15).

Table 3.11-15
Jim Creek, Downstream of Denver Water Diversion, Fish Population Data, Percent of Total Catch, and Summary Parameters (1993 and 2005)

Species/Date	1993	2005
Brook trout	90%	100%
Rainbow trout	10%	0%
Average density (fish/ha)	588	1,688
Range	**N/A**	**N/A**
Average biomass (kg/ha)	10.1	24.3
Range	**N/A**	**N/A**

Source: CDOW, 2005a; GEI, 2013.
Notes:
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable

North Fork Ranch Creek

North Fork Ranch Creek is a small, steep stream. This stream was dry for several hundred yards downstream of the diversion during sampling in 2005. This stream is a "severely" diverted stream. It has no bypass flow and is fully diverted at times. The average annual native flow depletion under Current Conditions for this stream is 53%; the average depletion in June, the month with highest flows, is only 34% (refer to Appendix H-12). However, through much of the fall, winter, and early spring, the stream is fully diverted. This stream has crossed a flow-based tipping point.

No fish were present in the dry section of stream downstream of the diversion during sampling in 2005; the stream was fully diverted. No benthic macroinvertebrate sample could be collected in 2005. However, North Fork Ranch Creek was sampled near the mouth in 1996, and a population of cutthroat trout was present. Density was estimated to be 528 fish/ha. This density is lower than the 50th percentile of Platts and McHenry, so the North Fork of Ranch Creek could be considered collapsed or near collapse, depending upon sampling location. It is also possible that the fish in the North Fork of Ranch Creek are migrants from the mainstem of Ranch Creek, not year-round inhabitants.

Above the diversion, the North Fork of Ranch Creek flows through private land, so data are limited for this stream. No fish were captured during a 2000 USFS survey, but USFS land only encompasses the headwaters of the stream. No data are available for the more productive reaches downstream of the forest boundary. The North Fork of Ranch Creek is estimated to support a low to moderate density of cutthroat trout (50-150 fish/mile), and the genetic status of the population is categorized as unaltered (Hirsch et al. 2006).

Downstream of the diversion, the severely diverted flows and dry channel for much of the year indicate that North Fork Ranch Creek has passed an ecological tipping point. McCarthy (2008) indicates that water enters the stream from groundwater and tributary sources and these inputs likely aid in the recovery of the fish and invertebrate populations downstream.

Dribble Creek

Dribble Creek is a small, steep stream (refer to Section 3.3). Upstream of the diversion, Dribble Creek was less than 1 meter wide at the 2010 fish sampling site and the streambed was often obscured by earth or woody debris. Dribble Creek has no bypass flow, and it is fully diverted at times. It was fully diverted and dry downstream of the diversion during the time of fish sampling in 2010.

No fish were found at the site upstream of the diversion and no fish were in the dry section downstream of the diversion. Dribble Creek is too small to support a fish population. However, the high rate of diversion and dry streambed indicates that it is past an ecological tipping point.

Main Ranch Creek

Ranch Creek has a bypass flow of 4 cfs in summer and 2 cfs for the remainder of the year. Native flow diversions under Current Conditions average 30% annual with diversions of 20-32% in June and July on average (refer to Appendix H-12). There is another diversion downstream of the Denver Water diversion, Klein Ditch, that can divert water that is bypassed from the Denver Water diversion.

Ranch Creek was surveyed below the confluence of the North Fork of Ranch Creek and has a steep channel. The average bankfull width was approximately 7 meters (refer to Section 3.3). Step-pool morphology was the predominant habitat type. Cobble and boulders were the most common substrate types, and coarse sand was observed downstream of boulders and in overbank deposits. Banks were stable and vegetation was predominantly willow and conifers (refer to Section 3.3).

Ranch Creek is 303(d) listed for temperature under the Clean Water Act (CWA). Temperature exceedances were frequent in Ranch Creek from 2005 through 2009 (refer to Section 3.2). The maximum temperature observed in Ranch Creek between 2005 and 2009 was 24.3°C, a potentially lethal temperature for trout if it occurred over the time scale of days. These data suggest that acute, short-term temperature stresses are probably experienced by trout in Ranch Creek. MWAT temperatures in Ranch Creek were always within the optimal temperature range for trout. Exceedances of MWAT criteria were rare: three were observed at two sites in a four-year time span. The periodic exceedance of DM values when MWAT values generally met State standards; this suggests that stressful and potentially lethal temperatures occurred only for short periods of time (i.e., a few hours or less).

Main Ranch Creek was sampled upstream of the diversion in 2010, and a total of 31 brook trout were collected. Fish total length ranged from 46 mm to 212 mm and included a wide size range from YOY to adults. Densities were estimated to be 780 fish/ha, and biomass was estimated to be 20 kg/ha.

Downstream of the diversion, fish populations were sampled in 1978, 1985, 1986, 1993, and 2005 (Table 3.11-16). In 1993, brook trout, brown trout, rainbow trout, longnose sucker, mottled sculpin, and speckled dace were collected, with mottled sculpin the dominant species. Total fish density was 1,615 fish/ha. Biomass estimates were not calculated. In 2005, only brook trout were collected, amounting to 133 fish/ha and only 2.2 kg/ha.

Table 3.11-16
Main Ranch Creek, Downstream and Upstream of Denver Water Diversion, Fish Population Data, Percent of Total Catch, and Summary Parameters (1978 to 2005)

Species/Date	1978	1985	1986	1993	2005
Brook trout	100%	62%	100%	11%	100%
Brown trout	0%	29%	0%	7%	0%
Rainbow trout	0%	3%	0%	15%	0%
Longnose sucker	0%	3%	0%	4%	0%
White sucker	0%	3%	0%	0%	0%
Mottled sculpin	0%	0%	0%	59%	0%
Speckled dace	0%	0%	0%	4%	0%
Average density (fish/ha)	132	1,545	1,345	1,615	133
Range	**N/A**	**N/R**	**N/R**	**N/R**	**N/R**
Average biomass (kg/ha)	N/R	N/R	N/R	N/R	2.2
Range	**N/R**	**N/R**	**N/R**	**N/R**	**N/R**

Source: CDOW, 2005b; GEI, 2013.
Notes:
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

The density of fish at sites in Main Ranch Creek was similar to the small stream 50th percentile of Platts and McHenry on only two of five occasions, indicating a sustaining population. Density in 2010 was also low upstream of the diversion, suggesting the stream in this area does not support high density of fish. Density estimates over time exhibit fluctuations likely due to natural events, but indicate no increasing or decreasing trends.

Macroinvertebrate data collected in 2005 downstream of the diversion indicate the presence of an abundant, diverse, and healthy community. Density was 43,361 organisms/m^2 (Table 3.11-17), an order of magnitude higher than for most other sites. The number of taxa collected was 46, higher than at many other sites. The sample contained invertebrates from a wide range of groups including many EPT taxa, and midges, along with a few mite and worm taxa. EPT taxa accounted for 46% of the total taxa (Table 3.11-17). There were seven families represented that prefer erosional habitats, but most of the taxa were from families with no preference for erosional or depositional habitats. Nine taxa had density estimates of greater than 1,000 organisms/m^2, so there was not a single taxon or a few taxa that were dominating the community; this is also reflected in the Shannon-Weaver Diversity Index (H') of 3.43, which indicates a healthy, well-balanced community.

Table 3.11-17
Main Ranch Creek, Downstream of Denver Water Diversion, Macroinvertebrate Population Data Summary Parameters (2005 to 2010)

Reach/Site	Date	Density (#/m²)	Number of Taxa	Number of EPT Taxa (%)	H'	MMI Score	HBI
Below Diversion	2005	43,361	46	21 (46)	3.43	--	--
Near Tabernash	September 13, 2010	--	--	--	3.24	65.3	3.80
	February 26, 2011	--	--	--	3.66	63	3.66

Source: CDPHE; GEI.
Notes:
-- = no data
#/m² = number of individuals per square meter
% = percent
EPT = Ephemeroptera, Plecoptera and Trichoptera
H' = Shannon-Weaver Diversity Index
HBI = Hilsenhoff Biotic Index
MMI = Macroinvertebrate Multimetric Index

Data from two samples collected on Ranch Creek near Tabernash by CDPHE were available. The sample collected in 2010 had an MMI score of 65.3, and the sample collected in 2011 had an MMI score of 63.0. Both of these scores indicate that Ranch Creek is attaining its aquatic life use. The diversity values from these sites were similar to the values from the 2005 site (Table 3.11-17).

The abundant and healthy macroinvertebrate community indicates that flow and water quality are suitable to sustain the healthy populations of invertebrates including numerous sensitive species. This may likely be due to the bypass flow in this reach. The fish community does not sustain abundant populations. Main Ranch Creek is sustaining fish populations and likely has not yet reached an ecological tipping point.

Middle Fork Ranch Creek

Middle Fork Ranch Creek is a small, narrow, steep stream (refer to Section 3.3). At the fish sampling site downstream of the diversion in 2005 the width was just over 2 meters. There is no bypass flow for Middle Fork Ranch Creek. There is no individual native flow diversion estimated for Middle Fork Ranch Creek; the estimation also contains South Fork Ranch Creek. The native flow diversions under Current Conditions for both streams are 61% on average and 43-84% in the high flow months (refer to Appendix H-12).

The cutthroat trout population upstream of the Denver Water diversion on Middle Fork Ranch Creek is protected by a barrier to upstream migration, either by dry channels downstream of the diversion or by a gradient barrier lower in the watershed. A 2000 USFS survey resulted in a total population estimate of 99 fish for Middle Fork Ranch Creek from the Denver Water diversion to the headwaters. Although this reach is approximately 4,000 meters long, fish were only captured within 800 meters upstream of the diversion (Ficke et al. 2003). Cutthroat trout density upstream of the diversion is low (0-50 fish/mile, Hirsch et al. 2006). Although the genetic status of the cutthroat trout in Middle Fork Ranch Creek has not been tested, these fish are considered unaltered (Hirsch et al. 2006).

This stream was flowing downstream of the diversion in 2005, but fish were absent. Fish presence upstream of the diversion suggests that flow diversion may be the cause of the lack

of fish downstream of the diversion. However, fish were captured in low densities (i.e., below the small stream 50th percentile of Platts and McHenry) by CPW in 1979 and 1992 near the confluence with the South Fork of Ranch Creek. Density estimates ranged from 130 to 538 fish/ha. This suggests that the biological status of the stream improved with distance from the diversion. McCarthy (2008) indicates that flows from groundwater and tributaries enter the stream just downstream of the diversion, which may account for some of the recovery. However, it is also possible that the fish in the Middle Fork of Ranch Creek are migrants from the main stem of Ranch Creek, not year-round inhabitants.

Benthic macroinvertebrates in the section of stream just downstream of the diversion were sampled in 2005 and exhibited a healthy and diverse community. The species composition included many sensitive species such as the 20 EPT taxa, and there were five families that prefer erosional habitats. Most of the taxa were from families with no preference for erosional or depositional habitats. Density was 6,262 organisms/m^2, and there were 46 taxa, similar to many other streams sampled in 2005. The Shannon-Weaver Diversity Index (H') was 4.43, indicating a healthy, well-balanced macroinvertebrate community.

The fish populations downstream of the diversion appear to be near collapse or collapsed, but a diverse macroinvertebrate population persists. This suggests that flow changes were severe enough to exclude most fish but not severe enough to substantially affect the macroinvertebrate community. This indicates that Middle Fork Ranch Creek may be past an ecological tipping point.

South Fork Ranch Creek

South Fork Ranch Creek was fully diverted and was dry downstream of the diversion at time of sampling in 2005 precluding the collection of fish or macroinvertebrate samples. This stream has no bypass flow, and it is fully diverted at times. There is no individual native flow diversion estimated for South Fork Ranch Creek; the estimation also contains Middle Fork Ranch Creek. The native flow diversions under Current Conditions for both streams are 61% on average and 43-84% in the high flow months (refer to Appendix H-12). The South Fork of Ranch Creek is a moderately steep and narrow channel (refer to Section 3.3). Downstream of the diversion, groundwater, wetlands, and tributaries add water to the channel (McCarthy 2008).

The diversion on South Fork Ranch Creek has not isolated cutthroat trout from invading nonnative salmonids. In 2003, CPW sampled six stations along South Fork Ranch Creek upstream of the diversion and collected brook and cutthroat trout (Table 3.11-18). Brook trout comprised 82% and native cutthroat trout comprised 18% at the most downstream site near the diversion. There was a transition to higher proportions of cutthroat trout upstream through the sites. The upstream-most site contained 100% cutthroat trout because it is located upstream of a perched culvert that prevents upstream passage of brook trout. Population surveys indicated that there were fewer than 100 cutthroat trout in the South Fork of Ranch Creek upstream of the Denver Water diversion (Horstman 1999, as cited in Ficke et al. 2003). This stream supports low densities of cutthroat trout (0-50 fish/mile, Hirsch et al. 2006). Although the genetic status of the cutthroat trout population has not been tested, these fish are considered unaltered (Hirsch et al. 2006). The diversion apparently has been recently modified to function as a barrier, however, no recent data were available to evaluate the status of the cutthroat population upstream of the barrier.

Table 3.11-18
South Fork Ranch Creek, Upstream of Denver Water Diversion, Fish Population Data, Percent of Total Catch, and Summary Parameters (2003)

Species/Site	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Brook trout	88%	70%	50%	33%	100%	0%
Cutthroat trout	12%	30%	50%	67%	0%	100%
Density (fish/ha)	349	526	90	90	77	233

Source: CDOW, 2003.
Notes:
% = percent
fish/ha = fish per hectare

Downstream of the diversion, South Fork Ranch Creek was sampled in 1978, 1983, and 1992 and was dry in 2005. In 1978, cutthroat trout were sympatric with brook trout, and their densities were estimated to be 296 and 81 fish/ha, respectively. In 1983, a dense (2,690 fish/ha), population of cutthroat trout was present. In 1992, cutthroat trout were absent, and this reach of South Fork Ranch Creek supported approximately 1,076 brook trout/mile. This stream was dry at time of sampling in 2005. Four fish density estimates are available for this stream downstream of the diversion. The fish density was higher than the small stream 50th percentile of Platts and McHenry on one of four occasions, but fish were absent downstream of the diversion on the fourth occasion (in 2005). This indicates that the fish population in this stream is near collapse or has collapsed, and temporal trends suggest that this population has decreased over time.

Wolverine Creek

This stream was sampled upstream of the diversion in 2010 and fish were absent. Wolverine Creek was less than 1 meter wide and very shallow upstream of the interceptor. There was very low flow and the poorly-defined channel was overgrown with willows. At the time of sampling, all of the water in Wolverine Creek flowed into the interceptor and the channel was dry downstream.

Wolverine Creek likely never supported fish due to its small size. However, the stream is fully diverted at times and downstream of the interceptor the stream has likely passed a tipping point.

Cub Creek

Cub Creek is a very small, steep stream (refer to Section 3.3). At the fish sampling site upstream of the diversion in 2010, the width was less than half a meter and the flow was very low, going below the surface in some spots. Cub Creek has no bypass flow, and it is fully diverted at times. Downstream of the diversion in 2010 the stream was fully diverted and dry. The native flow diversion under Current Conditions for Cub and Buck creek is 73% on average and up to 88% during high flow months (refer to Appendix H-12).

No fish were present upstream of the diversion during sampling in 2010. Cub Creek was not sampled for fish or macroinvertebrates downstream of the diversion because there was no standing or running water. Cub Creek is too small to support a fish population. This stream is severely diverted and the dry channel below the diversion indicates that an ecological tipping point has been crossed.

Buck Creek

Buck Creek is a small, steep stream (refer to Section 3.3). At the fish sampling site upstream of the diversion in 2010 the width was less than 2 meters and downstream of the diversion the width was less than 1 meter. It has no bypass flow, and it is fully diverted at times. The native flow diversion under Current Conditions for Cub and Buck creeks is 73% on average and up to 88% during high flow months (refer to Appendix H-12).

Fish sampling upstream of the diversion on Buck Creek in 1983 indicated that no fish were present. However, a 2007 survey upstream of the diversion resulted in the capture of 46 brook trout and one rainbow trout. The resulting density estimates were 680 brook trout and 15 rainbow trout/ha. This stream was sampled upstream and downstream of the diversion in 2010, but fish were absent, suggesting that the fish population both upstream of the diversion collapsed between 2007 and 2010. However, the stream is small and narrow. Fish were only present upstream of the diversion in one of three surveys, and Buck Creek is directly connected with the Moffat Collection System, which contains fish. It is more likely that fish occasionally access this stream from the Denver Water aqueduct and that Buck Creek does not support self-sustaining fish populations. However, the high rate of diversion of native flows suggests that Buck Creek has crossed a tipping point downstream of the diversion.

Meadow Creek

Meadow creek is a mid-sized stream with sections of steep and low gradient channels (refer to Section 3.3). At the supplemental fish sampling site just downstream of the Denver Water diversion in 2005, the channel was almost 9 feet wide. There is a bypass flow of 3 cfs in summer and 1.5 cfs for the rest of the year on this stream for the sections downstream of Meadow Creek Reservoir and downstream of the Denver Water diversion. However, less than a mile downstream of the Denver Water diversion the Vail Ditch also diverts from the stream and, at times in late spring through early fall, fully diverts the stream.

No data exist for fish populations in Meadow Creek upstream of the Englewood diversion. However, Meadow Creek Reservoir upstream of the diversion has predominantly brook trout with a few cutthroat and rainbow trout (CDOW 2011b). There are brook trout in the two mile section of the stream between the diversion and the reservoir. Cutthroat trout are thought to be present in Meadow Creek and East Meadow Creek upstream of the reservoir because a small number of cutthroat trout was captured during Meadow Creek Reservoir gill net surveys in 2007. However, no population or density estimates have been calculated. No data are available for the genetic lineage of this population.

Downstream of the diversion, fish populations were sampled at various locations in 1979, 1981, 1993, 2005, 2006, and 2007. In 1993, brook trout, brown trout, and mottled sculpin were collected, with brook trout the dominant species at a site in lower Meadow Creek near Tabernash (Table 3.11-19). In 2005, only brook trout were collected at the supplemental site just downstream of the diversion, amounting to 252 fish/ha and 1.4 kg/ha. During the 2006 sampling effort brook trout were captured in densities that were higher than the 1993 and 2005 values. Cutthroat trout are thought to be present in Meadow Creek and East Meadow Creek, because a small number of cutthroat trout was captured during Meadow

Creek Reservoir gill net surveys in 2007. However, no population or density estimates have been calculated. No data are available for the genetic lineage of this population. Meadow Creek Reservoir is approximately 2 miles upstream of the Denver Water diversion.

Table 3.11-19
Meadow Creek, Downstream of Denver Water Diversion, Fish Population Data, Percent of Total Catch, and Summary Parameters (1993, 2005, and 2006)

Species/Date	1993	2005	2006
Brook trout	77%	100%	100%
Brown trout	3%	0%	0%
Mottled sculpin	20%	0%	0%
Average density (fish/ha)	139	252	4,344
Range	**N/A**	**N/A**	**N/A**
Average biomass (kg/ha)	N/R	1.4	N/R
Range	**N/A**	**N/A**	**N/A**

Source: CDOW 2005a, 2011b; Chadwick Ecological Consultants supplemental sampling in 2005.
Notes:
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

This stream was sampled at a single site below the diversion on three occasions. Density estimates were higher than the small stream 50th percentile of Platts and McHenry on one of the three occasions, suggesting that fish populations in this stream are healthy to sustaining.

Macroinvertebrates were sampled in 2005 at the supplemental site just downstream of the diversion. The density of 4,212/m^2 and the 53 taxa collected were comparable to the values collected at many other sites in 2005. The species composition included a wide variety of invertebrates including ten species of mayflies, numerous stoneflies and caddisflies, and many other species. There were 22 EPT taxa present representing 42% of the total taxa. Most taxa were from families with no preference for erosional or depositional habitats, but there were five families, representing eight individual taxa, that prefer erosional habitats. The invertebrate community is healthy and diverse, as evidenced by the Shannon-Weaver Diversity Index (H') score of 3.81.

One sample was collected on Meadow Creek below Meadow Reservoir in 2006 using CDPHE protocols. This sample had an MMI score of 69.4, indicating that Meadow Creek is attaining its aquatic life use. Diversity was 4.39, somewhat higher than for the 2005 sample.

The presence of healthy invertebrate populations and the persistence of fish populations at all sampling sites in Meadow Creek indicates that it is a mildly diverted stream in most sections. The available information suggests that this stream has not crossed an ecological tipping point. However, there may be a short section downstream of the Vail Ditch where the cumulative diversions may fully divert the stream and the channel is dry until flow returns from groundwater and other inputs.

Trail Creek

Trail Creek does not have a Denver Water diversion but is just downstream of diversions on North and South Trail creeks. In 2005, Trail Creek was sampled just downstream of the confluence of North Trail and South Trail creeks, to provide information on biota downstream of these two tributary diversions. Trail Creek is a narrow, steep, small stream (refer to Section 3.3). At the fish sampling site in 2005 the stream width was just over 2 meters.

In 2005 there was water present in the channel of Trail Creek just downstream of the confluence of North Trail and South Trail creeks. Fish were absent despite the fact that the sampling site contained flowing water and one deep pool. The bypass agreement for Trail Creek maintains a low flow year-round, but it may be insufficient to sustain fish. Fish populations may have collapsed in this stream, but there are insufficient data available to determine whether they were historically present.

A moderate density of 2,802/m^2 and relatively high number of taxa of invertebrates (51) were found in 2005. The macroinvertebrate community included a wide variety of species including many EPT taxa and six families that prefer erosional habitats. Most of the insect taxa were from families with no preference for erosional or depositional habitats. The bypass flows on the upper streams apparently allow sufficient water to sustain healthy, diverse populations of macroinvertebrates in Trail Creek with a Shannon-Weaver Diversity Index (H') of 4.45. It appears from the limited data that Trail Creek is mildly diverted in its tributaries and has not passed a tipping point.

North Trail and South Trail Creeks

Both of these streams are small, steep streams. Both of these streams are diverted near their mouth and there are only short sections of stream downstream of the diversions. There are bypass flows of 0.25 cfs in both streams, and they may be "mildly" diverted tributaries. These streams were not sampled for fish or macroinvertebrates downstream of the diversions because of the short distance between the diversions and the stream mouths. The absence of fish in Trail Creek downstream of the confluence of these two streams indicates that there are no fish in the short sections of these streams downstream of the diversions.

These streams were both sampled upstream of the diversions in 2010. No fish were present in North Trail or South Trail creeks. Both streams were steep and approximately 1 meter wide—they may be too small to support fish on a year-round basis.

There is insufficient data to determine if these two short sections of stream are past a tipping point. The bypass agreements suggest that a tipping point may not yet have been crossed.

Hurd Creek

Hurd Creek is a small, steep stream (refer to Section 3.3). At the fish sampling sites in 2010 and 2005 the width was 2 to 3 meters. There is a bypass flow of 1 cfs year round in this stream.

At a site several miles downstream of the diversion, fish populations were sampled in 1993. Brook trout, brown trout, and mottled sculpin were collected, with the trout species being

nearly equal in abundance. Total fish density was 5,745 fish/ha and was well above the 50th percentile of Platts and McHenry. Biomass estimates were not calculated. In 2005, no fish were collected during sampling in Hurd Creek at a site just downstream of the diversion, although there was water present in the channel.

Since this stream was sampled at a single site downstream of the diversion on two occasions, density estimates are available. The density estimate from 1993 was well above the small stream 50th percentile of Platts and McHenry, but fish were absent in 2005. Because fish presence in this stream is inconsistent, the population status is difficult to determine. It could be that the fish are sustained only in some years although it could be that the population collapsed between 1993 and 2005.

Hurd Creek was sampled upstream of the Englewood diversion in 2010. No fish were present. This stream was extremely steep, and the channel consisted of alternating abandoned beaver ponds and a steep, braided channel.

Hurd Creek contained relatively high density and number of taxa of macroinvertebrates in 2005. Density was 3,380/m^2, comparable to most other streams and the number of taxa was 50, higher than many streams. Species composition included a wide variety of invertebrates including many species that are usually sensitive to flow or water quality degradation such as the EPT taxa. There were five families that prefer erosional habitats represented, many families with no preference for erosional or depositional habitats, and the Shannon-Weaver Diversity Index (H') was 3.96, indicating that a healthy, balanced macroinvertebrate community was present.

The lack of fish at sites just upstream and just downstream of the diversion suggests that this portion of the stream does not have habitat suitable to support fish The macroinvertebrate data indicate that flow and water quality are sufficient to sustain healthy populations and fish are present at high density further downstream of the diversion. This indicates that Hurd Creek is not yet past an ecological tipping point.

Hamilton Creek

Hamilton Creek is a small steep stream with a stream width of over 2 meters at the 2005 fish sampling site downstream of the diversion. There is a bypass flow of 1.5 cfs in June through April and 1 cfs in May through early June.

Downstream of the diversion, CEC conducted fish population sampling in 2005 and collected brook trout. Total density was 484 fish/ha, and total biomass was 14.5 kg/ha. This density was lower than the small stream 50th percentile of Platts and McHenry. This population could be considered near collapse, but the data used to support this classification are extremely limited. The diversion dam at Hamilton Creek has been modified to form a barrier to upstream fish passage. Therefore, the upstream cutthroat trout population in this stream is protected from nonnative salmonids.

In 2000, a USFS population survey resulted in a population estimate of 1,206 ± 202 fish for Hamilton Creek from the Denver Water diversion to the headwaters. In 2003, CPW sampled five stations along Hamilton Creek upstream of the diversion and collected only cutthroat trout at each site. At one site, 183 fish were captured in a single electrofishing pass, and at the other four sites, total densities ranged from 456 to 8,847 fish/ha. Biomass estimates were not made. Hamilton Creek was surveyed upstream of the diversion again in

2009, and density estimates ranged from 159 to 699 fish/ha. The genetic status of this cutthroat trout population is unaltered (Hirsch et al. 2006) and they are assumed by the USFWS to be greenback lineage cutthroat trout given the uncertainty in genetics.

This stream contained a relatively high density at the site downstream of the diversion in 2005 with 10,604/m^2. The number of taxa of 47 was comparable to many other sites. The high density was partly the result of high numbers of midges, but the third most abundant taxon was a mayfly (*Baetis tricaudatus*). There were many sensitive insects, including the EPT taxa, and there were seven families that prefer erosional habitats. Most of the insect taxa were from families with no preference for erosional or depositional habitats. The Shannon-Weaver Diversity Index (H') of 3.97 indicates that there was a healthy, diverse community, and that the assemblage was not dominated by only one or a few taxa.

Diversions on Hamilton Creek may be sufficient to have affected the fish populations but not the macroinvertebrate populations. The very limited data suggest that the fish populations downstream of the diversion are near collapse but the macroinvertebrate community is healthy. This stream may be approaching a tipping point from a fishery perspective.

Cabin Creek

Cabin Creek is larger than many of the other streams in the Englewood-Ranch Gravity System. The average width of the stream at the 2005 fish sampling site downstream of the diversion is nearly 4 meters. This stream also is not as steep as the other streams (refer to Section 3.3). Cabin Creek has a bypass agreement for 2 cfs year-round although there are downstream diversions that can divert this flow.

Cabin Creek supports an allopatric cutthroat trout population. A 2000 USFS survey resulted in a total population estimate of 2,121 ± 326 fish in Cabin Creek from the Denver Water diversion to the headwaters. Two sites were sampled upstream of the Englewood diversion in 2003. Only cutthroat trout were collected. At one site, fish density was 2,088 fish/ha, but a biomass estimate was not made. At the other site, fish density was 257 fish/ha, with total biomass of 4.7 kg/ha. Low densities of cutthroat trout (600-700-fish/ha) were also estimated for this stream in 2005 and 2006. The genetic status of the cutthroat population upstream of the diversion appears to be altered (Hirsch et al. 2006). The Denver Water diversion is not a barrier to upstream fish movement, but brook trout are absent upstream of it. Instead, brook trout invasions have probably been prevented by an impassable road culvert or a gradient barrier.

Downstream of the diversion, fish populations have been sampled in several years (1979, 1983, 1996, 1999, 2003, and 2005). In every year except 2003, cutthroat trout was the only species collected, and density estimates ranged from 269 to 3,365 fish/ha. In 2003, the site sampled was located 1 mile below the USFS road, considerably downstream of the diversion, whereas the other sites were generally near or upstream of the confluence with Ranch Creek. Brook trout dominated the population at that site, comprising 99% of the population and 92% of the biomass. Brown trout comprised the rest of the population.

Cabin Creek was sampled at a single location downstream of the diversion on eight occasions. The estimated densities were greater than the small stream 50th percentile of Platts and McHenry on two of these occasions, and they were similar to the 50th percentile

on two more occasions. This suggests a sustaining population. However, no temporal trends are apparent in the density data.

Benthic macroinvertebrates were sampled in 2005 at a site downstream of the diversion. The community was diverse and abundant with density of 6,852/m^2 and 52 taxa. The species composition included 23 EPT taxa along with beetles, midges and other flies, mites, and worms. Most of the insect taxa were from families with no preference for erosional or depositional habitats, but there were six families that prefer erosional habitats, and the Shannon-Weaver Diversity Index (H') was 3.85, indicating a healthy, well-balanced community.

Cabin Creek supports a sustaining fish population and a relatively high density and number of taxa of invertebrates. As with several, of the streams in the area, diversions in Cabin Creek may be sufficient to affect the fish populations but not the macroinvertebrate populations. This stream is not yet near a tipping point.

Little Cabin Creek

Little Cabin Creek has a bypass agreement for 0.25 cfs year-round and there are downstream diversions that also divert water from the stream. Little Cabin Creek is a small steep stream like many of the other Fraser River tributaries (refer to Section 3.3). At the time of sampling in 2005, there was water in the channel of Little Cabin Creek downstream of the diversion. This section supported a community of invertebrates with relatively high density and number of taxa. Density of 3,769/m^2 and 52 taxa compare well to most other streams. The species composition included a diverse assemblage including eight stonefly species, eight caddisfly species and numerous species of mayflies and true flies. There were six families present that prefer erosional habitats, one of which, the Simuliidae, had the most abundant taxon (1,915 organisms/m^2) at the site. Most insect taxa were from families with no preference for erosional or depositional habitats. The Shannon-Weaver Diversity Index (H') was 3.10, indicating a healthy, well-balanced macroinvertebrate community.

No fish were present downstream of the Denver Water diversion in 2005, and no fish were present upstream of the diversion in 2010. CPW sampled this stream in 1979 and no fish were collected. There are no other data available for Little Cabin Creek. Fish may be absent from this small stream due to natural factors. This stream is less than 1 meter wide at the sites upstream and downstream of the diversion, and the stream flows underground in several places. It is unlikely that this stream can support fish.

Apparently Little Cabin Creek is a "mildly" diverted stream. Similar to many of the other streams in the area, the macroinvertebrate community is healthy but the fish community is limited or absent. In the case of Little Cabin Creek, fish are likely precluded due to small stream size and the current flow regime is supporting a healthy invertebrate community. This suggests that Little Cabin Creek is not yet near an ecological tipping point.

General Observations in the Fraser River Tributaries – When brook trout and cutthroat trout were sympatric, brook trout were generally the dominant species (comprising greater than 50% of the community). Little Vasquez Creek, Jim Creek, the Ranch Creek complex (Middle Fork, South Fork, and Main Ranch), and Hamilton Creek are considered core

conservation populations (Hirsch et al. 2006). These are given the highest priority in terms of management and protection.

Although the status and distribution of native lineages of cutthroat trout is uncertain (Metcalf et al. 2012), cutthroat trout populations in the following streams are considered to be genetically pure: Iron Creek, Little Vasquez Creek, the North Fork of Ranch Creek, Hamilton Creek, and Jim Creek. However, the genetic status of cutthroat trout populations in Cabin Creek, the Middle Fork of Ranch Creek, the South Fork of Ranch Creek, and Vasquez Creek is less clear (Hirsch et al. 2006; Young et al. 1996). These populations could contain genetic characteristics of rainbow trout, other cutthroat trout subspecies, or both.

Diversions as Fish Barriers

The existing diversions on Little Vasquez Creek and Hamilton Creek are effective barriers to non-native fish species. The diversion at Hamilton Creek was modified to prevent upstream movement of brook trout. The diversions at Cabin Creek, the Middle and North Forks of Ranch Creek, and McQueary Creek may not be fish barriers, but Cabin Creek flows through some barriers to upstream migration downstream of Forest Road 128, and the middle and north forks of Ranch Creek and McQueary Creek are steep and characterized by very low flows downstream of their diversions. These barriers have protected cutthroat trout populations that may be native lineages (Metcalf et al. 2012) from invasion. The diversion dams on Jim Creek, the South Fork of Ranch Creek, Bobtail Creek, and Steelman Creek are not barriers, and brook trout can be found in the headwaters in all four streams.

Isolation Management of Cutthroat Trout

Isolation of pure cutthroat trout populations has serious management implications because headwater streams are often fragmented and characterized by small size and low water temperatures. Low temperatures in headwater streams can limit recruitment of cutthroat trout. Laboratory studies showed that fish held in a cold temperature regime survived poorly after swim-up (Coleman and Fausch 2007a), and extensive field surveys of six Colorado headwater streams found that streams with fewer than 800 degree-days prevented recruitment (Coleman and Fausch 2007b). Low temperatures also limit trout distributions in Wyoming—fish from the Genus *Oncorhynchus* required streams with maximum July temperatures of at least 13ºC for successful reproduction (Mullner and Hubert 2005). A combination of appropriate temperatures, deep pools, and minimum stream size is required for successful translocations (Harig et al. 2000). This model was applied to streams in the Arapaho & Roosevelt National Forests, and the most important variable affecting population size was stream length (Young et al. 2005). The authors acknowledged that longer streams are more likely to contain complex habitat, deep pools, and habitat heterogeneity than short ones. A stream must be approximately 3 km long to support a population of 500 fish (Young et al. 2005), the minimum viable population size under the Greenback Cutthroat Trout Recovery Plan (USFWS 1998).

Isolation management also selects against mobile individuals—this life history strategy is not preserved in the population (Fausch and Young 1996), as mobile individuals move downstream and cannot return. For example, in a Wyoming study of four isolated stream segments, cutthroat trout were translocated into fishless areas upstream of barriers, and most of them left the segments upstream of the barriers. Fewer cutthroat trout remained in

isolated segments than in sympatric populations alongside brook trout. Incomplete habitat requirements in the 1.6 to 3.7 km-long study reaches was cited as a reason for translocation failures (Novinger and Rahel 2003).

If invasion risk is high and if it will invariably lead to cutthroat trout extirpation, isolation is recommended (Fausch et al. 2009). Because all of the unchecked brook trout invasions within the Project area have led to extirpation of cutthroat trout, isolation management should continue to be used as a management strategy.

Entrainment Rates into Diversions

Entrainment rates of fish into diversions depend upon interactions between stream flow, diversion rate and timing, and timing of fish migrations (Bahn 2007; Carlson and Rahel 2007), and they appear to differ between watersheds. This phenomenon has not been extensively studied, and the literature is equivocal with respect to population-level effects of entrainment. A study on the Smiths Fork River in Wyoming showed that entrainment rates resulted in mortality rates of 1.2 to 7.1%. The three studied diversions removed an average of 32% of the river's flow (Carlson and Rahel 2007). The authors concluded that, in comparison with natural annual mortality rates (42.6%), entrainment-caused mortality rates are low. On the other hand, a multi-year field study in Montana showed that the number of Bonneville cutthroat trout (*Oncorhynchus clarkii utah*) entrained in agricultural diversions exceeded the number of fish that successfully moved downstream (Bahn 2007).

Entrainment rates in the Moffat Collection System are unknown. The diversions do not include screens or other mechanisms to prevent entrainment. The previously described studies involved larger systems with diversions located further from the headwaters. Therefore, entrainment risks in these streams would likely be different from those in the Fraser River and Williams Fork tributaries, because these diversions have confined cutthroat trout to the headwaters. Given the small size of the stream segments above them, the Moffat Collection System diversions may present a substantial entrainment risk for native cutthroat trout. However, it is also possible that the isolated cutthroat trout populations upstream of these diversions have lost their mobile component—downstream migrants cannot return to isolated headwater populations, regardless of whether or not they are entrained. The cutthroat trout populations upstream of the diversions have sustained themselves for decades since the diversions were first installed with the diversions functioning and entraining fish as they have in the past. The Project would not change the total amount of water going past the diversion point, either into the diversion or passing the diversion and going downstream, and fish would be potentially entrained with the water in either case and lost to the upstream population. The additional diversions during a few months in some of the wetter years with the Project should not affect the ability of the populations to continue to sustain themselves.

3.11.6.2 Williams Fork River

The Project and its alternatives include additional diversions of water from tributaries in the Williams Fork River Basin. This would result in depletions in average annual flows of greater than 10% in the mainstem of the Williams Fork River upstream of the South Fork. Therefore, the Williams Fork River upstream of the South Fork and all tributaries with Denver Water diversions has full descriptions of aquatic biological resources. Downstream

of the South Fork, changes in annual and monthly flows would be less than 10% and this section of the river has a brief description of aquatic resources. The Surface Water classification for the Williams Fork River and its tributaries is Aquatic Life Cold Class 1 with CS-I temperature standards.

Williams Fork River: Upstream of the Confluence with the South Fork

Habitat

PHABSIMs are available for the Williams Fork River in the section upstream of the South Fork. Habitat simulation for brook trout indicates that habitat availability for adults is highest at flows of 5 to 20 cfs (Chadwick and Associates 1986).

A geomorphic survey resulted in the classification of this reach as a moderate gradient stream (refer to Section 3.3). The average bankfull width was 9 meters. Shallow riffle was the predominant habitat type. Bed materials were predominantly cobble and gravel, and sand was uncommon. Stream banks are stable, and vegetative cover includes mosses, grasses, willows, and conifers.

Fish

The fish populations in the Williams Fork River mainstem are typical of a Rocky Mountain alpine coldwater fishery. Surveys have been made periodically since the 1960s (Chadwick and Associates 1986). Fish species composition in the Williams Fork River has been variable over time; species collected upstream of the South Fork include brook trout, brown trout, cutthroat trout, rainbow trout, and Paiute sculpin (Table 3.11-20). Rainbow trout have been collected in the 1970s, 1990s, and 2000s, but they have never formed a large proportion of the total catch. CPW does not stock this section of the river. Brook trout were often the most numerous trout species, but mottled sculpin formed the highest percentage of the total catch when they were present. The few cutthroat trout collected may have moved downstream from populations in tributaries. Paiute sculpins were rare in all collections, and were more abundant at sites downstream of the South Fork (Chadwick and Associates 1986). Total fish density ranged from 822 to 1,367 fish/ha in samples from the 1980s, with brook trout accounting for 90 to 99% of the density. Total fish biomass ranged from 26 to 82 kg/ha with brook trout comprising 86 to 99% of the biomass. Biomass was not estimated in the 1990s or 2000s. Whirling disease has been identified as present within the Williams Fork mainstem.

Table 3.11-20
Williams Fork River, Upstream of the South Fork Williams Fork, Fish Population Data, Percent of Total Catch, and Summary Parameters (1993 to 2007)

Species/Date (Sites)	1993 (3)	1996 (1)	1999 (1)	2001 (1)	2007 (1)
Brook trout	18.8%	0%	0%	97%	37.5%
Brown trout	0%	0%	44%	0%	0%
Cutthroat trout	0%	100%	0%	0%	0%
Rainbow trout	14.2%	0%	0%	3%	0%
Mottled sculpin	67%	0%	56%	0%	62.5%
Average density (fish/ha)	3,113	2[1]	10,763	22,453	4,258
Range	**240-5,598**	**N/A**	**N/A**	**N/A**	**N/A**
Average biomass (kg/ha)	N/R	N/R	N/R	N/R	N/R
Range	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

Source: CDOW, 2011b.
Notes:
[1]Population estimate for stream reach from diversion to headwaters. Reported range is a 95% confidence interval.
Number of sites represented in each time period in parentheses.
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

Fish density estimates in the Williams Fork River have consistently been above the 50th percentile of Platts and McHenry (Table 3.5-14), indicating that the fish assemblages in this stream are healthy. There also appears to be no temporal trend in fish densities, suggesting that observed variation in density are natural.

Benthic Macroinvertebrates

Benthic macroinvertebrate populations were sampled through the entire mainstem Williams Fork River in fall 1984 and spring 1985 (Table 3.11-21). At the five sites upstream of the South Fork on the mainstem, density estimates ranged from 892 to 2,351 organisms/m^2, represented by 15 to 32 taxa per site. A wide range of invertebrate taxa were collected, included in the groups Ephemeroptera, Plecoptera, Coleoptera, Trichoptera, Diptera, Turbellaria, Hirudinea, Oligochaeta, and Pelecypoda (Chadwick and Associates 1986). These invertebrate groups are typical groups found in Rocky Mountain streams (Ward 1986, 1994; Ward et al. 2002). Throughout the stream, sixteen taxa represented eight families that prefer erosional habitats, although not all taxa or families were present at each site. Most of the insect taxa were from families with no preference for erosional or depositional habitats. The Shannon-Weaver Diversity Index (H') values ranged from 2.07 to 3.74, all indicating healthy, relatively diverse macroinvertebrate communities in almost all cases. Two of the lowest Shannon-Weaver Diversity Index (H') values, 2.07 and 2.54, were reported from the site located approximately 1 km downstream of Williams Fork Reservoir, where impoundment effects (e.g., higher densities of Hydropsychidae and certain midges due to the altered flow regime) probably account for the lower score. The 1996 sample collected by the CDPHE WQCD near this same location had even lower diversity, with only three species present and worms accounting for 99% of the invertebrates present.

Table 3.11-21
Williams Fork River, Downstream of Denver Water Diversions, Macroinvertebrate Population Data Summary Parameters (1984 to 2006)

Reach/Site	Date	Density (#/m²)	Number of Taxa	Number of EPT Taxa (%)	H'	MMI Score	HBI
WF-1	Fall 1984	842	15	10 (67)	2.50	--	--
WF-2	Fall 1984	1,295	29	18 (62)	3.72	--	--
	Spring 1985	1,090	26	14 (54)	3.08	--	--
WF-2A	Fall 1984	1,452	24	17 (71)	3.33	--	--
	Spring 1985	1,113	24	17 (71)	3.17	--	--
WF-3	Fall 1984	1,045	26	20 (77)	3.19	--	--
	Spring 1985	2,351	28	17 (61)	2.81	--	--
WF-4	Fall 1984	1,353	23	15 (65)	2.80	--	--
	Spring 1985	1,551	32	20 (63)	3.39	--	--
WF-5	Fall 1984	1,657	30	20 (67)	3.20	--	--
	Spring 1985	2,875	36	26 (72)	3.48	--	--
WF-6	Fall 1984	1,940	26	16 (62)	3.16	--	--
	Spring 1985	3,448	35	22 (63)	3.74	--	--
WF-7	Spring 1985	12,179	22	12 (55)	2.54	--	--
	Fall 1985	9,265	20	9 (45)	2.07	--	--
Williams Fork Reservoir	September 12, 1996	287	3	0 (0)	0.09	--	--
Henderson Mine	September 20, 2006	--	--	--	3.44	58.5	3.40
FR 141 Bridge	September 19, 2006	--	--	--	3.46	55.5	2.58

Source: CDPHE; Chadwick and Associates, 1986.
Notes:
-- = no data
#/m² = number of individuals per square meter
% = percent
EPT = Ephemeroptera, Plecoptera and Trichoptera
FR = Forest Road
H' = Shannon-Weaver Diversity Index
HBI = Hilsenhoff Biotic Index
MMI = Macroinvertebrate Multimetric Index
WF = Williams Fork

Two samples were collected in 2006 from Williams Fork using CDPHE protocols. The sample collected from a site near the Henderson Mine had an MMI score of 58.5, while the sample from the site "at FR 141 at bridge at gage" had an MMI score of 55.5 (Table 3.11-21). Both samples indicate that Williams Fork is attaining its aquatic life use.

Tipping Point Evaluation

The total amount of flow diverted upstream of this section of the Williams Fork River is not known. However, the native flow depletions from the four main headwater tributary streams range from 49-55% on an annual average and 24-43% during the peak flow month of June. This suggests that a flow tipping point has not yet been crossed in the mainstem of the Williams Fork River. The fish data for the mainstem indicate that the population is healthy with no trends over time and has not crossed an ecological tipping point. The limited amount of data for macroinvertebrates also indicates the presence of healthy and diverse communities. Overall, the available information indicates that the Williams Fork River has not crossed an ecological tipping point.

Williams Fork River: South Fork to Colorado River

The Williams Fork River downstream of the South Fork would have changes in annual flow of 10% or less with the Project alternatives. Therefore, this section of the river and the aquatic resources are described only briefly.

The Williams Fork River was surveyed near the Sugarloaf Campground. This stream was classified as a shallow gradient stream with average bankfull width of 14 meters, and average bankfull depth of 0.5 meter (refer to Section 3.3). Riffles and glides were the predominant habitat types. Cobble and gravel were the predominant sediment types, but sand was common on inside meander beds and in the active channel. Stream banks were mostly stable and supported woody and herbaceous vegetation, but braiding has occurred in localized areas.

Dissolved oxygen levels are lower than the minimum State standards downstream of the Sugarloaf Campground, but these low levels appear to be localized (refer to Section 3.2). Zinc levels at this site have also occasionally exceeded State standards. Dissolved oxygen levels are lower than minimum State standards downstream of the Williams Fork Reservoir in fall, and this is thought to be a function of reservoir turnover. Denver Water is currently modifying the reservoir outlet to increase dissolved oxygen levels (refer to Section 3.2).

The fish population of the Williams Fork River between the South Fork and Williams Fork Reservoir was sampled in 1978 and 1984, each with a site near the confluence with the South Fork and a second site just upstream of the inlet to the reservoir. Brown trout, rainbow trout, and Paiute sculpin were collected at both sites in both years. Brook trout were dominant in the upper site in 1978 but were absent from the lower site; in 1984, however, they comprised approximately 30% of the fish collected at both sites. In both years, reservoir-resident kokanee salmon were collected at the site just upstream of the reservoir. Cutthroat trout, longnose suckers, and speckled dace have been collected in small numbers at these sites. Total fish biomass was not measured in 1978, but was 32.5 and 80.7 kg/ha in 1984.

In the section of the Williams Fork River downstream of Williams Fork Reservoir, sampling results from one site in 1985 contained rainbow and brown trout, mottled sculpin, and longnose sucker. Rainbow trout were the predominant species present and comprised 68% of the density and 50% of the biomass. Brown trout comprised the bulk of the remainder of the density and biomass. Sculpin and sucker were much less abundant. Total fish density and biomass at this site in 1985 was 1,529 fish/ha and 74 kg/ha, respectively. This section of the river was stocked once by CPW in 2000 with approximately 3,000 small (4 inches) rainbow trout (CDOW 2006c). Williams Fork Reservoir is commonly stocked with kokanee salmon and Rainbow trout.

Benthic macroinvertebrate data from 1984 and 1985 are available from three sites on the Williams Fork River downstream of the South Fork (Chadwick and Associates 1986). The data indicate the presence of diverse, healthy communities including sensitive species. One sample from 1996 was from the "Williams Fork River at Williams Fork Reservoir." The data suggest that the sample was taken from within the reservoir or a slack water area near the reservoir, since it was composed of only three taxa, all of which prefer lentic habitats: one specimen of *Caecidotea* (an aquatic isopod), two specimens of *Chironomus*, a midge, and 285 specimens of Tubificidae (worms).

The total amount of flow diverted before the Williams Fork River downstream of the South Fork is not known but is less than in the upstream section of the river. This indicates that a flow tipping point has not yet been crossed in the river downstream of the South Fork. The limited fish data for this section indicate that the population is healthy and has not crossed a tipping point. The limited amount of data for macroinvertebrates also indicates the presence of healthy and diverse communities. Overall, the available information indicates that the Williams Fork River downstream of the South Fork has not crossed an ecological tipping point.

Williams Fork: Tributaries

Denver Water's diversions from four tributaries near the headwaters of the Williams Fork River result in depletions in average annual flows of greater than 10%. These tributaries include: McQueary, Jones, Bobtail, and Steelman creeks. These tributaries form the headwaters of the Williams Fork River. There are no fish or benthic invertebrate data available for Jones Creek; however, aquatic biological resources are described in detail for the remaining three tributaries.

Denver Water diversion structures function as barriers to upstream migration of fish in McQueary, Bobtail, and Steelman creeks, and populations upstream of the barriers are isolated as long as the gates on the bottom of the structure are closed. However, when the gates are open and water is flowing past the diversion, brook trout may be able to swim upstream past the diversions. The Denver Water diversion structures on Bobtail and Steelman creeks apparently have not isolated the cutthroat trout populations upstream of the diversions from invading brook trout. Brook trout are present upstream in Bobtail and Steelman creeks and have been increasing in proportion over the last few years. Bobtail and Steelman creeks have some of the highest-quality habitat of the cutthroat trout streams in the Project area (Hirsch et al. 2006; Ficke et al. 2003). Both of these streams are considered Core Conservation Populations. The cutthroat trout in both streams are assumed by the USFWS to be greenback lineage cutthroat trout given the uncertainty in genetics.

Fish populations both upstream and downstream of the barriers are described in this section. For invertebrates and habitat, potential effects would only occur downstream of the diversions, but information for sites upstream and downstream of the diversion on the tributaries is described.

Habitat

McQueary, Jones, Bobtail, and Steelman creeks have no bypass flows and are fully diverted at times. The native flow diversions for the four streams are from 49-55% on average and 24-82% in the high flow months. Flow is added to the channel from groundwater and other inputs downstream of the diversions in these streams.

Geomorphic surveys have been conducted downstream of the Denver Water diversions on McQueary Creek, Jones Creek, Bobtail Creek, and Steelman Creek. All four streams are narrow and steep (refer to Section 3.3). McQueary Creek and Bobtail Creek both have exceeded State standards for zinc. No water quality issues have been identified for Steelman Creek (refer to Section 3.2).

Fish

The fish populations in these upper tributaries of the Williams Fork River are typical of Rocky Mountain headwater, coldwater fisheries. Brook trout and cutthroat trout are the species present, dominating these headwater streams in varying proportions (Chadwick and Associates 1986; GEI 2013). No fish are stocked in these streams by CPW.

Benthic Macroinvertebrates

The benthic invertebrate populations of the upper Williams Fork River tributaries are typical of mountain stream invertebrate communities (Ward 1986, 1994; Ward et al. 2002). Benthic invertebrate population data do not exist for Jones Creek. Based on data from 1984, a total of 39 individual taxa were collected, representing the taxonomic groups Ephemeroptera, Plecoptera, Trichoptera, Diptera, Coleoptera, Collembola, Hydracarina, Oligochaeta, and Turbellaria (Chadwick and Associates 1986). The number of taxa in these three streams was nearly identical, and averaged 26 taxa per stream. The presence of a diverse macroinvertebrate community including sensitive species indicates that water quality is sufficient to sustain healthy invertebrate assemblages in these streams. Density in the tributaries was lower than at many other streams in the Project area averaging just over 1,000 organisms/m^2.

McQueary Creek

Upstream of the diversion on McQueary Creek, fish populations were sampled in 1978, 1984, 2000, and 2003; only cutthroat trout were collected. No density or biomass estimates were made in 1978, but in 1984, density was 154 fish/ha and biomass was 13.5 kg/ha. A 2003 CPW survey found similarly low densities. According to a 2000 population survey, McQueary Creek supported a population of cutthroat trout upstream of the diversion; the population size was estimated to be 453±154 fish (Ficke et al. 2003). Downstream of the diversion, fish were absent in 1978, but brook trout were collected in 1984. Density of brook trout was 476 fish/ha, and total biomass was 20.9 kg/ha. In 2003, cutthroat trout was the only species collected downstream of the diversion, with a total density of 182 fish/ha. The genetic status of this population has not been tested, but McQueary Lake was stocked with cutthroat trout from the Trapper's Lake hatchery (Chadwick and Associates 1986). After 1956, the Colorado River cutthroat trout produced in the Trapper's Lake hatchery were introgressed with Yellowstone cutthroat trout (Rogers 2011a), therefore the cutthroat trout in McQueary Creek are hybridized.

In 1974, macroinvertebrate densities ranged from 391 to 792 organisms/m^2 at three sites upstream and downstream of the diversion on McQueary Creek. There are no data on individual taxa for 1974. In 1984, the same three sites were sampled and densities ranged from 799 to 6,619 organisms/m^2, and numbers of taxa ranged from 18 to 25. At each site, two families that prefer erosional habitats (Perlodidae and Rhyacophilidae) were present, but most taxa were from families with no preference for erosional or depositional habitats. Shannon-Weaver Diversity Index (H') values ranged from 2.28 to 3.16, with the low value being from the site near the forks upstream of Lake McQueary at the top of the drainage; it is likely that the elevation and small size may be limiting the benthic macroinvertebrate communities at that site. The Shannon-Weaver Diversity Index (H') values at the other sites, each within 1 km upstream or downstream of the diversion, indicate healthy, diverse macroinvertebrate communities.

Fish density estimates were available for McQueary Creek on three occasions. On two occasions, densities were lower than the 50th percentile of Platts and McHenry, and fish were absent on the third occasion. The small population size upstream of the diversion and the low density both upstream and downstream of the diversion suggest that the populations in both sections are sustaining but may be near an ecological tipping point.

Bobtail Creek

Fish populations upstream of the Denver Water diversion in Bobtail Creek have been sampled periodically since 1978, when three sites were sampled. Two sites had no fish present, while 5 cutthroat trout were captured at a third site. In 1984 and 1985, two groups collected fish population data in this stream; in 1984, CEC reported a population dominated by cutthroat trout, with brook trout present in small proportions (Table 3.11-22). Total density was 186 fish/ha, and total biomass was 11.0 kg/ha. CPW collected 25 brook trout and 4 cutthroat trout in 1984 and 12 cutthroat trout in 1985, but did not estimate total fish density or biomass. From 1992 to 2003, brook trout were common and comprised at least 44% of the total density. A 2000 USFS survey produced a population estimate of 791 ± 165 cutthroat trout, but brook trout outnumbered cutthroat trout by a ratio of 4:3 (Ficke et al. 2003). At one site in 2001, an extremely high total density of 21,083 fish/ha was reported; this is likely due to large numbers of young fish, although no biomass estimates exist from that site to verify this. At a different site the same year, total fish density was 663 fish/ha and total fish biomass was 50.4 kg/ha. In 2003, brook trout biomass was estimated at 22.4 kg/ha at one site. The most recent cutthroat trout density estimate for Bobtail Creek is 0-50 fish/mile (Hirsch et al. 2006). In most cases, fish were not weighed, and biomass estimates could not be obtained. A brook trout removal was conducted in 2001 to alleviate competitive pressure on cutthroat trout, but the proportion of brook trout was similar in 2001 and 2003, indicating that the brook trout population quickly rebounded through recolonization, reproduction, or a combination of the two. Further brook trout removals were planned for summer 2011 (Rogers 2011b). The cutthroat trout in Bobtail Creek are not genetically altered; this stream supports a "core conservation population" (Hirsch et al. 2006), and the cutthroat trout are assumed by the USFWS to be greenback lineage cutthroat trout given the uncertainty in genetics.

Table 3.11-22
Bobtail Creek, Upstream of Denver Water Diversion, Fish Population Data, Percent of Total Catch, and Summary Parameters (1984 to 2003)

Species/Date (Sites)	1984 (1)	1992 (1)	2001 (5)	2003 (2)
Brook trout	7%	57%	65%	66%
Cutthroat trout	93%	43%	35%	34%
Average density (fish/ha)	186	28 captured[1]	4,574	662
Range	**N/A**	**N/A**	**323-21,083**	**657-667**
Average biomass (kg/ha)	11.0	N/R	N/R	N/R
Range	**N/A**	**N/A**	**N/R**	**N/R**

Source: Chadwick and Associates, 1985, 1986; Ficke et al., 2003; CDOW, 2005a.
Notes:
[1] Data from 1992 reflect number captured, since insufficient data were included to calculate total density and biomass estimates.
Number of sites represented in each time period are shown in parentheses.
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

Downstream of the diversion, fish populations have been sampled at two sites in 1984 and at one site in 2001. In all years, only brook and cutthroat trout were collected. In 1984, total fish density at one site was 978 fish/ha, with brook trout comprising 86% of the population; total fish biomass was 58.6 kg/ha. At a separate site, one brook trout and twelve cutthroat trout were captured, but total density or biomass estimates were not available. In 2001, total fish density was 653 fish/ha, with brook trout comprising 86% of the population. All three available density estimates were lower than the 50th percentile of Platts and McHenry, suggesting that the fish population in this stream is sustaining but may be near collapse. This section of the stream is downstream of the historic Bobtail Mine near the diversion, which may also have negative effects on fish density through decreased water quality.

The benthic macroinvertebrate communities upstream and downstream of the diversion are very similar to each other. In 1974, density ranged from 222 to 303 organisms/m^2. In 1984, density ranged from 823 to 2,351 organisms/m^2, number of taxa ranged from 25 to 27 taxa, and the Shannon-Weaver Diversity Index (H') ranged from 2.18 to 2.80. The higher values for most parameters for both years were for the site downstream of the diversion. Most taxa at both sites were from families with no preference for erosional or depositional habitats; however, both sites also had three families that prefer erosional habitats in 1984.

Steelman Creek

Upstream of the Denver Water diversion in Steelman Creek, fish populations have been sampled in 1974, 1978, 1984, 2000, 2003, and 2004. In 1974 and 1978, cutthroat trout was the only species collected at the two sites, but total densities or biomass estimates were not reported. Cutthroat trout was also the only species collected in 1984, with total density of 492 fish/ha and total biomass of 24.3 kg/ha (Table 3.11-23). By 2000, brook trout began to comprise sizeable proportions of the population. Although a 2000 USFS survey produced a cutthroat trout population estimate of 908±532 fish, brook trout outnumbered the native fish by a ratio of 4:1 (Ficke et al. 2003). Eight consecutive sites were sampled in 2004; however, data from all eight sites were combined in the CPW report, and biomass estimates were not made. The most recent cutthroat trout density estimate is 151-400 fish/mile; these cutthroat trout are 90-99% genetically pure; therefore, the cutthroat trout in Steelman Creek constitute a "conservation population" (Hirsch et al. 2006) and they are assumed by the USFWS to be greenback lineage cutthroat trout given the uncertainty in genetics.

Table 3.11-23
Steelman Creek, Upstream of Denver Water Diversion, Fish Population Data, Percent of Total Catch, and Summary Parameters (1984 to 2004)

Species/Date (Sites)	1984 (1)	2000	2003 (2)	2004 (1)
Brook trout	0%	80%	35%	47%
Cutthroat trout	100%	20%	65%	53%
Average density (fish/ha)	492	908	933	647
Range	**N/A**	**N/A**	**925-941**	**N/A**
Average biomass (kg/ha)	24.3	N/R	N/R	N/R
Range	**N/A**	**N/A**	**N/A**	**N/A**

Source: Chadwick and Associates, 1985, 1986; Ficke et al., 2003; CDOW, 2003, 2005a.
Notes:
Number of sites represented in each time period are shown in parentheses.
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

Downstream of the diversion, fish populations were sampled in 1978, and 1984. In 1978, two cutthroat trout and one brook trout were collected. Density and biomass estimates were not reported. In 1984, brook trout dominated the community comprising 79% of the density. Total density was 792 fish/ha, and total biomass was 57.1 kg/ha. Both available density estimates were lower than the small stream 50th percentile of Platts and McHenry. As a result, it appears that the Steelman Creek trout population is sustaining but may be near collapse downstream of the diversion.

In 1974, total macroinvertebrate density upstream of the diversion was 427 organisms/m^2, dropping to 73 organisms/m^2 downstream of the diversion. Downstream of the diversion in 1984, oligochaete worms comprised about 65% of the total density, which was nearly three times higher than upstream of the diversion, but the sites upstream and downstream of the diversion were otherwise relatively similar. The number of taxa ranged from 25 to 26 taxa, the Shannon-Weaver Diversity Index (H') ranged from 3.32 to 3.65, and the site upstream of the diversion had four families that prefer erosional habitats, while the site downstream of the diversion had only two. Most of the insect taxa were from families with no preference for erosional or depositional habitats.

General Observations in the Williams Fork River Tributaries – In McQueary Creek, the diversion apparently isolates cutthroat trout upstream from brook trout downstream. However, the isolated cutthroat trout are apparently not a pure population of native Colorado River cutthroat trout, since non-native Trappers Lake-strain cutthroat trout were stocked in McQueary Lake (Chadwick and Associates 1986). In Bobtail and Steelman creeks, the cutthroat trout have apparently been genetically isolated and are considered to be genetically pure (Chadwick and Associates 1986; Young et al. 1996) and are assumed by USFWS to be greenback cutthroat trout. However, brook trout are present and have been increasing in proportion over the last few decades.

3.11.6.3 Colorado River

Project alternatives could change average annual flow in the Colorado River in the section between the Fraser and Blue rivers by less than 10%. However, during early summer of average years, changes would be slightly more than 10% in only a single month. Therefore, based on the potential changes in flow and in response to comments to the Draft EIS, a brief description of the aquatic resources is provided for this section of the Colorado River.

This section of the Colorado River is classified Aquatic Life Cold Class 1 by CDPHE. The reach of the Colorado River between Windy Gap and the confluence with Troublesome Creek is designated Gold Medal Waters by the CPW. The mainstem of the Colorado River downstream of Granby Reservoir has CS-II temperature standards of 23.8ºC DM and 18.2ºC MWAT. The Colorado River in the section from the 578 Road Bridge just downstream of Windy Gap Reservoir to the confluence with the Blue River is on the 303(d) List for exceedances of maximum water temperatures and manganese (refer to Section 3.2). The short section of the river from Windy Gap Reservoir downstream to approximately one mile to the 578 Road Bridge is also on the Monitoring and Evaluation List for aquatic life due to a low MMI score.

Habitat

Three sets of weighted usable area habitat versus flow curves were available for the Colorado River from Windy Gap Reservoir downstream to the confluence with the Williams Fork River (Grand County 2008, 2010). The habitat versus flow curves were developed from a site in summer 2008 (Grand County 2010) were updated from a study by Barry Nehring of CPW in 1985 and for a study in 2006 by Miller Ecological Consultants (Grand County 2008). Three sets of weighted usable area habitat versus flow curves were available for the Colorado River between the Williams Fork River confluence and the Blue River confluence and were presented in the Grand County Stream Management Plan (Grand County 2008, 2010). They are the result of work done in 2006 by Miller Ecological and in summer 2007 by Tetra Tech (Grand County 2008).

In the Colorado River upstream of the Williams Fork River, the habitat relationships indicate relatively high habitat availability for trout at flows of 75 cfs to nearly 700 cfs. There is a CWCB minimum flow of 90 cfs for this segment. In the river between the Williams Fork and Blue rivers, habitat availability for trout is highest at 200 cfs to 600 cfs. There is a CWCB minimum flow of 135 cfs for the portion of this segment upstream of the KB Ditch and 150 cfs downstream of the KB Ditch.

Geomorphic surveys were conducted at two sites on the Colorado River, near Parshall and at the Kemp-Breeze State Wildlife Area (SWA). This stream reach has a shallow gradient and the average bankfull width was approximately 43 meters with average bankfull depth of 1.2 meters (refer to Section 3.3). Riffles and glides were the predominant habitat types and cobble was the most common bed material. However, sand and gravel were common but there were no signs of unusual sediment accumulation (refer to Section 3.3).

Fish

The Colorado River in the reach between the confluences with the Fraser and Blue rivers is managed for rainbow and brown trout. Other species, including white, longnose, and

flannelmouth suckers, longnose dace, mottled sculpin, and mountain whitefish are also collected (Table 3.11-24). Fish population sampling has been conducted on this reach of the Colorado River multiple times a year since this area became a focus for whirling disease research after Windy Gap Reservoir was implicated as a sink for the causative agent, *M. cerebralis* (Thompson et al. 1999; Thompson and Nehring 2000). This section of the river is stocked by CPW with small (6 inches or less) rainbow trout. In the past few years, an average of nearly 80,000 rainbow trout has been stocked annually.

Table 3.11-24
Colorado River, Windy Gap Reservoir to Williams Fork River Confluence, Percent of Total Catch, and Summary Parameters (2001 to 2010)

Species/Hybrid	Site Name – Year							
	CRR 2001	CRR 2002	GC 2003	CRR 2004	RB 2006	RB 2007	PG 2008	LB 2010
Brook trout	--	--	--	--	<1	<1	--	--
Cutthroat trout-rainbow trout	--	--	--	--	--	<1	--	--
Kokanee salmon	--	--	--	--	--	2	--	--
Brown trout	84	80	63	64	21	25	58	84
Rainbow trout	8	11	14	14	30	37	6	16
Snake River cutthroat trout	--	--	--	--	<1	--	--	--
Mottled sculpin	4	1	--	--	46	33	--	--
Creek chub	--	--	2	--	--	--	3	--
Longnose dace	<1	4	--	--	--	--	--	--
Speckled dace	--	--	13	11	<1	--	31	--
Longnose sucker	2	2	4	7	2	3	2	--
White sucker	<1	2	4	4	--	--	--	--
Johnny darter	--	<1	--	--	--	--	--	--
Total # fish collected	**418**	**316**	**857**	**258**	**694**	**601**	**542**	**N/R**
Trout density (fish/ha)	**406**	**312**	**489**	**245**	**532**	**670**	**351**	**626**

Source: CDOW, 2011b.
Notes:
-- = no data
< = less than
CRR = Chimney Rock Ranch
fish/ha = fish per hectare
GC = Gilbert Campground
LB = Lone Buck
RB = behind red barn
PG = Paul Gilbert

Fish data are available at a number of sites in the Colorado River between Windy Gap Reservoir and the Williams Fork River. Brown trout were the dominant trout species in this reach of river from 2001 through 2010. Rainbow trout were collected at high densities in 2007 and 2006. However, this reach of stream is routinely stocked with rainbow trout and the high densities observed in these years are likely the result of collecting these stocked rainbows (Ewert 2011a, 2011b). The rainbow trout densities in the remaining years also probably include fish stocked by CPW.

Brook trout, Snake River cutthroat trout, cutthroat-rainbow hybrid trout, and kokanee were collected only occasionally in low numbers from 2001 through 2008, generally representing less than 1% of the catch. Although density data were not always available for mottled sculpin and speckled dace, these species were collected frequently, sometimes at moderate

to high abundances. Longnose suckers and white suckers were also collected frequently, but at low densities. Creek chub, longnose dace, and johnny darter were collected only occasionally at low abundances. Of all the species collected, only mottled sculpin and speckled dace are native to the Colorado River Basin (Nesler 1997). Long-term research in this segment has documented a shift from a trout population dominated by rainbow trout to a population dominated by brown trout (Nehring et al. 2000), as seen in the current population. From 1979 through 1988, rainbow trout were the dominant trout species; occurring at a density (543 per hectare [ha]) as much as 10 times greater than the brown trout density (51/ha) in 1988 at the Lone Buck site in the Hot Sulphur Springs SWA (Nehring et al. 2000). From 1994 through 1998, the trend was reversed at this site, with brown trout occurring at greater densities than rainbow trout in all but one year (Nehring et al. 2000). Long-term data are also available for the Paul Gilbert site within this study segment, and demonstrates the same shift in dominance from rainbow trout in the 1980s to brown trout in the 1990s (Nehring et al. 2000). Whirling disease is considered the primary factor for the decline in the rainbow trout population from the levels observed in the 1980s (Nehring et al. 2000).

There is some evidence that brown trout have also been affected by whirling disease, immediately downstream from Windy Gap dam. A large number of brown trout fry had clinical signs of whirling disease at the Hitching Post Bridge site, 1.6 km downstream from Windy Gap Dam, from 1994 through 1998 (Nehring et al. 2000). Age-1 brown trout were much less abundant at the Hitching Post Bridge site than at a site further downstream near Parshall in 1999 (Nehring et al. 2000).

The current trout population in this segment is dominated by brown trout and the total trout density remains high and is similar to densities prior to whirling disease. Density has sometimes been near or above the 50th percentile of density for large streams of 668/ha, and generally has been higher than the 25th percentile of 382 fish/ha (Table 3.11-24). Overall, based on the high trout densities observed in recent years and that this segment of the Colorado River has retained its Gold Medal Water status and the current trout population appears to be sustaining to healthy.

The current fish community in the Colorado River between the Williams Fork River and the Blue River is dominated by brown trout, as evidenced by data collected by CPW from 1998 to 2008 at the Parshall-Sunset site (Table 3.11-25). From 2001 through 2010, brown trout comprised 93 to 96% of the fish sampled in a given year. Rainbow trout were the next most abundant species in most years, accounting from 2 to 5% of the fish sampled. White suckers were the second most abundant species in 2003, accounting for 4% of the fish sampled. In 1998, 90% of fish collected were brown trout and 9% were rainbow trout. Snake River cutthroat trout, mottled sculpin, longnose dace, speckled dace, longnose suckers, and white suckers were collected at low abundances in some years. The CPW has stocked this segment with large numbers of 4 to 5 inch rainbow trout in recent years; however, successful survival and recruitment has been limited (Ewert 2011a, 2011b).

Table 3.11-25
Colorado River, Williams Fork River to Blue River,
Percent of Total Catch and Summary Parameters (1998 to 2010)

Species/Date	1998	2001	2002	2003	2004	2007	2008	2010
Brown trout	90	95	96	93	95	96	96	95
Rainbow trout	9	4	2	2	3	2	3	5
Snake River cutthroat trout	<1	--	--	--	--	--	--	--
Mottled sculpin	<1	--	<1	--	--	--	--	--
Longnose dace	--	<1	<1	<1	--	--	--	--
Speckled dace	--	--	--	--	<1	<1	<1	--
Longnose sucker	--	<1	<1	<1	<1	--	<1	--
White sucker	1	--	1	4	2	<1	<1	--
Total # fish collected	**862**	**2,059**	**3,141**	**2,873**	**1,599**	**1,846**	**1,378**	**N/R**
Trout density (# fish/ha)	**N/R**	**793**	**1,750**	**1,989**	**858**	**1,406**	**889**	**1,033**

Source: CDOW, 2011b.
Notes:
< = less than
-- = no data
fish/ha = fish per hectare
ha = hectare
N/R = not reported

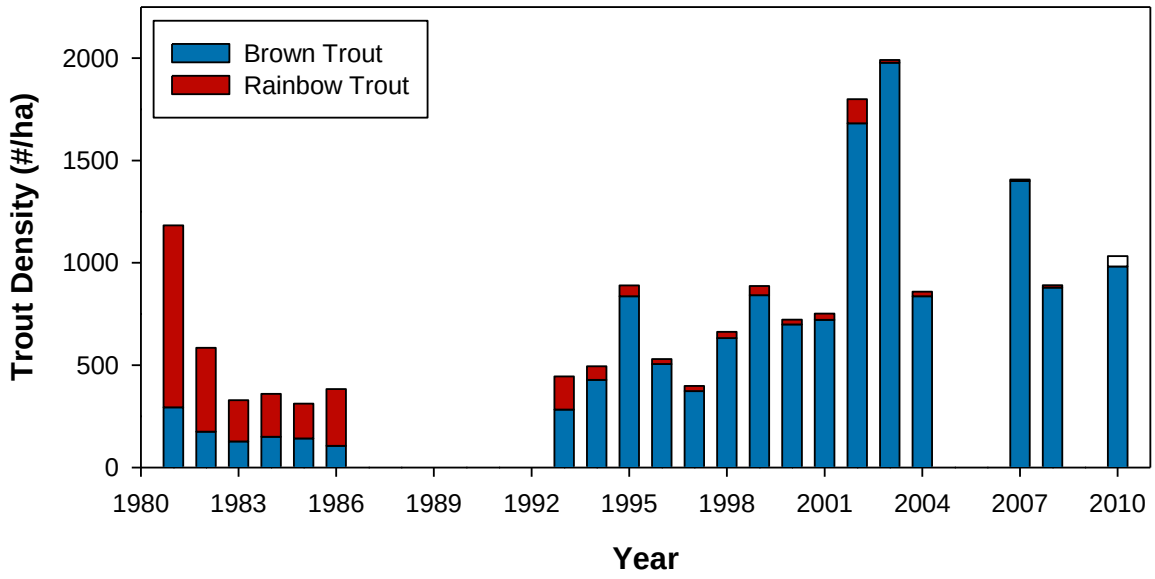
Long-term research in this section of the Colorado River has also documented a shift from a trout population dominated by rainbow trout to a population dominated by brown trout due to the effects of whirling disease (Nehring et al. 2000). At the Kemp-Breeze SWA from 1981 through 1986, brown trout densities (Figure 3.11-2), were generally less than 200/ha and were always less than rainbow trout densities, which were generally greater than 200/ha (Nehring et al. 2000). From 1993 through 1999, the opposite was true, as brown trout density ranged from 283/ha to 842/ha, while rainbow trout density ranged from 25/ha to 162/ha (Nehring et al. 2000). Biomass estimates of brown trout and rainbow trout also followed the same trend as for density (Figures 3.11-2 and 3.11-3).

Long-term data from a CPW sampling site on the Colorado River near Parshall indicate considerable annual variability in trout density and biomass since 1981 (Figures 3.11-2 and 3.11-3). Both density and biomass were highest in 2002 and 2003, after the 2002 drought. Linear regression was used to identify any trends in total trout density and total trout biomass in this segment of the Colorado River for two time periods: 1983 through 2010, and 2000 through 2010. There is a trend of increasing trout density between 1983 and 2010, but no trends were detected between 2000 and 2010. Total density for the most recent sample in 2010 was above the median value for the entire time period, and it was highest in 2003 (Figure 3.11-2). Trout density since 2002 has generally been higher than in the 1980s and 1990s.

Trout biomass exhibited no trends between 1983 and 2010, but there was a decreasing trend between 2000 and 2010. Trout biomass was highest in the drought year of 2002 and lowest in 2010 (Figure 3.11-3). In all years since 1981, total trout biomass has exceeded the criterion for a Gold Medal Trout fishery of 67 kg/ha (60 pounds per acre) and in many years has been two or three times this level (Figure 3.11-3). Trout density since 1998 has consistently been above the 50th percentile for larger streams and has sometimes been above

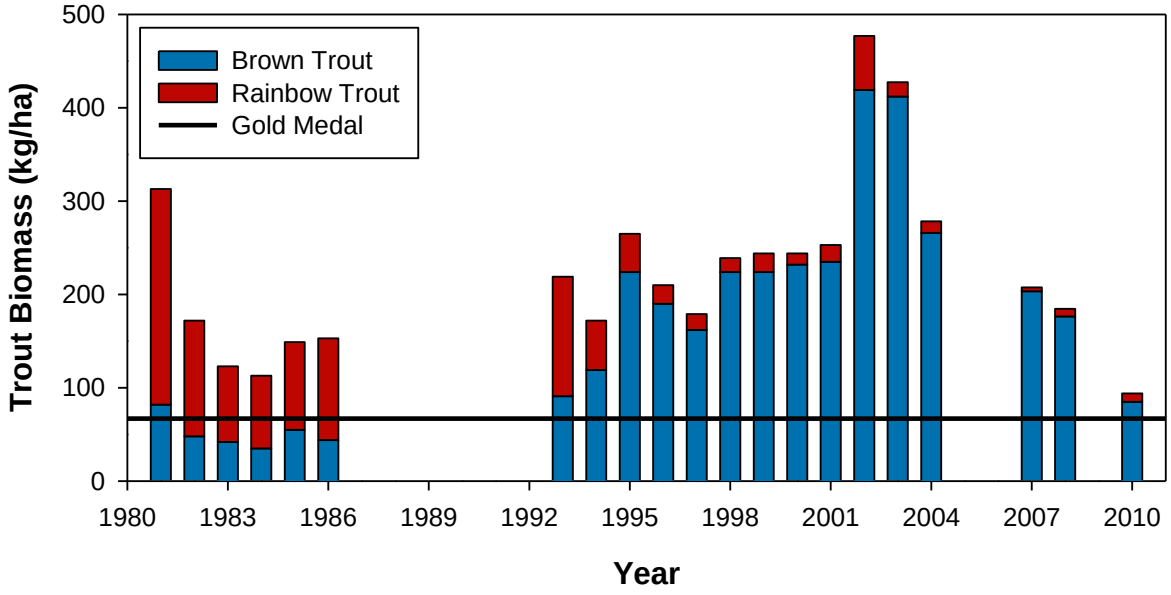
the 75th percentile of 980/ha (Table 3.11-25). This comparison indicates that the fishery is healthy in the Colorado River downstream of the Williams Fork River.

Figure 3.11-2
Trout Density at the Kemp-Breeze SWA Site on the Colorado River, 1983-2010



Source: CDOW, 2011b.

Figure 3.11-3
Trout Biomass at the Kemp-Breeze SWA Site on the Colorado River, 1983-2010



Source: CDOW, 2011b.
Note: The biomass criterion for Gold Medal Trout Waters is also shown.

Population estimates at the Kemp-Breeze SWA demonstrate the variable nature of trout populations, which is largely attributed to the size of age-1 and older year classes for fish greater than 6 inches (Ewert 2011a, 2011b). In 2008, the trout population estimate was 4,756 trout/mile greater than 6 inches, substantially lower than the 11,255 trout/mile estimate for 2003 but there does not appear to be a trend over time since 2001. However, the number of larger brown trout greater than 14 inches has declined since 2000 (Ewert 2011a, 2011b). Therefore, it appears there has been no recent trend in the density of brown trout but there may be fewer large (greater than 14 inches) brown trout in the last few years.

Benthic Macroinvertebrates

Recent sampling along the Colorado River in 2010 by Nehring et al. (2011) indicated the presence of a wide variety of invertebrate taxa at sites from Windy Gap Reservoir downstream to the confluence with the Blue River. Sampling results from spring and fall 2010 resulted in the collection of 44 to 55 taxa at the sites. At all sites, there were numerous species of EPT and other macroinvertebrate groups. The density of the giant salmonfly (*Pteronarcys californica*), was low at most sites and this species was absent from two sites just downstream of Windy Gap Reservoir (Nehring et al. 2011).

The giant salmonfly has a widespread distribution in throughout the western U.S. and Canada (Kauwe et al. 2004) and a sparse distribution in Colorado (Kondratieff and Baumann 2000). The giant salmonfly has a 2- to 5-year life cycle, most of which is aquatic (DeWalt and Stewart 1995; Stewart and Stark 1993; Townsend and Pritchard 1998). Because these stoneflies are classified as shredders (Merritt et al. 2008), their distribution within streams is tied to deposits of allochthonous matter, which are often patchily distributed (Kauwe et al. 2004). Populations of giant salmonflies appear to be decreasing in the Colorado River within the Project area (Nehring et al. 2010, 2011), but trends in other areas within its native range are unknown.

Macroinvertebrate communities were sampled in the Colorado River downstream of Windy Gap Reservoir in 2008 (Rees 2009). Macroinvertebrate density at a site downstream of Windy Gap Reservoir was 13,019 individuals/m^2, and 38 taxa were collected including a wide variety of invertebrates (Rees 2009). Macroinvertebrate data were evaluated with Multiple Index Score, by Rees (2009). The Multiple Index Score indicated that the macroinvertebrate community in this stream was slightly impaired (Rees 2009).

Four macroinvertebrate samples were collected between 2007 and 2011 by the CDPHE WQCD at a site just downstream from Windy Gap Reservoir. One sample from October 2008 was analyzed by CDPHE; that sample had an MMI score of 44.6 (Table 3.11-26), which is in the gray area. Another sample from the same site in September 2010 had a score of 58.7, which indicates no impairment. The other CDPHE WQCD samples were not scored with MMI. The total number of taxa in each sample was difficult to determine because of varying levels of taxonomic resolution within the same sample. The number of taxa collected in those four samples ranged from 12 to 55. The samples varied considerably in species composition. The sample from 2008 contained a diverse mix of a wide variety of invertebrates including species of EPT taxa, beetles, and families that prefer erosional habitats. EPT taxa accounted for 22 to 33% of the total taxa. Most of the insect taxa were from families with no preference for erosional or depositional habitats.

Table 3.11-26
Colorado River, Downstream of Windy Gap Reservoir, Macroinvertebrate Population Data Summary Parameters (2007 to 2010)

Reach/Site	Date	Density (#/m²)	Number of Taxa	Number of EPT Taxa (%)	H'	MMI Score	HBI
Windy Gap Reservoir to Williams Fork Confluence							
CR-WGD	Fall 2008	13,019	38	18 (47)	3.02	--	--
WG 11	Fall 2010	11,394	48	27 (56)	2.79	37.4	4.75
CWQCD 12102	10/9/2007	--	55	12 (22)	--	--	--
	3/28/2008	--	12	4 (33)	--	--	--
	10/1/2008	--	33	--	--	44.6	--
	10/2010	--	42	13 (31)	3.72	58.7	3.21
WG 12	Spring 2010	15,314	38	23 (61)	--	--	--
WG 12	Fall 2010	12,322	51	29 (57)	3.45	46.0	4.97
Hwy 40 Bridge	Fall 2010	20,606	63	41 (65)	--	--	--
WG 13	Spring 2010	6,487	31	22 (71)	--	--	--
WG 13	Fall 2010	10,150	40	26 (65)	3.29	59.6	2.86
Williams Fork Confluence to Blue River Confluence							
WG 21	Spring 2010	5,977	35	24 (69)	--	--	--
WG 21	Fall 2010	12,051	53	35 (66)	--	--	--
Skylark Ranch	Fall 2010	11,633	44	26 (59)	--	--	--
WG 22	Spring 2010	11,889	35	26 (74)	--	--	--
WG 22	Fall 2010	13,421	51	33 (65)	--	--	--
WG 31	Spring 2010	5,707	39	26 (67)	--	--	--
WG 31	Fall 2010	11,225	48	30 (63)	--	--	--
WG 32	Spring 2010	9,106	29	24 (83)	--	--	--
WG 32	Fall 2010	21,094	51	33 (65)	--	--	--

Source: CDPHE; Nehring et al., 2011.
Notes:
-- = no data
#/m² = number of individuals per square meter
% = percent
CWQCD = Colorado Water Quality Control Division
EPT = Ephemeroptera, Plecoptera and Trichoptera
H' = Shannon-Weaver Diversity Index
HBI = Hilsenhoff Biotic Index
Hwy = Highway
MMI = Macroinvertebrate Multimetric Index
WG = Windy Gap

Three samples in Segment 1 of the Colorado River from Nehring et al. (2011) were also scored by the CDPHE WQCD and resulted in MMI scores that indicated no impairment at two of the sites (Table 3.11-26). At Site WG 11, which roughly corresponds to the CDPHE WQCD site just downstream of Windy Gap Reservoir, the MMI score was 37.4, which would indicate impairment. Because of the low score and conflict with numerous other samples that indicated no impairment, the short section of the Colorado River between Windy Gap Reservoir and the 578 Road Bridge (approximately 1 mile) is on the Monitoring and Evaluation List for aquatic life impairment.

Sampling by Nehring et al. (2011) in 2010 in the segment of the Colorado River between the Williams Fork and Blue rivers resulted in the collection of a wide variety of invertebrates. The number of taxa in the samples ranged from 29 to 53 and density from

5,707 to 21,094 individuals/m^2. The samples included numerous species of EPT taxa and there were at least a few *P. californica* at nearly every site. EPT taxa represented the majority on the invertebrates, accounting for 59 to 83% of the total taxa.

A study of the macroinvertebrate community in the Colorado River downstream of Windy Gap Reservoir was conducted from 1980 to 1981. In the Colorado River between Windy Gap Reservoir and the Blue River the samples resulted in the collection of 27 to 57 taxa per site including a wide variety of invertebrates (Erickson 1983). Macroinvertebrate densities were high—they varied from 1,700 to 14,000 individuals/m^2 throughout the entire study reach (Erickson 1983). The density of giant salmonflies varied in space and by season. Density of this species ranged from 0 to 200 individuals/m^2 during the study period, but densities were lower near Kremmling, where unembedded cobble substrates were less common (Erickson 1983).

Tipping Point Evaluation

The total amount of flow diverted from the upper Colorado River is over 60%, which suggests that this river may be approaching flow thresholds, at least in the upper reaches. However, the fish data for the mainstem of the Colorado River indicate that the fish population is healthy to sustaining. Whirling disease has resulted in a shift in the population from rainbow trout to brown trout but there are no trends over time in overall trout density indicating that the total population has not crossed an ecological tipping point. However, trout biomass appears to have declined in recent years. This is also reflected in the number of trout greater than or equal to 6 inches in length which has fluctuated over time without displaying trends, but the number of trout greater than or equal to 14 inches in length have declined in recent years. The data for macroinvertebrates also indicates the presence of healthy and diverse community, although there have apparently been shifts in species composition over time. Overall, the available information indicates that the Colorado River has not crossed an ecological tipping point.

3.11.6.4 Blue River

The alternatives for the Moffat Project would change average annual flows in the Blue River Basin by less than 10%. However, in the section of the Blue River between Dillon and Green Mountain reservoirs, changes in the operation of the Denver Water system would result in changes in average monthly flow of up to 10% in late summer of average years. Downstream of Green Mountain Reservoir, average annual flow changes due to the Moffat Project alternatives would be less than 10%. In response to comments on the Draft EIS, a full description of aquatic resources was provided for the river reach between Dillon and the confluence with the Colorado River. The Blue River in the Project area is classified as Aquatic Life Cold Class 1 with CS-I temperature standards. The Blue River downstream of Dillon Reservoir to the confluence with the Colorado River is considered to be Gold Medal Waters by CPW. The Blue River from Dillon Reservoir downstream to Rock Creek is on the State of Colorado Monitoring and Evaluation List for non-attainment of aquatic life due to low MMI scores. CDPHE recognizes two segments in this section of the Blue River; Segment 1 from Dillon Reservoir to the confluence with North Rock Creek, and Segment 2 from North Rock Creek to the confluence with the Colorado River.

Blue River: Dillon Reservoir to Green Mountain Reservoir

Habitat

CPW developed PHABSIM habitat relationships for brown trout in two segments of the Blue River between Dillon and Green Mountain reservoirs (Chadwick and Associates 1986). These relationships indicate that habitat for most life stages of brown trout have highest availability at flows of approximately 40 to 200 cfs.

A geomorphic survey was conducted on the Blue River 10 miles south of Green Mountain Reservoir. This stream was classified as a low-gradient, wide stream. The average bankfull width was 30 meters, and the average bankfull depth was 1.5 meters (refer to Section 3.3). Riffle-pool complexes are the predominant habitat type in this reach. Boulders and cobble were the most common sediment types. The stream banks are stable, and bank vegetation is predominantly willows and conifers and there were no signs of unusual sediment accumulation (refer to Section 3.3).

Fish

Fish populations have been periodically sampled by CPW in this section of the Blue River since the 1970s (Tables 3.11-27 and 3.11-28). Fish species collected over the years include brook, cutthroat, rainbow, and brown trout, rainbow/cutthroat trout hybrids, kokanee salmon, mottled sculpin, lake trout, and longnose, white, and bluehead suckers. This section of the Blue River is annually stocked by CPW usually with small (15 cm or less) whirling disease resistant rainbow trout. The stocking rate in the last few years has ranged from approximately 22,000 fish per year (fish/year) to over 51,000 fish/year. A small number (1,624 individuals) of Snake River cutthroat trout were also stocked in this section in 2002 (GEI 2013). CPW also annually stocks Dillon and Green Mountain reservoirs with species that may include rainbow trout, Snake River cutthroat trout, and kokanee salmon in any given year. These fish may also move into the section of the Blue River between these two reservoirs. Whirling disease was detected within the Blue River watershed.

Historically, brown trout dominated the fish communities in most of the Blue River (Table 3.11-27), but the relative abundance of rainbow trout has increased in recent years (Table 3.11-28). Species composition in the Blue River can also be affected by seasonal migrations. For example, in 2003, when sampling efforts within the Project area were focused near Green Mountain Reservoir, upstream-migrating Kokanee salmon were the most abundant species (Table 3.11-28). Brook trout have generally been collected in small numbers (≤ 6 fish/ha). This distribution of brook trout and brown trout is typical in Rocky Mountain streams (Vincent and Miller 1969).

Table 3.11-27
Blue River: Dillon Reservoir to Green Mountain Reservoir, Fish Population Data, Percent of Total Catch, and Summary Parameters (1976 to 2000)

Species/Date (Sites)	1976-1980 (5)	1981-1985 (8)	1986-1990 (3)	1991-1995 (7)	1996-2000 (7)
Brook trout	9%	8%	<1%	<1%	<1%
Brown trout	80%	75%	94%	91%	74%
Cutthroat trout	<1%	0%	0%	0%	<1%
Cutthroat/rainbow trout hybrid	0%	0%	0%	0%	7%
Kokanee salmon	0%	0%	1%	0%	0%
Longnose sucker	0%	0%	0%	<1%	<1%
Rainbow trout	11%	17%	5%	8%	18%
White sucker	0%	0%	0%	<1%	<1%
Average number of fish collected	138	350	278	314	148
Range	**9-288**	**129-738**	**8-420**	**130-461**	**65-368**

Source: Chadwick and Associates, 1986; CDOW, 2005a.
Notes:
Number of sites represented in each time period are shown in parentheses. Biomass data not reported.
< = less than
% = percent

Table 3.11-28
Blue River: Dillon Reservoir to Green Mountain Reservoir, Fish Population Data, Percent of Total Catch, and Summary Parameters (2001 to 2008)

Species/Date (Sites)	2001 (3)	2002 (15)	2003 (5)	2005 (6)	2007 (2)	2008 (1)
Brook trout	<1%	<1%	0%	0%	<1%	0%
Cutthroat trout	0%	0%	<1%	0%	0%	0%
Brown trout	95%	68%	18%	37%	56%	24%
Rainbow trout	5%	21%	38%	49%	42%	74%
Cutthroat/rainbow trout hybrid	0%	8%	0%	14%	<1%	0%
Kokanee salmon	0%	0%	43%	0%	1%	1%
Mottled sculpin	0%	0%	0%	0%	<1%	0%
Longnose sucker	0%	1%	<1%	0%	0%	1%
Bluehead sucker	0%	<1%	0%	0%	0%	0%
Average number of fish collected	120	91	133	96	454	74
Range	**57-222**	**23-213**	**39-265**	**40-149**	**150-758**	**N/A**
Average biomass (kg/catch)	30	53	75	118	N/R	N/R
Range	**8-63**	**8-120**	**27-189**	**41-183**	**N/A**	**N/A**

Source: CDOW, 2005a, 2011b.
Notes:
Number of sites represented in each time period are shown in parentheses.
< = less than
% = percent
kg = kilogram
N/A = not applicable
N/R = not reported

Based on a compilation of data conducted by Chadwick and Associates in 1985, total fish density estimates average 479 fish/ha. Biomass estimates demonstrate an excellent fishery, with up to 217.6 kg/ha (Chadwick and Associates 1986). Recent collections confound total density and biomass estimation, since fish species were sampled inconsistently. For example, at some sites, brown trout were sampled in a two-pass depletion method while other fish species were sampled only in a single electrofishing pass. Thus, density and biomass estimates for the Blue River reflect actual catch abundance, rather than density or biomass per hectare. As a result of varying methods, the status and trends of the fish populations in the Blue River are difficult to evaluate. However, the most recent catch data do not indicate any trends and this stream's continued status as a Gold Medal Water suggests that the fish assemblage is healthy.

Benthic Macroinvertebrates

Benthic macroinvertebrate populations in the Blue River in the segments upstream of Green Mountain Reservoir about 3 km downstream of the Blue River Campground were sampled at one site in spring and fall 1985 (Chadwick and Associates 1986). Density estimates were 3,785 and 4,206 organisms/m^2, represented by 30 to 32 taxa per site (taxa/site) (Table 3.11-29). The taxonomic groups collected included Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Diptera, and Turbellaria. These communities are typical of Rocky Mountain streams (Ward 1986, 1994; Ward et al. 2002). There were six to seven families that prefer erosional habitats, with more families in the spring. The Shannon-Weaver Diversity Index (H') in the spring was 3.13, indicating a healthy, balanced community; however, the index dropped to 2.30 in the fall, primarily because the pollution- and perturbation-sensitive heptageniid mayfly (*Rhithrogena hageni*), made up 60% of the total density.

MMI scores for nine samples collected by the USFS in 2005 and 2006 were also available for these two segments (Table 3.11-29). Six samples were collected within CDPHE's Segment 1, and four of those scores did not attain the threshold for unimpaired aquatic life; however, two scores indicated no impairment. The nonattaining scores were at sites closest to the dam at Dillon Reservoir. Because of the mix of attaining and non-attaining scores and because the data are outside of the period of record for the 2012 listing cycle, CDPHE's Segment 1 of the Blue River is on the Monitoring and Evaluation List for aquatic life impairment. All three samples from the USFS collected in CDPHE's Segment 2 (downstream of Rock Creek) indicated attainment of the aquatic life use classification, and Segment 2 of the Blue River has been removed from the Monitoring and Evaluation List.

Table 3.11-29
Blue River, Downstream of Dillon Reservoir, Macroinvertebrate Population Data Summary Parameters (1985 and 2004 to 2006)

Reach/Site	Date	Density (#/m²)	Number of Taxa	Number of EPT Taxa (%)	H'	MMI Score	HBI
Rock Creek to Green Mountain Reservoir							
Downstream of Straight Creek	August 25, 2005	--	--	--	3.5	65.4	2.3
	September 21, 2006	--	--	--	2.1	36.0	4.6
	August 25, 2005	--	--	--	1.9	35.7	3.5
	September 21, 2006	--	--	--	2.8	25.8	4.8
Bald Eagle Road	August 17, 2005	--	--	--	2.4	33.4	4.7
	September 21, 2006	--	--	--	2.4	43.9	2.8
Blue River Campground	August 18, 2005	--	--	--	3.5	64.3	3.1
	September 21, 2006	--	--	--	3.9	53.0	5.2
BR1	Spring 1985	4,206	32	20 (63)	3.13	--	--
	Fall 1985	3,785	30	19 (63)	2.30	--	--
Wildlife Refuge	August 25, 2005	--	--	--	3.5	62.1	3.8
Green Mountain Reservoir to Colorado River							
BR2	Spring 1985	4,381	36	21 (58)	3.71	--	--
	Fall 1985	2,851	31	17 (55)	3.65	--	--
Trough Road	October 25, 2004	--	25	4 (17)	2.63	17.5	6.75

Source: CDPHE; Chadwick and Associates, 1986.
Notes:
-- = no data
#/m² = number of individuals per square meter
% = percent
EPT = Ephemeroptera, Plecoptera and Trichoptera
H' = Shannon-Weaver Diversity Index
HBI = Hilsenhoff Biotic Index
MMI = Macroinvertebrate Multimetric Index

Blue River: Green Mountain Reservoir to Colorado River

Habitat

Weighted usable area habitat versus flow relationships were developed for the Blue River downstream of Green Mountain Reservoir in summer 2007 and were presented in the Grand County Stream Management Plan (Grand County 2008, 2010). The curves indicate highest habitat availability foe most life stages of rainbow and brown trout from approximately 150 to 400 cfs. The CWCB adopted minimum flows of 85 cfs in summer and 60 cfs in winter for this section of the Blue River.

Fish

Fish populations downstream of Green Mountain reservoir are dominated by brown and rainbow trout and mottled sculpin, but are also composed of several other species, such as kokanee salmon and bluehead and longnose sucker. These other species are resident in Green Mountain Reservoir and the Colorado River and may enter the Blue River within this reach.

Fish data were available for five locations on the Blue River downstream of Green Mountain Reservoir from 2000 through 2006 (Table 3.11-30). Nine fish taxa were collected including one unknown warmwater species and one cutthroat-rainbow trout hybrid over the seven different sampling events. Brown trout were the dominant species present in four of the seven samples and rainbow trout were the dominant species in the remaining three samples. Brown trout comprised between 21 and 91% of the fish sampled at a site, while rainbow trout comprised between 8 and 47% of the fish sampled at a site. The remaining species were collected only occasionally at low abundances.

Table 3.11-30
Blue River: Green Mountain Reservoir to Colorado River, Fish Population Data, Percent of Total Catch, and Summary Parameters (2001, 2002, 2005, and 2006)

Species/Date (Sites)	2001 (2)	2002 (2)	2005 (2)	2006 (2)
Brown trout	59%	42.5%	39%	90%
Cutthroat/rainbow trout hybrid	13%	21.5%	14%	0%
Cutthroat trout	0%	0%	0%	<1%
Bluehead sucker	0%	1%	0%	0%
Longnose sucker	0%	1%	0%	0%
Mottled sculpin	0%	0%	0%	<1%
Rainbow trout	26%	34%	47%	9%
White sucker	1%	0%	0%	0%
Unknown	<1%	0%	0%	0%
Average number of fish collected	138	113	142	415
Range	**138**	**96-130**	**135-149**	**256-574**

Source: CDOW, 2005a, 2011b.
Notes:
Number of sites represented in each time period are shown in parentheses.
< = less than
% = percent

The relatively large proportions of rainbow trout collected are attributed to stocked fish as this reach is stocked annually with large numbers of rainbow trout (GEI 2013). Snake River cutthroat have also been stocked within this reach in the past (GEI 2013).

Fish data from CPW in 2006 for the Blue River downstream of Green Mountain Reservoir, were evaluated in the Grand County Stream Management Plan (Grand County 2008, 2010). These data indicate that brown trout were the dominant fish species present as the density estimate for brown trout greater than 150 mm was 1,676 per mile compared to 138 rainbow trout greater than 150 mm per mile (Grand County 2008). Spawning habitat was assessed in 2007 and was determined to be limited in this reach because of a lack of gravel (Grand County 2008). The spawning gravel that was present was largely limited to the stream margins (Grand County 2008). Differences in sampling methods make it difficult to classify the status and trends of fish populations in this reach of the Blue River. However, this portion of the Blue River appears to support a healthy population given the fish data and its status as a Gold Medal Water.

Benthic Macroinvertebrates

Benthic invertebrate data for the Blue River downstream of Green Mountain Reservoir were evaluated in the Agreement on Wolford Mountain Reservoir and Green Mountain Reservoir Exchanges Environmental Assessment. Benthic invertebrate data were available since 1993 and population numbers and diversity metrics were considered excellent during the early years of the time-period. In the last six years of the period of study the numbers and diversity were dramatically lower (ERO 2007). The cause of the decline is unknown; however, it may be related to an increase in didymo, which can form continuous mats over the substrate and is known to increase with decreasing flushing flows.

Benthic macroinvertebrate populations in the Blue River in the segments downstream of Green Mountain Reservoir were sampled at one site in spring and fall 1985 (Chadwick and Associates 1986). Density estimates ranged from 2,851 to 4,381 organisms/m^2, represented by 31 to 36 taxa/site (Table 3.11-29). There was a wide variety of invertebrates collected, representing the taxonomic groups Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Diptera, and Oligochaeta. These communities are typical of Rocky Mountain streams (Ward 1986, 1994; Ward et al. 2002). Most of the insect taxa were from families with no preference for erosional or depositional habitats, but there were seven families that prefer erosional habitats. The Shannon-Weaver Diversity Index (H') scores were each well above 3.50, indicating healthy communities.

A 2004 sample collected by Riverwatch, apparently at Trough Road just south of Kremmling, was used to calculate an MMI score; the score of 17.5 does not attain the threshold for unimpaired aquatic life use (Table 3.11-29). This sample had a Shannon-Weaver Diversity Index (H') of 2.62, and contained at least 25 taxa. The low score was primarily due to a larger number of non-insect taxa and low number of clinger taxa, but there was still one insect family present that prefers erosional habitats (Glossosomatidae). Poff et al. (2006) did not classify rheophilic traits for non-insects, so it is not known if the many non-insect taxa collected prefer erosional or depositional habitats. This site is within CDPHE's Segment 2 of the Blue River, but samples collected by the USFS further upstream in 2005 and 2006 indicated attainment and the segment has been removed from the Monitoring and Evaluation List.

Tipping Point Evaluation

The fish data for the Blue River indicate that the population is healthy and maintaining Gold Medal status. There are no trends over time and the data indicate that the total population is not near a tipping point. The data for macroinvertebrates also indicates the presence of healthy and diverse community, although there have apparently been shifts in species composition over time. Overall, the available information indicates that the Blue River has not crossed an ecological tipping point.

3.11.6.5 South Boulder Creek

South Boulder Creek receives water from the diversions in the Moffat Collection System. The alternatives would increase average annual flow by less than 10% in most sections of the stream. However, during parts of the year, changes in operations could change flows by more than 10% in several sections. Therefore, a full description of aquatic resources is provided for the affected river reach along South Boulder Creek from the Moffat Tunnel

downstream to the South Boulder Diversion Canal. Gross Reservoir is also included in the overall study area due to changes in operations and proposed enlargement with several alternatives, therefore, a full description of aquatic resources is provided. South Boulder Creek and Gross Reservoir in the overall study area are classified as Aquatic Life Cold Class 1. South Boulder Creek has CS-II temperature standards.

Fish populations were sampled in South Boulder Creek periodically since the 1960s by CPW or CEC (Miller Ecological Consultants, Inc. 1997; Chadwick and Associates 1986; GEI 2013), South Boulder Creek in the overall study area contains several species of trout, along with suckers, and longnose dace. In the past, CPW stocked rainbow trout in sections of the stream upstream of Gross Reservoir; however, no stocking was conducted from 2000 to 2005. Several species of trout are routinely stocked in Gross Reservoir by CPW. Resident, naturally reproducing rainbow trout is the dominant fish species present in South Boulder Creek in the overall study area. Whirling disease has been identified as present within the South Boulder Creek watershed.

South Boulder Creek: Moffat Tunnel to Gross Reservoir

Habitat

PHABSIMs were developed for brook and rainbow trout for two segments of South Boulder Creek upstream of Gross Reservoir in 1985 (Chadwick and Associates 1986). These relationships were re-evaluated and updated by Miller Ecological Consultants (1997).

The updated habitat relationships for the section of South Boulder Creek from the Moffat Tunnel to near Pinecliffe indicate highest habitat availability for most life stages of brook and rainbow trout at flows in the range of approximately 50 to 200 cfs. In the canyon between Pinecliffe and Gross Reservoir, habitat for brook and rainbow trout is highest over a broad range of flows from 100 to 800 cfs.

A geomorphic survey was conducted on South Boulder Creek upstream of Rollinsville. This stream was classified as a steep, wide stream. The average bankfull width was 13 meters, and the average bankfull width was 0.7 meter (refer to Section 3.3). Riffle was the only habitat type observed. Cobble and boulders were the predominant substrate types. Sand was uncommon and not accumulating. The stream banks were stable because the stream is channelized between the railroad grade and the Moffat Tunnel Road in this reach, but the banks also support some vegetation (refer to Section 3.3).

Fish

Upstream of Gross Reservoir, resident rainbow trout are the main component of the fishery, with cutthroat, brook, and brown trout also present in smaller numbers (Table 3.11-31). White and longnose sucker are also present. Total fish density averages 814 fish/ha. Trout species represent the largest proportion of biomass in this stream, although suckers comprised up to 30.8 kg/ha in one year. Fish biomass data were only available for the period from 1985 to 1991.

Table 3.11-31
South Boulder Creek: Upstream of Gross Reservoir, Fish Population Data, Percent of Total Catch, and Summary Parameters (1963 to 1991)

Species/Date (Sites)	1963 (2)	1974[1] (1)	1984 (1)	1985 (2)	1988 (1)	1991 (2)
Brook trout	86.8%	0	21.4%	68.7%	43.5%	17.5%
Brown trout	0	0	0	0	0	0.2%
Cutthroat trout	1.5%	0	0	1.4%	0	10.1%
Longnose sucker	0	0	7.1%	1.7%	0	7.3%
Rainbow trout	0	82 captured	71.4%	28.1%	56.5%	61.3%
White sucker	0	0	0	0	0	36.4%
Unid. sucker	2.6%	present	0	0	0	0
Average density (fish/ha)	N/R	N/A	N/A	173	905	1,363
Range	**N/R**	**N/A**	**N/A**	**50-295**	**N/A**	**872-1,853**
Average biomass (kg/ha)	N/R	N/A	N/A	22.4	40.1	38
Range	**N/R**	**N/A**	**N/A**	**2.6-42.2**	**N/A**	**24.2-51.7**

Source: Chadwick and Associates, 1985, 1986; Miller Ecological Consultants, 1997.
Notes:
[1]Data from 1974 reflect number captured, since insufficient data were reported to estimate total density and biomass.
Number of sites represented in each time period are shown in parentheses.
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

Benthic Macroinvertebrates

Benthic macroinvertebrate populations were sampled at two sites in the fall of 1984 and spring of 1985 in the section of South Boulder Creek in the overall study area. Upstream of Gross Reservoir, density estimates averaged 2,349 organisms/m^2, represented by an average of 29 taxa/site (Table 3.11-32). A total of 39 taxa were collected, representing the taxonomic groups Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Diptera, and Oligochaeta (Chadwick and Associates 1986), the typical groups for streams in the mountains of Colorado (Ward 1986, 1994; Ward et al. 2002). There were five families that prefer erosional habitats, and most of the insect taxa were from families with no preference for erosional or depositional habitats. Shannon-Weaver Diversity Index (H') values ranged from 2.61 to 3.15, indicating healthy, balanced benthic macroinvertebrate communities (Table 3.11-32).

Table 3.11-32
South Boulder Creek, Benthic Macroinvertebrate Data (1984 and 1985)

Site	Upstream of Gross Reservoir		Downstream of Gross Reservoir	
Parameter/Date	**1984**	**1985**	**1984**	**1985**
Density (#/m²)	1,652	3,046	2,164	2,072
Taxa richness (#)	25	33	30	25
Diversity (H')	2.61	3.15	3.38	3.22

Source: Chadwick and Associates, 1986.
Notes:
# = number
H = a dimensionless measure of the diversity or evenness of the distribution of bugs among the species
#/m^2 = number of individuals per square meter

South Boulder Creek: Gross Reservoir to South Boulder Diversion Canal

Habitat

PHABSIMs were developed for brook and rainbow trout for one segment of South Boulder Creek downstream of Gross Reservoir in 1985 (Chadwick and Associates 1986). Miller Ecological Consultants, Inc. (1997) re-evaluated and updated these relationships for the section of South Boulder Creek downstream of Gross Reservoir, indicating that habitat availability for the younger life stages of rainbow trout (fingerlings and juveniles) is highest at flows between 50 and 200 cfs; for adult trout maximum habitat levels are in the range of 400 to 800 cfs.

A geomorphic survey was conducted on South Boulder Creek downstream of Gross Reservoir. This stream was classified as a steep, narrow type stream; average bankfull width was 19 meters, and average bankfull depth was 1 meter (refer to Section 3.3). The habitat types in this reach were variable and included step-pool complexes and riffles. The bed material consisted of cobble, boulders, and bedrock outcroppings. The active channel also contains significant amounts of coarse sand and fine gravel. The stream banks are mostly stable, but bank failure was observed in localized areas (refer to Section 3.3).

Fish

In the section of South Boulder Creek downstream of Gross Reservoir and upstream of the South Boulder Diversion Canal, resident rainbow trout comprise the bulk of the fishery. A few brown trout are also present, along with longnose and white sucker and longnose dace (Table 3.11-33). Total fish density averages approximately 2,412 fish/ha. Biomass estimates are not available, except for the time period 1983-1985, in which biomass averaged 127 kg/ha.

Table 3.11-33
South Boulder Creek: Downstream of Gross Reservoir, Fish Population Data, Percent of Total Catch, and Summary Parameters (1976 to 1996)

Species/Date (Sites)	1976 (3)	1983-85 (4)	1988 (1)	1991 (1)	1995 (1)[1]	1996 (2)
Brown trout	0	0	0	<1%	58%	15%
Cutthroat/rainbow trout hybrid	0	32%	0	0	0	0
Longnose dace	2%	2%	9%	9%	0	5%
Longnose sucker	0	1%	5%	13%	5%	9%
Rainbow trout	98%	65%	86%	78%	14%	71%
White sucker	0	0	0	<1%	23%	0
Average density (fish/ha)	N/R	2,594	2,583	2,492	267 captured	1,979
Range	**N/R**	**1,557-3,557**	**N/A**	**N/A**	**N/A**	**1,172-2,786**
Average biomass (kg/ha)	N/R	126.6	N/R	N/R	46 kg	N/R
Range	**N/R**	**87-201**	**N/A**	**N/A**	**N/A**	**N/R**

Source: Chadwick and Associates, 1985, 1986; CDOW, 2006c; Miller Ecological Consultants, 1997.
Notes:
[1]Data from 1995 reflect number captured, since insufficient data were reported to estimate total density or biomass.
Number of sites represented in each time period are shown in parentheses.

<	= less than	kg/ha	= kilograms per hectare
%	= percent	N/A	= not applicable
fish/ha	= fish per hectare	N/R	= not reported
kg	= kilogram		

Benthic Macroinvertebrates

Benthic macroinvertebrate populations were sampled at two sites in the fall of 1984 and spring of 1985 in the section of South Boulder Creek in the Project area. Downstream of Gross Reservoir, density estimates averaged 2,118 organisms/m^2, represented by an average of 28 taxa/site (Table 3.11-32). Taxonomic groups included the Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Diptera, and Oligochaeta (Chadwick and Associates 1986), the typical groups for streams in the mountains of Colorado (Ward 1986, 1994; Ward et al. 2002). As with the site upstream of Gross Reservoir, there were five families that prefer erosional habitats downstream of Gross Reservoir. Also, most of the taxa were from insect families with no preference for erosional or depositional habitats. Shannon-Weaver Diversity Index (H') values ranged from 3.22 to 3.38, indicating healthy, balanced benthic macroinvertebrate communities (Table 3.11-32).

New Zealand mud snail populations have been identified in South Boulder Creek; however, the only currently known population is at the confluence with Boulder Creek, downstream of the Project area (CDOW 2007b).

Tipping Point Evaluation

The available data indicate that the fish and macroinvertebrate populations in South Boulder Creek both upstream and downstream of Gross Reservoir are healthy. Overall, the available information indicates that the South Boulder Creek has not crossed an ecological tipping point.

3.11.6.6 North Fork South Platte River

The proposed Moffat Project and its alternatives would affect flows in the North Fork South Platte River downstream to the confluence with the South Platte River. The changes in average annual flow would be much less than 10%. However, the changes in flow in some months would be more than 10%. Therefore, this affected river reach has a full description of aquatic resources. The North Fork South Platte River has a classification of Aquatic Life Cold Class 1 with CS-II temperature standards.

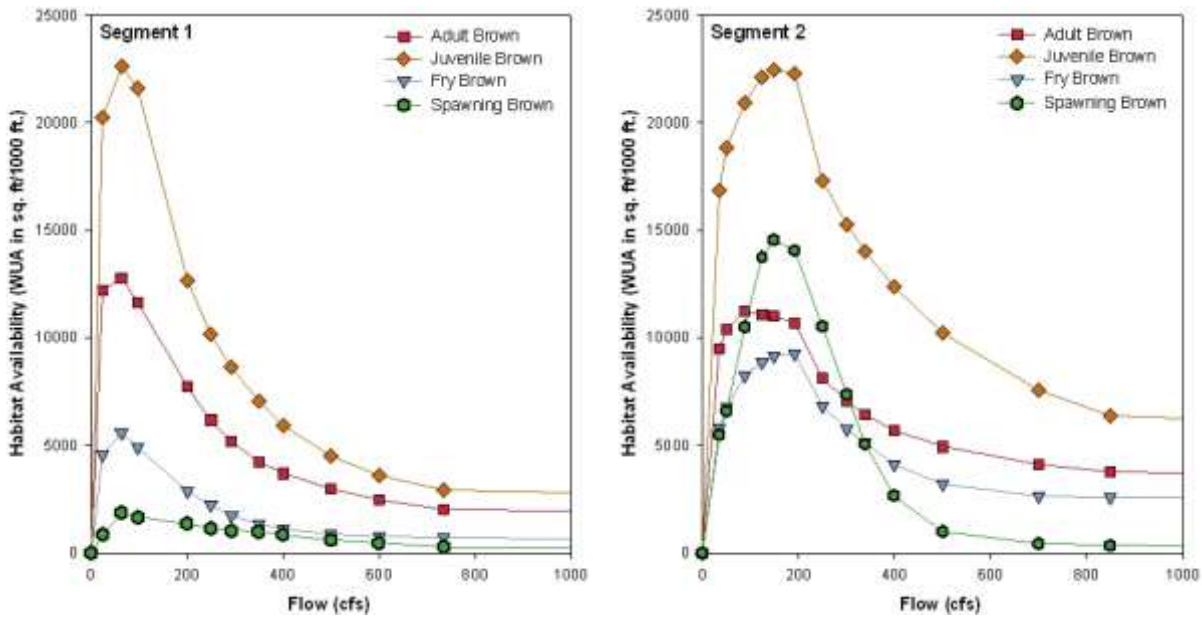
Based on past PHABSIM modeling, the portion of the North Fork in the Project area was divided into two segments. Segment 1 extends from Roberts Tunnel downstream to Buffalo Creek and Segment 2 is from Buffalo Creek downstream to the confluence with the South Plate River.

Habitat

PHABSIM habitat relationships were developed for rainbow and brown trout in two sections of the North Fork South Platte River downstream of Roberts Tunnel by CPW (Figure 3.11-4) (Chadwick and Associates 1986). The habitat relationships indicate highest habitat availability at flows from 25 to 200 cfs in the North Fork South Platte River downstream to Buffalo Creek (Segment 1). In the section of the North Fork South Platte River downstream of Buffalo Creek, habitat for most life stages of rainbow and brown trout is highest at flows ranging 35 to 250 cfs (Segment 2).

Geomorphic analyses at two sites on the North Fork indicate that the channel is wide with a shallow gradient (refer to Section 3.3). The channel is 15 to 21 meters wide with a cobble-gravel substrate. The habitat is mostly riffles with smaller areas of pools, runs, and glides. The banks were generally stable and there are areas of bank stabilization with rocks.

Figure 3.11-4
Habitat Availability (in Weighted Useable Area in Square Feet per 1,000 Feet of Stream) for Various Life Stages of Brown Trout in Segments 1 and 2 of the North Fork South Platte River



Source: Chadwick and Associates, 1986.
Notes:
cfs = cubic feet per second
sq. ft. = square feet
WUA = weighted useable area

Fish

Fish populations in the North Fork South Platte River have been sampled since the 1960s (Chadwick and Associates 1986) (Table 3.11-34). Fish species collected include brook trout, brown trout, rainbow trout, speckled dace, and bluehead, longnose, and white sucker. Brown trout have consistently been the dominant species, both in terms of abundance and biomass. Density estimates have averaged 745 fish/ha and vary over a wide range. Most of the estimates are between the 25th and 50th percentiles of Platts and McHenry for small streams. This indicates the fishery is sustaining to healthy.

Table 3.11-34
North Fork South Platte River, Fish Population Data,
Percent of Total Catch, and Summary Parameters (1976 to 2004)

Species/Date (Sites)	1976 (6)	1983 (4)	1984-1985 (4)	1995 (5)	2004 (2)
Brook trout	<1%	0%	7%	0%	0%
Brown trout	90%	83%	90%	38%	87%
Rainbow trout	3%	2%	3%	17%	10%
Speckled dace	0%	0%	0%	14%	0%
Bluehead sucker	0%	0%	0%	14%	0%
Longnose sucker	7%	0%	0%	<1%	3%
White sucker	0%	0%	0%	17%	0%
"Suckers"	0%	15%	0%	0%	0%
Average density (fish/ha)	996	814	283	1,445	187
Range	**713-1,369**	**491-1,353**	**28-810**	**190-3,440**	**86-288**
Average biomass (kg/ha)	N/R	94	26	N/R	N/R
Range	**N/R**	**47-221**	**0.5-71**	**N/R**	**N/R**

Source: Chadwick and Associates, 1985, 1986; CDOW, 2005a.
Notes:
Number of sites represented in each time period in parentheses.
< = less than
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/R = not reported

In general, the fish community in the North Fork South Platte River is typical of a Rocky Mountain foothills coldwater fishery. Speckled dace and bluehead sucker are confined to the West Slope in Colorado and are unexpected in the North Fork. However, both species were reported from a site approximately 1 km above Estabrook in March 1995 (CDOW 2006c). Whirling disease was detected within the North Fork South Platte River.

Benthic Macroinvertebrates

The benthic macroinvertebrate populations were sampled at seven sites in this reach of the North Fork South Platte River in spring and fall 1984 and spring 1985 (Chadwick and Associates 1986). Total density estimates ranged from 34 to 3,615 organisms/m^2, with an average of 1,377 organisms/m^2. Total number of taxa/site has ranged from 5 to 40 taxa, averaging 25 taxa/site. Both densities and number of taxa were lowest in the upper reaches of the stream. A total of 76 individual taxa were collected, representing the taxonomic groups Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Diptera, Oligochaeta, Turbellaria, Hydracarina, Amphipoda, and Pelecypoda (Chadwick and Associates 1986). The number of families preferring erosional habitats ranged from three to six families. Shannon-Weaver Diversity Index (H') values ranged from 1.57 to 4.15, with only two values falling below 2.50 (Stations 2 and 3 in the fall of 1984); this indicates that, generally, the benthic macroinvertebrate communities in the North Fork South Platte River are healthy and well-balanced. The groups present in the benthic invertebrate community in the North Fork South Platte River are typical of a Rocky Mountain Front Range invertebrate community (Ward 1986, 1994; Ward et al. 2002).

Tipping Point Evaluation

The fish and macroinvertebrate data for the North Fork indicate the presence of healthy populations. Overall, the available information indicates that the North Fork South Platte River has not crossed an ecological tipping point.

3.11.6.7 South Platte River

The alternatives would slightly change flows along the length of the South Platte River between Antero Reservoir and the Henderson gage and this portion of the river is included in the overall study area. There would be no changes in average annual flow in most sections of the river, and relatively minor changes of less than 3% in other sections. The biological resources of these reaches of the South Platte River are briefly discussed. Flows in some months would change by more than 10% in the river between the North Fork South Platte River and Bear Creek and these sections receive a full description of aquatic resources. The South Platte River downstream of Chatfield Reservoir is Section 303(d) listed for arsenic.

There are six mainstem reservoirs on the South Platte River, including Antero, Spinney Mountain, Eleven Mile Canyon, Cheesman, Strontia Springs, and Chatfield. These reservoirs are stocked with hundreds of thousands of fish every year by CPW (CDOW 2006a). Fish species stocked in the upper four reservoirs between 2000 and 2005 include brown, cutthroat, and rainbow trout, cutthroat/rainbow trout hybrids, splake, kokanee salmon, and smallmouth bass. Fish species stocked in Chatfield Reservoir between 2000 and 2005 include cutthroat and rainbow trout, cutthroat/rainbow trout hybrids, channel catfish, walleye, yellow perch, black crappie, bluegill, largemouth bass, smallmouth bass, gizzard shad, and spottail shiner. Some of these species may be found in stream segments near the reservoirs as they migrate for spawning.

Whirling disease was detected within the South Platte River. New Zealand mud snail populations have been identified within the upper reach of the South Platte River, particularly within the seven miles immediately downstream of Eleven Mile Canyon Reservoir (CDOW 2007b).

South Platte River: Antero Reservoir to Confluence with North Fork South Platte River

Over 30 individual sites have been sampled periodically from 1968 to 2005 within the reaches of the South Platte River upstream of the North Fork South Platte River (CDOW 2006c, 2007b). Fish populations in this area are dominated by trout (brook, brown, and rainbow) and sucker (longnose and white) species. Longnose dace are native to the river and speckled dace are native to the western slope, although both species have been reported. Occasionally, other species, such as northern pike, kokanee salmon, splake, spottail shiner, three-spined stickleback, cutthroat/rainbow trout hybrids, and fathead minnow, are collected. Several of these species are resident in the reservoirs and are found near the reservoirs during stream spawning.

This section of the South Platte River is classified as Aquatic Life Cold Class 1. Four reaches of this segment of the South Platte River are considered to be Gold Medal Waters by CPW: (1) from Antero Reservoir to the inlet of Spinney Mountain Reservoir,

(2) between Spinney Mountain Reservoir and Eleven Mile Canyon Reservoir, (3) from Cheesman Dam downstream to the upper boundary of the Wigwam Club, and (4) from the lower Wigwam Club boundary to Scraggy View picnic ground. The segments of the South Platte River downstream of Antero and Cheesman reservoirs are on the Monitoring and Evaluation List for aquatic life impairment. These two segments had low MMI scores that indicated impairment from samples taken below the respective reservoirs. Benthic macroinvertebrates below reservoirs sometimes have modified community characteristics and species composition that score poorly with MMI but are productive and can support Gold Medal fisheries.

CDPHE WQCD macroinvertebrate data are available for this segment of the South Platte River; two samples were collected in July 2006: one downstream of Antero Reservoir, and one downstream of Cheesman Reservoir. The sample downstream of Antero Reservoir contained a minimum of 26 taxa, and the sample downstream of Cheesman Reservoir contained a minimum of 33 taxa. The total number of taxa could not be calculated from the available data. Both samples had MMI scores that did not attain the threshold for unimpaired aquatic life use, but both samples also had Shannon-Weaver Diversity Index (H') scores greater than 3.30, which suggest an unstressed macroinvertebrate community. The segments of the South Platte River downstream of Antero and Cheesman reservoirs are on the Monitoring and Evaluation List for aquatic life impairment.

South Platte River: North Fork South Platte River to Strontia Springs Reservoir

As described above, the Moffat Project and its alternatives would affect flows in the North Fork South Platte River downstream to the confluence with the South Platte River. The changes in average annual flow would be much less than 10%; however, the changes in flow in some months would be more than 10% in the North Fork South Platte River. Because the North Fork South Platte River contributes more than 10% of the base flow of the South Platte River at this point (Chadwick and Associates 1986), flows in the South Platte River downstream of the confluence to Strontia Springs Reservoir could be affected by the proposed Moffat Project and its alternatives.

This section of the South Platte River is classified as Aquatic Life Cold Class 1 with CS-II temperature standards.

Habitat

Habitat data are not available for this short reach of the South Platte River.

Fish

Two sites were sampled within this reach in 1978. Brown and rainbow trout and longnose suckers were collected. Brown trout were the dominant species, and the number of longnose suckers was not reported. Total density and biomass exceeded 122 fish/ha and 61.6 kg/ha, respectively, at the two sites.

Benthic Macroinvertebrates

One site was sampled within this reach in the fall of 1984 and the spring of 1985. Total density ranged from 773 to 5,632 organisms/m^2, and taxa richness ranged from 21 to 41 taxa. Taxonomic groups included Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Diptera, Turbellaria, and Oligochaeta (Chadwick and Associates 1986). The groups present

in the benthic invertebrate community in this reach of the South Platte River are typical of a Rocky Mountain Front Range invertebrate community (Ward 1986, 1994; Ward et al. 2002). Five families that prefer erosional habitats were present in the fall of 1984, and seven families that prefer erosional habitats were present in the spring of 1985. Shannon-Weaver Diversity Index (H') values ranged from 3.76 to 3.88, indicating healthy, well-balanced benthic macroinvertebrate communities.

South Platte River: Strontia Springs Reservoir to Chatfield Reservoir

Between Strontia Springs and Chatfield reservoirs, much of the South Platte River is confined within a narrow, steep canyon, Waterton Canyon. This section of the South Platte River is classified as Aquatic Life Cold Class 1 with CS-II temperature standards.

Habitat

PHABSIMs are available for the South Platte River in the Waterton Canyon section. Habitat simulation for brown and rainbow trout indicates that habitat availability is highest at flows of 30 to 300 cfs (Chadwick and Associates 1986).

Fish

In Waterton Canyon, fish populations, which have been sampled periodically since the 1970s, are comprised primarily of brown and rainbow trout, longnose and white sucker, and longnose dace. Brown trout are generally the dominant species. Snake River cutthroat trout were reported once, in 2004. At the bottom of the canyon near Chatfield Reservoir, the same mix of species is found, along with some warmwater and reservoir-resident species, such as black bullhead, creek chub, fathead minnow, largemouth bass, smallmouth bass, and yellow perch.

Benthic Macroinvertebrates

Two sites were sampled within this reach in the spring and fall of 1985. Total density ranged from 1,377 to 7,970 organisms/m^2, and taxa richness ranged from 23 to 33 taxa. Taxonomic groups included Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Diptera, Amphipoda, Gastropoda, Turbellaria, and Oligochaeta (Chadwick and Associates 1986). The groups present in the benthic invertebrate community in this reach of the South Platte River are typical of a Rocky Mountain Front Range invertebrate community (Ward 1986, 1994; Ward et al. 2002). Among the samples, there were seven families that prefer erosional habitats, represented by 11 distinct taxa. Most of the insect taxa were from families with no preference for erosional or depositional habitats. Shannon-Weaver Diversity Index (H') values ranged from 2.37 to 3.86; the singular low value was due to an abundance of two sensitive EPT taxa (*Hydropsyche* sp. and *Ephemerella dorothea*) reported as *E. infrequens*, since discovered to be a subspecies of *E. dorothea* (Jacobus and McCafferty 2003). These two taxa represented 74% of the total density in the sample collected in the fall of 2005.

South Platte River: Chatfield Reservoir to Confluence with Bear Creek

The Moffat Project and its alternatives would slightly change operations along the length of the South Platte River, resulting in changes to flow greater than 10% in some months in the

section of the river between Chatfield Reservoir and Bear Creek, therefore, this section of river is described in more detail.

The section of the South Platte River downstream of Chatfield Reservoir downstream to the Burlington Ditch in Denver, the classification is Aquatic Life Warm 1. Downstream of the Burlington Ditch, the classification is Aquatic Life Warm 2. Both sections are also on the 303(d) List for arsenic.

Habitat

PHABSIM habitat relationships are available for rainbow trout for the section of the South Platte River downstream of Chatfield Reservoir. The relationships indicate that habitat availability for fry and juvenile rainbow trout is highest at flows less than 80 cfs. For adult rainbow trout, habitat levels are highest at flows ranging from 100 to 300 cfs. Habitat availability for the warmwater fish species that are present in this section of the river was not modeled.

Fish

Fish have been sampled numerous times over the years in this section of the South Platte River, collecting a total of 19 species (Table 3.11-35) (GEI 2013). This section was stocked by CPW in 2000 and 2005 with a few thousand small (less than 5 inches) brown trout, but this species has only accounted for less than 1% of the total catch in any sample year. Creek chub, longnose dace, longnose sucker, and white sucker frequently are the dominant species in this section of the river.

In the coldwater section of the river upstream of Bowles Avenue, the sampling in 2005 resulted in the collection of one brown trout and numerous other species, including black crappie, carp, creek chub, fathead minnow, green sunfish, Iowa darter, largemouth bass, longnose dace, longnose sucker, mosquitofish, sand shiner, smallmouth bass, and white sucker (Table 3.11-36). Collections in 1979, 1985, and 2003 at various sites within the reach yielded many of these species, as well as plains topminnow, rainbow trout, yellow perch, johnny darter, and brook stickleback (Chadwick and Associates 1986; CDOW 2006c) (Table 3.11-36). Many of these warmwater species, such as the bass, perch, and crappie, probably move downstream from Chatfield Reservoir.

The river at Bowles Avenue (at the juncture of the coldwater and warmwater designated sections) has been sampled in 1979, 1987, and 1990. In the 1979 sampling episode, salmonids were absent, and the assemblage was comprised of longnose sucker, white sucker, creek chub, fathead minnow, and yellow perch. In 1987, six brown trout were captured, along with the above mix of species. In 1990, the same species were present, along with one rainbow trout, one carp, two green sunfish, and 727 longnose dace.

In the warmwater section of the South Platte River between Bowles Avenue and Bear Creek, the species composition is similar to that of the coldwater section (Table 3.11-36). Collection in 2005 produced black crappie, brook stickleback, carp, creek chub, fathead minnow, green sunfish, largemouth bass, longnose dace, mosquitofish, smallmouth bass, and white sucker. In 1979, 1986, 1987, 1988, 1990, and 1995, several of these species were collected at various sites within the reach.

Whirling disease was detected within the lower South Platte River.

Table 3.11-35
South Platte River: Chatfield Reservoir to Bear Creek, Fish Population Data, Percent of Total Catch, and Summary Parameters (1979 to 2003)

Species/Date (Sites)	1979-1980 (7)	1986[1] (3)	1987-1988 (2)	1990 (1)	1995 (3)	2003 (1)
Black crappie	<1%	<1%	0%	0%	0%	0%
Brook stickleback	0%	5%	0%	0%	0%	0%
Brown trout	<1%	<1%	<1%	<1%	0%	0%
Channel catfish	0%	0%	0%	0%	4%	0%
Common carp	<1%	<1%	<1%	<1%	4%	0%
Creek chub	13%	4%	7%	27%	2%	3%
Fathead minnow	10%	<1%	<1%	0%	9%	0%
Green sunfish	<1%	<1%	0%	<1%	0%	2%
Iowa darter	0%	0%	0%	0%	0%	10%
Johnny darter	0%	<1%	0%	0%	0%	20%
Largemouth bass	4%	<1%	<1%	0%	8%	5%
Longnose dace	11%	28%	2%	54%	0%	0%
Longnose sucker	20%	2%	76%	<1%	6%	0%
Plains topminnow	0%	0%	0%	0%	0%	3%
Rainbow trout	<1%	<1%	0%	<1%	0%	0%
Smallmouth bass	0%	<1%	0%	0%	0%	33%
White sucker	23%	59%	13%	18%	60%	25%
Yellow perch	5%	<1%	<1%	0%	8%	0%
Unid.	11%	0%	0%	0%	0%	0%
Average number of fish collected	114	2,559	366	1,351	18	40
Range	**49-154**	**276-4,786**	**169-563**	**N/A**	**4-26**	**N/A**
Average biomass (kg/ha)	N/R	50	N/R	N/R	N/R	N/R
Range	**N/R**	**13 - 118**	**N/R**	**N/A**	**N/R**	**N/A**

Source: Chadwick and Associates, 1988; CDOW, 2005a.
Notes:
[1]Population parameters for 1986 represent fish/ha (density) and kg/ha (biomass).
Number of sites represented in each time period are shown in parentheses.

< = less than
% = percent
fish/ha = fish per hectare
kg/ha = kilograms per hectare
N/A = not applicable
N/R = not reported

Table 3.11-36
South Platte River: Chatfield Reservoir to Bear Creek, Fish Population Data and Percent of Total Catch by Habitat in Warm and Coldwater Sections (2005)

Species/Habitat	Coldwater Section[1]			Warmwater Section		
	Backwater	Bank/Riprap	Snag	Backwater	Bank/Riprap	Snag
Black crappie	<1%	0%	0%	1%	0%	0%
Brook stickleback	0%	05	0%	0%	0%	0%
Common carp	<1%	0%	0%	0%	<1%	0%
Creek chub	10%	13%	9%	0%	7%	12%
Fathead minnow	42%	7%	0%	2%	1%	0%
Green sunfish	1%	24%	18%	0%	8%	2%
Iowa darter	0%	<1%	9%	0%	0%	0%
Largemouth bass	<1%	3%	0%	0%	3%	0%
Longnose dace	0%	1%	0%	0%	1%	2%
Longnose sucker	0%	0%	0%	0%	0%	0%
Mosquitofish	23%	0%	0%	85%	<1%	0%
Smallmouth bass	0%	12%	18%	0%	2%	12%
Sand shiner	0%	1%	0%	0%	0%	0%
White sucker	22%	37%	45%	12%	77%	85%
Total Collected	**1,729**	**215**	**11**	**201**	**286**	**101**

Source: GEI, 2013.
Notes:
[1]One brown trout was seined in an open-water riffle, not included in analyses.
< = less than
% = percent

Benthic Macroinvertebrates

Benthic macroinvertebrate data from 1985 and 1986 indicate the presence of several classes/orders of invertebrates, including Ephemeroptera, Plecoptera, Trichoptera, Odonata, Diptera, Isopoda, Amphipoda, Hydracarina, Gastropoda, Oligochaeta, Hirudinea, and Turbellaria (Chadwick and Associates 1988). The invertebrate communities are typical of the transition zone from Rocky Mountain foothills to the high plains (Ward 1986). Density at the two sites in the section of the South Platte River was higher than at other streams in the Project area, ranging from near 6,000 organisms/m^2 to over 40,000 organisms/m^2. The number of taxa was similar to other streams, averaging over 23 taxa per sampling site. Most Shannon-Weaver Diversity Index (H') scores were low, below 2.50. This appears to be primarily due to the abundance of erosional habitat-preferring hydropsychid caddisflies and simuliids, as well as baetid mayflies and midges, an assemblage typical of the transition zone from the Rocky Mountain foothills to the high plains, particularly as it enters the urban Denver Metropolitan area (Ward 1986).

In 2005, three sites were sampled for benthic macroinvertebrates within this segment of the South Platte River. Total densities averaged 6,325 organisms/sample, ranging from 2,085 to 14,081 organisms/sample. Number of taxa was similar to the samples collected in 1986 and 1987, averaging 28 taxa/sample, ranging from 20 to 32 taxa. Taxonomic groups included Ephemeroptera, Plecoptera, Hemiptera, Trichoptera, Odonata, Diptera, Isopoda, Amphipoda, Hydracarina, Gastropoda, Oligochaeta, Hirudinea, and Turbellaria, as in

1985-1986. The Shannon-Weaver Diversity Index (H') was above 3.00 for five of the six samples, indicating healthy invertebrate communities, and an improvement from 1985 to 1986.

South Platte River: Bear Creek to Henderson Gage

Downstream of the confluence with Bear Creek to the Henderson gage, fish populations are dominated by warmwater species. Representative species include black crappie, bluegill, common carp, creek chub, fathead minnow, green sunfish, Iowa darter, johnny darter, largemouth bass, mosquitofish, plains killifish, smallmouth bass, and yellow perch. The classification of the South Platte River in this section is Warm Class 1. The South Platte River in the Denver Metropolitan area from Littleton to the Burlington Ditch is on the 303(d) List for arsenic, from the Burlington Ditch to Big Dry Creek for *E. Coli*, and from the Burlington Ditch to Clear Creek for cadmium.

3.12 TRANSPORTATION

3.12.0 Overview

The Moffat Collection System Project (Moffat Project or Project) area covers a large portion of north-central Colorado, particularly north and west of the Denver Metropolitan area. The surface transportation network in this area includes both roadways and railroads. The primary entity responsible for transportation planning is the region's Metropolitan Planning Organization, the Denver Regional Council of Governments (DRCOG).

Nine counties (Denver, Broomfield, Arapahoe, Adams, Douglas, Gilpin, Jefferson, Boulder, and Clear Creek) and 52 cities (including Denver, Boulder, Brighton, Broomfield, Golden, and Nederland) participate in DRCOG. Four counties located in the Project area participate in DRCOG (Adams, Boulder, Denver, and Jefferson). Additionally, the Gross Reservoir haul routes pass through Broomfield and Weld counties. In preparing the regional transportation plan, DRCOG coordinates with various local, State, and Federal agencies, including CDOT, the Regional Transportation District, the Regional Air Quality Council, Colorado Department of Public Health and Environment (CDPHE), the Federal Highway Administration (FHWA), and the Federal Transit Administration.

Metro Vision 2030 Plan is the regional transportation plan that was adopted in January 2005 to address the future growth of the Denver Metropolitan area (DRCOG 2005). The plan was updated by DRCOG in 2011 to evaluate a new planning horizon of 2035 (DRCOG 2011). The plan provides a vision of how local governments want to see the region develop over the next 25 years and provides a set of policies and implementation actions to achieve this.

Project Area Transportation

There are numerous interstate, State, and county highways and roads within the Project area that would potentially be affected by the proposed Moffat Project. The interstate highways include:

- Interstate (I-) 70, which runs east-west across Colorado
- I-25, which runs north-south on the eastern side of the Rocky Mountains
- I-76, which connects Denver to I-80 in the northeastern part of Colorado
- I-270, located in the northeastern quadrant of I-25 and I-70 in Denver, connects all three interstates

The U.S. highways in the Project area include:

- U.S. Highway (US) 6, which runs east-west across Colorado, generally paralleling I-70 west of Denver and I-76 east of Denver
- US 36, which originates in eastern Colorado, runs through Denver, and northwest to Boulder
- US 85, which runs north-south, from south of Denver north through Fort Lupton to Greeley and beyond

- US 287, which originates in eastern Colorado, goes through Denver, and continues north to Fort Collins before entering Wyoming

These and other roadways in the Project area are shown on Figure 3.12-1.

Traffic volumes for these and all roadways mentioned in this section were gathered from two main sources, DRCOG and CDOT. As such, the traffic data were collected in different years and data are not available in all locations, particularly the minor roadways. Available traffic volumes are shown in Figure 3.12-1.

Several roadways in the Project area have improvements planned. The major roadways in the Project area, along with their existing condition and planned improvements, are listed in Table 3.12-1.

Table 3.12-1
Transportation Network Improvements

Facility	Segment	Existing	Improvement
I-25	Denver to Longmont	4- and 8-lane freeway with HOV	6- and 8-lane freeway with HOV
I-70	Idaho Springs to Aurora	6-lane freeway with HOV	6- and 8-lane freeway with HOV
I-76	Denver to Brighton	2- and 4-lane freeway	4- and 6-lane freeway
I-270	I-76 to I-70	4-lane freeway	6-lane freeway
US 36	I-25 to Boulder	4-lane freeway	6-lane freeway
US 85	Denver to Brighton	4-lane major regional arterial	6-lane major regional arterial
US 287	Denver to Lafayette	4-lane major regional arterial	None
US 287 Bypass	Lafayette	4-lane major regional arterial	None
SH 72	Wheat Ridge to Nederland	2-lane principal arterial	4-lane principal arterial (Wheat Ridge to SH 93)
SH 93	Golden to Boulder	2-lane principal arterial	4-lane principal arterial (Golden to Boulder County line)
SH 119	US 6 to Boulder	2-lane principal arterial	None
SH 128	SH 93 to Broomfield	2-lane principal arterial	4-lane principal arterial
CR 77S	SH 72 to Gross Reservoir	2-lane unpaved road	None
CR 2050	County Line Road to Aggregate Facilities	2-lane arterial	None
Arapahoe Road	US 287 Bypass to County Line Road	2-lane arterial	None
Brighton Road	I-76 to SH 22	2-lane arterial	None
County Line Road	Arapahoe Road to CR 2050	2-lane principal arterial	None

Source: DRCOG, 2005, 2011.
Notes:
CR = County Road
HOV = high occupancy vehicle
I-# = Interstate #
SH # = State Highway #
US # = U.S. Highway #

There are two single-track railroads in the Project area that carry 25 to 30 trains per day. The primary cargo hauled on both railroad lines is coal. The Brush Subdivision Line is a Burlington Northern Santa Fe line that generally parallels I-76 northeast out of Denver to Chicago. This rail line is located in the general vicinity of Alternatives 8a and 13a. The Moffat line is a Union Pacific line that extends from Denver to points east and west. This rail line is in the vicinity of the Leyden Gulch site and Gross Reservoir.

3.12.1 Reservoirs

3.12.1.1 Gross Reservoir

The most direct route to Gross Reservoir is from State Highway (SH) 72 (Coal Creek Canyon Drive), a two-lane paved roadway. SH 72 runs from I-70 in Wheat Ridge, connects to SH 119 south of Nederland, and continues north. From SH 72, County Road (CR) 77S (Gross Dam Road) in Crescent Village leads to the reservoir. Approaching the dam, Gross Dam Road is an unpaved road with numerous sharp curves and steep grades. Gross Dam Road splits to provide access to the Dam and Haul Road recreation areas to the west, and CR 77 (Flagstaff Road) provides access to the reservoir from Boulder. Additional access to Gross Reservoir can be obtained from CRs 97, 132, and 68, and by four-wheel drive roads on U.S. Forest Service (USFS) lands. However, these routes are also unpaved roads and have much longer travel times than the SH 72 route. The Union Pacific rail line also travels from Denver westward. There are sidings on this line at Gross Reservoir.

Off-site commercial sources may be used to provide supplemental material for the proposed enlargement of Gross Reservoir Dam. LaFarge Sand and Aggregate Industries Sand are both located southeast of Longmont and can be accessed from CR 2050. Refer to Figure 2-5 in Chapter 2, for the proposed haul route and affected roads.

3.12.1.2 Leyden Gulch Reservoir Site

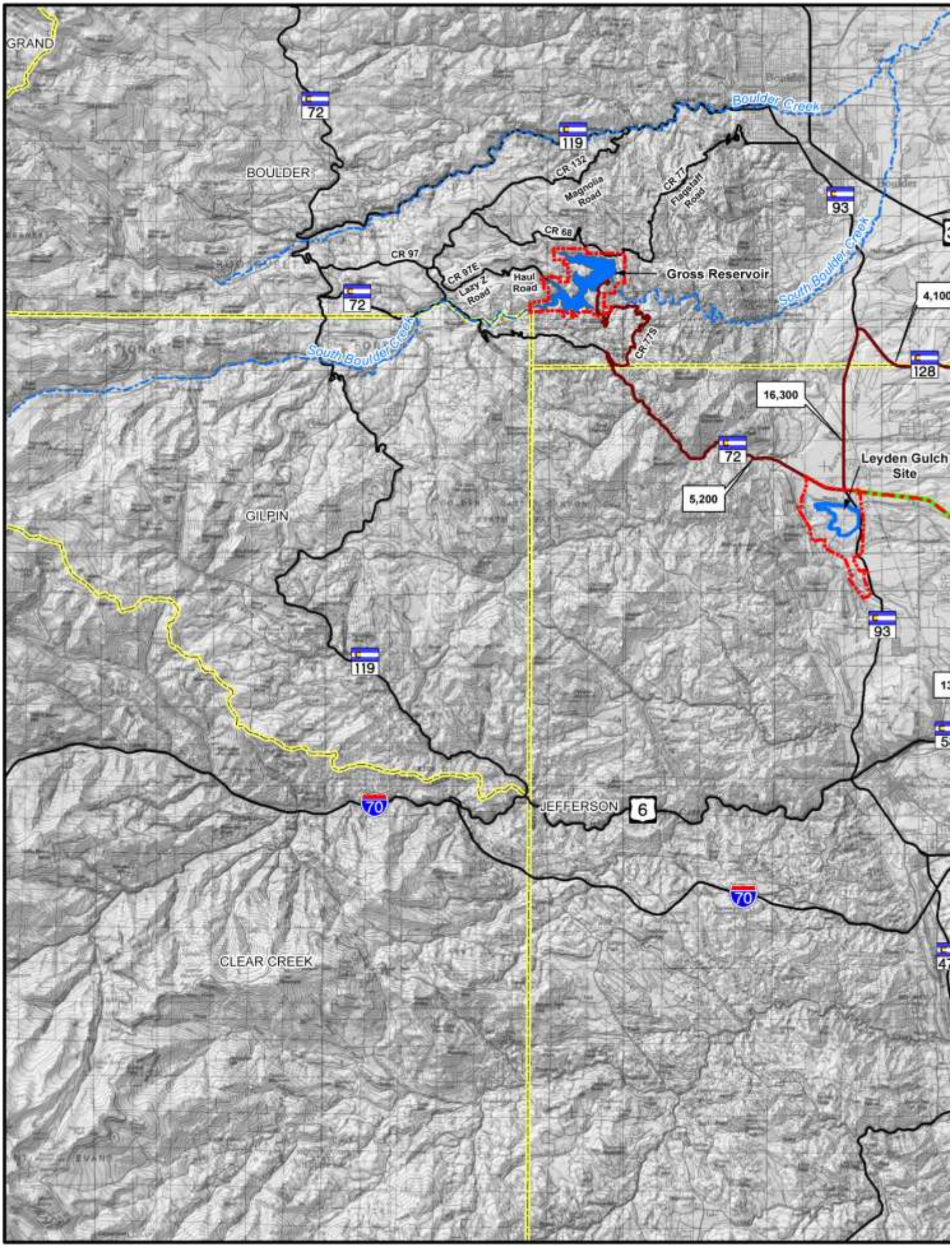
The Leyden Gulch site is located in the southwest quadrant of SH 72 and SH 93. SH 72 is described in Section 3.12.1.1. SH 93 runs north-south from Golden to Boulder. This site is accessible by both of the aforementioned roadways.

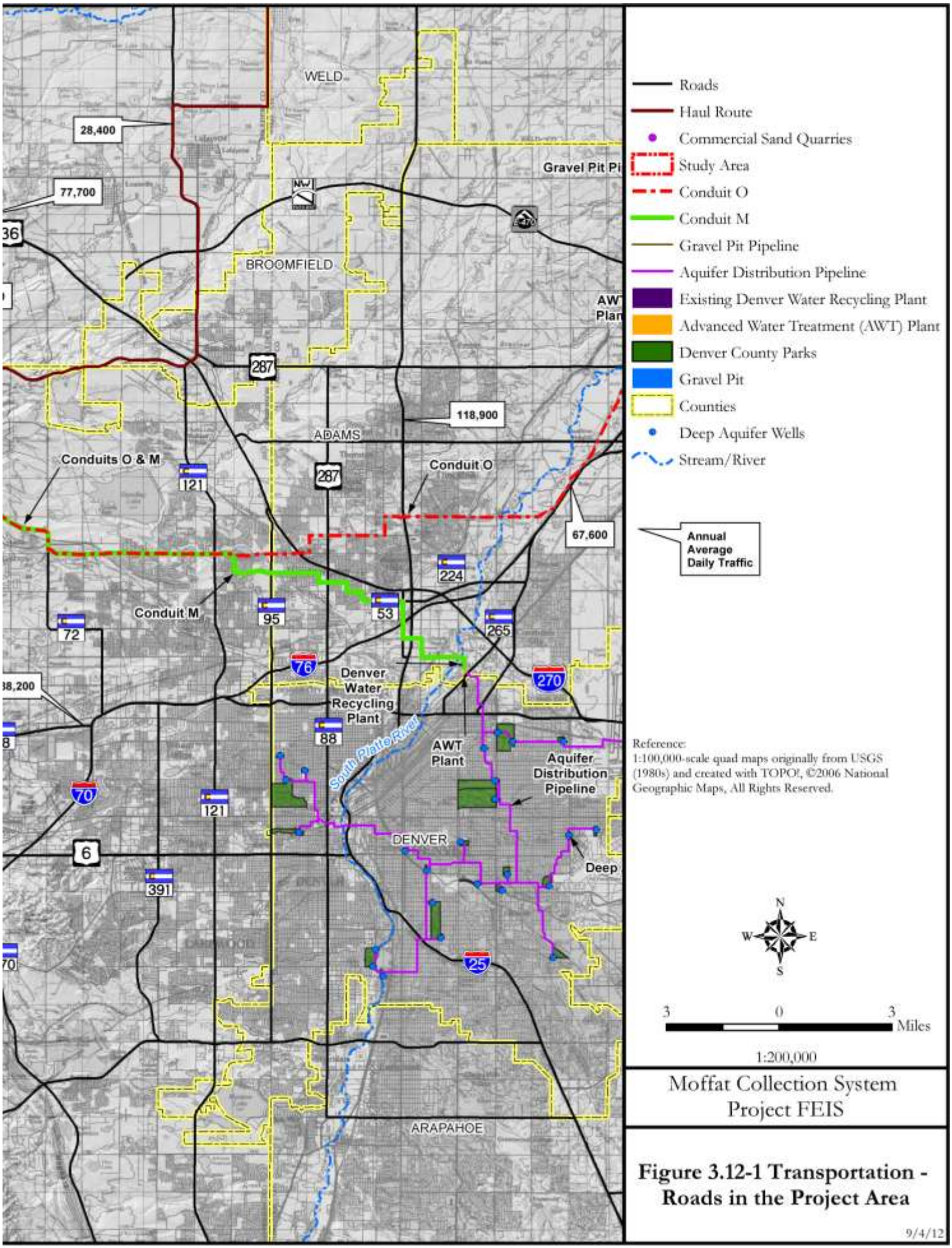
3.12.2 Conveyance Systems

The area surrounding Conduits M and O is mostly urbanized and would be accessed through the local street network in Adams, Denver, and Jefferson counties. The major roads crossed by these conduits are shown on Figure 3.12-1.

3.12.3 South Platte River Facilities

The proposed facilities would be located along the South Platte River in the Brighton area, which is in the northeast section of the Denver Metropolitan area in Adams County. Construction access would be obtained using existing paved and unpaved roads in Adams County. The most direct route to the study area would be accessed by US 85, a four-lane divided highway, with connections to local roads.


GRAND
72
BOULDER
119
Boulder Creek
CR 132
Magnolia Road
CR 77
Flagstaff Road
93
CR 68
CR 97
CR 97E
Lazy Z Road
Haul Road
Gross Reservoir
South Boulder Creek
72
South Boulder Creek
CR 117S
4,100
128
16,300
72
Leyden Gulch Site
5,200
GILPIN
93
119
70
JEFFERSON
6
70
CLEAR CREEK



Moffat Collection System Project FEIS

Figure 3.12-1 Transportation - Roads in the Project Area

9/4/12

3.12.4 Denver Basin Aquifer Facilities

The proposed 27 injection/extraction well sites would be located within the urban Denver Metropolitan area at City and County of Denver parks, golf courses, and at the Denver International Airport nursery site. Access to these sites would be obtained using existing urban roads such as Colorado Boulevard, Pena Boulevard, South Monaco Parkway, Sheridan Boulevard, Louisiana Avenue, West Jewell Avenue, and other roads shown in Figure 3.12-1.

3.13 AIR QUALITY

3.13.0 Overview

Air quality is primarily controlled by the magnitude and distribution of pollutant emissions (fugitive and point source) within any given region and the regional climate. The transport of pollutants from specific source areas is strongly affected by local topography. These factors and how they relate to the Moffat Collection System Project (Moffat Project or Project) area are described in the following sections.

Meteorology and Climate in the Project Area

Both the geographical and meteorological characteristics of the Denver Metropolitan area and the Rocky Mountains to the west are major factors affecting air quality conditions in the Project area. Topography is particularly important in channeling pollutants along valleys, creating upslope and downslope circulation that entrains airborne pollutants, and blocking the flow of pollutants toward certain areas. The topography of the Project area varies from moderately steep mountains, canyons, and mesas in the north-central and south-central portions, to rolling hills and gently sloping river valleys in the eastern and western regions. Elevations range from about 6,000 to nearly 9,000 feet.

The National Climatic Data Center maintains data from a national network of cooperative- and government-operated (i.e., military bases, airports, etc.) meteorological monitoring stations. The following tables (Tables 3.13-1 and 3.13-2) show meteorological data for each county in the Project area (WRCC 2010a). Wind data are not as available as the other meteorological parameters and thus are provided for only two weather stations in Colorado. Table 3.13-3 shows wind data for the years 2004 through 2007 for two sites near the Project area, Broomfield Jefferson County Airport (KBJC) and Mountain Research Station (Boulder 14W) (CISL 2010; NOAA 1998).

3.13.1 National Ambient Air Quality Standards

"Air Pollution" is a general term that refers to one or more substances that degrade the quality of the atmosphere. Individual air pollutants degrade air quality by reducing human or animal health, reducing visibility, damaging property, and/or reducing the productivity or vigor of crops or natural vegetation. Regulations for air pollutant emissions exist to protect human health and welfare and the environment.

Major sources of air pollution include the following:

- Combustion of fossil fuels for industrial uses such as electricity generation and heating
- Combustion of fossil fuels for residential heating (e.g., furnaces and water heaters)
- Combustion of fuels, such as residential wood burning, incineration, and gas and forest fires
- Emissions from industrial/commercial processes (e.g., refineries and manufacturing)

Table 3.13-1
Average Maximum and Minimum Temperatures (°F)

County	Site ID	January		February		March		April		May		June		July		August		September		October		November		December		Annual	
		Max °F	Min °F	Max °F	Min °F	Max °F	Min °F	Max °F	Min °F	Max °F	Min °F	Max °F	Min °F	Max °F	Min °F	Max °F	Min °F	Max °F	Min °F	Max °F	Min °F	Max °F	Min °F	Max °F	Min °F	Max °F	Min °F
Boulder	50848	44.8	20.5	47.0	22.5	53.1	27.8	61.8	35.7	70.4	44.3	80.5	52.8	86.3	58.7	84.6	57.5	76.9	49.0	66.0	39.0	53.8	28.9	46.1	22.3	64.3	38.2
Jefferson	52790	44.3	10.0	45.5	12.2	49.8	18.3	56.6	25.5	65.2	33.9	75.3	41.1	81.6	46.8	79.3	45.3	72.1	37.1	62.3	26.8	51.0	18.2	44.8	10.8	60.7	27.2
Denver	52220	43.8	17.0	46.9	20.4	52.7	26.2	61.3	34.3	70.9	44.1	81.6	52.8	88.2	59.0	85.8	57.3	77.4	48.1	66.1	36.7	52.7	25.5	45.0	18.3	64.4	36.6
Adams	51179	42.3	13.1	46.3	17.1	53.2	23.4	62.5	31.9	72.1	41.7	83.4	50.5	90.3	56.6	87.8	55.0	79.3	46.0	67.6	34.5	52.8	22.6	44.2	15.1	65.2	34.0
Weld	53553	41.6	15.4	47.1	19.9	56.2	26.8	64.6	34.7	73.7	44.2	83.9	52.7	90.0	58.3	87.7	56.2	79.5	46.9	66.5	35.4	51.3	24.6	41.8	16.4	65.3	36.0

Source: WRCC, 2010a.
Notes:
°F = degrees Fahrenheit
ID = identification
Min = minimum
Max = maximum

Table 3.13-2
Average Total Precipitation and Snowfall (inches)

County	Site ID	January		February		March		April		May		June		July		August		September		October		November		December		Annual	
		Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall	Precipitation	Snowfall
Boulder	50848	0.59	9.6	0.78	11.2	1.72	16.5	2.64	11.4	2.97	2.3	1.89	0	1.73	0	1.61	0	1.52	1.1	1.47	5.1	1.01	11.8	0.78	10.6	18.71	79.5
Jefferson	52790	0.55	8.6	0.69	9.7	1.67	18.7	2.21	14.0	2.57	3.4	2.14	0.1	2.23	0	2.31	0	1.47	1.5	1.27	7.4	0.93	12.0	0.75	10.0	18.79	85.3
Denver	52220	0.50	7.3	0.56	7.0	1.25	12.2	1.79	8.3	2.42	1.6	1.69	0	1.96	0	1.74	0	1.14	1.5	1.01	4.1	0.81	8.6	0.58	7.8	15.45	58.6
Adams	51179	0.42	6.3	0.40	5.3	0.96	8.9	1.66	6.0	2.49	0.6	1.85	0	2.13	0	1.83	0	1.21	1.0	0.83	2.8	0.63	5.9	0.42	5.9	14.83	42.7
Weld	53553	0.47	5.9	0.36	4.2	1.06	7.4	1.82	4.9	2.42	0.8	1.87	0	1.54	0	1.36	0	1.11	0.7	1.04	3.2	0.75	6.8	0.51	6.6	14.32	40.4

Source: WRCC, 2010a.
Notes:
ID = identification
mph = miles per hour

Table 3.13-3
Wind Data

Station	Monitored Metric	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
KBJC[1]	Prevailing Wind Direction	W	N	W	N	N	N	N	N	N	N	W	W	N
	Mean Wind Speed (mph)	10	9	10	9	9	9	8	8	8	8	8	10	9
	Maximum Wind Speed (mph)	62	37	63	38	34	57	51	51	46	61	40	67	67
Boulder 14W[2]	Mean Wind Speed (mph)	9	8	7	5	5	5	4	4	5	6	7	9	6
	Maximum Wind Speed (mph)	29	26	29	25	21	25	13	13	20	26	27	28	29

Notes:
[1]Source: CISL, 2010.
[2]Source: NOAA, 1998.
N = north
mph = miles per hour
W = west

- Evaporative emissions and solvent usage (refueling of automobiles, and other common household solvents such as paint thinner)
- On-road vehicles, such as cars, trucks, buses, and motorcycles
- Fugitive dust from unpaved roads
- Off-road vehicles, such as aircraft, boats, locomotives, farm equipment, construction machinery and lawn mowers
- Natural sources including windblown dust and soot from wildfires

The U.S. Environmental Protection Agency (EPA) has the responsibility for developing and enforcing regulations that govern air quality. The 1970 Federal Clean Air Act (CAA) established National Ambient Air Quality Standards (NAAQS) designed to protect public health. Seven air pollutants (criteria pollutants) have been identified by the EPA as being of concern nationwide: carbon monoxide (CO), sulfur oxides (SO_x), nitrogen dioxide (NO_2), ozone (O_3), particulate matter less than 10 and 2.5 microns in diameter (PM_{10} and $PM_{2.5}$), and lead (Pb). Although SO_x is listed as the criteria pollutant, ambient concentrations are actually measured as sulfur dioxide (SO_2). The sources of these pollutants, their effects on human health, and their concentrations in the atmosphere vary considerably. Table 3.13-4 shows the NAAQS standards for each of the criteria pollutants.

Table 3.13-4
National Ambient Air Quality Standards

Pollutant	Primary Standards	Averaging Time	Secondary Standards
Carbon monoxide (CO)	9 ppm (10 mg/m^3)	8-hour[1]	None
	35 ppm (40 mg/m^3)	1-hour[1]	None
Lead (Pb)	1.5 µg/m^3	Quarterly average	Same as primary
	0.15 µg/m^3	Rolling 3-Month Average[2]	Same as primary
Nitrogen dioxide (NO_2)	0.053 ppm (100 µg/m^3)	Annual (arithmetic mean)	Same as primary
	0.1 ppm	1-hour[3]	None
Particulate matter (PM_{10})	N/A[4]	N/A[4]	-------
	150 µg/m[5]	24-hour[5]	Same as primary
Particulate matter ($PM_{2.5}$)	12.0 µg/m[5]	Annual[6] (arithmetic mean)	15.0 µg/m[5] (Annual)
	35 µg/m[5]	24-hour[7]	Same as primary
Ozone (O_3)	0.08 ppm/ 0.075 ppm[8]	8-hour[9]	Same as primary

Table 3.13-4 (continued)
National Ambient Air Quality Standards

Pollutant	Primary Standards	Averaging Time	Secondary Standards
Sulfur oxides (measured as SO_2)	75 ppb	1-hour[10]	0.5 ppm (3-hour)

Source: EPA, 2010e.
Notes:
Averaging times are based on the following:
[1]Not to be exceeded more than once per year.
[2]Final rule signed October 15, 2008.
[3]To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 0.100 ppm (effective January 22, 2010).
[4]Due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the agency revoked the annual PM_{10} standard in 2006 (effective December 17, 2006).
[5]Annual Mean – not to be exceeded more than once per year on average over 3 years.
[6]To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 $\mu g/m^3$.
[7]To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 $\mu g/m^3$ (effective December 17, 2006).
[8]The 1997 standard of 0.08 ppm – and the implementation rules for that standard – will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.
[9]To attain the 0.08-ppm standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor over each year must not exceed 0.084 ppm. To attain the revised 0.075-ppm standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor over each year must not exceed 0.075 ppm.
[10]Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.
------- = indicates that the sampling site does not collect data for that pollutant
$\mu g/m^3$ = micrograms per cubic meter
mg/m^3 = milligrams per cubic meter
N/A = not applicable
ppb = parts per billion
ppm = parts per million

A Statewide monitoring network measures ambient concentrations of criteria pollutants. If ambient criteria pollutant concentrations do not exceed the NAAQS, an area is designated as an attainment area. In contrast, an area with pollutant concentrations that exceed the NAAQS for one or more pollutants are designated as non-attainment areas for these pollutants. Colorado is designated as an attainment area for CO, NO_2, O_3 (1-hour), SO_x, PM_{10} and $PM_{2.5}$. The Denver Metropolitan area is designated non-attainment for the 8-hour O_3 standard based on the 0.08 parts per million (ppm) ozone NAAQS, and is expected to be designated non-attainment based on the revised 0.075-ppm ozone NAAQS. The Denver Metropolitan area consists of Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, and parts of Larimer and Weld counties. Table 3.13-5 shows the monitored values for the counties in the Project area where land-disturbing activities would occur or areas that would contain haul routes.

The Denver Metropolitan area volunteered to participate in the EPA Early Action Compact Protocol process for the purpose of deferring the effective date of a non-attainment designation while implementing emission control measures to reduce ambient ozone concentrations. However, the three-year average of the fourth-highest daily maximum ozone concentrations exceeded the 0.08-ppm 8-hour standard during the summer of 2007. Ozone non-attainment provisions became effective on November 20, 2007.

Table 3.13-5
National Ambient Air Quality Standard Monitoring Data

County	Criteria Pollutants											
	CO (ppm)		NO_2 (ppm)	O_3 (ppm)		SO_2 (ppm)		$PM_{2.5}$ ($\mu g/m^3$)		PM_{10} ($\mu g/m^3$)		Pb ($\mu g/m^3$)
	2nd Max 1-hr	2nd Max 8-hr	Annual Mean	2nd Max 1-hr	4th Max 8-hr	2nd Max 24-hr	Annual Mean	98th Percentile	Annual Mean	2nd Max 24-hr	Annual Mean	Quarterly Mean
Boulder	3.3	2.4	-------	0.089	0.076	-------	-------	23	7.73	35	21	-------
Jefferson	-------	-------	-------	0.93	0.074	-------	-------	-------	-------	-------	-------	-------
Denver	4.5	1.9	0.025	0.09	0.072	0.008	0.002	19.4	7.9	56	30	0.01
Adams	3.1	1.7	0.016	0.095	0.076	0.008	0.002	20.3	8.62	107	32	-------
Weld	3.2	2.2	-------	0.092	0.073	-------	-------	21.8	8.12	60	22	-------

Source: EPA, 2010e.
Notes:
Cells with "-------" indicate that the sampling site does not collect data for that pollutant.

$\mu g/m^3$ = micrograms per cubic meter
CO = carbon monoxide
hr = hour
Max = maximum
NO_2 = nitrogen dioxide
O_3 = oxide
Pb = lead
PM = particulate matter
ppm = parts per million
SO_2 = sulfur oxide

3.13.2 Regional Haze/Visibility/Extinction

Regional haze results in reduced visibility in many cities and scenic areas. Haze is caused when sunlight encounters tiny particles and moisture in the air. Some light is absorbed by particles while other light is scattered, which reduces the clarity and color of what we see. Some types of particles such as sulfates scatter more light, particularly during humid conditions.

Visibility is generally defined as the maximum distance a landscape can be viewed against the background of the sky. Visibility is commonly expressed in terms of visual range, which is defined as the distance at which a large black object just disappears from view.

The CAA requires states to treat the Class I areas with the most stringent degree of protection from future degradation of air quality. Class I areas include each national park over 6,000 acres and each national wilderness area over 5,000 acres that existed as of the date of enactment (August 7, 1977) of the CAA. There are 12 Class I areas in Colorado (Table 3.13-6).

Table 3.13-6
Colorado Class I Areas

Black Canyon of Gunnison National Park	Mesa Verde National Park
Eagles Nest Wilderness Area	Mount Zirkel Wilderness Area
Flat Tops Wilderness Area	Rawah Wilderness Area
Great Sand Dunes National Monument	Rocky Mountain National Park
La Garita Wilderness Area	West Elk Wilderness Area
Maroon Bells-Snowmass Wilderness Area	Weminuche Wilderness Area

Source: NPS, 2006.

The closest Class I areas to the Project are Eagles Nest Wilderness Area (managed by the USFS) and Rocky Mountain National Park (managed by the National Park Service [NPS]). Visibility monitoring has been ongoing at 50 NPS locations, including Rocky Mountain National Park, as a part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) program.

Extinction, in the form of inverse megameters (Mm^{-1}), is also a common measure of air quality and is proportional to the amount of light lost as it travels over 1,000 kilometers (km). Extinction is most useful for relating visibility directly to particle species concentrations in air. To understand the correspondence between visual range and extinction, a 10 Mm^{-1} extinction value is about 400 km visual range, while 1,000 Mm^{-1} is about 4 km visual range.

Maps of national visibility on the 20 percent (%) clearest days and 20% haziest days, averaged over the 5-year period of 2001 through 2005, have been generated by the NPS (NPS 2005). The values for Colorado are shown in Table 3.13-7.

Table 3.13-7
Average Visibility for 2001-2005

Location	20% Haziest Days (Mm^{-1})	20% Clearest Days (Mm^{-1})
Project Area and Western Class I Areas	<40	<8

Source: NPS, 2005.
Notes:
The data include the region encompassing Rocky Mountain National Park and Eagles Nest Wilderness Area.
Mm^{-1} = inverse megameters

IMPROVE visibility measurements for 2004 are shown in Table 3.13-8 for the two closest Class I areas to the Project area. Values were generated based on procedures in the EPA's Draft Guidance for Tracking Progress Under the Regional Haze Rule. As shown in Table 3.13-8, visibility for 2004 was better for the Eagles Nest area than for Rocky Mountain National Park.

The State of Colorado has established a visibility standard applicable to all communities along the Front Range that participate in the Automobile Inspection and Readjustment program. This is administered by the CDPHE Air Pollution Control Division. The standard is 0.076 per km of atmospheric extinction, which means that less than 7.6% of the light in a km of air is blocked by particles. This standard applies to a four-hour average between 8:00 a.m. and 4:00 p.m., when relative humidity is less than 70%. To determine relative visibility (i.e., good, fair, poor), data from a transmissometer is converted to a Visibility Standard Index score, where values 0 to 50 are considered "good," 51 to 100 are "moderate," 100 to 200 are "poor," and 200-plus are "extremely poor." A value of 101 is poor and equates to the 0.076 km standard.

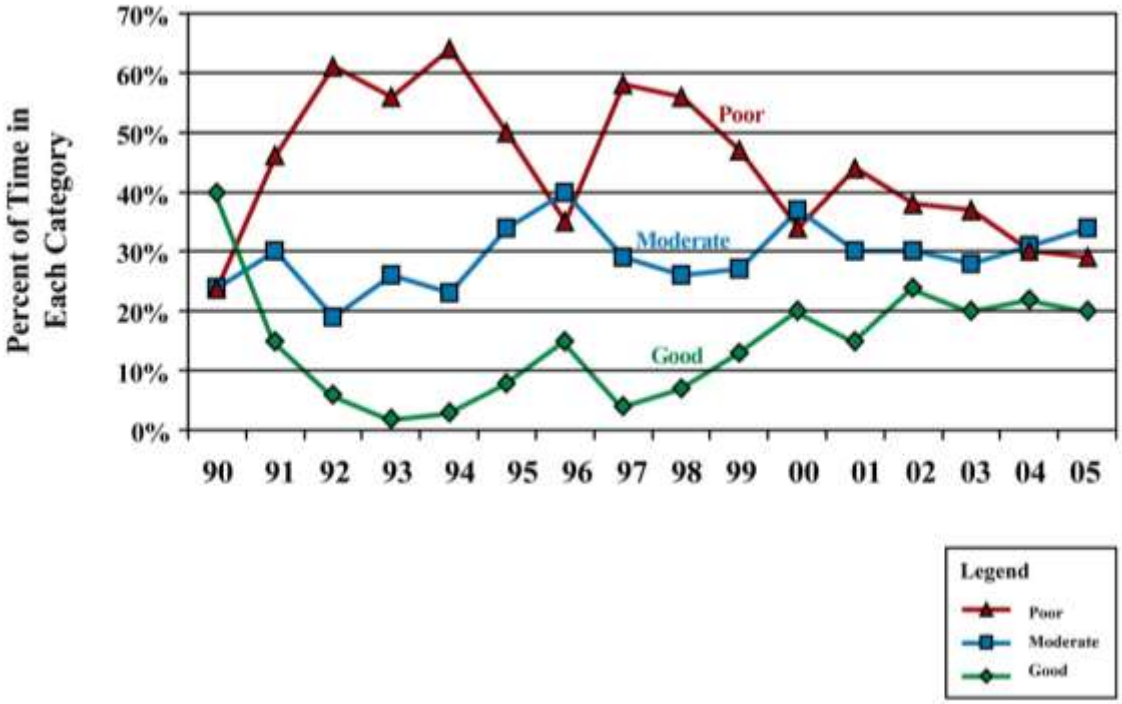
Table 3.13-8
Mean Visibility Data

Condition	Extinction[1] b_{ext} (Mm^{-1})	Standard Visual Range (km)
Rocky Mountain National Park (ROMO1)		
Best 20% Visibility Days	11.8	308
Middle 20% Visibility Days	19.1	196
Worst 20% Visibility Days	37.4	109
White River National Forest (WHRI1)[2]		
Best 20% Visibility Days	10.1	324
Middle 20% Visibility Days	15.7	221
Worst 20% Visibility Days	26.9	142

Source: CSU, 2010.
Notes:
Summary data are based on new IMPROVE algorithms.
[1]Atmospheric light extinction is a fundamental metric used to characterize air pollution impacts on visibility. It is the fractional loss of intensity in a light beam per unit distance due to scattering and absorption by the gases and particles in the air. Light extinction (*bext*) can be expressed as the sum of light scattering by particles (*bs,p*), scattering by gases (*bs,g*), absorption by particles (*ba,p*) and absorption by gases (*ba,g*).
[2]Representative monitoring for Maroon Bells, West Elk, Eagles Nest, and Flat Tops Class I areas.
% = percent
km = kilometer
Mm^{-1} = inverse megameters

Figure 3.13-1 shows the percentage of good, moderate, and poor days in the Denver and Front Range area from 1990 to 2005. Visibility in the Denver and Front Range area has been improving in recent years, with a higher proportion of good visibility days and fewer poor visibility days. Visibility is expected to continue to improve as stricter emissions standards for gasoline and diesel motor vehicles are put into place.

Figure 3.13-1
Visibility Trends in Denver and the Front Range
(1990 through 2005)



Source: CDPHE, 2006.
Note: These percentages do not total 100% because "extremely poor" visibility days are not shown.

3.13.3 Status of State Implementation Plans

Colorado is in attainment of all NAAQS except for the 8-hour ozone standard. The CDPHE Air Quality Control Commission (AQCC) adopted an Ozone Action Plan in 2004 and entered into the Early Action Compact in 2007. Table 3.13-9 shows the cities and counties that are in non-attainment and maintenance areas for criteria pollutants.

Table 3.13-9
NAAQS Non-attainment and Maintenance Areas in the Denver Area

Pollutant	City	County
Non-Attainment		
Ozone (8-hour)	Denver	Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer, and Weld
Maintenance		
CO, PM_{10}	Denver	Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, and Jefferson

Source: EPA, 2010f.
Notes:
CO = carbon monoxide
PM = particulate matter

3.13.4 Air Quality Conformity

The CAA's general conformity provisions require Federal agencies to ensure that planned Federal actions located in an area designated "non-attainment" or "maintenance" do not impair State and local efforts to improve or maintain air quality. General conformity provisions apply on a per-pollutant basis to areas that meet one of the following criteria:

1. The area is designated as non-attainment for one or more pollutants, or
2. The area is designated as a maintenance area (an area that was previously designated non-attainment and is working to maintain acceptable air quality).

The CDPHE AQCC incorporated by reference EPA's provisions of Title 40, Part 51, Subpart W, and Title 40, Section 6.303 in Air Quality Regulation 10.

The Federal agency responsible for approving an action is required to determine if the action conforms to the applicable non-attainment or maintenance area State Implementation Plan (SIP). Colorado's SIPs establish conformity criteria and procedures that are consistent with Federal conformity provisions.

The general conformity process is broken down into two steps that must be completed prior to commencement of a Federal action:

1. A conformity analysis to determine if *de minimis* or regional significance thresholds are exceeded (Table 3.13-10). The conformity analysis has two steps:
   a) An applicability analysis, to determine whether the action meets a regulatory exemption (listed in 40 Code of Federal Regulations [CFR] 93.153c), and
   b) If the action is not exempt, emission calculations to determine if *de minimis* threshold is exceeded.
2. If the action is not exempt and *de minimis* or regional significance thresholds are exceeded, a Conformity Determination must be performed.

The general conformity threshold for volatile organic compounds (VOCs) is 100 tons per year assuming that the Denver 8-hour ozone non-attainment area classification is considered maintenance. Based on the information provided in the SIP, activities conducted inside the Denver Metropolitan area would need to be evaluated for conformity.

Table 3.13-10
Conformity *de Minimis* Threshold Levels

Pollutants/Maintenance Areas	Tons per Year
Ozone (NO_X, SO_2 or NO_2)	
Marginal or moderate ozone non-attainment area	100
Ozone (VOCs)	
Maintenance areas inside an ozone transport region	50
Maintenance areas outside an ozone transport region	100
CO	
All Maintenance Areas	100
PM_{10}	
All Maintenance Areas	100
Pb	
All Maintenance Areas	25

Source: 40 CFR Part 93.153.
Notes:
Denver is located outside of an ozone transport region.
CO = carbon monoxide
NO_2 = nitrogen dioxide
NO_x = oxides of nitrogen
Pb = lead
PM = particulate matter
SO_2 = sulfur oxide
VOC = volatile organic compound

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3.14 NOISE

3.14.0 Overview

Noise is defined as unwanted sound and is often considered detrimental to human health and the environment (EPA 1974). The types of noise being considered for the proposed Moffat Collection System Project (Moffat Project or Project) include noise generated from additional vehicular traffic, short-term construction traffic and activities, and facility operating noise.

Measuring Noise

Sound levels cover a very large range and are usually measured on a logarithmic scale expressed as decibels (dB) in relation to a reference level of zero, which is the threshold of human hearing. Perceived sound is dependent on the wave amplitude (loudness), frequency (pitch), and duration of exposure. As sound propagates logarithmically, sound levels are not additive when combined. Therefore, for example, if two sounds each of 70 dB occur at the same time, the resultant measured sound is only a 3 dB increase to 73 dB. Additional sounds add proportionately less to the total dB level measured. Frequencies in the range of 1,000 to 6,000 Hertz are heard more easily by the human ear and are therefore weighted higher than those outside this range. A-weighted sound levels are those within the frequency range of human hearing (1,000 to 6,000 Hertz), and the measurement convention for this range is referenced as dBA (A-weighted decibel scale [human ear]).

The U.S. Environmental Protection Agency (EPA) has adopted the following four descriptors for sound, all normally measured as dBA, which take into account how sound is propagated and heard (EPA 1974):

- **A-weighted Sound Level (L_A)** – Corresponds to the way the human ear perceives the magnitude of sounds at different frequencies.
- **A-weighted Sound Exposure Level (SEL)** – This is the intensity of sound measured over a period for time, usually of one-second duration. The SEL allows direct comparison of sounds with different magnitudes and duration.
- **Equivalent Sound Level (L_{eq})** – A summation of the individual sound energies over a given period of time, usually one hour, and is expressed in dBA.
- **Day-Night Average Sound Level (L_{dn})** – This is the L_{eq} for a full 24-hour period taking into account the increased perception of sound at night by adding 10 dBA to the period between 10 p.m. and 7 a.m.

An additional factor in assessing noise includes the "startle effect" of sudden temporary loud sound. The startle effect primarily impacts wildlife and can result in breeding disruption (particularly in song birds) and hormonal changes in mammals due to increased release of "fight or flight" hormones (adrenaline and related compounds) (Gladwin et al. 1988). Because the frequency range of sound heard varies significantly among species, and is often different from the human range, noise effects on wildlife are not always readily

predictable. Typically, the larger the difference in space between the ears, the lower the sound frequency range that hearing is adjusted to.

Noise levels above L_A 134 dBA may cause temporary human hearing impairment and permanent damage is predicted from exposure to L_A 140 dBA or higher. EPA has predicted that exposure to an L_{eq} of 70 dBA for 24 hours per day, 365 days per year over 40 years would result in a hearing loss of less than 5 dBA in 96 percent (%) of the population. This degree of loss is generally acceptable for long-term human exposure (EPA 1974). The World Health Organization takes a more protective approach and recommends general human exposure to less than 50 dBA to protect from annoyance during daytime activities and less than 45 dBA at night (WHO 2000).

Noise Criteria

In the Federal-Aid Highway Act of 1970, Congress directed the Federal Highway Administration (FHWA) to develop standards for vehicular noise levels compatible with different land uses. These standards are found in Procedures for Abatement of Highway Traffic Noise and Construction Noise (23 Code of Federal Regulations [CFR] 772).

FHWA's noise policy is implemented using Colorado Department of Transportation's (CDOT) Noise Analysis and Abatement Guidelines (CDOT 2013). The guidelines state that noise mitigation must be considered for any receptor (i.e., residence or commercial development) where predicted noise levels, using design-year traffic volumes and roadway conditions approach or exceed the CDOT Noise Abatement Criteria (NAC).

The CDOT NAC are expressed in dBA (Table 3.14-1). Also, since passing vehicles generate traffic noise and traffic volumes constantly fluctuate, the L_{eq} is used to characterize traffic noise impacts. The NAC that may apply to the Project alternatives are activity categories B, C, D, E, F, and G.

The CDOT guidelines also state that noise abatement should be considered when the new noise levels resulting from a proposed action "substantially exceed the existing noise levels." This criterion is defined as an increase in the L_{eq} of 10 dBA or more above existing noise levels. In general terms, a doubling in the amount of vehicular traffic results in only a 3 dBA increase in L_{eq}. Therefore, a substantial increase in both vehicular volume and speed would be required to increase sound levels by 10 dBA.

The CDOT guidelines define "noise sensitive receivers," in general, as "any location where traffic noise may be detrimental to the enjoyment and functional use of the property…" These include "areas of frequent human use such as schools, parks, hotels, and commercial centers." Primary consideration is given to outdoor areas of frequent human use that are adjacent to individual properties such as front and back yards or porch areas of residences, school playgrounds, and areas such as recreational trails and parks.

Table 3.14-1
CDOT Noise Abatement Criteria[1] – A-Weighted Sound Level-Decibels (dBA)

Activity Category	$L_{eq}(h)$[2]	Description of Activity Category
A	56 (exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B[3]	66 (exterior)	Residential.
C[3]	66 (exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreational areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
D	51 (interior)	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E[3]	71 (exterior)	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreational areas, Section 4(f) sites, schools, television studios, trails, and trail crossings.
F	N/A (N/A)	Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, ship yards, utilities (water resources, water treatment, electrical), and warehousing.
G	N/A (N/A)	Undeveloped lands that are not permitted for development.

Source: CDOT, 2013.
Notes:
[1]CDOT noise impact criteria are 1 dBA lower (more stringent) than FHWA values in 23 CFR 772, to identify noise levels that "approach" the FHWA criteria.
[2]Hourly A-weighted equivalent level for the noisiest hour of the day in the design year. Parenthetical words identify the evaluation location.
[3]Includes undeveloped lands permitted for this activity category.
dBA = A-weighted decibel scale
L_{eq} = equivalent sound level, time averaged over a period of emission.
N/A = not applicable (i.e., Noise Abatement Criteria [NAC] Activity Categories F and G receptors are non-sensitive to traffic noise or undeveloped land uses, and are not subject to a NAC value)

Under the Noise Control Act of 1972, Congress directed the EPA to conduct research and implement controls of noise on a national level. In 1992 States and local agencies took over the regulation of community noise. Colorado Revised Statutes (C.R.S.) Section-30-15-401(1)(m) authorizes counties to regulate noise on public and private property in Colorado. Maximum permissible noise levels in Colorado are stated in C.R.S. 25-12-103 and are implemented on the county level (Tables 3.14-2a through 3.14-2d). The counties in the Project area where land disturbing activities and increased vehicular traffic may occur are Adams, Boulder, Denver, and Jefferson.

Table 3.14-2a
Allowable Noise Levels (dBA)
Adams County

Land Use/Zone District	7 a.m. – 10 p.m. (10 p.m. – 7 a.m.)
Residential	55 (50)
Public Land	55 (50)
Commercial (C-0)	55 (50)
Commercial (C-1 thru C-5)	60 (55)
Industrial (I-1)	60 (55)
Industrial (I-2 thru I-3)	80 (75)
Agricultural	80 (75)

Source: Adams County, 2007a.
Notes:
Construction (10 p.m. to 6 a.m.) = not allowed without a special use permit, 80 dBA during the day
dBA = A-weighted decibel scale

Table 3.14-2b
Allowable Noise Levels (dBA)
Boulder County

Land Use	7 a.m. – 7 p.m. (7 p.m. – 7 a.m.)
Residential, public facilities and lands	55 (50)

Source: Boulder County, 1992.
Notes:
Construction (7 a.m. to 7 p.m.) = 80 dBA, (7 p.m. to 7 a.m.) = 75 dBA
dBA = A-weighted decibel scale

Table 3.14-2c
Allowable Noise Levels (dBA)
City and County of Denver

Source Premises	Receptor Premises			
	Residential	Commercial	Industrial	Public
	7 a.m. – 10 p.m. (10 p.m. – 7 a.m.)	7 a.m. – 10 p.m. (10 p.m. – 7 a.m.)	7 a.m. – 10 p.m. (10 p.m. – 7 a.m.)	7 a.m. – 10 p.m. (10 p.m. – 7 a.m.)
Residential	55 (50)	65 (60)	80 (75)	75 (70)
Commercial	55 (50) **60 (60)*	65 (60)	80 (75)	75 (70)
Industrial	55 (50) **65 (65)*	65 (60)	80 (75)	75 (70)
Public	55 (50) **60 (60)*	65 (60)	80 (75)	75 (70)

Source: City and County of Denver, 2008.
Notes:
*Allowable noise levels where these land uses existed prior to the residential land uses.
Construction (9 p.m. to 7 a.m.) = not allowed unless the Board of Environmental Health grants a variance.
dBA = A-weighted decibel scale

Table 3.14-2d
Allowable Noise Levels (dBA)
Jefferson County

Land Use/Zone District	L(25)	L(0)	Periodic/Impulsive
	7 a.m. – 7 p.m.	7 a.m. – 7 p.m. (7 p.m. – 7 a.m.)	7 a.m. – 7 p.m. (7 p.m. – 7 a.m.)
Residential, Park, School	55	65 (50)	50 (45)
Commercial	60	70 (55)	55 (50)
Light Industrial	70	80 (65)	65 (60)
Industrial	80	90 (75)	75 (70)

Source: Jefferson County, 2006; Jefferson County, 2011.
Notes:
L(25) and L(0) are noise frequencies. The (25) and (0) are the percentages of time during a study period that the sound pressure level is exceeded. The Periodic/Impulsive column refers to periodic or impulsive bursts of noise. The allowable noise levels for periodic or impulsive noise is usually 5 dBA below normal allowable noise levels. The allowable noise level in the L(25) column can be exceeded 25% of the time. The allowable noise level in the L(0) column cannot be exceeded; in other words, this is the maximum allowable noise level.
dBA = A-weighted decibel scale

3.14.1 Reservoirs

Existing noise levels were not measured in the reservoir study areas, but rather background levels are estimated to be typical for the land types and uses. Noise measurement recordings from other studies are described, where applicable.

3.14.1.1 Gross Reservoir

A baseline noise survey was conducted at the Gross Reservoir study area as part of the Federal Energy Regulatory Commission relicensing in 1997. The predominant sources of background noise were the rustling of vegetation in the wind, vehicular traffic, and the water flowing from the valve house outlet at the base of the dam. Noise measurements were recorded at the base of Gross Dam where water was rapidly outflowing from the valve house, on the north side of the reservoir in a picnic area about 0.8 mile south of the Lake Shore Subdivision, at the recreational area on the south side of Gross Dam, and the South parking area.

Noise levels varied considerably between these locations. The noise produced by water flowing out of the valve house below Gross Dam was 80.7 dBA measured at a location 30 feet from the outflow. The average noise on the north side of the reservoir was 50.1 dBA. The average noise level at the South Dam recreational area was 68.6 dBA. The average noise level at the south parking lot was 55.3 dBA, mainly influenced by human activity and vehicles arriving at and departing from the recreational area (Denver Water 1998b). The background noise levels in the more remote portions of the Gross Reservoir study area are estimated to be in an L_{dn} range of 30 to 40 dBA.

3.14.1.2 Leyden Gulch Reservoir Site

The Leyden Gulch site is located in a generally undeveloped area. Housing occurs to the west of Leyden Gulch behind a section of the Ralston Buttes. Due to the existence of State Highway (SH) 72 and SH 93 and the Union Pacific Railroad, the background sound levels

are approximated to be in an L_{dn} range of 50 to 65 dBA. This is consistent with traffic noise measurement readings conducted by CDOT for the Northwest Corridor Environmental Impact Statement (EIS) (CDOT 2006). During peak traffic hours, measurements taken at SH 93 and Leyden Road averaged 64 dBA. An average reading of 60 dBA was recorded at 82nd Avenue/Leyden Road near Partridge Park (Sherman 2007).

3.14.2 Conveyance Systems

Existing noise levels were not measured along Conduits M and O, thus background noise levels are approximated for these areas based on typical land types and uses. In moderately urban areas, such as Westminster, the L_{dn} is approximately 60 to 80 dBA. In rural areas, such as the far western portion of Conduits M and O, L_{dn} is between 40 to 55 dBA.

3.14.3 South Platte River Facilities

The storage, diversion, conveyance, and treatment facilities associated with the South Platte River are located primarily in an area consisting of light industrial uses (e.g., gravel mining), rural, residential, agricultural, and recreational land uses. Estimated noise levels associated with these types of land uses range from 30 to 55 dBA. This is consistent with measurements taken in the vicinity of the study area associated with the extension of 120th Avenue (FHWA and CDOT 2003). For example, measurements recorded in rural residential areas near Brighton have average noise levels of 54 dBA. A reading taken near Adams County Regional Park was recorded as 50 dBA.

3.14.4 Denver Basin Aquifer Facilities

Existing noise levels were not measured within the study area as part of the EIS, rather background volumes typical for urban land uses were interpolated as between 60 to 80 dBA Traffic measurements taken at various locations in Denver for the US 36 Corridor EIS averaged 65 dBA (FHWA and FTA 2009).

3.15 RECREATION

3.15.0 Overview

This section presents a description of the existing recreation resources in the Moffat Collection System Project (Moffat Project or Project) area.

3.15.1 Reservoirs

3.15.1.1 Gross Reservoir

Gross Reservoir is located in Boulder County north of the unincorporated communities of Wondervu and Miramonte. Lands within the study area are owned by the Board of Water Commissioners (Denver Water), the U.S. Forest Service (USFS), and private landowners. The Roosevelt National Forest administrative boundary bisects Gross Reservoir north-south; however, land management within the study area is the responsibility of the USFS and Denver Water. The study area is bounded on the west by USFS lands and private lands to the north and south. Walker Ranch Park (a Boulder County open space property) lies adjacent to the study area to the east. The Boulder County Sheriffs' office provides law enforcement at the reservoir through a contract with Denver Water; Colorado Parks and Wildlife (CPW) (previously called Colorado Division of Wildlife) manages the fishery at the reservoir.

Gross Reservoir has a surface area of 418 acres and 11 miles of shoreline that offer numerous year-round outdoor recreation opportunities. Recreational opportunities at Gross Reservoir include: non-motorized boating, fishing, hiking, picnicking, bicycling, camping, ice fishing, horseback riding, off-highway vehicle (OHV) riding, 4-wheel driving, and sightseeing. In general, wildlife is an important aspect of the recreational experience at Gross Reservoir. For example, bird and wildlife viewing is a popular activity and as well as hunting for deer, elk and turkey on USFS lands west of Gross Reservoir. Because Gross Reservoir provides drinking water to the Denver Metropolitan area, no body contact, such as wading or swimming, is allowed with the water. Until recently, no boating of any kind was permitted on the reservoir. However, as a condition of Federal Energy Regulatory Commission (FERC) relicensing, beginning in 2005 non-motorized car-top boating is allowed from Memorial Day through September 30 each year. Additionally, the Gross Reservoir Recreation Management Plan is being implemented throughout the study area, and facility improvements to all recreational areas are ongoing (Denver Water 2004b, 2008a).

Past Denver Water surveys indicate that Gross Reservoir's most desirable attributes are its feeling of remoteness, the lack of human-made structures and human intervention, and other scenery-related attributes and activities, such as sightseeing and wildlife viewing (Denver Water 2004b, 2008a). Vehicle counts conducted in 2004 and 2005, for weekends as well as weekdays during all four seasons, support an estimate of annual visitation. A factor of 2.2 people per vehicle, and a turnover rate of 1.5 were applied to the vehicle counts. Annual visitation for 2004 is estimated at 15,167 while annual visitation for 2005 is estimated at 21,975. This increase in visitation is likely attributable to the beginning of

non-motorized car-top boating in 2005 (Denver Water 2005a). The majority of this use occurs between Memorial Day and Labor Day. An informal visitor study conducted in 1998 revealed other information about recreation use at Gross Reservoir (Denver Water 1998c):

- 37 percent (%) of visitors are from Boulder County, and the remaining 63% are from the Denver Metropolitan area.
- 50% of use occurs on summer weekends, 30% on summer weekdays, and 10% on fall weekends; the remaining 10% use occurs during the remainder of the year.
- The most popular activities were fishing (70%), picnicking (40%), hiking (26%), sight-seeing (15%), camping (10%), and swimming at Jumping Rock (6%, although an illegal activity). Respondents may have chosen more than one answer in the survey resulting in a percentage greater than 100%.

There are nine designated recreation sites at Gross Reservoir: North Shore Recreation Area, Peninsula Recreation Area, Dam Recreation Area, South Boulder Creek Outlet, Haul Road/Osprey Recreation Area, South Boulder Creek Inlet, Winiger Gulch Inlet, Winiger Ridge Access and Recreation Area, and Rocky Point/Jumping Rock. Existing and planned site-specific facilities and recreation opportunities at these sites are shown on Figure 3.15-1 and in Table 3.15-1.

Recreational use also occurs on South Boulder Creek, both above and below Gross Reservoir. This use is discussed in Section 3.15.5.5.

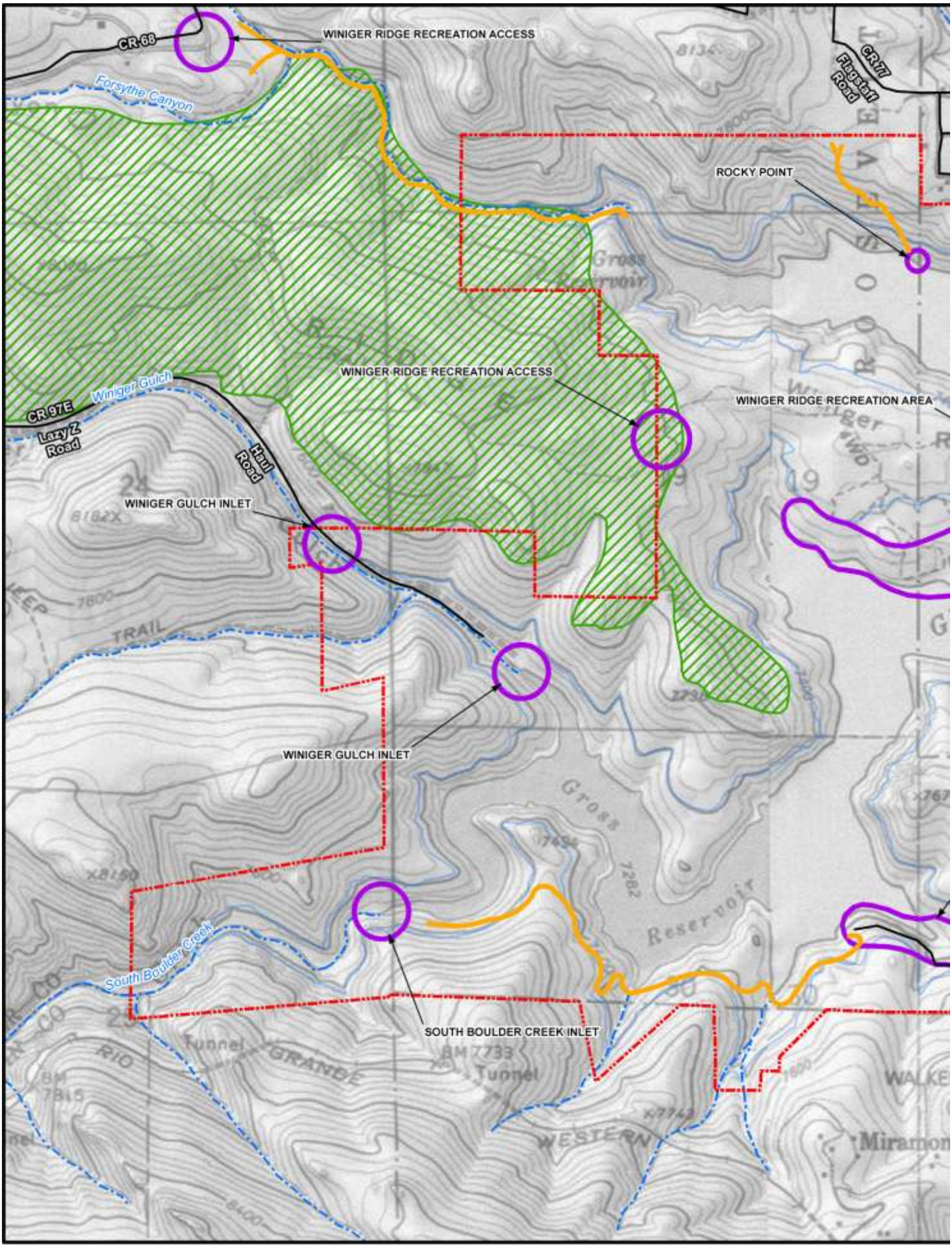
Table 3.15-1
Existing and Planned Recreation Facilities at Gross Reservoir

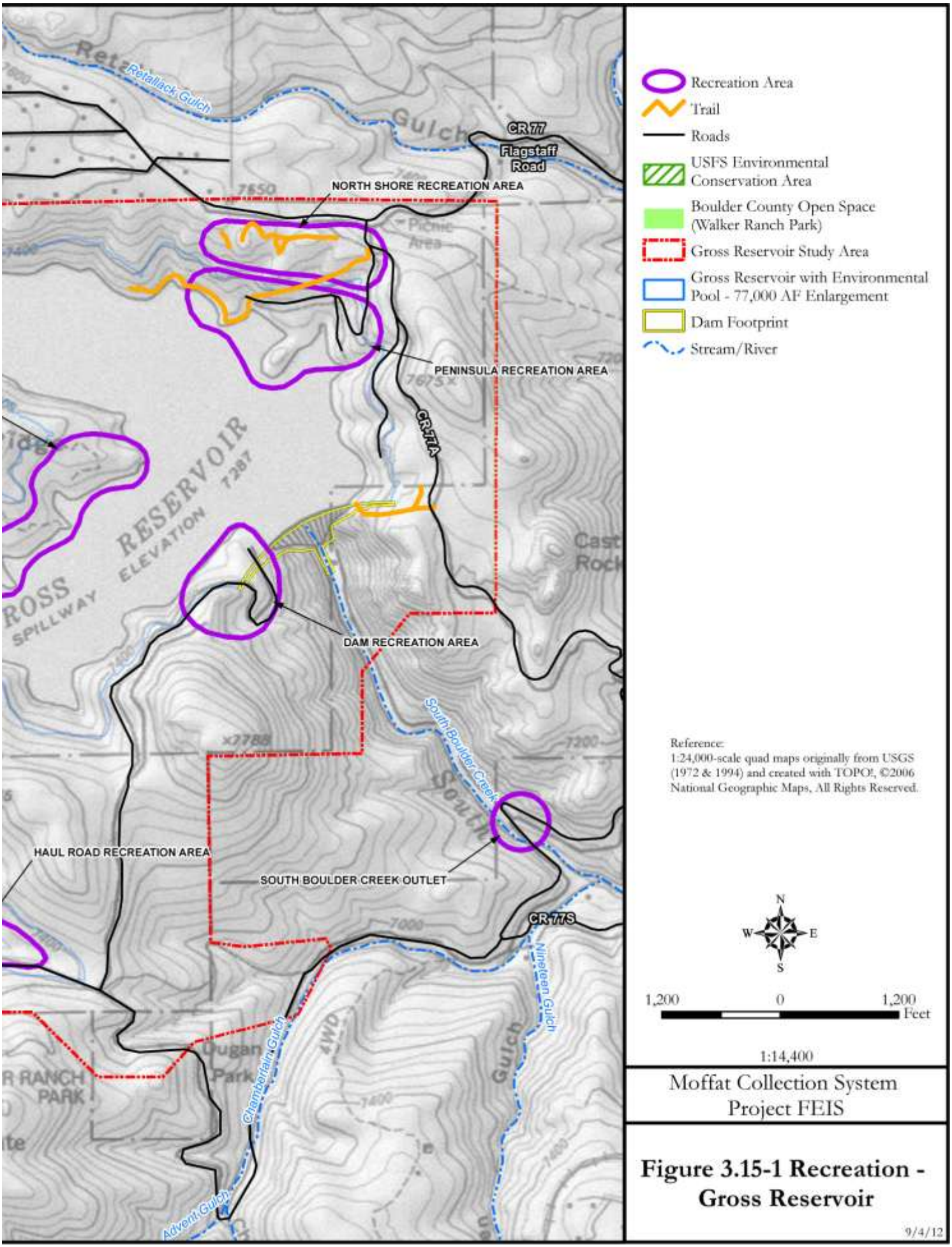
Site	Facility	
	Existing	**Planned**
North Shore Recreation Area	• 40 parking spaces (2 ADA-access) • 15 dispersed formal and informal picnic sites • Renovated picnic shelter • 2 permanent pit toilets • Trail from North Shore to Rocky Point • Gated emergency and service access road • Disabled access from parking lot to picnic shelter • Hiking access • Improved trail from parking area to peninsula area • Formalized overlooks	No additional facilities
Peninsula Recreation Area	• Day use picnic sites (10 developed sites and 2 group sites) • Fishing access • Boating access • Hiking access • Trail connections • Restroom facilities • Revegetation	No additional facilities

Table 3.15-1 (continued)
Existing and Planned Recreation Facilities at Gross Reservoir

Site	Facility	
	Existing	Planned
Dam Recreation Area	• 38 car parking lot (with parking drop off and turn around and ADA access) • Trail connections • Revegetation • 2 permanent pit toilets • Overlook • Interpretive signage • Renovated picnic shelter • Fishing and hiking access • Day use picnic sites (20 developed sites and 3 group sites) • Restroom facilities	No additional facilities
South Boulder Creek Outlet	• 10 parking spaces/picnic tables • Trail access for kayak put-in and fishing	No additional facilities
Haul Road/ Osprey Recreation Area	• 20 car parking lot (with parking drop off and turn around and ADA access) • Day use picnic sites (10 developed sites and 2 group sites) • Fishing, boating and hiking access • 2 permanent pit toilets • Trail connections • Revegetation • Signage	No additional facilities
South Boulder Creek Inlet	• Trail access from Haul Road Recreation Area • Parking (at Haul Road)	No additional facilities
Winiger Gulch Inlet	• 4-wheel driving, hiking, biking, fishing, and equestrian access • Trailhead and connection to Forsythe Creek • 10 camping sites • Boat access	No additional facilities
Winiger Ridge Access and Recreation Area	• 4-wheel driving, hiking, biking, fishing, and equestrian access • Trailhead and connection to Forsythe Creek • 11 camp sites • Boat access • Closed roads to motorized use • 10 parking spaces, including 2 for horse trailers	No additional facilities
Rocky Point	• Trail from North Shore to Rocky Point • Hiking and fishing access	No additional facilities

Source: Denver Water, 2004b.
Notes:
Existing conditions were verified during EDAW fieldwork on September 16 and September 28, 2005.
ADA = Americans with Disabilities Act
FERC = Federal Energy Regulatory Commission
WD = wheel drive


WINIGER RIDGE RECREATION ACCESS
CR 68
Forsythe Canyon
CR 77
Flagstaff Road
ROCKY POINT
WINIGER RIDGE RECREATION ACCESS
WINIGER RIDGE RECREATION AREA
Winiger Gulch
CR 97E
Lazy Z Road
Haul Road
WINIGER GULCH INLET
TRAIL
WINIGER GULCH INLET
Gross Reservoir
South Boulder Creek
SOUTH BOULDER CREEK INLET
Tunnel
RIO GRANDE
Tunnel
WESTERN
Miramon



Moffat Collection System Project FEIS

Figure 3.15-1 Recreation - Gross Reservoir

9/4/12

USFS Lands and Roads

USFS lands in the study area are managed under the roaded natural and semi-primitive motorized recreation opportunity spectrum classes. Human evidence in roaded natural classes are characterized by a natural setting that may have modifications, which range from being easily noticed to strongly dominant to observers within the area. However, from sensitive travel routes and use areas these alterations would remain unnoticed or visually subordinate. There is strong evidence of designed roads and/or highways. However, structures are generally scattered, remaining visually subordinate or unnoticed to the sensitive travel route observer. Structures may include utility corridors, microwave installations, and similar facilities. Frequency of contact is moderate to high on roads; and low to moderate on trails and away from roads. On-site regimentation management and controls are noticeable, but harmonize with the natural environment. There are no criteria for remoteness or size in the roaded natural classification (ROS 2007).

The semi-primitive motorized classes contain open primitive roads that are not maintained for the use of standard passenger-type vehicles, but rather OHVs and high clearance vehicles. These open roads generally consist of tracks, ruts, or ungraded rocky-rough surfaces that are not drained. The semi-primitive motorized classes are typically 2,500 acres or more in size, but may be smaller if the area contains private lands that make a logical unit. Human evidence in these classes are characterized by a natural setting that may have moderately dominant alterations, but would not draw the attention of motorized observers on trails and primitive roads within the area. Any closed improved roads must be managed to re-vegetate and harmonize with the natural environment. There is strong evidence of primitive roads and the motorized use of trails and primitive roads at Gross Reservoir. Structures are rare and isolated; there are typically no transmission lines present in the semi-primitive motorized classes. Visitor management tools and controls such as parking facilities, physical barriers, signage, and information kiosks, are obvious. Control facilities such as parking areas, barriers and signs harmonize with the natural environment. Visitor information facilities are not elaborate or complex. Users should encounter less than 20 other parties per day on trails and in dispersed areas, during at least 80% of the primary use season. Users may meet numerous other parties on roads and developed recreation sites. Developed sites often are at full capacity but do not exceed 80% of the design capacity over the season of operation (ROS 2007).

Access to recreation areas on the north side of Gross Reservoir is provided primarily from Flagstaff Road, also known as Boulder County Road (CR) 77. Access to recreation areas on the south side is provided primarily from Boulder CR 77S, also known as Gross Dam Road.

Forest Road (FR) 359, a high-clearance vehicle roadway, runs from the intersection with Boulder CR 68 to the shoreline at Winiger Ridge. Access along this road is restricted from December through May to protect elk winter range. Winiger Gulch Inlet can be accessed through USFS lands via Boulder CR 97E. The road is closed to motorized vehicles at the USFS boundary; however, it is open to foot, bicycle, and equestrian use. The Forsythe Canyon Trail begins approximately 0.5 mile down FR 359 and follows Forsythe Creek down into a wooded, rocky canyon to the reservoir shoreline in Forsythe Canyon. In the

spring the small creek forms a small, picturesque cascading waterfall that is a popular hiking destination.

Walker Ranch Park

Walker Ranch Park consists of 3,778 acres open to the public and managed by the Boulder County Department of Parks and Open Space. Recreational opportunities include fishing on South Boulder Creek and more than 12 miles of multi-use trails for hiking, mountain biking, and equestrian use. Picnic facilities are available at both the Flagstaff Road and Pica Road trailheads (Boulder County 2005a). Visitation to Walker Ranch Park is counted at both the Walker Ranch Loop trailhead and the Meyers-Homestead Loop trailhead. In 2005, approximately 25,000 visitors were counted on the Walker Ranch Loop and 24,000 visitors were counted on the Meyers-Homestead Loop (Bauer 2006). No other visitation use data are available for this area.

3.15.1.2 Leyden Gulch Reservoir Site

Land surrounding the proposed reservoir site and related facilities is primarily owned by Denver Water and is not open for public access. The site does not offer any recreational use; therefore, no recreation facilities have been developed.

Both Jefferson County and the City of Boulder maintain open space near the Leyden Gulch site (Figure 3.16-2). Jefferson County Open Space lands are located west and northwest of the site and are part of the Coal Creek Canyon conservation complex. In addition to wildlife and other natural values, these lands are part of the Front Range Mountain Backdrop, which is a conservation priority for Jefferson County, as stated in the county's Open Space and Parks Five-Year Master Plan (Jefferson County 2008). The plan identifies the study area(s) as a "potential open space preservation area." Additionally, Map 4 in the plan, "Potential Trail Corridors," identifies two segments planned across the Leyden Gulch site to enhance trail connectivity to Coal Creek Canyon and other open space properties. These are considered Trails 2000 priorities by the Jefferson County Open Space Department, but have yet to be constructed. No visitor use data has been collected or is available for the Coal Creek Canyon open space property (Reince-Schwartz & Wojcik 2006). The City of Boulder Open Space property, Jewell Mountain Open Space, is actually located in Jefferson County, north of State Highway 72. Jewell Mountain Open Space is protected through a conservation agreement and is not open to public use. There are no plans to open this area to the public in the future (City of Boulder 2006). No other existing or planned recreation opportunities exist within the Leyden Gulch site.

3.15.2 Conveyance Systems

3.15.2.1 Conduit M

Conduit M would be constructed in existing streets; however, the conduit may cross or come into close proximity of several parks and recreation areas:

Arvada

- Pioneer Park

- Alice Sweet Thomas Park
- Two Ponds National Wildlife Refuge (NWR)
- Meadowglen Park
- Lake Arbor Park

Westminster

- Fireman Park
- F.M. Day Park

Existing recreational uses occurring at these facilities include, but are not limited to, bicycling, hiking, walking, jogging, wildlife viewing, basketball, softball/baseball, soccer, tennis, and various passive recreational activities.

Conduit M would cross a segment of the South Platte River Trail near the intersection of Pecos Boulevard and West 64th Avenue (Adams County 1999). The pipeline corridor would also cross a proposed Trails 2000 trail segment near West 80th Avenue and Kipling Street (Jefferson County 2008).

3.15.2.2 Conduit O

Conduit O would be constructed in existing streets; however, the conduit may cross or come into close proximity of parks and recreation areas. Existing recreational uses occurring at these facilities include, but are not limited to, bicycling, hiking, walking, jogging, wildlife viewing, basketball, softball/baseball, soccer, tennis, and various passive recreational activities. Existing and planned recreational facilities in the vicinity of the pipeline include several municipal parks in Thornton (i.e., Trailhead Park), Westminster, and Arvada. The Arvada and Westminster recreation areas listed under Conduit M (Section 3.15.2.1) are also near Conduit O. A portion of Conduit O is near the northwestern boundary of the Rocky Mountain Arsenal NWR, located in Commerce City. Additionally, the portion of Conduit O in Brighton would be near Adams County Regional Park, Riverdale Dunes, Riverdale Knolls Golf Courses, and the 80th Avenue Trail. This portion of Conduit O would also be near two proposed trails along 104th Avenue and 120th Avenue.

3.15.3 South Platte River Facilities

The Worthing, North Tower, South Tower, and Challenger pits may be used to provide water storage. All four pits, with the exception of the Challenger Pit, are located in unincorporated Adams County near the southwest quadrant of the Exit 36 interchange of E-470 and Old Brighton Road. These three gravel pits lie adjacent to the municipal boundary of Brighton and the eastern edge of the South Platte River. The Challenger Pit is located in unincorporated Adams County near the intersection of Baseline Road (168th Avenue) and Tucson Street. The Worthing Pit is used for water skiing, and several trailers used for seasonal residences/vacation homes are located on the north side of the lake. In 2006, Adams County Regional Park was under construction on the west side of the South Platte River and features a golf course, fishing, a nature preserve, segments of the South Platte Trail, volleyball, outdoor concert facilities, and a rodeo arena. Despite the

presence of several engineered structures, this river segment near the proposed diversion structure is used for kayaking and other water-based activities, primarily confined to the west bank. A new residential golf community, Riverdale Dunes, is located adjacent to the South Platte River on west of the gravel pits. A portion of the proposed South Platte Heritage Project Trail Corridor would run adjacent to the gravel pits along the river (Adams County 1997). Additionally, a trail and trailhead are proposed along 120th Avenue (Adams County 1999). Colorado Park and Veteran's Park, both City of Brighton parks, are located south of the Challenger Pit, on the north and south sides of 160th Avenue. These parks contain basketball and tennis courts, playgrounds, restrooms, picnic shelters, horseshoe pits, open play areas, and natural surface trails.

Alternatives 8a and 13a would require the construction of a small dechlorination facility that would be located on less than 0.1 acre near the Moffat Collection System delivery point in unincorporated Jefferson County. Existing and planned recreational facilities and uses for this area are discussed in Section 3.15.1.2.

3.15.4 Denver Basin Aquifer Facilities

Alternative 10a would require a new Advanced Water Treatment Plant (AWTP) that would be located in the vicinity of the existing Denver Water Recycling Plant. The site is in a highly industrial area and does not contain parks or recreational facilities. The distribution pipelines connecting the well sites and the proposed AWTP near the existing Denver Water Recycling Plant would all be constructed in existing streets. Construction of the distribution pipelines would involve two open cuts crossings of the South Platte River near Ruby Hill Park in south Denver, and near Mile High Stadium in central Denver. Recreational use, including kayaking, rafting and other white water activities, on the South Platte River at these locations is high, especially during the peak flow times of late spring and early summer (Confluence Kayaks 2007).

The proposed well sites would all be located within the urbanized areas of the City and County of Denver and are primarily sited within existing parks:

- Zeckendorf Place Park
- Washington Park
- Verbena Park
- Sloan's Lake Park
- Ruby Hill Park
- Pferdestellar Park
- Pasquinel's Landing
- Park Hill Golf Course
- Martin Luther King Park
- Lakewood/Dry Gulch Park
- Highland Park
- Denver International Airport nursery site
- Denison Park
- Crestmoor Park
- Cranmer Park
- Cook Park
- Congress Park
- City of Nairobi Park
- City Park
- City Park Golf Course
- Cherry Creek North Park
- Burns Park
- Alamo Placita Park

Parks identified as potential well site locations vary in size and recreation amenities offered. Several parks, such as Zeckendorf Place and Denison, are very small and offer limited recreational opportunities or amenities; such parks may consist of only limited playground equipment, a single picnic table, or a single sculpture. However, some parks are very large in comparison, such as City Park or Washington Park, and offer numerous recreational opportunities and amenities, including water-based recreation. Active recreational facilities and activities in large parks identified as potential well site locations include tennis courts, basketball courts, athletic fields, bike and foot paths, informal play areas, golfing, wading pools, and playgrounds. Several parks also contain multi-purpose indoor recreation centers with both indoor and outdoor swimming pools. Passive recreation facilities and activities include picnic shelters and pavilions, flower gardens, community gardens, historical features, statues and sculptures, concert and music venues, museums, and substantial passive turf and native vegetation areas.

3.15.5 River Segments

The characterization of recreational resources and opportunities focused on the overall study area segments, as described in Section 3.0 and shown in Figure 3.0-1. Several of these drainages provide a variety of recreational opportunities at the regional and local scale.

In 1996, the Pike and San Isabel National Forests issued a Wild and Scenic River Eligibility and Classification Determination for the South Platte River and the North Fork South Platte River, which identified 72.3 miles of river as eligible. In 2004, the Record of Decision (ROD) for the South Platte Wild and Scenic River Study and Final EIS were released. The South Platte Protection Plan (SPPP) was a locally-generated alternative included in the Final EIS, and was included as part of the preferred alternative in the ROD. The goal of the SPPP is to protect the Outstandingly Remarkable Values (ORVs) and instream flows in the eligible river segments, pending the eventual resolution of suitability and/or designation of the river segments as Wild and Scenic. The eligible river segments include a 49.4-mile stretch of the South Platte River between Elevenmile Reservoir and the confluence with the North Fork South Platte River, and a 22.9-mile stretch of the North Fork South Platte River from just below Bailey to the confluence with the South Platte River.

Additionally, in the summer of 2006, the Kremmling and Glenwood Springs Field Offices of the Bureau of Land Management (BLM) began the eligibility phase of a Wild and Scenic Rivers evaluation as part of their Resource Management Plan (RMP) revision process. The Wild and Scenic Rivers study process is composed of two main components: the eligibility phase and the suitability phase. The eligibility phase involves identifying eligible rivers and stream segments, and determining a tentative classification (Wild, Scenic, or Recreational) based on the current level of development along a river corridor. To be eligible for designation, a river must be free flowing and contain at least one ORV that is scenic, recreational, geological, fish-related, wildlife-related, historic, cultural, botanical, hydrological, paleontological, or scientific.

Upon conclusion of the eligibility phase, the BLM prepared a Wild and Scenic Eligibility Report that identified five river segments within the Moffat Collection System Project EIS study area (portions of the Colorado and the Blue rivers) that were eligible for inclusion in

the National Wild and Scenic Rivers System (NWSRS) (BLM 2007). The Wild and Scenic Suitability Report followed in April 2010. In the report, the BLM states: "The purpose of the suitability phase of the study process is to determine whether eligible rivers would be appropriate additions to the NWSRS by considering tradeoffs between corridor development and river protection." Portions of the Colorado (segments above Kremmling) and Blue rivers within the Project area were deemed "not suitable" by the BLM to be included in the NWSRS. Conversely, several segments of the Colorado River below Kremmling were considered suitable for inclusion.

Colorado has over 9,000 miles of rivers and creeks, 168 miles of which are considered Gold Medal Water streams. The Colorado Wildlife Commission has acknowledged that segments with Gold Medal Water status offer the greatest potential for trophy trout fishing. The official criteria for Gold Medal Water streams is a minimum trout standing stock of 60 pounds per acre and a minimum average of 12 quality trout (any trout 14 inches or longer in length) per acre (State of Colorado Wildlife Commission 2008). Colorado Merit Waters do not have Gold Medal Water status as defined by the CPW, but are still considered high quality fishing locations within the State (Colorado Fishing Network 2005).

3.15.5.1 Fraser River

The Fraser River Basin, from the upper tributaries to the confluence with the Colorado River, offers numerous, diverse, high-quality fishing experiences. The upper tributaries that feed the Fraser River are best known for their small stream fishing opportunities. Public access via the Arapaho & Roosevelt National Forests (ARNF) is available on many of the upper tributaries that feed the Fraser River from the west including, Iron Creek, St. Louis Creek, King Creek, and Elk Creek. St. Louis Creek is a designated Colorado Merit Water stream (Colorado Fishing Network 2005). Tributaries that feed the Fraser River from the east are also fishable, but many flow through private lands that are inaccessible to the general public. Recreational use on many of these tributaries is sporadic, however, use increases significantly during the peak season period from spring runoff through fall (Fishin' Hole Sporting Goods 2005; MoHenry's Trout Shop 2005).

In 2005, an amendment to the RMP for the ARNF was adopted that identified a portion of the upper Fraser River (Midland Campground to Forest boundary) and St. Louis Creek as High Value Recreation Stream Segments. The amendment further provides for the USFS to cooperate with other entities to address instream flow needs, including those needed to support recreational uses.

The Fraser River, from Winter Park to the confluence of the Colorado River, offers a variety of recreation opportunities including fishing and kayaking. Only limited portions of the Fraser River are open to the public because much of the land adjacent to the river is privately owned. From Winter Park to the Town of Fraser the river can be accessed by the Fraser River Trail, USFS campgrounds, and sporadic road turnouts. There is also a 2-mile stretch of the river flowing through Conzen's Ranch Open Space that is publicly accessible. Access to the river is limited downstream of the Town of Fraser (Colorado Fishing Network 2009). No formal data on use levels or other information on recreational use is available. On an average day during the peak season, approximately five to seven anglers may be seen on the stretches of the river accessible to the public. On weekend days during this same

period 10 to 12 anglers may be seen at any one time (MoHenry's Trout Shop 2005). Several private fishing ranches hold property along the banks of the Fraser River and allow river access for a fee. Many of these facilities also offer guest services such as fishing guides and lodging. Other guide services in the Fraser River valley also offer access to the river through agreements with private landowners and fishing ranches. As access from the private fishing ranches is strictly controlled, very few people are on any one stretch of the river at a given time (Devil's Thumb Ranch 2005).

No commercial rafting companies operate on the Fraser River; however, there are opportunities for private boats, such as kayaks, during spring runoff when the water level is high enough to allow it. The quality of whitewater recreation during this time period is reportedly excellent (MoHenry's Trout Shop 2005). Kayak use on the Fraser River is becoming increasingly popular (MoHenry's Trout Shop 2005). Typically, there are 10 to 20 boats on the river during the week and 50 to 70 boats on the river on weekends during the early peak season (Mad Adventures 2005; MoHenry's Trout Shop 2005). Other uses on the Fraser River include people using inflatable kayaks ("duckies" or "funyaks"). No whitewater recreation opportunities exist on any of the Fraser River tributaries.

3.15.5.2 Williams Fork River

The Williams Fork River Basin, from the upper tributaries to the confluence with the Colorado River, offers numerous fishing opportunities. The upper reaches of the Williams Fork and its tributaries are best known for their small stream fishing opportunities. There is little or no parking near these upper segments; thus, they are accessible only by hiking or mountain biking on ARNF lands adjacent to the river. Many stretches of the Williams Fork run through private lands above the Williams Fork Reservoir. The highest quality fishing on the Williams Fork can be found below the William Fork Reservoir and the confluence of the Colorado River, near U.S. Highway (US) 40. Public access is available to the Williams Fork Reservoir and the Colorado River at the Kemp-Breeze Units, managed by the CPW (Colorado Fishing Network 2005). In 1997 (most recent data available), an estimated 7,427 angler trips occurred on the Williams Fork below the reservoir (EDAW 2001). More recently, it has been estimated that informal use on this segment is approximately 30 to 50 anglers per weekend day and slightly less on weekdays (Crosby 2005). The Williams Fork River is considered a Colorado Merit Water stream and the segment below the Williams Fork Reservoir has Gold Medal Water stream status (Crosby 2005; Colorado Fishing Network 2005).

3.15.5.3 Colorado River

The upper Colorado River, from the confluence with the Fraser River to Kremmling, offers outstanding fishing opportunities, considered to be among the best in the State (Cutthroat Anglers 2005; Fishin' Hole Sporting Goods 2005). Specifically, the stretch from the confluence with the Fraser River to Troublesome Creek (approximately 4 miles east of Kremmling), is listed as a Gold Medal Water stream (Colorado Fishing Network 2005). There are several public access points along US 40, mostly managed by the CPW. Some of the access points require a short hike and, in places, there is a steep descent to the river. Due to its accessibility and renowned fishing, use on this stretch is high. On a typical weekend day between spring runoff and fall 25 to 30 anglers may be seen on this one

stretch at any given time. Weekdays during the same period may see slightly fewer anglers (Cutthroat Anglers 2005; Fishin' Hole Sporting Goods 2005).

A very limited amount of boating occurs in the upper sections above Kremmling, mainly through Byers Canyon, but the segments below Kremmling are heavily used and support use by numerous commercial outfitters. The primary use area begins approximately 3 miles downstream of Kremmling and extends through Gore Canyon to Pumphouse Recreation Area. In 2010, there were approximately 41,500 commercial user days on the upper Colorado River. Over the past decade, use levels reached a low of 29,449 in 2005 but otherwise have generally ranged from 32,000 to 37,000 per year until the sharp increase in 2010 (CROA 2011). On an average day in the early season, there may anywhere from 25 to 50 private kayaks on the upper Colorado River. On a peak weekend day for this same period, there may anywhere from 50 to 100 private kayaks on the river (KODI 2005; Mad Adventures 2005; Never Summer Outdoor Products 2005). The Gore Canyon Race is also held on this stretch of the river each August. One of the most popular whitewater races in the U.S., the Gore Canyon Race is typically held around the third week of the month and results in a temporary closure to the general public of the BLM managed Pumphouse recreation site.

Three segments of the Colorado, located between Windy Gap and the mouth of Gore Canyon, were initially classified as recreational for purpose of being deemed eligible for Wild and Scenic River status. ORVs for these segments that made them eligible for designation included scenic resources, high quality fishing, historic elements, and wildlife habitat (BLM 2007). Subsequently, a conceptual plan for a wild and scenic management alternative was prepared by a stakeholders group, which included local governments, State and Federal agencies and several utilities and public interest groups (Upper Colorado River Stakeholder Group 2008). The stakeholder group deferred from making a recommendation on whether or not BLM should proceed with a suitability determination, but outlined a series of strategies for in-stream flow protection and other management issues. The Wild and Scenic Suitability Report published by the BLM in 2010 deemed these segments of the Colorado River "not suitable" for listing in the NWSRS (Tetra Tech 2010).

BLM addressed the segments below Kremmling in separate Draft RMP/EIS documents that were released in 2011. The preferred alternative in both RMPs includes a determination that much of the Colorado River between Kremmling and Glenwood Springs is suitable for inclusion in the Wild and Scenic Rivers Act. A variation of the preferred alternative in both field offices would defer designation by adopting and implementing the Stakeholder Group Management Plan. If monitoring indicates that the Stakeholder Group Management Plan was not providing an adequate level of protection, BLM would initiate a process to evaluate suitability at a future date (BLM, Colorado River Valley and Kremmling Field Offices 2011).

3.15.5.4 Blue River

The Blue River between Dillon Reservoir and Green Mountain Reservoir provides excellent tailwater fishing opportunities year round. The entire reach of the Blue River from Dillon Reservoir to the confluence with the Colorado River near Kremmling is a Gold Medal Water stream (Colorado Fishing Network 2005). The Blue River's size, abundance and size of fish, accessibility from I-70, and proximity to Denver and the Front Range make

this a highly popular fishing destination. On a typical weekend day during peak fishing season, an estimated 100 to 150 anglers are on the river between Dillon Reservoir and Green Mountain Reservoir. On a typical weekday during the same period, an estimated 25 anglers may be on the river (Blue River Anglers 2005; Cutthroat Anglers 2005). The Blue River below Green Mountain Reservoir is open to the public for approximately 3 miles through the canyon, however access is limited to certain time periods. Below the canyon the majority of the land on either side of the river is private. The tail water below the dam at Green Mountain Reservoir reportedly provides for excellent fishing when flows allow. There is no commercial guided fishing below Green Mountain Reservoir (Cutthroat Anglers 2010). The Blue River also provides good whitewater opportunities for rafting and kayaking when dam releases provide water levels adequate enough to allow these activities. In 2004 there were approximately 788 commercial rafting user days on the Blue River, and in 2003 there were approximately 264 commercial rafting user days (CROA 2004). The highest use recorded since 1988 occurred in the year 1995 with a total of 9,338 commercial rafting user days. The lowest occurred in 2002 with 0 commercial rafting user days during a severe drought period when there was not enough water released for whitewater activities (CROA 2004). There are no commercially guided whitewater trips on the Blue River below Green Mountain Reservoir, however private use on this stretch does occur when water levels permit. Private boat kayak use on the Blue River is high due to the high-quality paddling and accessibility. It is estimated that there were approximately 200 private boat paddlers per weekend day on the Blue River during the 15-day season in 2005. On weekdays during the same period, it is estimated there were approximately 50 or more private boat paddlers on the Blue River during the 15-day season in 2005 (KODI 2005).

Two segments of the Blue River were preliminarily classified as recreational and wild for purpose of being deemed eligible for Wild and Scenic River status (BLM 2007). Segment 2 occurs from the BLM land boundary downstream of the confluence with Spring Creek to the BLM land boundary located upstream of the confluence with Spruce Creek. Segment 3 includes several small sections of the Blue River as it occurs on BLM land from approximately 0.25-mile upstream of the confluence with Dry Creek to approximately 1 mile upstream of the confluence with the Colorado River. The BLM also has an established fishing access and boat take-out at the downstream end of this segment. ORVs for these segments that made them eligible for potential designation included high quality fishing and floatboating, wildlife habitat, and high biodiversity. The Wild and Scenic Suitability Report published by the BLM in 2010 deemed these segments of the Blue River "not suitable" for listing in the NWSRS (Tetra Tech 2010).

3.15.5.5 South Boulder Creek

South Boulder Creek offers a variety of recreation opportunities including fishing and kayaking on two sections. The upper section goes from the East Portal of the Moffat Tunnel to Gross Reservoir, and the lower section goes from Gross Reservoir to the South Boulder Diversion Canal. Fishing on both sections is good and moderately popular with anglers, but is not considered heavy. Use is heavier in the spring and summer than in fall and winter (Kohler 2006). A typical weekend day during peak season between spring runoff and fall may see between 12 and 24 anglers on both sections, while a typical

weekday during the same period may see anywhere between 6 and 12 anglers on both sections (Rocky Mountain Anglers 2005).

Kayaking on South Boulder Creek is a popular activity, due to its proximity to Boulder and other Front Range communities. Certain portions of the upper section are technically challenging due to narrow stream channels, while the lower section can be challenging during spring runoff due to high volumes of water. A typical weekend day during early season may see between 10 and 15 private boat paddlers on the lower section and slightly less on the upper section. A typical weekday evening during the same period may see approximately five private boat paddlers on the lower section (American 2005; Boulder County 2005a).

South Boulder Creek flows though Eldorado Canyon State Park which allows both fishing and kayaking. Kayaking is still possible on the portion of South Boulder Creek that flows through the park, but it becomes more challenging due to shallow water. While it is possible to kayak South Boulder Creek through the park during high water, it is often un-navigable during normal and low water levels. A typical peak season day between spring runoff and fall may see an average of 15 to 20 anglers and only 3 to 5 kayakers on this stretch (Eldorado 2005).

3.15.5.6 North Fork South Platte River

Large segments of North Fork South Platte River from the East Portal of the Roberts Tunnel to the confluence of the South Platte River are on private land and are therefore not open to public use. The quality of fishing on segments open to the public is relatively poor and overall use is low. On an average peak season day between spring runoff and fall there may be approximately 10 anglers on all stretches open to the public from the Roberts Tunnel portal to the confluence with the South Platte River. However public access fishing on USFS lands along the North Fork is an important activity and there are periods throughout the year in which use can become rather high. Higher quality fishing is available to the general public downstream, between the confluence of the North Fork South Platte River and Strontia Springs Reservoir, of which use is light. Below the Strontia Springs Reservoir Dam, the South Platte River is a very popular, high-quality area for fishing (Blue River Anglers 2005; Rocky Mountain Anglers 2005).

Privately owned segments of the North Fork South Platte River offer outstanding fishing opportunities. Several private fishing ranches exist along the corridor from the East Portal of the Roberts Tunnel to the confluence of the South Platte River and guarantee high-quality fishing, with regards to the number of fish caught and size per fish. Permitted use along private land adjacent to the river is high. One example of use occurring along this stretch on private land shows a total of 1,288 angler days for 2004 (Boxwood Gulch 2005).

As noted in the introduction to Section 3.15.5, a 22.9-mile segment of the North Fork South Platte River between Bailey and Strontia Springs Reservoir is eligible for designation as a Wild and Scenic River, based on its recreational, wildlife, and cultural (historic) values. A buffer of ¼-mile on each side of the river segment is managed under the SPPP.

The potentially affected segment of the South Platte River from Antero Reservoir to the Henderson gage is approximately 110 miles. Due to the length of this reach and the minor

level of anticipated flow change, this reach will only be described generally. For the majority of its distance in Park, Douglas, and Jefferson counties, the South Platte River is adjacent to State-owned or USFS lands (Pike National Forest) and recreational resources, such as Spinney Mountain State Wildlife Area, Eleven Mile Canyon Reservoir State Recreation Area, and Chatfield State Recreation Area. Recreational opportunities along this stretch are numerous and include fishing, scenic and nature viewing, hiking, and picnicking. There are also limited areas suitable to kayaking and rafting that encompass Class I through Class V+ rapids (All About Rivers 2006; Colorado Directory 2006). In 2004 there was an estimated 836 commercial rafting user days along the South Platte River (CROA 2004).

In Arapahoe County, the City and County of Denver, and Adams County, the South Platte is dominated by private lands of various land use types, including industrial uses in Arapahoe County, high-rise office uses in downtown Denver, and active agricultural uses in Adams County. Recreation opportunities on the South Platte River are numerous and the river is considered a valuable recreational resource to numerous communities in the greater Denver Metropolitan area. Recreation opportunities include, but are not limited to: fishing, wildlife viewing, kayaking, non-commercial rafting, picnicking, scenic viewing, walking, hiking, and bicycling. Additionally, the South Platte River trail system, as well as other local trails systems are adjacent to or intersect the river at numerous points along its course. This stretch, extending from below Chatfield Reservoir through the greater Denver Metropolitan area, is anticipated to have a larger reduced flow than the upper stretch during the month of August of wet and dry years.

As noted in the introduction to Section 3.15.5, a 49.4-mile stretch of the South Platte River between Elevenmile Reservoir and Strontia Springs Reservoir is eligible for designation as a Wild and Scenic River, based on its recreational, fisheries, and wildlife values. A buffer of ¼-mile on each side of the river segment is managed under the SPPP.

3.16 LAND USE

3.16.0 Overview

This section provides information on land ownership, public lands, land jurisdiction, relevant management plans, zoning, and existing and planned land uses for each Moffat Collection System Project (Moffat Project or Project) component.

3.16.1 Reservoirs

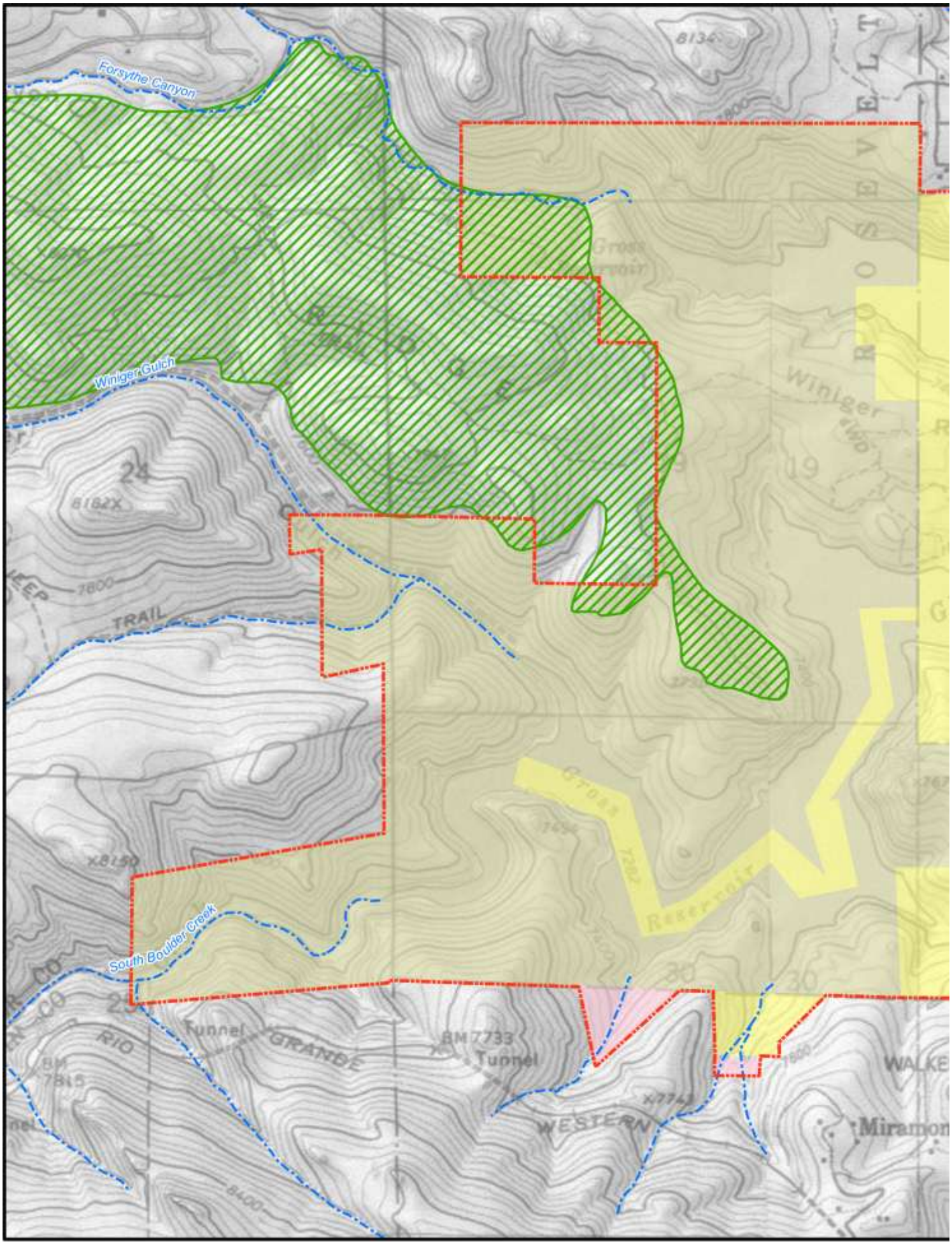
3.16.1.1 Gross Reservoir

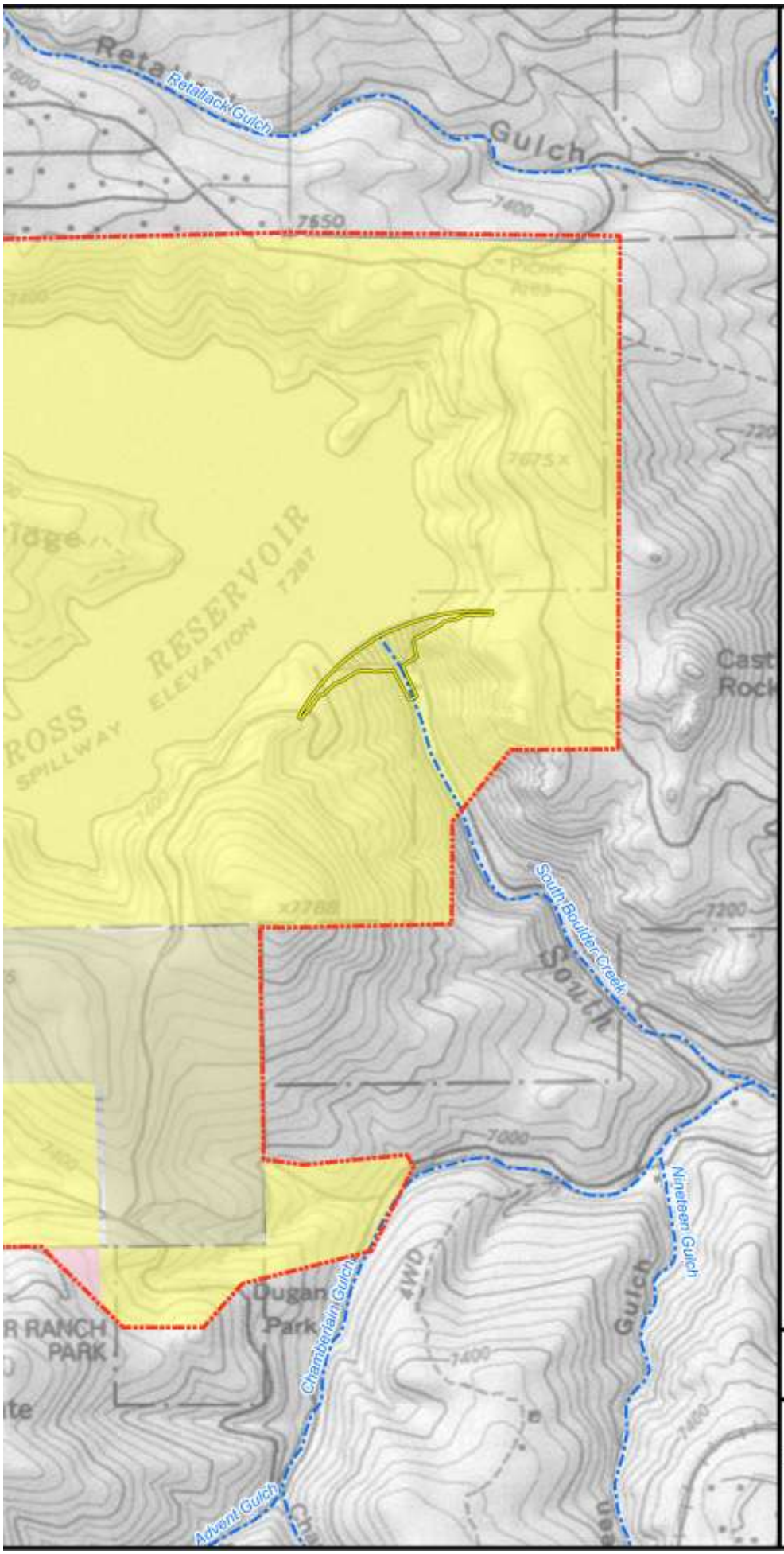
Gross Reservoir is located within Boulder County north of the unincorporated communities of Wondervu and Miramonte. Lands within the study area boundary are primarily owned by the Board of Water Commissioners (Denver Water) and the U.S. Forest Service (USFS) (Figure 3.16-1). The study area also includes small portions of private land parcels within the southern boundary. Land management within the study area is the responsibility of the USFS and Denver Water; management activities and policies are consistent with the Arapaho & Roosevelt National Forests Land and Resource Management Plan (RMP) and Intergovernmental Agreements (USFS 1997b, 2005b). Recreational activities on USFS lands at Gross Reservoir are managed by Denver Water. The western half of the study area is bordered by USFS lands. Private lands are located adjacent to the northeast and southern boundaries. The study area is bordered by Boulder County Open Space's Walker Ranch Park to the east. The Union Pacific Railroad (UPRR) operates an east-west line south of the southern boundary of the study area.

Existing Land Use

Existing land uses within the study area include recreation and reservoir maintenance facilities. Recreational facilities (i.e., parking, signage, picnic benches, shelters, and restrooms) have been installed at nine locations around Gross Reservoir as described in Section 3.15. These sites accommodate a limited number of recreation activities such as fishing, sightseeing, and picnicking and facilitate other dispersed activities such as hiking. Denver Water maintenance structures are consolidated at the dam and the junction of the Dam Road and Haul Road.

Boulder County has zoned the study area as Forestry, which permits rural land uses that conserve forest resources, protect the natural environment, and preserve open areas (Boulder County 2005b). Winiger Ridge (W2 of Section 19S 71W, S2 of Sections 13 and 14 and N2 of Sections 22, 23, and 24, 1S 72W) is listed as a Natural Landmark in the Boulder County Comprehensive Plan (1999). A Natural Landmark is defined as a prominent landscape feature designated for scenic, visual, and natural resource values. Upper and lower South Boulder Creek, including lands surrounding Gross Reservoir, are classified in the Boulder County Comprehensive Plan – Open Space Plan Map as Open Streamside Corridors (Boulder County 2012). The intent of the open streamside corridors classification is to ensure that natural water courses remain free from development.


Forsythe Canyon
Winiger Gulch
South Boulder Creek
TRAIL
Tunnel
RIO
GRANDE
WESTERN
Tunnel
Winiger
Reservoir
Miramon



Denver Water Board

USDA Forest Service - Arapaho & Roosevelt National Forest

Private or Right-of-Way

USFS Environmental Conservation Area

Gross Reservoir Study Area

Dam Footprint

Stream/River

Reference:
1:24,000-scale quad maps originally from USGS (1972 & 1994) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Land ownership from Boulder County (2006) and Denver Water (2008).

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Moffat Collection System Project FEIS

Figure 3.16-1 Land Ownership - Gross Reservoir

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Gross Reservoir and its vicinity are also included in the Magnolia Environmental Preservation Plan (MEPP) planning area. The MEPP planning area encompasses approximately 22 square miles in the mountain region west of Boulder, from Boulder Creek on the north, South Boulder Creek on the south, the Peak-to-Peak Highway on the west and Gross Reservoir on the east. Initiated in 1997, the MEPP is a referral entity for the Boulder County Comprehensive Plan regarding land use decisions for the rural area surrounding Magnolia Road. The MEPP sets forth goals for scenic and rural character preservation.

Management of National Forest lands in the vicinity of Gross Reservoir is guided by the 1997 RMP (USFS 1997b), which is included in the Thorodin Geographic Area subunit of the plan. Several goals and desired conditions are defined for the Thorodin area, including:

- Emphasize the maintenance and enhancement of flora and fauna throughout the area.
- Maintain the area's recreational setting and provide for year-round recreational use.
- Manage recreational uses and road and trail networks to reduce erosion or deterioration of riparian areas and watershed conditions.

Several amendments to the 1997 RMP were adopted in 2005. Many of these amendments focus on specific projects, activities, or geographic areas not directly relevant to the Moffat Collection System Project. Those amendments with more direct relevance for the Moffat Project include adjustments to the list of Management Indicator Species, adoption of the new Scenery Management System (SMS), and stream flow protection standards and guidelines. Each of these amendments is incorporated in the discussion within the applicable resource sections of this chapter.

Planned Land Use

The recreational and scenic amenities in this region have provided steady investment in mountain homes for year-round and part-time residents on dispersed 35-acre lots and in subdivisions. The 60-lot Lakeshore Park subdivision is located directly adjacent to the north Project boundary. Aspen Meadows and Forsythe Rock subdivisions are located east of South Boulder Creek outlet and the rural residential communities of Miramonte, Wondervu, Cedar-Ridge Estates, and Juniper Heights are located within 1.5 miles to the south.

In 2006, there were no approved or current subdivision developments on private lands within the study area, although mountain home development is expected to continue on adjacent private lands in the future.

The Gross Reservoir Recreation Management Plan is being implemented throughout the study area, and facility improvements to all recreational areas are ongoing (Denver Water 2004b, 2008a). Refer to Section 3.15 for more information on recreational facility improvements in the study area.

3.16.1.2 Leyden Gulch Reservoir Site

The proposed reservoir and facilities are located in Jefferson County south of the intersection of State Highway (SH) 72 and SH 93. Denver Water owns over 900 acres at this site, all of which have been annexed by the City of Arvada. Jefferson County has purchased lands west of the reservoir site to preserve as open space. Unincorporated lands to the south and east of the reservoir site remain in private ownership. Boulder County open space is located north of SH 72.

Existing Land Use

The Leyden Gulch site is largely undeveloped and is used for agriculture (livestock grazing). Annexed lands owned by Denver Water are zoned Light Industrial and Commercial (Figure 3.16-2). The majority of Jefferson County open space that has been annexed by the City of Arvada adjacent to the Leyden Gulch site has been zoned for commercial and low-density residential development. The area in the vicinity of the proposed dam, spillway, and pipeline are unincorporated and have been zoned by Jefferson County as Agricultural District 2 with the intent of providing for general farming, ranching, intensive agricultural uses and agriculturally related uses while protecting the surrounding land from any harmful effects. The area is generally located outside of the 2030 Urban Growth Boundary/Area defined by the Metro Vision 2030 Plan.

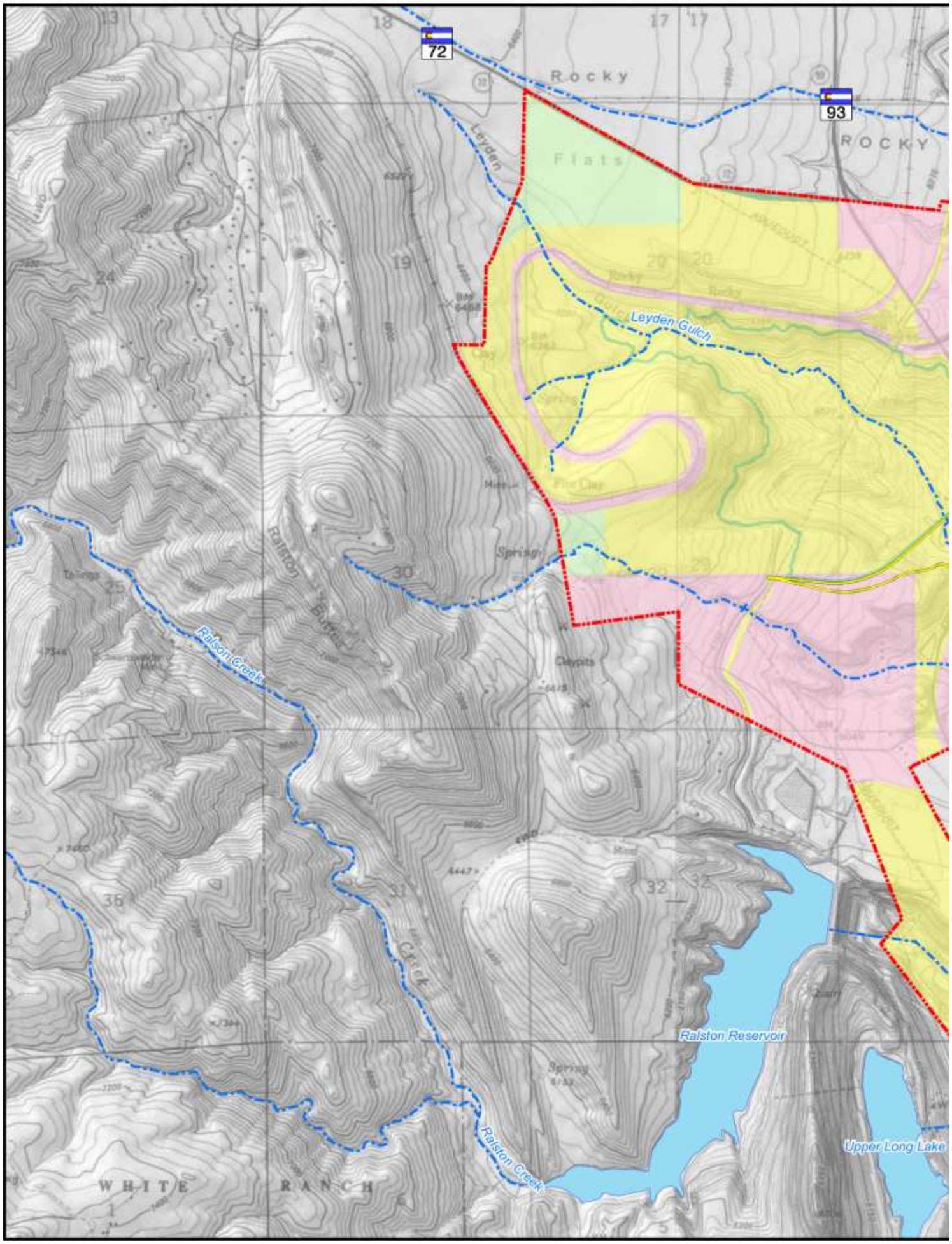
Denver Water has granted grazing leases on the property that provide for one Animal Unit Month (AUM) per 25 acres (Denver Water 2000b). This translates to approximately 36 AUMs of grazing per year.

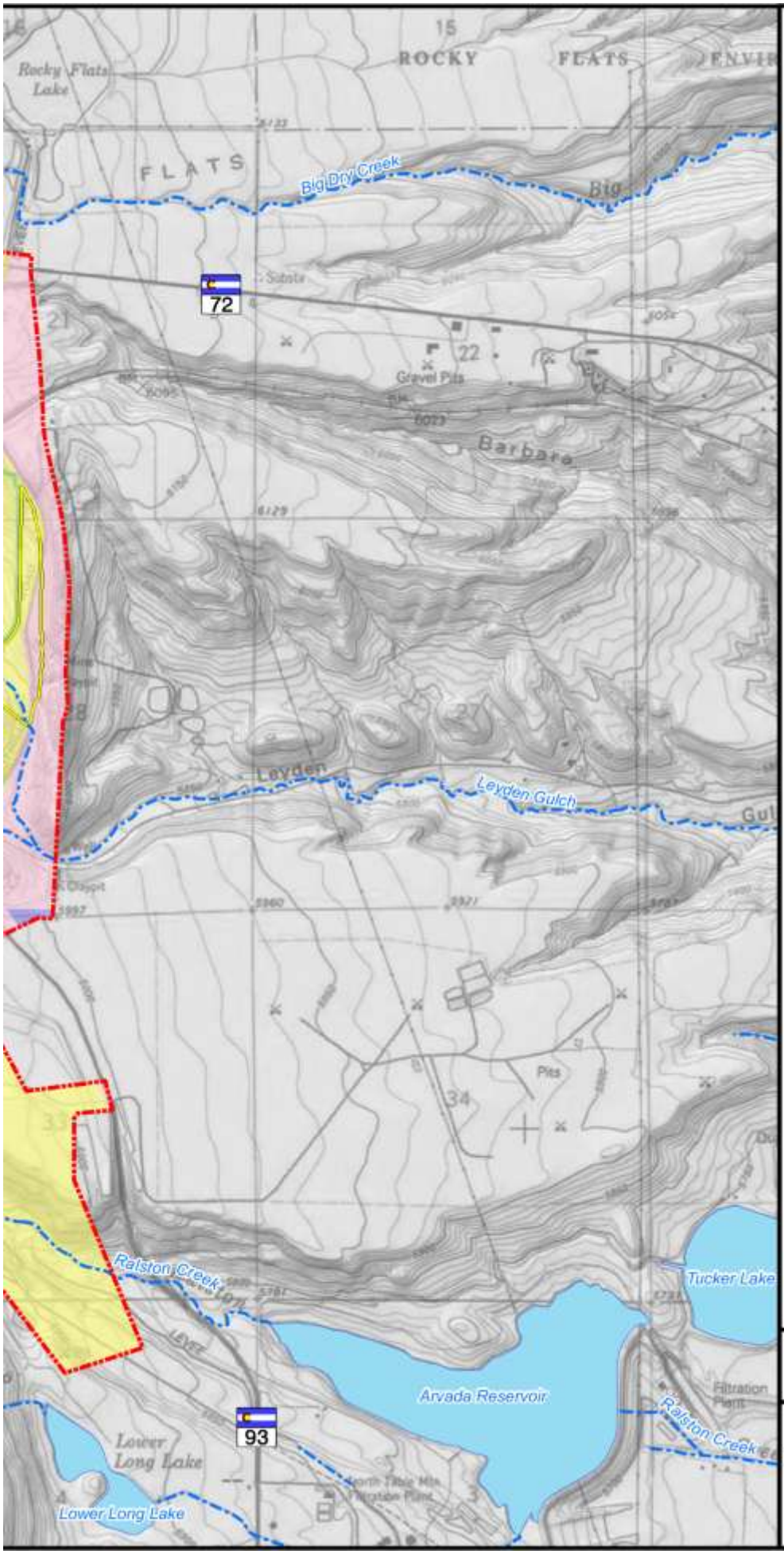
The majority of land adjacent to the Leyden Gulch site remains in agricultural use or has been purchased for open space. Grazing continues on the Coal Creek Open Space complex owned by Jefferson County and Boulder County between the proposed reservoir site and the hogback features to the west. Mining has historically occurred on a hogback formation east of SH 93 and the proposed dam site; Denver Water does not own the mineral rights at this site. There is one uninhabitable agricultural building on the site that would be either demolished or relocated to facilitate Project construction and operation. Two mountain home subdivisions, Blue Mountain Estates and Jefferson Center Highlands, and other rural residential uses overlook the site from ridgelines to the west. Existing land uses to the south are agricultural with three older occupied homesites within 0.8 mile of the proposed spillway location.

The UPRR crosses under SH 93 and switchbacks on the western portion of the reservoir site, climbing north towards Eldorado Springs. The South Boulder Creek Diversion Canal enters the study area from the north, is siphoned under Leyden Gulch for approximately 3,000 feet, and continues south to Ralston Reservoir. BFI Foothills Landfill, a municipal solid waste landfill, borders the study area to the east of SH 93.

Planned Land Use

The City of Arvada's 2005 Comprehensive Plan designates those portions of the site within the corporate limits of Arvada as public lands, with Leyden Gulch proposed as a 0.5-mile wide greenway of open space and parks (City of Arvada 2005).


72
93
Rocky
ROCKY
Flats
Leyden
Leyden Gulch
Ralston Buttes
Ralston Creek
Ralston Reservoir
Upper Long Lake
WHITE
RANCH



Denver Water Board
Jefferson County Open Space
Boulder County Parks & Open Space
City of Arvada
Private or Right-of-Way
Leyden Gulch Site Study Area
Leyden Gulch Site - 31,300 AF
Dam Footprint
Lake or Reservoir
Stream/River

Reference:
1:24,000-scale quad maps originally from USGS (1994) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Land ownership from Jefferson County (2005).

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Moffat Collection System Project FEIS

Figure 3.16-2 Land Ownership - Leyden Gulch Site

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The study area is within the expected growth corridor of the northwest Denver Metropolitan area and will experience change in the near future (estimated 1 to 5 years). The intersection of SH 72 and SH 93 is zoned for commercial development by the City of Arvada and several subdivisions are planned in the region. Although the majority of the region remains unincorporated, it is highly probable that residential growth will continue westward from Westminster, Arvada, Wheat Ridge, and Golden, with commercial and industrial development along SH 72 and SH 93.

The greatest determinant of future growth adjacent to the study area will be transportation network improvements and open space conservation efforts. As described in Section 3.12, SH 72 and SH 93 are major arterials for the northwest Denver Metropolitan region. Portions of the Leyden Gulch study area are within the Northwest Corridor Transportation and Environmental Planning Study area (CDOT 2008). Initially, an Environmental Impact Statement (EIS) was being prepared by the Colorado Department of Transportation (CDOT) and the Federal Highway Administration (FHWA) to examine long-range transportation needs in the northwest Denver Metropolitan area. Most of the EIS alternatives included a new or expanded north-south route, one of which, the Regional Arterial Alternative RB, utilizes SH 72 and SH 93 in the vicinity of the study area (CDOT 2006). If the Regional Arterial Alternative RB, had been selected as the preferred route it may have conflicted with the proposed Leyden Gulch Reservoir configuration. Due to declining funding and a lack of consensus, CDOT decided not to complete the Northwest Corridor EIS. Instead, data collected for the EIS was incorporated into the Northwest Corridor Transportation Planning and Environmental Study that is publicly available and can be used by a governmental agency or the private sector should an entity decide to move forward with a future project that does not involve Federal funding. As a result of growth trends, acquiring the foregrounds for views of the Front Range mountain backdrop is an overarching priority for Jefferson County, as stated in their Open Space and Parks Five-Year Master Plan (Jefferson County 2008). All of the study area is identified as a "potential open space preservation area" and two Trails 2000 segments are planned across the study area to enhance trail connectivity to the Coal Creek Canyon and North Area conservation open spaces.

3.16.2 Conveyance Systems

3.16.2.1 Conduit M

Conduit M runs from 0.25 mile east of the intersection of SH 72 and SH 93 in Jefferson County to north of the intersection of York Street and U.S. Highway (US) 265 in Adams County. The conduit is approximately 18 miles long; 11 miles in Jefferson County and 7 miles in Adams County. The conduit corridor passes through the municipalities of Arvada, Westminster, and Commerce City. The conduit would primarily follow existing roads and right-of-ways, such as SH 72, SH 53, 62nd Avenue, 70th Avenue, 76th Avenue, and 80th Avenue, and cross several major highways including SH 121 (Wadsworth Boulevard), SH 224, US 95, US 287, and Interstate (I-) 25. No Federal lands are crossed by this conduit.

From the proposed Moffat Collection System delivery point on SH 72 in Jefferson County, 6 miles of Conduit M would occur in less intensively developed areas with agricultural and

rural residential land uses. Planned land uses for undeveloped areas in the City of Arvada crossed by the conduit include commercial, office, light industrial, and low-density residential development. The next 5 miles in the eastern portion of Jefferson County would occur in areas transitioning from rural to suburban and urban, primarily consisting of commercial and residential uses. The 7-mile segment of conduit within Adams County transects urban areas dominated by single-family and attached residential and highway commercial uses. The southernmost 3 miles, from SH 53 to the Denver Water Recycling Plant, crosses Clear Creek, South Platte River, I-76, and I-25 in an area dominated by highway, commercial, and light and heavy industrial uses, with some vacant lands remaining.

3.16.2.2 Conduit O

Conduit O travels east from the intersection of SH 72 and SH 93 in Jefferson County to its terminus in Adams County near the communities of Henderson and Hazeltine Heights. The conduit is approximately 25 miles long; 10 miles in Jefferson County and 15 miles in Adams County. Approximately 9 miles of the western end of the Conduit O alignment are the same as the Conduit M alignment to SH 121. The first 6 miles of Conduit O would occur in less intensively developed areas with agricultural and rural residential land uses. Planned land uses for undeveloped areas in the City of Arvada crossed by the conduit include commercial, office, light industrial and low-density residential development. Conduit O continues for 1.5 miles in Jefferson County, then enters Adams County. Within Adams County, Conduit O traverses urban and suburban areas in Westminster, Federal Heights, and Thornton. At mile 19, Conduit O turns northeast paralleling I-76 and US 85 in Commerce City and unincorporated Adams County, in areas transitioning from rural to suburban and urban uses, primarily consisting of commercial, industrial, and residential uses in Hazeltine Heights and Henderson.

3.16.3 South Platte River Facilities

Gravel Pits

Worthing Pit is located in Adams County, southwest of the Exit 36 interchange (E-470 and Old Brighton Road), adjacent to the eastern edge of the South Platte River. Worthing Pit is located just south of the Brighton municipal boundary, in an area of active gravel mining and other light industrial uses. The county zoning is Agricultural–1, the purpose of which is to provide rural single-family dwellings and limited farming uses; extraction and disposal uses are permitted. Several small mining operation facilities, including fixed and mobile offices, and several private residences lie in and around these gravel pit sites. An existing gravel lake in the study area is used for water skiing, and several trailers are used for seasonal residences for water-skiing enthusiasts on the north side of Worthing Pit. Additional residential development is planned in and around Worthing Pit. In 2006, Adams County Regional Park was under construction opposite the South Platte River to the west and features a golf course, fishing opportunities, a nature preserve, segments of the South Platte Trail, volleyball, outdoor concert facilities, and a rodeo arena.

The North Tower and South Tower pits are also located in Adams County, northwest of the Exit 36 interchange (E-470 and Old Brighton Road), adjacent to the eastern edge of the

South Platte River. The North Tower and South Tower pits have been incorporated into the City of Brighton. Active mining operations have ceased in the vicinity, and current uses include fixed and mobile residential units, boating, and water skiing. The South Tower Pit is subject to the Willow Bay Planned Unit Development agreement; zoning includes a combination of residential, parks, and open space (City of Brighton 2006). The North Tower Pit, while annexed by the City of Brighton, retains its previous zoning by Adams County as Agriculture-3 (City of Brighton 2006).

The Challenger Pit is under construction west of the South Platte River approximately three miles north of the North Tower Pit, one mile west of the City of Brighton and the interchange of US 85 and Bridge Street, within unincorporated Adams County. The northern boundary of the Challenger Pit is on the Adams-Weld county line. The county zoning is Agricultural–1, the purpose of which is to provide rural single-family dwellings and limited farming uses; extraction and disposal uses are permitted. Agricultural, active gravel mining, and other light industrial uses occur within and in the vicinity of the study area.

All four gravel pits are located in the City of Brighton Rivers and Lakes Joint Planning Area (City of Brighton 2009). This joint City/County planning area was established to keep "the land open for farming, public open space and minimizing area of regional flood hazards. If development occurs, it should be at the lowest densities possible with clustering used so as to preserve large open tracts. These areas will be critical for a distinguishing landscape between Brighton and Commerce City" (City of Brighton 2009). Most land in this joint planning area is largely expected to remain unincorporated although some areas will be appropriate for annexation. The City of Brighton Land Use Plan anticipates that all four storage areas will remain as agriculture or other non-urban uses (City of Brighton 2009). Relevant policies from the City of Brighton Comprehensive Plan for the study area include the following: Policy 5.9: Make Connections to Water Wherever Possible.

Whenever a development project abuts the river or man-made lakes, include those areas in the overall planning for the area. Acquire lands around the river and lakes whenever possible.

Work to create a complete system of open space areas and trails along the length of the South Platte River within Brighton. Work with and support county and adjacent cities efforts to develop corridor plans (e.g., the Heritage Trail Plan).

Diversion

The proposed diversion structure would be located in unincorporated Adams County, near the Worthing Pit. The diversion and conveyance would be located in an area of active gravel mining and other light industrial uses west of Brighton Road. Gravel mining operation facilities and private residences exist immediately east of the conveyance facility. Additional residential development is planned in the vicinity of the City of Brighton Rivers and Lakes Joint Planning Area. In 2006, Adams County Regional Park was under construction to the west, with fishing, a nature preserve, and segments of the South Platte Trail adjacent to the South Platte River. Despite several engineered structures, this river segment is used for kayaking and other water-based activities with access points primarily confined to the west bank.

Conveyance

A new pipeline would be necessary to distribute water between the gravel pit storage sites. The pipe would be buried within existing roadways that run between the gravel pits. The gravel pit pipeline crosses irrigated agricultural fields and urbanized lands between the Challenger and North Tower pits. Urbanized areas include single-family residential neighborhoods, neighborhood parks, large-lot residential and agricultural residential properties, and some industrial uses related to gravel mining.

3.16.4 Denver Basin Aquifer Facilities

A new Advanced Water Treatment Plant (AWTP) would be located in the vicinity of the existing Denver Water Recycling Plant. Approximately 7 acres of property would be necessary to accommodate the upgraded plant. This property parcel would be located in an existing industrial district, on or adjacent to lands that have already been impacted by existing industrial development. Treated water from the AWTP would be conveyed via a pipeline system to dedicated injection/recovery wells in order to recharge the Denver Basin aquifer at various locations throughout the Denver Metropolitan area.

Generally, all areas crossed by the injection/recovery wells distribution line are urban in character and are already developed. The distribution network crosses nearly every land use type in Denver including: industrial, commercial, office or business, shopping, residential, estate-like residential, and mixed use. Potential concerns for route segments include one crossing of Cherry Creek and two crossings of the South Platte River. The network transects several Denver Historic Districts/neighborhoods including Washington Park, Park Hill, City Park, and City Park Golf Course. Construction of the connecting pipelines would use existing roadway easements.

The proposed well sites are located within the urbanized areas of the City and County of Denver, primarily throughout the city and county park system. Approximately 20 parks have been identified for well placement. The parks vary in size and character, including small, neighborhood parks with limited recreational amenities to large, regional parks supporting a variety of uses and infrastructure developments.

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3.17 VISUAL RESOURCES

3.17.0 Overview

This section describes existing scenic quality and landscape characteristics, relevant management direction, visual absorption capacity, and user sensitivity to change for each Moffat Collection System Project (Moffat Project or Project) component and the areas that may be potentially affected.

Scenic quality, as defined in the U.S. Forest Service (USFS) Scenery Management System, is a harmonious relationship between physical, biological, and cultural attributes that, when viewed by people, elicits psychological and physiological benefits. Visual absorption capacity refers to the relative ability of a landscape to accept contrasting human modifications without a loss in character (USDA 1995). Existing landscape character refers to the unit's scenic attributes (landform, water, cultural elements, and vegetation) combined with the cultural values that people assign to landscapes. Landscape character descriptions define a unit's "sense of place," or scenic expression, as well as providing a written baseline condition from which to monitor change in scenic resources in the future (USDA 1995). User sensitivity to change is determined by evaluating factors such as visibility of the site, proximity to sensitive land uses, the number and type of potential viewers, and the purpose of their visit to the analysis area.

3.17.1 Reservoirs

3.17.1.1 Gross Reservoir

The visual and cultural image of Gross Reservoir is characterized by clear reservoir water, rocky shorelines and steeply sloped forested hillsides set against high mountain peaks in the background (Denver Water 2004b). The reservoir is located in the steep foothills of the Colorado Front Range, in a landscape that has been sculpted by deep erosion, deposition of headwater stream material, and the downward migration of unconsolidated rock. Elevations within the study area range from 6,900 feet below the dam on South Boulder Creek to 7,800 feet on some of the small peaks and ridges. In most cases, the terrain slopes steeply towards the reservoir, with most slopes ranging from 20 to 60 percent (%). Warm, south-facing slopes are dominated by ponderosa pine stands with some small grassland openings from past fires or disturbances, while north-facing slopes are dominated by closed canopy mixed-conifer forests, punctuated only by rock outcroppings and small aspen groves. Aspen stands and aspen/cottonwood communities in wet ravine areas, which create seasonal interest in color and texture, are slowly being replaced by conifer forest. Weather, season, or time of day create continued viewer interest by dramatically altering the color intensity, reflection, shadow, form, texture, such as snow cover and tree defoliation during the winter and leaf color in the fall.

As a human-made reservoir, the existing landscape character is largely a result of human activities that have many positive visual characteristics. Properly sited and maintained recreational trails and signage, for example, contribute to the recreational character of the area and are considered positive elements in the landscape. However, certain activities

have negatively impacted the visual character. Deviations from the form, line, color, and texture of the natural landscape include the dam, overhead utilities, buildings, roads, signage, and impacts due to unmanaged recreational activities at designated recreation areas (refer to Section 3.15). At certain times of the year the setting is also influenced by the drawdown zone that surrounds the reservoir, a conspicuous element of the landscape because water levels in the reservoir are low and a large area of barren soil becomes exposed.

Some of the study area's most visible lands on the North Shore/Peninsula, Dam, and Winiger Ridge are also those most impacted by human uses. The Dam Recreation Area was used as a staging area during dam construction. Its highly modified contours (form), poorly vegetated surface (texture), overhead utilities (lines), and barren slope of loose and light-colored material extending into the reservoir (color) make the Dam Recreation Area the most visible human impact in the study area. At the same time, the dam's convex form and sheer vertical drop have placed the Gross Reservoir Dam in cultural memory as a visual landmark. As a result, the Dam Recreation Area overlook(s) adjacent to the dam are one of the most popular destinations at the reservoir. The overlook(s) provides excellent, panoramic views of the study area.

Off-road vehicle use, dispersed camping, and cross-country travel have damaged vegetation and accelerated the natural erosion process, resulting in localized visual change. Most of the soils present have a high erosion susceptibility, which is exacerbated by the steep slopes that occur in the area. The lines and colors created by road and trail networks are highly visible on the Winiger Ridge and North Shore/Peninsula recreation areas, and in grass/forb rangelands and ponderosa pine communities. Moderate recreational impacts in and around rock outcroppings and on north-facing slopes are typically absorbed by the form and texture of the natural features.

Existing land uses include recreational and maintenance facilities, and a variety of recreation opportunities. A dozen homes in the Lakeshore Park subdivision east of North Shore Recreation Area overlook the reservoir and are visible from several vantage points. No residential subdivisions or other uses are proposed near the study area, although 35-acre and larger mountain home development is expected to continue in the future. Older recreational facilities on the North Shore/Peninsula have been sited in highly visible locations, resulting in a contrast to the visual character.

Certain areas around the reservoir display particularly distinctive visual qualities that create positive or negative responses in the viewer. Past surveys conducted by the Board of Water Commissioners (Denver Water) indicate that the sites with the most human intervention and landscape disturbance were generally rated by users as having the lowest scenic quality in the study area, while the sites that were more pristine were rated highest (Denver Water 2003j). Three areas in particular have very high scenic quality:

1. Forsythe Canyon with its steeply sloping granite walls in the foreground and views to the snow-covered Indian Peaks. The Forsythe Canyon Trail begins approximately 0.5 mile down Forest Road (FR) 359 and follows Forsythe Creek down into a wooded, rocky canyon to the reservoir shoreline in Forsythe Canyon. In the spring the small creek forms a small, picturesque cascading waterfall that is a popular hiking destination.
2. South Boulder Creek Inlet with its rapids dissipating into the waters of Gross Reservoir.

3. South Boulder Creek in the rocky V-shaped canyon below the dam, a popular destination for kayakers and hikers.

Overall, scenic quality at the reservoir is rated as high, while Winiger Ridge and North Shore/Peninsula are rated as moderate, and the Dam Recreation Area is rated as low for the reasons described above. Both Winiger Ridge and North Shore/Peninsula have the potential to have high to very high scenic quality, but have been degraded by unmanaged recreational use, inappropriate facility siting, and increased erosion.

Article 414: Visual Resource Protection Plan, of the Gross Reservoir Federal Energy Regulatory Commission license, establishes a desired landscape character for lands managed by Denver Water within the study area, or the appearance of the landscape to be retained or created over time (Denver Water 2003j). It states that:

> *The overall landscape character around the reservoir should remain natural appearing with limited human intervention. Forested areas should display diversity of vegetation and successional stages of plant development. Meadows and forest openings should be natural appearing and managed in absence of natural fire cycles. The recreation facilities should be developed to meet the roaded natural classification in the Forest Service's recreation opportunity spectrum. Visitors to this area should be provided with facilities and site amenities that are convenient, yet appropriate for the setting. Within this area, opportunities to get away from others in more remote and natural settings should be made available (p. 41).*

The Arapaho & Roosevelt National Forests Plan designates USFS-owned lands adjacent to Gross Reservoir with a scenic integrity objective of High, requiring that "the valued landscape character 'appear' intact. Deviations may be present but must repeat the form, line, color, texture, and pattern common to the landscape character so completely and at such a scale that they are not evident" (USDA 1995).

As described in Section 3.15, both one-time and frequent visitors utilize Gross Reservoir in the summer months for fishing, sightseeing, picnicking, hiking, biking, horseback riding, camping, cliff-jumping, and four-wheeling. Past Denver Water visitor surveys indicate that Gross Reservoir's most desirable attributes are its feeling of remoteness, the lack of man-made structures and/or human intervention, other scenery-related attributes, and the opportunity for scenery-related activities such as sightseeing and wildlife viewing (Denver Water 2004b). Due to the recreational nature of users and the scenic amenities valued by residents, user sensitivity to visual change is considered to be high.

Article 416: Recreation Management Plan and Article 414: Visual Resource Protection Plan proposes improving all existing recreation areas, and constructing one new site (Denver Water 2004b). These plans delineate facility design standards (i.e., configurations, alignments, building materials and colors, landscaping and screening, erosion control and restoration techniques) and site-specific recommendations for future uses and improvements. Under these guidelines, the desired landscape character would continue to be achieved over time resulting in improvements to several degraded areas.

3.17.1.2 Leyden Gulch Reservoir Site

The Leyden Gulch study area is located southwest of the intersection of State Highway (SH) 72 and SH 93, northwest of the cities of Arvada and Golden, in Jefferson County. Leyden Gulch is a prominent valley, beginning 0.25 mile southeast of the broad, sloping alluvial fan of Coal Creek Canyon and extending through the old coal-mining Town of Leyden, 2 miles east of the study area. The valley's landforms are rolling grassland hills, with occasional steep side-slopes on Leyden Creek. The valley's only natural barrier to its eastward expansion is the north-south trending vertical spires of the Fox Hills/Laramie Formation's sandstone and claystone hogback. This 1-mile long hogback is one of the most pronounced formations in the Boulder-Golden region, and occurs further east within the Great Plains transition zone than most hogback formations in the region. As such, the vertical spires are one of the most striking landforms experienced in the 20 mile drive between Boulder and Golden along SH 93, along with North Table Mountain and views of the Front Range. Historic clay mines and rock quarries are evident on the west face of the hogback; the east face, which serves as a municipal landfill, is hidden from view along SH 93.

There is no public access to the study area. It is seen in the foreground by commuters on SH 93, which has an annual average daily traffic count of 19,300 vehicles (CDOT 2005), and briefly in the middleground by travelers on SH 72. Traveling south on SH 93, the viewer drops 250 feet from the alluvial bench to the crossing of Leyden Creek with panoramic views westward towards the Front Range mountain backdrop and the grass-covered headwaters of Leyden Gulch. The hogback towers overhead to the east, its dark varnished beds of sandstone highlighted by scattered shrubs and ponderosa pine. With the exception of the hogback, most views are directed towards the pine-covered Front Range backdrop, as foreground views are predominantly grassland with pockets of shrubs. The reservoir site is highly visible. The headwaters of Leyden Gulch carry the curvilinear switchbacks of the Denver and Northern Railroad, which climbs north towards Eldorado Springs. Tan-colored railroad cars are permanently parked along the easternmost curve in the track, filled with rock to provide a wind barrier preventing cars on passing trains from being blown off the track (Abbott and Noe 2005). Electrical distribution lines, unpaved roads, cattle fences, and the South Boulder Diversion Canal are visible within the study area, but are subordinate to or are compatible with the open, rangeland character of the region.

Continuing south from the crossing of Leyden Creek, the Front Range landscape rises 200 feet to a bench, with views directed to North Table Mountain and the Denver Metropolitan area across uniform-appearing rangeland in the foreground. A limited number of agricultural and residential structures are visible in the foreground from this segment, although their dispersed pattern is compatible with the rangeland character of the foothills/Great Plains transition zone. Approximately 30 homes are visible in the foothills west of SH 93 between Coal Creek Canyon and Ralston Reservoir.

Several properties in the headwaters of Leyden Gulch, north and west of the proposed reservoir site, are owned and maintained by Boulder County and Jefferson County open space programs. Most of these properties were acquired as part of the Front Range Mountain Backdrop/Foreground Preservation Project, a coordinated planning effort between five Front Range counties begun in 1995, to ensure that the foothills, hogbacks,

and other key Front Range visual areas are protected. Preserving foreground views of the Front Range has been a focus of open space preservation in every Jefferson County Open Space Master Plan since the program's inception in 1972 (Jefferson County 2008). Open space programs and citizen groups were instrumental in modifying a proposal for an 18,000-acre commercial-residential master planned district, known as the Jefferson Center Development Plan, at the intersection of SHs 72 and 93. Approximately 1,000 acres in the study area have been annexed by Arvada and are intended for commercial and office development, with up to 6,000 new residential units, according to the Jefferson Center Urban Renewal Plan adopted in 2004 (City of Arvada 2005). Privately-held rangeland properties, which are an important element of the existing landscape character, are expected to continue experiencing growth pressures, transitioning to residential and commercial uses unless otherwise protected.

The contrast created by the drop in elevation within Leyden Gulch, and the steep uplift of the hogback to the east creates a high degree of scenic interest. The scenic quality of the remaining study area is low due to the uniform vegetation and rolling topography, except as it serves to frame views of the hogback, or other high quality natural features beyond the study area, such as the Front Range. Visual absorption capacity within the site varies with distance from viewing points, but is typically low within the proposed reservoir site, and moderate between the proposed dam site and Ralston Reservoir outlet. User sensitivity to visual change is high due to the high number of daily travelers and ongoing efforts by local governments and citizen groups to preserve foreground views of the Front Range Mountain backdrop.

3.17.2 Conveyance Systems

3.17.2.1 Conduit M

Conduit M runs east from the intersections of SHs 72 and 93 in Jefferson County approximately 18 miles to Commerce City north of downtown Denver. The conduit would primarily follow existing collector and arterial road corridors. From the Moffat Collection System delivery point on SH 72, approximately 6 miles of conduit would occur in natural, agricultural, or rural residential areas. This portion of the conduit crosses a rolling landscape primarily vegetated with grasses and shrubs. Terrain and vegetation along these first 6 miles of the conduit is fairly uniform with little variation or visual interest. Scenic quality in this rural area is moderate, and is expected to change as residential and office development occurs in the near future according to the 2004 Jefferson Center Urban Renewal Plan (City of Arvada 2005). User sensitivity from SH 93 to 86th Parkway (approximately 4 miles) is moderate; however, sensitivity levels may be influenced by future development.

The remainder of the Conduit M, a distance of 12 miles, passes through urban and suburban developments. The visual character of the corridor changes with the degree and type of development. Overall, scenic quality and user sensitivity in urban and suburban areas is low due to the high degree of development and landscape modifications that have already occurred. In general, visual absorption capacity in urban areas is high as these pipelines would be installed in existing right-of-ways (ROWs) already containing roads or utility structures. A number of more sensitive viewpoints also occur, including: Pioneer Park,

Alice Sweet Thomas Park, Two Ponds National Wildlife Refuge, Lake Arbor Park, and South Platte River Trail in Arvada; Fireman Park and F.M. Day Park in Westminster; and Clear Creek Trail in Adams County.

3.17.2.2 Conduit O

Conduit O travels east from the intersection of SHs 72 and 93, a total distance of approximately 30 miles through a varied landscape of agricultural, suburban, urban, and industrial uses. The corridor is adjacent to existing roadways for the majority of the alignment. The visual character of the corridor changes with the degree and type of development. Overall, the scenic quality and user sensitivity in urban and suburban areas, which generally encompasses all but the western and eastern most segments of the corridor, is low due to the high degree of development and landscape modifications already present. In general, visual absorption capacity in urban areas is high as these pipelines would be installed in existing ROWs already containing roads or utility structures.

The westernmost 6 miles of Conduit O, which is the same as the Conduit M corridor, is located in a more natural setting with agricultural and rural residential uses and a landscape dominated by rolling grasslands (refer to Section 3.17.2.1). The easternmost 5 miles of the corridor cross a more rural setting; however, terrain and vegetation are fairly uniform with little variation or visual interest. Much of the viewshed area adjacent to the South Platte River near the eastern terminus of Conduit O has been highly modified by gravel mining operations and has an engineered appearance.

A small dechlorination facility, located on less than one-acre of land, is proposed to be built near the existing Moffat Collection System delivery point. The site's scenic quality is moderate due to its undeveloped nature and proximity to an un-named drainage to the south and the primarily undeveloped Leyden Gulch Reservoir study area to the west. User sensitivity is also moderate because this area supports many residences and is also a main thoroughfare for recreationists.

3.17.3 South Platte River Facilities

The Worthing, North Tower, and South Tower pits are located near the Exit 36 interchange (E-470 and Old Brighton Road) in an active and historic gravel mining district. Major visual characteristics of the study area include an existing man-made lake, the South Platte River, E-470, and pockets of mature trees along ditches. These water resources provide a degree of visual interest; however, the entire study area, reservoirs, and river reach have been highly modified and have an engineered appearance, with many areas still undergoing revegetation. The highest quality scenic views are across the South Platte River towards bluffs and Adams County Regional Park, where a golf course, nature preserve, and restoration projects along the west South Platte River shoreline contrast with the raw condition of the eastern gravel mining district.

Active gravel mining continues adjacent to the Worthing Pit, south of E-470. Consequently, scenic quality is low, visual absorption capacity is high, and user sensitivity is low. Gravel mining has ceased adjacent to the North Tower and South Tower pits, and some areas are still undergoing revegetation, while extraction, reservoir creation, and residential development continue across the South Platte River north of E-470. North of

E-470, scenic quality is low, visual absorption capacity is moderate, and user sensitivity is low.

The Challenger Pit is under construction west of the South Platte River, west of the City of Brighton. The Challenger Pit is bounded by 168th Street to the north and Tucson Avenue to the east. Active gravel mining operations, and cement plant, and other light industrial uses in the vicinity of the study area create a highly modified and raw appearance to the landscape. Scenic quality is low, visual absorption capacity is high, and user sensitivity is low.

3.17.4 Denver Basin Aquifer Facilities

City and County of Denver parks and golf courses and one plant nursery (Denver International Airport nursery site) have been identified as potential locations for injection/extraction well clusters. The scenic quality and visual absorption capacity varies widely between the sites in relation to the size, use, and character of each park. User sensitivity varies between moderate to high as well because of the recreational character of these urban and suburban sites.

The proposed Advanced Water Treatment Plant (AWTP) would be located near the existing Denver Water Recycling Plant in the Denver Metropolitan area. Scenic quality and user sensitivity are low at this site given that it is industrial in character and previously disturbed.

Approximately 35 miles of 12- to 48-inch pipeline would be buried in Denver city streets. Visual absorption capacity is high as these pipelines would be installed in existing ROWs already containing roads or utility structures.

3.17.5 River Segments

In general, the Fraser River, Williams Fork, Colorado River, Blue River, South Boulder Creek, and North Fork South Platte River occur in scenic or visually sensitive locations. The setting in which the stream is viewed is equally important as the stream flow level when determining visual preferences. The surrounding topography, vegetation, complementary or incompatible uses, time of day, and the respective activity of viewers all contribute to the visual experience. This may be especially true in areas that are heavily dependent on visitation, such as mountain communities. In these settings, the visual experience often contributes to a broader recreation experience, and to some extent, helps to characterize surrounding land uses. Mountain communities are popular destinations for recreation, tourism, and as retirement and vacation destinations and the surrounding visual setting and passive beauty of rivers and streams helps to define the character of these areas. However, river water levels fluctuate diurnally and seasonally as a result of natural hydrologic cycles, reservoir management, irrigation practices, and diversions for other purposes. The stage or flow level affects the visual appearance of rivers and streams in a number of ways, such as boulders and/or bedrock that are submerged or present at the water surface; the amount of the channel that is occupied by water; or the relative stillness, turbulence, velocity, and/or whitewater at varying flows. Even in a natural State, Colorado streams are characterized by substantial variations in flow, typically reaching the highest flow levels in May or June and then rapidly dropping off through the remainder of the year

until they reach the low flows that predominate during the winter months. Throughout the year, flows can easily be 10 to 20 times greater during peak runoff than they are during winter. As a result, a stream is a dynamic system that rarely remains static and the viewer has an expectation of observing change over the course of the seasons.

3.18 CULTURAL/HISTORICAL/PALEONTOLOGICAL RESOURCES

3.18.0 Overview

Cultural resources include districts, sites, buildings, structures, and objects that represent past human activities. Significant cultural resources, or historic properties, include those resources that are listed, or considered eligible for listing, in the National Register of Historic Places (NRHP). The criteria for NRHP eligibility are set forth at 36 Code of Federal Regulations (CFR) 60.4:

> *The quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, building, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association and*
>
> *(a) that are associated with events that have made a significant contribution to the broad patterns of our history; or*
>
> *(b) that are associated with the lives of persons significant in our past; or*
>
> *(c) that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or*
>
> *(d) that have yielded, or may be likely to yield, information important in prehistory or history.*

Historical sites, such as buildings and ditches, are usually evaluated under the first three criteria, while archaeological sites, if eligible, are usually considered significant under the fourth criterion. Other cultural resources of local, regional, or State significance may be listed in the State Register of Historic Places (State Register), administered by History Colorado, formerly the Colorado Historical Society.

Consultation with Colorado State Historic Preservation Officer (SHPO), American Indian Tribes, and other interested parties was initiated in the fall of 2005 to discuss the Area of Potential Effects (APE), analyze methodologies, and gather information on specific concerns. To date, the following parties have been contacted: Arapaho & Roosevelt National Forests (ARNF) administered by the U.S. Forest Service (USFS), City and County of Denver, Grand County Historical Association, Boulder County, Jefferson County, and the cities of Lakewood, Westminster, and Wheat Ridge. A meeting with the U.S. Army Corps of Engineers (Corps), the SHPO, USFS, and Boulder and Jefferson counties was held on November 17, 2005.

American Indian Tribal Consultation

In compliance with 36 CFR 800 and 33 CFR Part 325 Appendix C (including the April 25, 2005 Corps' Interim Guidance), in October 2003, December 2007, and January 2008, 46 Federally recognized American Indian Tribes with an established interest in the area and the commissions on Indian affairs for the States of Colorado, Oklahoma, South Dakota,

Utah, and Wyoming, were notified of the Moffat Collection System Project (Moffat Project or Project) and invited to participate in Tribal Consultation, at their discretion. In addition, efforts were made in January 2008 to contact each of the 46 tribes by telephone. Consultation with an American Indian Tribe recognizes the government-to-government relationship between the Federal government and sovereign tribal groups, and Federal agencies must be sensitive to the fact that historic properties of religious and cultural significance to one or more tribes may be located on ancestral, aboriginal, or ceded lands beyond modern reservation boundaries.

The following Federally recognized tribes were contacted:

- Assiniboine and Sioux Tribes of Fort Peck
- Blackfeet Tribe
- Cheyenne River Sioux Tribe
- Chippewa Cree Tribe of the Rocky Boys' Reservation
- Confederated Salish and Kootenai Tribes
- Crow Creek Sioux Tribe
- Crow Nation
- Eastern Shoshone Tribe
- Flandreau Santee Sioux Tribe
- Gros Ventre and Assiniboine Tribe of Fort Belknap
- Iowa Tribe of Kansas and Nebraska
- Kickapoo Tribe in Kansas
- Lower Brule Sioux Tribe
- Northern Arapaho Tribe
- Northern Cheyenne Tribal Council
- Oglala Sioux Tribe
- Omaha Tribe of Nebraska
- Ponca Tribe of Nebraska
- Prairie Band of Potawatomi Nation
- Rosebud Sioux Tribe
- Sac and Fox Nation of Missouri in Kansas and Nebraska
- Santee Sioux Nation
- Sisseton-Wahpeton Sioux Tribe
- Spirit Lake Sioux Tribe
- Standing Rock Sioux Tribe
- Three Affiliated Tribes
- Turtle Mountain Band of Chippewa
- Winnebago Tribe of Nebraska
- Yankton Sioux Tribe
- Apache Tribe of Oklahoma
- Cheyenne-Arapaho Tribes of Oklahoma
- Comanche Nation
- Comanche Tribe of Oklahoma
- Fort Sill Apache Business Committee
- Iowa Tribe of Oklahoma
- Jicarilla Apache Tribe
- Kiowa Indian Tribe of Oklahoma
- Northern Ute Tribe, Uintah and Ouray Tribal Business Committee
- Otoe-Missouria Tribal Council
- Pawnee Nation of Oklahoma
- Ponca Tribe of Oklahoma
- Sac and Fox Nation
- Sac and Fox Tribe of the Mississippi in Iowa
- Southern Ute Indian Tribe
- Ute Mountain Tribe
- Trenton Indian Service Area

During the course of the telephone contacts, only a few tribes expressed any kind of concerns. A representative of the Blackfeet Tribe requested that they be notified should any inadvertent discoveries of archaeological sites or human remains occur. A representative of the Cheyenne River Sioux Tribe expressed an interest in knowing what other tribes had to say about the Project. A representative of the Ponca Tribe of Nebraska asked to be notified if any other nations express concerns. Follow-ups to these concerns were conducted through phone calls, letters, and notifications through the National Environmental Policy Act of 1969, as amended (NEPA) process.

Of the tribes from whom the Corps directly requested comments about the Project, the Northern Arapaho Tribe, Northern Cheyenne Tribal Council, Cheyenne-Arapaho Tribes of Oklahoma, the Southern Ute Indian Tribe, Ute Mountain Tribe, and their associated Tribal Historic Preservation Officers responded and expressed interest in providing input and participating in all phases of the Moffat Project. An offer was made to these Tribes to act as concurring parties to the Programmatic Agreement (PA) in 2009 (refer to Appendix L). Completion of consultation with these tribes will be accomplished before the PA is formalized.

The remaining tribes have not yet formally indicated an interest in participating in consultation for this undertaking, but they may do so at any time during the NEPA review process. Specific concerns and/or issues raised by a consulting tribe would be addressed as they arise, as appropriate. Each tribe would continue to receive information about the Moffat Project as it becomes available, and every opportunity would be taken to involve interested tribes in the planning and Project development process. In so doing, the Corps is taking proactive measures to fulfill their legal obligations for tribal consultation under Federal law.

Area of Potential Effects

For historic and archeological resources, the study area is termed the APE for direct Project effects. This area was determined through meetings and discussions with SHPO and other interested parties. The APE for the proposed reservoir sites includes the area to be affected by construction activities and the largest proposed pool levels, plus a 100-foot buffer zone. These areas were intensively surveyed for cultural resources, with the exception of a portion of the Leyden Gulch site for which permission to access was not obtained. The APE for indirect Project effects differs slightly from the APE for direct Project effects. Indirect effects include visual, auditory, or atmospheric elements that might substantially diminish those aspects that qualify a cultural resource for listing in the NRHP; whereas direct effects include effects caused by ground disturbance resulting from construction activities or activities associated with operation of the Project. A reconnaissance survey for potential historic standing structures that could be affected by the proposed reservoirs or reservoir expansion was conducted to assess indirect Project effects. The APE for Conduits M and O and the South Platte River Facilities is defined and searched by the legal sections in which these facilities are located. Additionally, a file search and literature review were conducted to assess the potential for the Denver Basin Aquifer Facilities to affect cultural resources. A search of the SHPO database was performed in 2006 to identify any cultural resources directly affected by the proposed well sites and their associated pipeline distribution systems. The direct APE was confined to the parks where the well sites would

be located and the representative streets where the pipelines would be constructed. Historically significant parks and parkways that intersect the pipelines or the wells were identified through the SHPO database. The parks not previously recorded as a cultural resource were researched to obtain their possible significance as a historic resource.

Paleontological Resources

Paleontological resources occur in many geologic formations located within the Project area. These formations can be ranked to indicate the likelihood of significant fossil occurrence.

- Class I areas are those that are known or are likely to produce abundant significant fossils that are vulnerable to surface disturbing activities.
- Class II areas are those that show evidence of fossils but are unlikely to produce abundant significant fossils.
- Class III areas are those that are unlikely to produce fossils.

Procedures that are followed to provide paleontological clearance for implementation of an alternative are driven by these classifications. A paleontological survey prior to ground disturbing activities may be recommended for Class I areas. Although surveys would not be required for Class II or Class III areas, mitigation measures may be taken to protect any significant fossil discoveries.

3.18.1 Reservoirs

3.18.1.1 Gross Reservoir

In 1997, an intensive cultural resources inventory was conducted within the Federal Energy Regulatory Commission (FERC) license boundary for Gross Reservoir. This inventory was conducted for the Board of Water Commissioners (Denver Water) as required for their application for renewal of the FERC hydroelectric license for the reservoir (Denver Water 1998b).

The previously recorded resources at the Gross Reservoir site include six sites and five isolated finds (IFs). IFs consist of single artifacts or features, such as pottery sherds, projectile points (e.g., arrowheads), pieces of glass, and prospector pits. The sites are all historic, including two railroad tunnels on the Denver & Rio Grande Railroad, the community of Miramonte, the Resumption Flume, a sheltered site, and a mine. The IFs include one prehistoric utilized flake and four historic prospect pits. Only the railroad tunnels have been assigned an age range, having been built during the early twentieth century. The other three sites and all of the IFs lack temporally diagnostic artifacts or features. The Resumption Flume (5BL7019.1) and one of the railroad tunnels (5BL455.2) have been officially determined eligible for listing in the NRHP. The Miramonte site (5BL5796) requires additional data before its eligibility can be evaluated, while the other three sites and all of the IFs are either officially not eligible or field not eligible. With the exception of the sites that have been determined not eligible for the NRHP, these sites are listed in Table 3.18-1.

Table 3.18-1
Previously Recorded Sites in the Gross Reservoir APE

Site Number	Description	Eligibility
5BL455.2	Denver & Rio Grande Western Railroad Tunnel	Officially Eligible
5BL5796	Miramonte (32179, 32185, 32189, 32191, and 32193 Coal Creek Canyon Drive)	Field Needs Data
5BL7019.1	Resumption Flume	Officially Eligible
5GL56	Tunnel 26	Field Not Eligible

Notes:
Refer to the Glossary for a definition of eligibility determinations.
APE = Area of Potential Effects

In 2005, URS Corporation (URS) conducted additional intensive cultural resources inventories of the areas of the proposed reservoir expansion that extended outside the area that was surveyed in 1997. A report on this inventory was submitted by the Corps to the SHPO (URS 2006) and to any American Indian Tribes that requested a copy. In a letter dated January 12, 2007, the SHPO concurred with the Corps' determinations of eligibility for the resources documented during this survey. This inventory resulted in the documentation of three new IFs and three new sites. The IFs are prospector pits that represent the ubiquitous historic use of this area for mineral exploration and extraction. Two of the sites, 5BL10208 and 5BL10209, also represent this activity and consist of adits, prospector pits, and tailing piles. The third site, 5BL10210, is the dam and reservoir, along with associated construction features and access roads, which has reached an age of 50 years old since the 1997 survey. Generally, properties eligible for listing in the NRHP are at least 50 years old. Of these IFs and sites, only 5BL10210 is considered eligible for listing in the NRHP under criteria a and c, because it represents the development of a significant trans-mountain water project in Colorado and it is associated with David Moffat, one of Colorado's most important financiers and industrialists. Table 3.18-2 provides a list of the sites and IFs that were documented during that survey and their NRHP eligibility determinations.

Table 3.18-2
Newly Recorded Cultural Resources in the Gross Reservoir APE

Site Number	Description	Eligibility
IFs		
5BL10205	Prospector Pits	Officially Not Eligible
5BL10206	Prospector Pit	Officially Not Eligible
5BL10207	Prospector Pit	Officially Not Eligible
Sites		
5BL10208	Mining Site (Adit, Pit, and Tailings)	Officially Not Eligible
5BL10209	Mining Site (Adit, Pit, and Tailings)	Officially Not Eligible
5BL10210	Gross Dam, Reservoir, Construction Features, Access Roads	Officially Eligible

Notes:
Refer to the Glossary for a definition of eligibility determinations.
APE = Area of Potential Effects
IF = Isolated Find

Paleontological Resources

Bedrock in the Gross Reservoir study area consists almost entirely of Precambrian Boulder Creek Granite. The granite is pink, medium to coarse grained, hard, and strong intrusive igneous rock that crops out over large areas at the site. Boulder Creek Canyon has nearly vertical cliffs hundreds of feet high composed of the granite. Paleontological potential for these types of geologic deposits is rated as Class III.

3.18.1.2 Leyden Gulch Reservoir Site

According to the files maintained by the Office of Archaeology and Historic Preservation (OAHP) at History Colorado, nine previous cultural resources surveys were conducted in the vicinity of the Leyden Gulch site. Four of these were conducted by the Colorado Department of Transportation (CDOT) for highway improvements, four were of open space parcels, and one was for a pipeline replacement project. Twelve previously recorded sites are located in the APE. Of these 12 sites, two sites are considered eligible for listing in the NRHP, eight sites are considered not eligible, one site needs additional data, and one site is unevaluated (see Table 3.18-3). The eligible sites include the South Boulder Diversion Conduit (5JF516), a segment of which is in the Project area (5JF516.2) but does not support the eligibility of the larger linear resource, and the Brooks Stone Circle Site (5JF3195). The Lindsay Ranch Site (5JF11) has not been evaluated, and more data are needed to evaluate a historic clay mine (5JF2401).

Table 3.18-3
Previously Recorded Cultural Resources in the Leyden Gulch Site APE

Site Number	Description	Eligibility
5JF11	Lindsay Ranch Site	Not Evaluated
5JF314	Independence Mine	Field Not Eligible
5JF318	South Boulder Canal	Officially Not Eligible
5JF367	Isolated Hearth	Field Not Eligible
5JF368	Isolated Open Camp	Field Not Eligible
5JF516	South Boulder Diversion Conduit	Officially Eligible
5JF516.2	South Boulder Diversion Conduit	Does Not Support Eligibility
5JF525	Unknown	Officially Not Eligible
5JF1242	Isolated Chert Flake	Field Not Eligible
5JF1246	Isolated Prospect Pits	Field Not Eligible
5JF2402	Clay Mine	Field Needs Data
5JF3195	The Brookes Stone Circle Site	Officially Eligible

Notes:
Refer to the Glossary for a definition of eligibility determinations.
APE = Area of Potential Effects

In 2005, URS conducted an intensive survey of the direct APE. A report on this inventory was submitted by the Corps to the SHPO in 2006 and revised in 2007 (URS 2007). In a letter dated January 12, 2007, the SHPO concurred with some of the Corps' determinations of eligibility for the resources documented during this survey, but requested additional information concerning several other resources. The Corps provided this additional information on April 4, 2007, and the SHPO replied in a letter dated May 8, 2007.

Table 3.18-4 provides a list of the sites and IFs that were documented during that survey and their NRHP eligibility determinations.

Table 3.18-4
Newly Recorded Cultural Resources in the Leyden Gulch Site APE

Site Number	Description	Eligibility
IFs		
5JF4298	Purple Glass	Officially Not Eligible
5JF4299	Wood/Sheet Metal Item	Officially Not Eligible
5JF4300	Benchmark 1952	Officially Not Eligible
5JF4301	Flake	Officially Not Eligible
5JF4302	Coke Bottle	Officially Not Eligible
5JF4303	Furrower	Officially Not Eligible
5JF4306	Cable, Wagon Parts, Barbed Wire	Officially Not Eligible
5JF4307	Cadastral Benchmark	Officially Not Eligible
5JF4391	Possible Developed Spring	Officially Not Eligible
5JF4392	Concrete Slab	Officially Not Eligible
5JF4393	Soil Test Pit/Borrow Pit	Officially Not Eligible
5JF4394	Soil Test Pit/Borrow Pit	Officially Not Eligible
5JF4395	Soil Test Pit/Borrow Pit	Officially Not Eligible
Sites		
5JF2224.3	Clear Creek-Ralston Canal	Officially Eligible
5JF2346.4	Denver Northwestern & Pacific Railroad (Union Pacific)	Officially Eligible
5JF2346.8	Rocky Spur	Officially Eligible
5JF4297.1	State Highway 93/Foothills Road	Eligible
5JF4304	Rock Circle	Officially Eligible
5JF4305	Rock Circle	Officially Eligible
5JF4308	Stone Circles	Officially Eligible
5JF4309	Stone Corral and Artifacts and Tie Downs	Officially Eligible
5JF4310	Dam	Officially Not Eligible
5JF4311	Collapsed Shed	Officially Not Eligible
5JF4312	Loafing Shed	Officially Not Eligible
5JF4313	Pond/Spring	Officially Not Eligible
5JF4314	Stone Circle	Officially Eligible
5JF4315	Stone Square	Officially Eligible
5JF4316	Stock Pond and Stove	Officially Not Eligible
5JF4317	Loafing Fence	Officially Not Eligible
5JF4318	Trash Scatter	Officially Eligible
5JF4319	Tailings Pile	Officially Not Eligible
5JF4320	Stone Foundation	Officially Eligible
5JF4321	Clay Mine	Officially Eligible
5JF4363.1	Wagon Road	Officially Eligible
5JF4396	Ralston Dam and Reservoir Construction Camp/Artifact Concentration	Officially Not Eligible
5JF4397	Ralston Dam and Reservoir Construction Camp/Foundations and Artifacts	Officially Not Eligible

Table 3.18-4 (continued)
Newly Recorded Cultural Resources in the Leyden Gulch Site APE

Site Number	Description	Eligibility
5JF4398	Clay Mine	Eligible
5JF4399.1	Ralston Reservoir's Auxiliary Spillway	Officially Eligible

Notes:
Refer to the Glossary for a definition of eligibility determinations.
APE = Area of Potential Effects
IF = Isolated Find

Paleontological Resources

Bedrock at the Leyden Gulch site consists of shale and sandstone of the Pierre Shale Formation. Paleontological potential for the Pierre Shale is rated as Class I.

3.18.2 Conveyance Systems

According to the files maintained by the OAHP, 27 previous cultural resources surveys were conducted in the vicinity of the proposed corridors for Conduits M and O. Twenty-two of these were conducted by CDOT for highway improvements, three were for unknown purposes, one was a historic buildings survey, and one was for a pipeline replacement project. Because of these surveys and other activities, approximately 159 cultural resources were recorded in the vicinity of the both conduits. Of the total 159 resources, the ones determined officially not eligible for the NRHP have been removed from this discussion. The remaining cultural resources located within the conduit corridors are listed in Table 3.18-5 and Table 3.18-6.

3.18.2.1 Conduit M

Table 3.18-5 summarizes the cultural resources within the Conduit M corridor, excluding those that have been determined officially not eligible for the NRHP.

Table 3.18-5
Previously Recorded Sites within the Conduit M APE

Site No.	Name	Description	Address	Eligibility
5AM73	No Name Recorded	Agricultural Complex	7151 N. Washington St., Adams County	No Determination
5AM125	Riverside Cemetery	Cemetery	5201 Brighton Blvd., Commerce City	Listed in NRHP
5AM442	Harris Park School Westminster Grade School Despain Sr., Pleasant Schoolhouse and Educational Center	School	7200 Lowell Blvd., Westminster	Listed in NRHP

Table 3.18-5 (continued)
Previously Recorded Sites within the Conduit M APE

Site No.	Name	Description	Address	Eligibility
5AM895	Union High School/ Westminster Junior High School/Alternative Center for Education	School	3455 West 72nd Ave., Westminster	Listed in NRHP
5AM1292	Gardner Ditch Heller Ditch	Gardner Ditch	No Address Available	Officially eligible
5AM1297.1	Burlington Northern and Santa Fe Railroad	Burlington Northern Santa Fe Railroad	No Address Available	Officially eligible
5AM1321.1	Sand Creek Railroad Junction, Union Pacific Railroad	Union Pacific Railroad	No Address Available	Officially eligible
5AM1538.1	No Name Recorded	Railroad	No Address Available	Officially eligible
5AM.1760.1	Denver Boulder Turnpike/ U.S. Highway 36	Highway	No Address Available	Field Needs Data
5DV4	No Name Recorded	Archaeological	No Address Available	No Determination
5DV1535	No Name Recorded	Building	4965 Clayton St., Denver	Field Needs Data
5DV4371	No Name Recorded	Building	4956 Clayton St., Denver	Field Not Eligible
5JF11	Lindsay Ranch Site	Prehistoric Archaeology/ Architecture	No Address Available	No Determination
5JF102	No Name Recorded	Historic Archaeology/ Homestead	No Address Available	Field Not Eligible
5JF104	No Name Recorded	Artesian Well/Barn/ Privy	No Address Available	Field Not Eligible
5JF416	Belgin Cemetery	Cemetery	7845 Simms St., Arvada	Field Not Eligible
5JF516	South Boulder Diversion Conduit	Irrigation Ditch	No Address Available	Officially Eligible
5JF516.2	South Boulder Diversion Conduit	Irrigation Ditch	No Address Available	Non-Contributing Segment/Officially Eligible
5JF1713	Enterprise Grange #25 Fremont Grange No. 181 Enterprise Grange Hall	Grange	7203 Simms St., Arvada	Listed in the State Register
5JF2209	No Name Recorded	House	8001 Alkire St., Arvada	No Determination
5JF2346.6	Denver Northwestern & Pacific/Denver Salt Lake/ Denver Rio Grande Western/ Southern Pacific/Union Pacific Railroad	Railroad	No Address Available	Officially Eligible

Table 3.18-5 (continued)
Previously Recorded Sites within the Conduit M APE

Site No.	Name	Description	Address	Eligibility
5JF2346.7	Denver Northwestern & Pacific/Denver Salt Lake/ Denver Rio Grande Western/ Southern Pacific/Union Pacific Railroad	Railroad	No Address Available	Officially Eligible
5JF2662	Leyden Union Sunday School Leyden Community Hall	Building	8183 3rd Ave., Arvada	Field Not Eligible
5JF2669	Leyden School	School	16455 W. 82nd Ave., Arvada	Field Not Eligible
5JF2689	McFadden/Moore Farm Moore Farm	Agricultural Complex	12429 W. 72nd Ave., Arvada	Field Not Eligible
5JF2699	Frank Ullman House Linn Property Would Residence	House	13900 W. 80th Ave., Arvada	Field Not Eligible
5JF2780	Leyden Coal Company Workers' Residence Sandusky Residence	House	8180 3rd Ave., Arvada	Field Not Eligible
5JF4336	Dudley C. Shoenberg Memorial Farm	Agricultural Complex	7255, 7201, 7225 Sheridan Blvd., Westminster	No Determination

Notes:
Refer to the Glossary for a definition of eligibility determinations.
APE = Area of Potential Effects

Paleontological Resources

Geologic materials along Conduit M consist almost entirely of alluvial and soil deposits. A large portion of the corridor is located in Slocum, Verdos, and Rocky Flats alluvium, consisting of sand and gravel with some interbedded silt and clay. A portion of Conduit M contains a cover of surficial soil deposits including loess, eolian sand, and colluvium. Paleontological potential for these types of geologic deposits is rated as Class III.

3.18.2.2 Conduit O

Table 3.18-6 summarizes the cultural resources within the Conduit O corridor, excluding those that have been determined officially not eligible for the NRHP.

Table 3.18-6
Previously Recorded Sites within the Conduit O APE

Site No.	Name	Description	Address	Eligibility
5AM3	Hazeltine Heights Site	Burial-Ossuary	No Address Available	No Determination
5AM23	Brighton Senior Center/ Water Utility/Brighton Town Hall	Building	575 Bush St., Brighton	Officially Eligible and State Register Eligible
5AM30	Great Western Sugar	Sugar Beet Refinery	601 Main St., Brighton	Officially Eligible
5AM31	Boulder Valley Railroad	Railroad Crossing	No Address Available	Field Not Eligible
5AM33	Brighton Depot	Terminal-Depot	269 Bridge St., Brighton	Field Eligible
5AM39	No Name Recorded	Prehistoric Open Camp	No Address Available	No Determination
5AM42	No Name Recorded	Prehistoric Open Camp/Hearth	No Address Available	No Determination
5AM43	No Name Recorded	Prehistoric Open Camp	No Address Available	No Determination
5AM65	First Presbyterian Church/ Brighton First Presbyterian Church (1886)	Church	147 South 1st Ave., Brighton	Officially Eligible and Listed on State Register
5AM67	Westminster University/ Belleview College	School	3455 West 83rd Ave., Westminster	Listed on NRHP
5AM80.1	Lower Clear Creek Canal	Irrigation Ditch	No Address Available	Officially Eligible
5AM82	Wehrman's Garage	Gas-Service Station	5 South 1st Ave., Brighton	Officially Eligible
5AM83	No Name Recorded	Commercial Building	107-117 Bridge St., Brighton	Field Not Eligible
5AM84	No Name Recorded	Commercial Building	164 Bridge St., Brighton	Field Not Eligible
5AM85	Carmichael Building	Commercial Building	168-172 Bridge St., Brighton	Field Not Eligible
5AM86	Lehrman Mercantile	Commercial Building	176-180 Bridge St., Brighton	Field Not Eligible
5AM87	Hunter Hardware	Commercial Building	177 Bridge St., Brighton	Field Not Eligible
5AM88	No Name Recorded	Commercial Building	234 Bridge St., Brighton	Field Not Eligible
5AM89	Gordon Hotel	Commercial Building/Hotel	236-244 Bridge St., Brighton	Field Eligible
5AM90	No Name Recorded	Commercial Building	274-284 Bridge St., Brighton	Field Not Eligible
5AM91	No Name Recorded	Commercial Building	300-348 Bridge St., Brighton	Field Not Eligible
5AM92	Adams County Courthouse/Brighton City Hall	Courthouse Building	22 South 4th Ave., Brighton	Officially Eligible

Table 3.18-6 (continued)
Previously Recorded Sites within the Conduit O APE

Site No.	Name	Description	Address	Eligibility
5AM93	First National Bank	Banking Institution	5 North Main St., Brighton	Field Not Eligible
5AM94	Leffingwell Building	Commercial Building	8 North Main St., Brighton	Field Eligible
5AM95	Fulmer Saloon	Saloon/Bar	12 North Main St., Brighton	Field Not Eligible
5AM96	Reuter Building	Commercial Building	14-16 North Main St., Brighton	Field Not Eligible
5AM97	Longen Drugs	Commercial Building	15 North Main St., Brighton	Field Not Eligible
5AM98	Dreyer Building	Commercial Building	18-20 North Main St., Brighton	Field Not Eligible
5AM99	Higgins Saloon	Saloon/Bar	24 North Main St., Brighton	Field Not Eligible
5AM100	J.C. Penny Company	Department Store	25 North Main St., Brighton	Field Not Eligible
5AM101	Schloos Clothing	Commercial Building	29 North Main St., Brighton	Field Not Eligible
5AM102	Public Service Company	Commercial Building	33 North Main St., Brighton	Field Not Eligible
5AM103	Eaton Sam General Store	General Store	39 North Main St., Brighton	Field Not Eligible
5AM104	Bank of Brighton	Banking Institution	43 North Main St., Brighton	Field Not Eligible
5AM106	Elks Lodge/Farmers State Bank	Theatre/Banking Institution	101 North Main St., Brighton	Field Eligible
5AM107	Homann Building	Commercial Building	117 North Main St., Brighton	Field Not Eligible
5AM108	The Alley	Restaurant	119 North Main St., Brighton	Field Not Eligible
5AM109	Shirley Café	Restaurant	121 North Main St., Brighton	Field Not Eligible
5AM110	Brighton Rec	Commercial Building	122 North Main St., Brighton	Field Not Eligible
5AM111	Brighton Discount	Commercial Building	123 North Main St., Brighton	Field Not Eligible
5AM112	Jam Bar	Saloon/Bar	124-126 North Main St., Brighton	Field Not Eligible
5AM113	Jam Bar 2	Saloon/Bar	130 North Main St., Brighton	Field Not Eligible
5AM114	Brighton Blade/ Rave-Krambecks	Publishing Building	139 North Main St., Brighton	Field Not Eligible
5AM115	Mor Value Stamp Company	Commercial Building	147 North Main St., Brighton	Field Not Eligible

Table 3.18-6 (continued)
Previously Recorded Sites within the Conduit O APE

Site No.	Name	Description	Address	Eligibility
5AM116	VFW Hall	Theatre	161 North Main St., Brighton	Field Not Eligible
5AM117	Freidman's	Grocery Store/ Supermarket	115 Strong St., Brighton	Field Not Eligible
5AM118	Moore's Saloon	Saloon/Bar	118 Strong St., Brighton	Field Not Eligible
5AM120	State Armory	Armory	300 Strong St., Brighton	Field Eligible
5AM121	Elkhorn Ranch	Agricultural Complex	No Address Available	No Determination
5AM127	Hughes Stage Station	Stage Stop	No Address Available	Field Needs Data
5AM133	Pleasant Plains School	School	East 144th Ave. and Potomac St., Brighton	Field Not Eligible
5AM134	Wolpert Cemetery/ United Brethren Cemetery	Cemetery (No Buildings)	124th Ave. and U.S. Highway 85, Brighton	No Determination
5AM138	Black Methodist Episcopal Cemetery/ Blundell Cemetery	Cemetery (No Buildings)	No Address Available	Field Not Eligible
5AM144	Dumont Fish Hatchery/ State Fish Hatchery	Fish Hatchery	6100 East 89th Ave.	Field Eligible
5AM189	James' Barn	Corral	8500 Steele St., Thornton	No Determination
5AM190	Brighton Ice/Light		North 5th Ave., Brighton	No Determination
5AM226	Stage Stop	House	12701 Brighton Rd., Brighton	Field Not Eligible
5AM258	Baseline Bridge	Bridge	City Road 168 and Baseline, Brighton	Officially Eligible
5AM260	No Name Recorded	House	142 North 4th Ave., Brighton	Officially Eligible
5AM442	Harris Park School Westminster Grade School, Despain Sr., Pleasant Schoolhouse, and Educational Center	School	7200 Lowell Blvd., Westminster	Listed on NRHP
5AM459.2	Denver Pacific Railroad/ Union Pacific Railroad	Railroad	No Address Available	Officially Eligible
5AM460.2	Fulton Ditch	Irrigation Ditch	No Address Available	Officially Eligible
5AM474.2	Brantner Ditch	Irrigation Ditch	No Address Available	Officially Eligible
5AM478	Boxcar (Adam's Aggregate)	Box Car	No Address Available	Field Not Eligible

Table 3.18-6 (continued)
Previously Recorded Sites within the Conduit O APE

Site No.	Name	Description	Address	Eligibility
5AM580	Brighton High School/ North Junior High School/ Brighton Heritage Academy	School	830 Bridge St., Brighton	Listed on NRHP/ Listed on State Register
5AM895	Union High School/ Westminster Junior High School/Alternative Center for Education	School	3455 West 72nd Ave., Westminster	Listed on NRHP
5AM899	William J. Gregory House	House	8140 Lowell Blvd., Westminster	Listed on NRHP/Listed on State Register
5AM902	William E. Sherart K/2 Farm/Standley Scott Farm	Agricultural Complex	14140 Brighton Rd., Brighton	Centennial Farm
5AM1238	Dickson Farm/Bromely Farm/Allen and Durland Farm	Single Dwelling	12855 Nome St., Brighton	Officially Eligible to the State Register
5AM1546	No Name Recorded	Historic Archaeology	No Address Available	Field Not Eligible
5AM1547	No Name Recorded	Historic Archaeology	No Address Available	Field Not Eligible
5AM1760.1	Denver Boulder Turnpike/ U.S. Highway 36	Highway	No Address Available	Field Needs Data
5JF11	Lindsay Ranch Site	Prehistoric Archaeology/ Architecture	No Address Available	No Determination
5JF102	No Name Recorded	Historic Archaeology/ Homestead	No Address Available	Field Not Eligible
5JF104	No Name Recorded	Artesian Well/Barn/ Privy	No Address Available	Field Not Eligible
5JF416	Belgin Cemetery	Cemetery	7845 Simms St., Arvada	Field Not Eligible
5JF516	South Boulder Diversion Conduit	Irrigation Ditch	No Address Available	Officially Eligible
5JF516.2	South Boulder Diversion Conduit	Irrigation Ditch	No Address Available	Non-Contributing Segment/Officially Eligible
5JF1713	Enterprise Grange #25 Fremont Grange No. 181/Enterprise Grange Hall	Grange	7203 Simms St., Arvada	Listed on the State Register
5JF2209	No Name Recorded	House	8001 Alkire St., Arvada	No Determination

Table 3.18-6 (continued)
Previously Recorded Sites within the Conduit O APE

Site No.	Name	Description	Address	Eligibility
5JF2346.6	Denver Northwestern & Pacific/Denver Salt Lake/ Denver Rio Grande Western/ Southern Pacific/ Union Pacific Railroad	Railroad	No Address Available	Officially Eligible
5JF2346.7	Denver Northwestern & Pacific/Denver Salt Lake/ Denver Rio Grande Western/ Southern Pacific/Union Pacific Railroad	Railroad	No Address Available	Officially Eligible
5JF2662	Leyden Union Sunday School Leyden Community Hall	Building	8183 3rd Ave., Arvada	Field Not Eligible
5JF2669	Leyden School	School	16455 W. 82nd Ave., Arvada	Field Not Eligible
5JF2689	McFadden/Moore Farm Moore Farm	Agricultural Complex	12429 W. 72nd Ave., Arvada	Field Not Eligible
5JF2699	Frank Ullman House Linn Property Would Residence	House	13900 W. 80th Ave., Arvada	Field Not Eligible
5JF2780	Leyden Coal Company Workers' Residence Sandusky Residence	House	8180 3rd Ave., Arvada	Field Not Eligible
5JF4336	Dudley C. Shoenberg Memorial Farm	Agricultural Complex	7255, 7201, 7225 Sheridan Blvd., Westminster	No Determination
5WL751	Boulder Valley Railroad	Grade Crossing	No Address Available	Field Not Eligible
5WL1413	No Name Recorded	Agricultural Complex	Road 23 ½	Field Eligible

Notes:
Refer to the Glossary for a definition of eligibility determinations.
APE = Area of Potential Effects

Paleontological Resources

Geologic materials along the Conduit O alignment consist almost entirely of alluvial and soil deposits. Some relatively short intervals of Conduit O contain a cover of surficial soil deposits including loess, eolian sand, and colluvium. In the South Platte River valley, Conduit O is underlain by recent alluvium consisting of sand and gravel with some interbedded silt and clay. Bedrock, consisting of sandstone and conglomerate with interbedded shale and claystone, does not crop out along Conduit O; however, bedrock may be encountered in excavations that extend below alluvium and soils. Paleontological potential for these types of geologic deposits is rated as Class III.

3.18.3 South Platte River Facilities

According to the files maintained by the OAHP, 10 cultural resources sites were found in the APE of the South Platte River Facilities. With the exception of the sites that have been determined not eligible for the NRHP, these sites are listed in Table 3.18-7.

Table 3.18-7
Previously Recorded Sites in the South Platte River Facilities APE

Site No.	Name	Description	Address	Eligibility
5AM121	Elkhorn Ranch	Agricultural Complex	No Address Available	No Determination
5AM1238	Dickson Farm Bromley Farm Allen and Durland Farm	House	12855 Nome Street, Brighton	Officially Eligible for the State Register
5AM31	Boulder Valley Railroad	Railroad Crossing	No Address Available	Field Not Eligible
5AM478	Boxcar (Adams Aggregate)	Boxcar	Brighton	Field Not eligible
5WL751	Boulder Valley Railroad	Grade Crossing	No Address Available	Field Not Eligible
5WL1413	No Name Recorded	Agricultural Complex	Road 23 ½	Field Eligible

Notes:
Refer to the Glossary for a definition of eligibility determinations.
APE = Area of Potential Effects

Paleontological Resources

Geologic materials along the South Platte River valley consist almost entirely of alluvium and soil deposits. In the South Platte River valley bottom, the diversion and gravel pit sites are underlain by recent alluvium consisting of sand and gravel with some interbedded silt and clay. Paleontological potential for these types of geologic deposits is rated as Class III.

3.18.4 Denver Basin Aquifer Facilities

Wells would be located such that they would not impact cultural resources in the City and County of Denver. A list of the significant historic parks and parkways in the vicinity of the wells and their associated pipeline distribution system are listed in Table 3.18-8.

Table 3.18-8
Sites Recorded in the Denver Basin Aquifer Storage and Recovery APE

Site No.	Name	Description	Eligibility
5DV50	City Park	Park	Listed in NRHP
5DV5306	Alamo Placita Park	Park	Listed in NRHP
5DV5308	Congress Park	Park	No Determination
5DV5311	City Park Golf Course	Golf Course	Listed in NRHP
5DV5313	Cranmer Park	Park	Listed in NRHP
5DV5320	Highland Park	Park	Listed in NRHP
5DV5333	Washington Park	Park	Listed in NRHP
5DV5339	Sloan’s Lake Park	Park	Field Needs Data

Table 3.18-8 (continued)
Sites Recorded in the Denver Basin Aquifer Storage and Recovery APE

Site No.	Name	Description	Eligibility
None	Crestmoor Park	Park	No Determination
None	Pferdestellar Park	Park	No Determination
None	Ruby Hill Park	Park	No Determination
None	Cook Park	Park	No Determination
None	Park Hill Golf Club	Golf Course	No Determination
None	Burns Park	Park	No Determination
5DV5314	Downing Street	Parkway	Listed in NRHP
5DV5315	East 4th Avenue	Parkway	Listed in NRHP
5DV5316	East 6th Avenue	Parkway	Listed in NRHP
5DV5317	East 7th Avenue	Parkway	Listed in NRHP
5DV5318	East 17th Avenue	Parkway	Listed in NRHP
5DV5323	Monaco Street	Parkway	Listed in NRHP
5DV5325	Montview Boulevard	Parkway	Listed in NRHP
5DV5330	Speer Boulevard	Parkway	Listed in NRHP

Notes:
Refer to the Glossary for a definition of eligibility determinations.
APE = Area of Potential Effects
NRHP = National Register of Historic Places

Paleontological Resources

Much of Denver County, including the potential sites for Denver Basin injection/extraction wells, contains a cover of surficial soil deposits such as loess, eolian sand, and colluvium. In the South Platte River valley and tributary valleys, the potential sites are underlain by recent alluvium consisting of sand and gravel with some interbedded silt and clay. Bedrock of the Denver Formation, consisting of sandstone and conglomerate with interbedded shale and claystone, crops out at small areas in Denver. Paleontological potential for these types of geologic deposits is rated as Class III.

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3.19 SOCIOECONOMICS

3.19.0 Overview

The affected socioeconomic environment within the Moffat Collection System Project (Moffat Project or Project) area is defined by the following areas of potential effects:

- Primary Impact Area (PIA) – The PIA for each project component is that area in which an immediate and direct effect from construction or operation may occur, such as an area of proposed inundation. PIAs generally include areas in the immediate vicinity of facilities proposed for construction or inundation.
- Secondary Impact Area (SIA) – The SIA is the geographic area in which indirect or linked socioeconomic effects resulting from Project component development or operation may occur, such as the larger area from which the construction workforce might be drawn.

PIAs are the immediate areas surrounding component sites, whereas SIAs are generally counties or the Denver Metropolitan area. Table 3.19-1 identifies the PIAs and SIAs by Project component and alternative. All Project-related effects are addressed in Section 5.19 regardless of whether a geographic area is designated as a primary or secondary impact area.

For each PIA and SIA the range of socioeconomic resources are described: demographic characteristics, economic characteristics, public facilities and services, and fiscal resources. Each of these resources has the potential to be affected by the construction or operation of one or more Project components. For example, municipal services may be affected by Project component operations such as the increased amount of construction workers in an area. All dollar figures have been adjusted to reflect constant 2010 dollars.

Socioeconomic information was collected from secondary and primary sources from Federal, State of Colorado, or local governmental entities. U.S. Bureau of Census decennial demographic and economic information is the basis for the PIA and SIA descriptions, since this source is consistent across the Project area and is considered the most accurate information available. Other Federal sources that were referenced include the U.S. Bureau of Labor Statistics for employment data and U.S. Bureau of Economic Analysis for income data. County and metropolitan planning agencies such as the Denver Regional Council of Governments provided socioeconomic information as well. In addition, the study team interviewed individuals responsible for public facilities and services within each PIA and SIA. Cooperation regarding the provision of that information varied, but most jurisdictions provided the necessary information for this report. Fiscal information was obtained from State of Colorado regulatory agencies, coupled with budgets from various jurisdictions.

Table 3.19-1
Socioeconomic Primary and Secondary Impact Areas for Each Project Component and Alternative

Alternative	Component/Primary Impact Area	Secondary Impact Area(s)		
Proposed Action (Alternative 1a) – Gross Reservoir Expansion	Gross Reservoir	Boulder County	Grand County	Denver Metropolitan area
Alternative 1c – Gross Reservoir Expansion with a new Leyden Gulch Reservoir	Gross Reservoir	Boulder County	Grand County	Denver Metropolitan area
	Leyden Gulch Reservoir	Jefferson County	Grand County	Denver Metropolitan area
Alternative 8a – Gross Reservoir Expansion with reusable return flows stored in gravel pits	Gross Reservoir	Boulder County	Grand County	Denver Metropolitan area
	South Platte River Facilities	Adams County	City of Brighton	Denver Metropolitan area
	Conduit O	N/A	N/A	Denver Metropolitan area
Alternative 10a – Gross Reservoir Expansion with deep aquifer storage and recovery	Gross Reservoir	Boulder County	Grand County	Denver Metropolitan area
	Denver Basin Advanced Water Treatment Plant	Adams County	N/A	Denver Metropolitan area
	Denver Basin Aquifer Storage and Recovery System (City and County of Denver)	N/A	N/A	Denver Metropolitan area
	Conduit M	N/A	N/A	Denver Metropolitan area
Alternative 13a – Gross Reservoir Expansion with agricultural water transfer and gravel pit storage	Gross Reservoir	Boulder County	Grand County	Denver Metropolitan area
	South Platte River Facilities	Adams County	City of Brighton	Denver Metropolitan area
	Conduit O	N/A	N/A	Denver Metropolitan area
	Water Rights Acquisition Area	Adams County	Weld County	Denver Metropolitan area

Note:
N/A = not applicable

3.19.1 Reservoirs

3.19.1.1 Gross Reservoir

Definition of the PIA

The PIA for the Gross Reservoir study area includes Gross Reservoir and the surrounding unincorporated areas to the north and south of the reservoir in Boulder County, as shown in Figure 3.19-1.

PIA Demographic Conditions

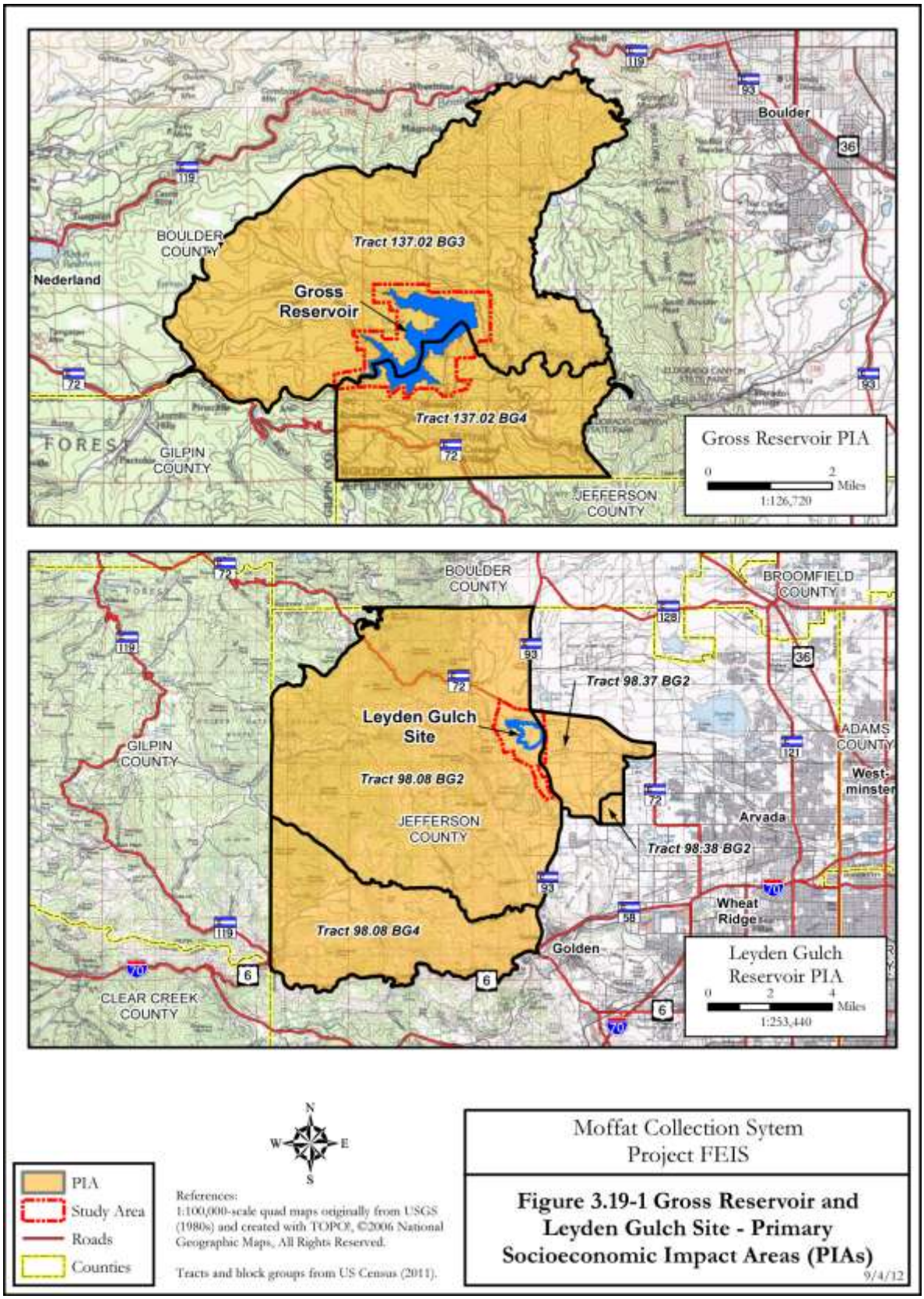
The PIA population contained about 1,700 persons in 2010, a decrease of about 1.7 percent (%) from 2000 (U.S. Census Bureau 2000, 2010a, 2010b). Comparatively, the State population increased by 16.9% between 2000 and 2010 (U.S. Census Bureau 2000, 2010a, 2010b). Whites comprise more than 90% of the PIA population (U.S. Census Bureau 2010a, 2010b). The PIA population exhibited a higher median age than the State average in 2010, almost 46 years for the PIA compared to 36 for the State (U.S. Census Bureau 2010a, 2010b). About two-thirds of PIA residents work within Boulder County (U.S. Census Bureau 2010c).

Of the 981 PIA housing units in 2010, 15% were for seasonal use, causing the vacancy rate to be an abnormally high 21% (U.S. Census Bureau 2010a, 2010b). The median home value in the PIA has grown rapidly since 2000, averaging almost $475,000 during the 2005-2009 period compared to $336,000 in 2000 (U.S. Census Bureau 2005-2009a, 2005-2009b; BLS 1990-2011). Median home values in the PIA were almost double the State average during the 2005-2009 period (U.S. Census Bureau 2005-2009a, 2005-2009b).

PIA Economic Conditions

The Gross Reservoir PIA is an affluent area as compared to the State. Median household income in the PIA averaged about $98,600 between 2005 and 2009, up 13% on a constant dollar basis since 2000 (U.S. Census Bureau 2000, 2005-2009a, 2005-2009b; BLS 1990-2011). Per capita incomes were about 50% higher than the State between 2005 and 2009 (U.S. Census Bureau 2005-2009a, 2005-2009b). PIA income from dividend, interest, rent, and retirement income is also proportionately higher than the State (U.S. Census Bureau 2005-2009a, 2005-2009b). Only 2.3% of PIA families were in poverty between 2005 and 2009, compared to 8.2% throughout the State (U.S. Census Bureau 2005-2009a, 2005-2009b).

Unemployment rates in the PIA are typically lower than for the State. Most of the PIA residents worked in white-collar occupations during the 2005-2009 period. Professional, scientific and management occupations employed the largest number of PIA residents, followed by sales and office occupations (U.S. Census Bureau 2005-2009a, 2005-2009b).


Boulder
BOULDER COUNTY
Nederland
Tract 137.02 BG3
Gross Reservoir
Tract 137.02 BG4
FOREST
GILPIN COUNTY
JEFFERSON COUNTY
Gross Reservoir PIA
0 2 Miles
1:126,720
BOULDER COUNTY
BROOMFIELD COUNTY
Tract 98.37 BG2
Leyden Gulch Site
GILPIN COUNTY
Tract 98.08 BG2
JEFFERSON COUNTY
ADAMS COUNTY
West-minster
Arvada
Tract 98.38 BG2
Wheat Ridge
Tract 98.08 BG4
Golden
CLEAR CREEK COUNTY
Leyden Gulch Reservoir PIA
0 2 4 Miles
1:253,440
N
W
E
S
PIA
Study Area
Roads
Counties
References:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.
Tracts and block groups from US Census (2011).
Moffat Collection Sytem Project FEIS
Figure 3.19-1 Gross Reservoir and Leyden Gulch Site - Primary Socioeconomic Impact Areas (PIAs)
9/4/12

PIA Public Facilities and Services

The PIA is well served with public and private services. Police and fire protection are provided by the Boulder County Sheriff's Office, Coal Creek Volunteer Fire Department, High Country Fire Protection District and Cherryvale Fire Protection District. Health services are provided by Boulder Community Hospital and Boulder Community Foothills Hospital. The PIA is served by the Boulder Valley RE-2 School District. Other service providers include the City of Boulder Public Library system and the Boulder County Household Hazardous Waste Facility. Residents of the PIA use individual septic systems to treat their wastewater. The PIA is not served by municipal or district water systems, rather residents obtain potable water from private wells.

3.19.1.2 Leyden Gulch Reservoir Site

Definition of the PIA

The Leyden Gulch Reservoir site PIA includes the proposed reservoir site, as well as the general area that surrounds the site in northwest Jefferson County. The PIA encompasses rural, unincorporated areas east and west of State Highway (SH) 93, from the Boulder County/Jefferson County line south to the northwestern edge of the City of Golden and includes some areas of the City of Arvada (Figure 3.19-1).

PIA Demographic Conditions

The Leyden Gulch Reservoir site PIA consisted of a mostly White, somewhat older, population of about 5,900 residents in 2010 (U.S. Census Bureau 2010a, 2010b). Between 2000 and 2010, the population increased by about 18%, or 1.7% per year (U.S. Census Bureau 2000, 2010a, 2010b). In 2010, about 91% of the population was White, non-Hispanic, compared with 70% Statewide (U.S. Census Bureau 2010a, 2010b). The median age in the PIA was almost 44 years, higher than the Statewide median age of about 36 years (U.S. Census Bureau 2010a, 2010b). Almost half of PIA residents work outside Jefferson County (U.S. Census Bureau 2010c).

The Leyden Gulch Reservoir site PIA includes about 2,200 housing units, about 2% of which are seasonal units (U.S. Census Bureau 2010a, 2010b). In 2010, the PIA had a housing vacancy rate of 4.4%, which was less than the Colorado average (U.S. Census Bureau 2010a, 2010b). The median home value in the PIA grew 23%, excluding inflationary effects, between 2000 and the 2005-2009 period (U.S. Census Bureau 2000, 2005-2009a, 2005-2009b; BLS 1990-2011). The median home value in the PIA averaged $510,000 between 2005 and 2009, more than double the State average during that period (U.S. Census Bureau 2005-2009a, 2005-2009b).

PIA Economic Conditions

PIA residents are generally more affluent than Colorado residents are. Between 2005 and 2009, the median household income in the PIA averaged almost $119,000, more than twice that of Colorado (U.S. Census Bureau 2005-2009a, 2005-2009b). During that period, none of the families living in the PIA was considered to be below the poverty level, compared with 8.2% of families in poverty Statewide (U.S. Census Bureau 2005-2009a, 2005-2009b). PIA unemployment rates have historically been lower than in Colorado. The majority of

PIA residents work in white-collar occupations, including management, professional, sales, office and related occupations. Consistent with these occupations, employment is concentrated in manufacturing, scientific, educational and healthcare industries (U.S. Census Bureau 2005-2009a, 2005-2009b).

PIA Public Facilities and Services

The Jefferson County Sheriff's Office, the Arvada Police Department and the Arvada Fire Department provide police and fire protection services to PIA residents. The Jefferson County Department of Health operates a health clinic in Arvada, and the Boulder Community Hospital and Exempla Lutheran Medical Center are nearby. The Jefferson County Public Library includes branches in Arvada and Golden. The City of Arvada provides treated potable water and wastewater services to many PIA residents while others have private wells and septic tanks. The BFI Foothills Landfill is located within the PIA and serves PIA residents as well as other residents in surrounding areas. The Jefferson County R-1 school district serves the PIA. These service providers offer adequate services to the Leyden Gulch site PIA residents.

3.19.2 Conveyance Systems

3.19.2.1 Conduit M

Definition of the PIA

The Conduit M PIA is limited to the roadways and utility corridors that the conduit is routed along and consists of a narrow strip of land that runs across Adams and Jefferson Counties. Conduit M would run through the municipalities of Arvada, Commerce City, and Westminster. There are no residential homes or commercial businesses located directly within this PIA. Given this PIA definition, the affected socioeconomic environment is limited to a description of county and municipal road and highway expenditures near Conduit M.

Road and Highway Expenditures

Expenditures on roads and highways in Adams County made up about 10% of total Adams County operating expenditures on average between 2001 and 2008 (DOLA 2001-2008; BLS 1990-2011). In 2007 and 2008, expenditures were $30.3 million and $30.1 million, respectively, higher than in previous years. Expenditures on roads and highways in Jefferson County averaged about 12.2% of total Jefferson County operating expenditures between 2001 and 2008 (DOLA 2001-2008; BLS 1990-2011). The county spent $23.1 million on roads and highways in 2008. In the City of Arvada, road and highway expenditures amounted to $12.0 million in 2008 (DOLA 2001-2008). These expenditures made up 20% of total operating expenditures between 2001 and 2008 (DOLA 2001-2008; BLS 1990-2011). The City of Westminster spent $6.8 million on roads and highways in 2008 and roughly 8.6% of the city's total annual operating expenditures, between 2001 and 2008 (DOLA 2001-2008; BLS 1990-2011). During this same period, road and highway expenditures in Commerce City accounted for 11.5% of total city operating expenditures.

The city spent $4.5 million on roads and highways in 2008 (DOLA 2001-2008; BLS 1990-2011).

3.19.2.2 Conduit O

Definition of the PIA

The Conduit O PIA is limited to the roadways and utility corridors that the conduit is routed along and consists of a narrow strip of land that runs across Adams and Jefferson counties. Conduit O would run through parts of unincorporated Adams County as well as the cities of Arvada, Thornton, and Westminster. There are no residential homes or commercial businesses located directly within this PIA. The definition of the PIA limits the socioeconomic discussion to a description of traffic and transportation patterns along these roadways and an explanation of county and municipal road and highway expenditures near Conduit O.

Road and Highway Expenditures

Expenditures on roads and highways in Adams County made up about 10% of total Adams County operating expenditures on average between 2001 and 2008 (DOLA 2001-2008; BLS 1990-2011). In 2007 and 2008, expenditures were $30.3 million and $30.1 million respectively, higher than in previous years. Expenditures on roads and highways in Jefferson County averaged about 12.2% of total operating expenditures between 2001 and 2008; 2008 expenditures were $23.1 million, lower than in previous years (DOLA 2001-2008; BLS 1990-2011).

In the City of Arvada, road and highway expenditures amounted to $12.0 million in 2008 (DOLA 2001-2008). These expenditures averaged 20% of total operating expenditures between 2001 and 2008 (DOLA 2001-2008; BLS 1990-2011). In Thornton, expenditures on roads and highways were $9.9 million in 2008, and comprised 12.5% of the city's total annual operating expenditures between 2001 and 2008 (DOLA 2001-2008; BLS 1990-2011. The City of Westminster spent $6.8 million on roads and highways in 2008, and an average of roughly 8.6% of total annual operating expenditures between 2001 and 2008 (DOLA 2001-2008; BLS 1990-2011.

3.19.3 South Platte River Facilities

There are two separate PIAs based on components for Alternatives 8a and 13a:

1. South Platte River Facilities (Alternatives 8a and 13a)
2. Water Rights Acquisition Area PIA in Adams and Weld Counties (Alternative 13a)

3.19.3.1 South Platte River Facilities PIA

Definition of the PIA

The South Platte River Facilities PIA includes the area surrounding four potential gravel pit storage sites and a proposed Advanced Water Treatment Plant (AWTP) in northern Adams County. Potential gravel pit storage sites are located in the area north of 120th Avenue, south of SH 7, west of SH 85 and east of the South Platte River. The proposed AWTP

would be located near the Worthing Pit. The PIA includes portions of the City of Brighton as well as areas south and west of Brighton, as shown in Figure 3.19-2.

PIA Demographic Conditions

The PIA is a rapidly growing area, which more than doubled its population between 2000 and 2010, and included about 23,000 residents in 2010 (U.S. Census Bureau 2000, 2010a, 2010b). More than 70% of PIA residents were White, while Hispanic/Latino residents made up about 20% of the total population in 2010; the racial diversity of the PIA was similar to that of the State (U.S. Census Bureau 2010a, 2010b). The median age in the PIA was 34 years, slightly younger than the Statewide median age (U.S. Census Bureau 2010a, 2010b). Just over half of PIA residents work outside Adams County (U.S. Census Bureau 2010c).

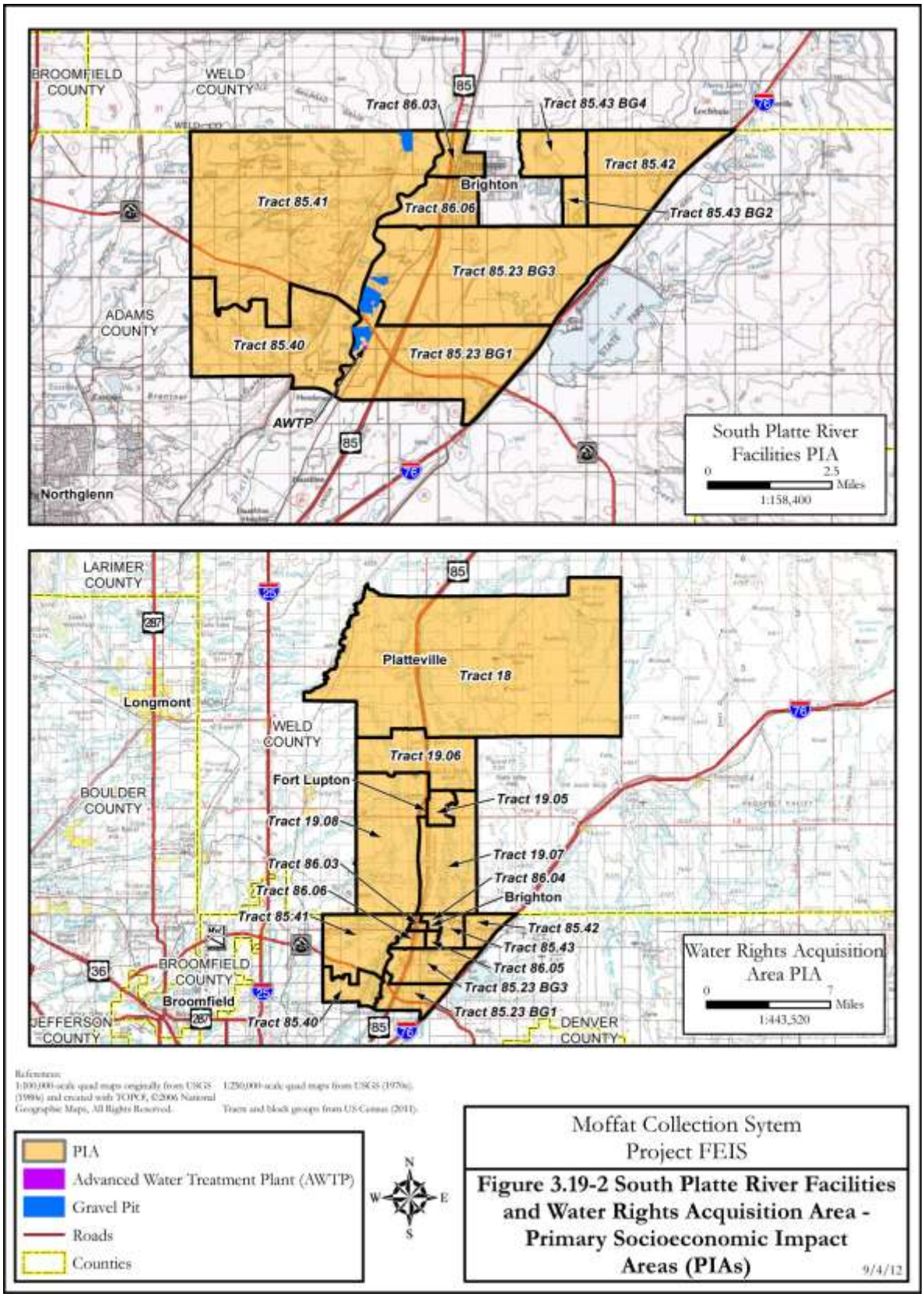
In 2010, the PIA included about 7,800 housing units and the vacancy rate was 4.5%, less than half the Statewide average (U.S. Census Bureau 2010a, 2010b). The median home value in the PIA averaged $304,000 between 2005 and 2009, which was about 25% higher than the comparable Statewide figure (U.S. Census Bureau 2005-2009a, 2005-2009b).

PIA Economic Conditions

The PIA is generally more affluent as compared to the State. Between 2005 and 2009, the median household income in the PIA averaged $91,000, 60% higher than in Colorado, and the per capita income was $30,600, 17% higher than in Colorado (U.S. Census Bureau 2005-2009a, 2005-2009b). Less than 2% of PIA families were considered to be below the poverty level, compared with 8.2% of families in poverty Statewide (U.S. Census Bureau 2005-2009a, 2005-2009b). The unemployment rate in the PIA is generally lower than the Statewide rate. More than 60% of PIA residents worked in management, sales and office occupations. The remaining PIA residents were mostly employed in the construction, professional, scientific, education and health industries (U.S. Census Bureau 2005-2009a, 2005-2009b).

PIA Public Facilities and Services

The City of Brighton Police Department and the Greater Brighton Fire Protection District provide police and fire protection services to PIA residents. The Tri-County Health Department (TCHD) provides services to PIA residents and operates a health clinic in Brighton, and the Platte Valley Medical Center is located in Brighton. The City of Brighton provides treated potable water and wastewater services to PIA residents. No solid waste disposal facilities are located in the PIA; residents use landfills and other facilities located outside of the PIA. The proposed Water Treatment Plant would likely use electricity provided by United Power, located in Brighton. The Brighton 27-J school district provides the PIA with educational services and the Rangeview Library District includes a branch in Brighton that serves PIA residents. All facilities and services provide adequate services to PIA residents except the Library District, which is struggling to keep up with demands.


BROOMFIELD COUNTY
WELD COUNTY
Tract 86.03
Tract 85.43 BG4
Tract 85.42
Brighton
Tract 85.41
Tract 86.06
Tract 85.43 BG2
Tract 85.23 BG3
ADAMS COUNTY
Tract 85.40
Tract 85.23 BG1
AWTP
Northglenn
South Platte River Facilities PIA
0
2.5
Miles
1:158,400
LARIMER COUNTY
Platteville
Tract 18
Longmont
WELD COUNTY
Tract 19.06
Fort Lupton
Tract 19.05
BOULDER COUNTY
Tract 19.08
Tract 19.07
Tract 86.03
Tract 86.04
Tract 86.06
Brighton
Tract 85.41
Tract 85.42
Tract 85.43
Tract 86.05
BROOMFIELD COUNTY
Tract 85.23 BG3
Broomfield
Tract 85.23 BG1
JEFFERSON COUNTY
Tract 85.40
DENVER COUNTY
Water Rights Acquisition Area PIA
0
7
Miles
1:443,520
PIA
Advanced Water Treatment Plant (AWTP)
Gravel Pit
Roads
Counties
N
W
E
S
Moffat Collection Sytem Project FEIS
Figure 3.19-2 South Platte River Facilities and Water Rights Acquisition Area - Primary Socioeconomic Impact Areas (PIAs)
9/4/12

3.19.3.2 Water Rights Acquisition Area

Definition of the PIA

Under Alternative 13a, water rights would be purchased from four ditches in northern Adams and southern Weld counties and stored in the South Platte River Facilities gravel pits. The Water Rights Acquisition Area PIA encompasses the portions of northern Adams County and southern Weld County near these ditches. The PIA includes agricultural land and rural unincorporated areas in both counties as well as several municipalities. The cities of Brighton and Fort Lupton and the Town of Platteville are within the PIA (Figure 3.19-2).

PIA Demographic Conditions

The PIA is a rapidly growing area that experienced average population growth of 4.4% per year between 2000 and 2010 and included over 60,400 people in 2010 (U.S. Census Bureau 2000, 2010a, 2010b). In 2010, non-Hispanic Whites made up about 57% of the PIA population, while Hispanic/Latino residents made up about 38% of the population (U.S. Census Bureau 2010c). The percentage of White residents increased by about 17% and the Hispanic/Latino population decreased slightly from 2000 (U.S. Census Bureau 2000, 2010a, 2010b). The median age in the PIA was 34 years, lower than the Statewide median of 36 years (U.S. Census Bureau 2010a, 2010b). About half the PIA residents commute to other counties for work (U.S. Census Bureau 2010c).

In 2010, the PIA had over 21,000 housing units and a 5.6% housing vacancy rate, less than the Statewide average of 10.8% (U.S. Census Bureau 2010a, 2010b). Between 2005 and 2009, the median home value averaged $232,000, slightly less than Colorado's median home value (U.S. Census Bureau 2005-2009a, 2005-2009b).

PIA Economic Conditions

Between 2005 and 2009, the median household income in the PIA was $67,500, higher than the Colorado median (U.S. Census Bureau 2005-2009a, 2005-2009b). The per capita income, however, was about 11% lower than the Statewide average due to larger PIA household sizes (U.S. Census Bureau 2005-2009a, 2005-2009b). About 8% of PIA families were below the poverty level, similar to the Statewide average (U.S. Census Bureau 2005-2009a, 2005-2009b). PIA unemployment rates have historically been similar to or slightly lower than Colorado rates. About half the PIA population is employed in white-collar occupations and half in blue-collar occupations, such as construction and production. PIA employment is concentrated in educational, health, social services, construction, retail trade and manufacturing industries (U.S. Census Bureau 2005-2009a, 2005-2009b).

PIA Agricultural Conditions

In 2007, Adams County included 895 farms and over 700,000 acres of farmland, including 17,000 irrigated acres (USDA 2007). The average farm size was about 780 acres and farm employment comprised about 1,600 persons. Adams County farmers sold about $153 million worth of agricultural products, including crops and livestock, in 2007, although almost half of all farms had annual sales of less than $2,500.

In 2007, Weld County had more than 3,900 farms and over 2 million acres of farmland, including 328,000 acres of irrigated land (USDA 2007). The average farm size was about 530 acres and farm employment was over 6,100 people. Weld County farmers sold about $1.5 billion worth of agricultural products, including crops and livestock, in 2007.

PIA Public Services and Facilities

The Adams County Sheriff's Department and the Weld County Sheriff's Office provide law enforcement services to unincorporated areas in each county, and the Fort Lupton, Platteville, and City of Brighton Police Departments serve PIA municipalities. The Greater Brighton Fire Protection District, Fort Lupton Fire Protection District, and Platteville-Gilcrest Fire Protection District provide PIA residents with fire protection services. The Platte Valley Medical Center, a full service hospital with a 24-hour emergency department, is located in Brighton and serves PIA residents. The TCHD provides additional health services to Adams County residents and the Weld County Department of Public Health and Environment serves Weld County residents. The Brighton branch of the Rangeview Library District and the Carbon Valley branch of the Weld Library District serve the PIA. Brighton residents obtain their water from the South Platte River and the Beebe Draw, and Fort Lupton and Platteville residents receive water from the Colorado-Big Thompson system. Additionally, some PIA residents receive water from ditches that divert off the South Platte River. Municipalities provide wastewater treatment to many PIA residents and others have individual septic systems. Solid waste generated in the PIA goes to landfills in the Denver area, and there are several composting facilities located within the PIA. The Brighton 27-J school district, Weld RE-3J, Weld RE-8, and Weld RE-1 school districts provide educational services to PIA residents. These facilities and service providers offer adequate services to PIA residents, except for the Rangeview Library District, which struggles to meet demands.

3.19.4 Denver Basin Aquifer Facilities

There are two separate PIAs based on Alternative 10a components:

1. Denver Basin Aquifer Facilities PIA in the City and County of Denver
2. AWTP PIA in Adams County

3.19.4.1 Denver Basin Aquifer Facilities PIA

Definition of the PIA

The Denver Basin Aquifer Facilities includes a water distribution pipeline system and an injection/recovery well field. The pipelines and well sites would be constructed in public locations (e.g., parks and golf courses, and roadways) within the City and County of Denver. Therefore, the PIA for this component is the City and County of Denver.

PIA Demographic Conditions

The population in Denver County grew by less than 1% per year on average between 2000 and 2010, reaching over 600,000 by 2010 (U.S. Census Bureau 2000, 2010a, 2010b). Denver County's population is younger than that of the State at 33.7 years of age (U.S. Census

Bureau 2010a, 2010b). The racial composition of the county remained stable between 2000 and 2010, with White residents making up about 52% of the Denver County population and Hispanic/ Latino residents making up about 32% of the population (U.S. Census Bureau 2000, 2010a, 2010b). Approximately 36% of the employed Denver County residents commute to other counties to work (U.S. Census Bureau 2010a, 2010b). The housing vacancy rate increased slightly in recent years, reaching almost 9% in 2010, but was still lower than the Statewide vacancy rate (U.S. Census Bureau 2010a, 2010b). The county experienced steady growth in median home values, which reached $250,100 in 2010, about 5.4% higher than the State median home value (U.S. Census Bureau 2010a, 2010b).

PIA Economic Conditions

As of 2010, households in Denver County were slightly smaller and generally less affluent as compared to the State. County per capita income grew by about 1% between 2000 and 2010 and was 5% higher than State average in 2010 at over $30,000 (U.S. Census Bureau 2000, 2010a, 2010b; BLS 1990-2011). Unemployment rates in the county almost quadrupled between 2000 and 2010, reaching 11.9% in 2010, more than 2% higher than the State unemployment rate (U.S. Census Bureau 2000, 2010a, 2010b). As of 2010, workers in Denver County were concentrated in white-collar occupations (U.S. Census Bureau 2010a, 2010b). In 2009, there were almost 22,000 business establishments in Denver County (U.S. Census Bureau 2009). At that time, finance and insurance services provided the highest employee compensation, with professional and technical services second in the lead. As of 2007, the professional and technical services sector generated the highest volume of sales with retail trade trailing closely behind (U.S. Census Bureau 2007).

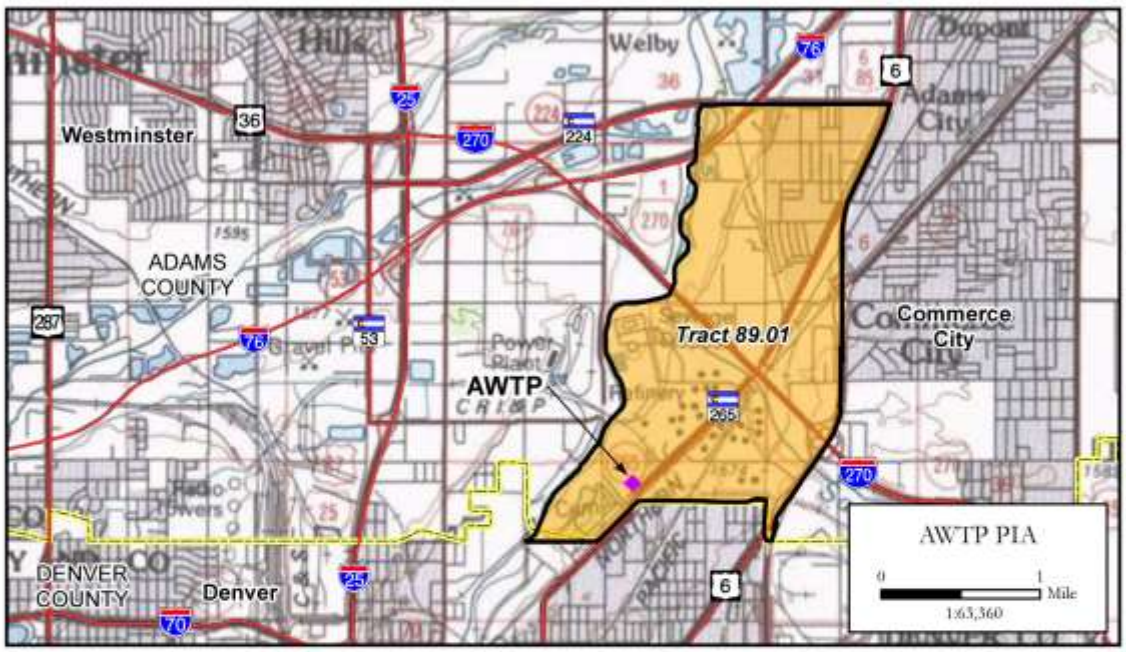
PIA Public Facilities and Services

Denver County receives law enforcement services from the Denver Police Department. The Denver Fire Department provides fire protection services. Denver County is served by eight hospitals, which offer a wide range of medical services. Denver Public Library serves the Denver County residents with a Central Library, 22 branch libraries, and a bookmobile. The Board of Water Commissioners (Denver Water) provides water to city and county residents. Denver's wastewater is treated by the Metro Wastewater Reclamation District Plant, which serves about 1.5 million people in the Denver Metropolitan area. Waste Management brings Denver's solid waste to the Denver-Arapahoe Disposal Site in Arapahoe County, the 6th largest landfill in the country. Denver has a household hazardous waste facility that is located in the county and operated by an outside contractor. The Denver Public School District is responsible for the educational services in the county.

3.19.4.2 Advanced Water Treatment Plant

Definition of the PIA

The AWTP PIA includes the location of a proposed water treatment facility and the surrounding area in southern Adams County. The new plant would be located near Denver Water's existing Water Recycling Plant. The PIA includes the area west of Brighton Boulevard, southwest of Interstate 270 and north of the Denver County/Adams County line. The PIA is generally an industrial area and includes the westernmost section of Commerce City (Figure 3.19-3).



References:
1:100,000-scale quad maps originally from USGS (1980s) and created with TOPO!, ©2006 National Geographic Maps, All Rights Reserved.

Tracts and block groups from US Census (2011).

- PIA
- Advanced Water Treatment Plant (AWTP)
- Roads
- Counties

N W E S

Moffat Collection Sytem
Project FEIS

Figure 3.19-3 Advanced Water Treatment Plant (AWTP) - Primary Socioeconomic Impact Areas (PIAs)

9/4/12

PIA Demographic Conditions

The PIA population decreased by about 4% between 2000 and 2010, at which point the PIA included about 2,300 residents (U.S. Census Bureau 2000, 2010a, 2010b). In contrast, the State population increased by 16.9% between 2000 and 2010 (U.S. Census Bureau 2000, 2010a, 2010b). In 2010, Hispanic/Latino residents made up about 64% of the PIA population; White residents comprised about 31% of the population, a decrease of about 6% since 2000 (U.S. Census Bureau 2000, 2010a, 2010b). The median age in the PIA is 31.3 years, less than Colorado's median age (U.S. Census Bureau 2010a, 2010b). About half of PIA residents commute to work outside Adams County (U.S. Census Bureau 2010a, 2010b).

The number of housing units in the PIA totaled 769 in 2010, an increase of 13 units compared to 2000 (U.S. Census Bureau 2000, 2010a, 2010b). The 2010 vacancy rate of about 7.5% was lower than the Statewide average of 10.8% (U.S. Census Bureau 2010a, 2010b). Between 2005 and 2009, the median home value in the PIA was $162,000, about 14% higher than in 2000, but lower than the median home value in Colorado (U.S. Census Bureau 2000, 2005-2009a, 2005-2009b; BLS 1990-2011).

PIA Economic Conditions

PIA residents are considerably less affluent than Colorado residents are. Between 2005 and 2009, the median household income in the PIA averaged $34,600, a decrease of about 14% on a constant dollar basis since 2000, and almost 41% less than throughout Colorado (U.S. Census Bureau 2000, 2005-2009a, 2005-2009b; BLS 1990-2011). PIA per capita income decreased by 4% between 2000 and the 2005-2009 period and was less than half that of Colorado (U.S. Census Bureau 2000, 2005-2009a, 2005-2009b; BLS 1990-2011). About 22% of PIA families were considered to be below the poverty level in between 2005 and 2009, more than double the Statewide rate (U.S. Census Bureau 2005-2009a, 2005-2009b). Between 2005 and 2009, the PIA unemployment rate averaged 13% and was considerably higher than the Statewide rate (U.S. Census Bureau 2005-2009a, 2005-2009b). More than 71% of PIA residents work in blue-collar occupations, including production, construction and service occupations. Consistent with these occupations, employment is concentrated in construction, manufacturing, retail trade, accommodation and food services, educational, health and social services industries (U.S. Census Bureau 2005-2009a, 2005-2009b).

PIA Public Facilities and Services

The Commerce City Police Department and the South Adams Fire Protection District provide law enforcement and fire protection services to PIA residents. Medical facilities available to PIA residents include North Suburban Medical Center in Thornton and St. Anthony Hospital North in Westminster. The TCHD also provides health services to the PIA and has an office in Commerce City. The Rangeview Library District includes a branch in Commerce City that serves PIA residents. The South Adams County Water and Sanitation District provide water and wastewater treatment to the PIA. Solid waste generated within the PIA is disposed of in Denver area landfills located outside the PIA.

Educational services are provided by Adams County School District 14. All public facilities and services provide adequate services to PIA residents except the Library District, which struggles to meet demands.

3.19.5 Secondary Impact Areas

The SIAs include:

- Adams County
- Boulder County
- City of Brighton
- Denver County
- Denver Metropolitan Area
- Grand County
- Jefferson County
- Weld County

3.19.5.1 Adams County

Adams County is part of the SIA for the following components: Water Rights Acquisition Area (Alternative 13a), Denver Basin AWTP (Alternative 10a), and South Platte River Facilities (Alternatives 8a and 13a).

Demographic and Economic Conditions

Averaging 2.3% per year, Adams County grew by nearly 26% between 2000 and 2010, reaching just over 440,000 persons by 2010 (U.S. Census Bureau 2000, 2010a, 2010b). Adams County's population is somewhat younger than the State average at 32 years (U.S. Census Bureau 2010a, 2010b). The county experienced a racial shift between 2000 and 2010 as the percentage of Whites dropped from 63% to 53% and the Hispanic/Latino representation increased from 28% to 38% of the county population (U.S. Census Bureau 2000, 2010a, 2010b). About 60% of Adams County workers commute to other metropolitan area counties (U.S. Census Bureau 2010a, 2010b).

The county's housing vacancy rate was about 5.7% in 2010, almost half the State average, and down from 8% in 2004 (U.S. Census Bureau 2000, 2010a, 2010b). Adams County median home values have decreased in recent years and were nearly 26% less than the State average in 2010 at about $188,000 (U.S. Census Bureau 2010a, 2010b). Adams County households are larger and median household income is slightly lower than the comparable State averages (U.S. Census Bureau 2010a, 2010b). County per capita income was less than the State average at $23,300 in 2010 (U.S. Census Bureau 2010a, 2010b). The county per capita income increased by almost 60% between 1990 and 2000, but between 2000 and 2010 the figure dropped by nearly 6% (U.S. Census Bureau 2000, 2010a, 2010b; BLS 1990-2011). Both the county and the State experienced a decrease in per capita income between 2000 and 2010 on a constant dollar basis (U.S. Census Bureau 2000, 2010a, 2010b; BLS 1990-2011).

Unemployment rates more than doubled in the county between 2000 and 2005 and continued to increase through 2010, reaching 11.4% (U.S. Census Bureau 2005a, 2005b, 2010a, 2010b). Adams County workers are more heavily concentrated in construction and

blue-collar occupations than workers are Statewide. In 2009, there were over 8,000 total business establishments in Adams County. The most recent sales figures from 2007 indicate the manufacturing sector, followed closely by the healthcare and social assistance sector, generated the highest volume sales. In addition, the wholesale trade sector contributed the highest amount of employee compensation.

Public Facilities and Services

Unincorporated areas in Adams County receive law enforcement services from the Adams County Sheriff's office. Six police departments serve the incorporated areas in the county. Fire protection services are provided to the county by ten fire departments and fire protection districts. Thirteen school districts are responsible for providing educational services to the county. Residents receive health services from North Suburban Medical Center in Thornton, St. Anthony North Hospital in Westminster, and the Platte Valley Medical Center in Brighton. The Rangeview Library District serves the majority of residents of Adams County. Water and wastewater services are provided by various municipal and rural agencies. As of 2006, Tower Road Landfill handles the county's solid waste. There are several solid waste disposal facilities in Adams County, including the State's only hazardous waste facilities. All of these providers, except the Library District, afford an adequate level of service to county residents.

Fiscal Conditions

Between 2000 and 2008, Adams County operating expenditures grew more rapidly than the operating revenues (DOLA 2001-2008; BLS 1990-2011). Average annual capital expenditures during this period were about $41 million (DOLA 2001-2008; BLS 1990-2011). County retail sales also increased between 2001 and 2008 and sales and use tax revenues were $30.5 million in 2008 (CDOR 2001, 2008).

3.19.5.2 Boulder County

Boulder County is part of the SIA for the Gross Reservoir component for all alternatives.

Demographic and Economic Conditions

The Boulder County population reached almost 295,000 persons by 2010, growing by less than 1% per year since 2000 (U.S. Census Bureau 2000, 2010a, 2010b). The age distribution of the county population is similar to that of the State; the median age of county residents is about 36 years (U.S. Census Bureau 2000). Whites constitute the majority of the Boulder County population, but between 2000 and 2010, the percentage of Hispanics increased from 10.5 to 13.4% (U.S. Census Bureau 2000, 2010a, 2010b). About 20% of employed Boulder County residents commute to other counties for work (U.S. Census Bureau 2010a, 2010b).

The county housing vacancy rate fluctuated between 2000 and 2010, but remained below the State average for the entire period; in 2010, the vacancy rate was 6.1% (U.S. Census Bureau 2000, 2010a, 2010b). Median home values in the county more than tripled between 1990 and 2004, however that growth has slowed dramatically in recent years (U.S. Census Bureau 1990, 2004a, 2004b; BLS 1990-2011). The county median home values were 33%

higher than the median home value in the State in 2010 at almost $353,000 (U.S. Census Bureau 2010a, 2010b).

The county unemployment rate increased from 2.3% in 2000 to 8.9% in 2010, but remains less than the Statewide unemployment rate (U.S. Census Bureau 2000, 2010a, 2010b). Employed Boulder County residents mostly work in white-collar occupations (U.S. Census Bureau 2010c). In 2009, there were about 11,300 business establishments in Boulder County (U.S. Census Bureau 2009). County sales figures from 2007 show that the professional, scientific and technical services sectors generated the highest volume of sales, and provided the highest employee compensation; the retail trade sector trailed closely behind in terms of sales volume (U.S. Census Bureau 2007).

Public Facilities and Services

The Boulder County Sheriff serves unincorporated areas in Boulder County as well as the towns of Superior and Lyons. Five police departments serve the incorporated cities and towns in Boulder County. Twenty-two fire protection districts and fire departments provide fire protection services. Boulder Valley RE-2 School District and St. Vrain Valley RE-1J School District are responsible for education in the county. County residents receive health care services from five hospitals. Libraries in Boulder County are operated by individual municipalities. The City of Boulder library system includes four branches. The majority of water is provided to Boulder County customers at the municipal level or through water districts. Wastewater services and treatment are generally provided at the municipal level or through sanitation districts. Boulder County has one household hazardous waste facility and other solid waste is transferred to landfills outside the county.

Fiscal Conditions

From 2001 to 2008, Boulder County's operating expenses grew more rapidly than its operating revenues (DOLA 2001-2008; BLS 1990-2011). Between 2001 and 2008, average annual capital expenditures were $45.9 million (DOLA 2001-2008; BLS 1990-2011). County retail sales more than doubled between 2001 and 2008 and sales and use tax revenues were $24.9 million in 2008 (CDOR 2001, 2008).

3.19.5.3 City of Brighton

The City of Brighton is part of the SIA for the following components: South Platte River Facilities (Alternatives 8a and 13a).

Demographic and Economic Conditions

The City of Brighton is a rapidly growing area, averaging annual growth of 4.8% between 2000 and 2010, and exceeding 33,000 people in 2010 (U.S. Census Bureau 2000, 2010a, 2010b). In 2010, Brighton's population was generally comprised of White and Hispanic/Latino residents; White residents made up about 55% of the population, while Hispanic/Latino residents made up about 40% (U.S. Census Bureau 2010a, 2010b). The median age in Brighton averaged 32 years in 2010, younger than the State's median age for the same period (U.S. Census Bureau 2010a, 2010b). Less than half of city residents commute outside Adams County to jobs elsewhere in the Denver area (U.S. Census Bureau 2010a, 2010b).

Brighton had a housing vacancy rate of 8.6% on average between 2007 and 2009. Vacancy rates in Brighton have historically been lower than Statewide rates and continued to remain below the Statewide average of 12.2% during that period (U.S. Census Bureau 2007-2009a, 2007-2009b). Between 2007 and 2009, Brighton's average median home value was $204,000, which was 16.6% lower than the State (U.S. Census Bureau 2007-2009a, 2007-2009b). However, between 2000 and 2009, the residents of Brighton became more affluent in terms of income. During this period, median household income in Brighton grew from about $58,000 to about $66,000, and by the 2007 to 2009 period, the county had surpassed the State's median household income by over $9,000 (U.S. Census Bureau 2000, 2007-2009a, 2007-2009b; BLS 1990-2011). In 2000, Brighton's per capita income was about 34% less than in Colorado; however, by the 2007 to 2009 period, per capita income in the city was only about 20% below the Statewide level (U.S. Census Bureau 2000, 2007-2009a, 2007-2009b; BLS 1990-2011).

In 2000, unemployment rates in Brighton were higher than the Statewide rate; however, by the 2007 to 2009 period, the city's average unemployment rate had dropped to below that of the State U.S. Census Bureau 2000, 2007-2009a, 2007-2009b). During this three-year time period, Brighton's unemployment rate was 5%, while the State unemployment rate was 6.3%. About two thirds of Brighton's residents work in white-collar occupations and about one third work in blue-collar occupations, including construction and production-related occupations (U.S. Census Bureau 2007-2009a, 2007-2009b). In 2007, Brighton had over 418 businesses, a 16% increase since 2002 (U.S. Census Bureau 2002, 2007). These businesses generated over $641 million in sales (U.S. Census Bureau 2007).

Public Facilities and Services

The City of Brighton Police Department provides law enforcement services to Brighton and the Adams County Jail is located within the Brighton city limits. The Greater Brighton Fire Protection District serves the Brighton area with five fire stations. Educational services are provided by the Brighton 27-J school district. The Platte Valley Medical Center is a full service hospital located in Brighton. The TCHD also has an office in Brighton. The Rangeview Library District serves Brighton residents through the Brighton branch. The City of Brighton obtains its water from the South Platte River and the Beebe Draw. The city discharges treated wastewater into the South Platte River. There is one medical waste facility in the city, but there are no landfills or other major solid waste facilities located within the Brighton city limits. All providers, except the Library District, afford an adequate level of services to county residents.

Fiscal Conditions

Total city revenues and operating expenditures increased 3.2% on an annual average between 2001 and 2008 and were approximately $28.6 million and $19.2 million, respectively, in 2008 (DOLA 2001-2008; BLS 1990-2011). Capital outlays varied substantially from year to year and were $12.1 million in 2008 (DOLA 2001-2008). Retail sales also increased and sales and use tax revenues for Brighton were $16.5 million in 2008 (CDOR 2001, 2008).

3.19.5.4 Denver County

Denver County is part of the SIA for the Denver Basin Aquifer Facilities (Alternative 10a).

Demographic and Economic Conditions and Public Facilities and Services

Refer to Section 3.19.4, Denver Basin Aquifer Facilities. The PIA conditions are the same as the SIA.

Fiscal Conditions

Between 2001 and 2008, Denver County operating expenditures increased by the same rate as total revenues (DOLA 2001-2008; BLS 1990-2011). Average annual capital expenditures amounted to $248.9 million during this period (DOLA 2001-2008; BLS 1990-2011). County retail sales more than doubled between 2001 and 2008 and sales and use tax revenues were $468 million in 2008 (CDOR 2001, 2008; BLS 1990-2011).

3.19.5.5 Denver Metropolitan Area

The Denver Metropolitan area is part of the SIA for all alternative components. The Denver Metropolitan area consists of the City and County of Denver as well as surrounding counties, including Boulder, Jefferson, Broomfield, Adams, Arapahoe, and Douglas.

Demographic and Economic Conditions

The Denver Metropolitan area's population reached nearly 2,856,000 people by 2010, growing 1.4% per year on average since 2000 (U.S. Census Bureau 2000, 2010a, 2010b). The age distribution of Denver Metropolitan area residents is similar to that of Colorado residents Statewide (U.S. Census Bureau 2010c). The Denver Metropolitan area experienced a slight change in its ethnicity distribution between 2000 and 2010 as the percentage of Whites decreased from 72 to 67%, and the percentage of Hispanics/Latinos increased from 18 to 22% (U.S. Census Bureau 2000, 2010a, 2010b). About 8% of Denver Metropolitan area residents work outside the Metropolitan area (U.S. Census Bureau 2010a, 2010b).

The housing vacancy rate in the Denver Metropolitan area was 5.8% as of 2010, lower than the Statewide average (U.S. Census Bureau 2010a, 2010b). The median home value in the Denver Metropolitan area at that time was $257,000, about 9% higher than the Statewide median home value (U.S. Census Bureau 2010a, 2010b). Households in the Denver Metropolitan area are smaller but more affluent than the State. The Denver Metropolitan area median household income and per capita income were both higher than the State average as of 2010 (U.S. Census Bureau 2010c). The unemployment rate in the Denver Metropolitan area was 9.9% in 2010. Most Denver Metropolitan area residents work in white-collar occupations (U.S. Census Bureau 2010a, 2010b). In 2009, the Denver Metropolitan area included over 85,000 businesses with more than $57.7 billion in annual payroll (U.S. Census Bureau 2009). As of 2007, Denver Metropolitan area businesses conducted over $222 billion in annual sales. The wholesale trade sector had the largest amount of sales and the professional and technical services industry provided the largest proportion of total compensation (U.S. Census Bureau 2007).

Public Facilities and Services

Public facilities and services include police services, fire departments, health services, libraries, water providers, wastewater services, solid waste disposal, and education.

For information on public facilities and services in the Denver Metropolitan area, refer to the information provided in the SIA descriptions for Adams, Boulder, Denver, Jefferson and Weld counties.

Fiscal Conditions

Fiscal conditions data for the Denver Metropolitan area include total revenues, total operating expenditures, capital outlay expenditures, retail sales and sales and use tax revenues for each jurisdiction. This information can be found in the SIA descriptions for Adams, Boulder, Denver, Jefferson and Weld counties.

3.19.5.6 Grand County

Grand County is part of the SIA for the following components: Gross Reservoir (all action alternatives) and Leyden Gulch Reservoir (Alternative 1c).

Demographic and Economic Conditions

Grand County is a growing area that experienced average growth of about 1.7% per year between 2000 and 2010, when the county included nearly 15,000 year-round residents (U.S. Census Bureau 2000, 2010a, 2010b). Historically, Grand County has experienced higher annual growth rates compared to the State; however, in recent years, the county's growth rates have decreased to be more in line with Statewide averages. In 2010, about 90% of Grand County residents were White, slightly less than in 2000. Hispanic/Latino residents made up almost 8% of the Grand County population in 2010, an increase of about 3% since 2000 (U.S. Census Bureau 2000, 2010a, 2010b). The average median age in Grand County was about 40 years, 4 years older than the Statewide median age in 2010 (U.S. Census Bureau 2010c). Only about 11% of residents commute to work in other counties, generally to Summit County (U.S. Census Bureau 2010a, 2010b).

Grand County's housing vacancy rates are considerably higher than Statewide rates due to the large number of seasonal units in the county. In 2000, when the county had a vacancy rate of about 53%, seasonal units made up 82% of vacant units (U.S. Census Bureau 2000). In 2010, the county vacancy rate had grown to nearly 65%, when about 56% of vacant units were seasonal units (U.S. Census Bureau 2010a, 2010b). Between 2005 and 2009, the county's median home value averaged $258,000 and was roughly 9% higher than Colorado's median home value during the period. For the same period, the median household income in the county was over $59,000, which was about 4.7% higher than the Statewide value. The per capita income during that period was about 4.3% lower than the Colorado average (U.S. Census Bureau 2005-2009a, 2005-2009b).

The Grand County unemployment rate averaged 4.2% between 2005 and 2009, which was lower than the State rate for the same period (U.S. Census Bureau 2005-2009a, 2005-2009b). Approximately three quarters of the county residents are employed in management, sales and related occupations, and about one quarter work in service and construction-related occupations. In Grand County, the largest percentage of residents

working in management, professional and related occupations, with sales and office occupations trailing slightly behind (U.S. Census Bureau 2005-2009a, 2005-2009b). In 2009, the county had over 900 businesses and in the most recent sales figures from 2007, the county generated just over $421 million in sales (U.S. Census Bureau 2007, 2009).

Tourism and recreation are important components of the Grand County economy. In 2005, visitor spending in the county amounted to more than $164 million, which supported over 2,300 jobs and provided about $53 million in earnings to local business owners and employees.[1] Tourism spending included $6.5 million in local tax receipts in 2005. As of 2007, Grand County businesses included 158 employer establishments and 130 non-employer establishments in industries that cater to tourists, including arts, entertainment, recreation, accommodations and food service businesses.[2] Together these establishments employed over 1,800 people and realized over $30.5 million of sales. In addition, there were over 250 retail trade establishments and over 425 establishments in the real estate, rental and leasing industries in the county in 2007.[3] Tourism in Grand County is mostly related to the available outdoor recreational amenities, which support boating, fishing, skiing, and a variety of other activities. For example, over 1 million skier visits are reported at the Winter Park Ski Resort annually and about 3 million people visit Rocky Mountain National Park every year, a portion of which is located in Grand County.[4] The availability of water-based recreational activities, especially fishing, is an attractive feature of visiting or living in Grand County. Fishing, boating, and other water-based recreation is discussed in detail in Section 3.15. Grand County visitors and residents who participate in recreational activities also make purchases related to those activities in the county. Local outfitters, tackle shops, private guides, and private property owners that allow river access provide services to anglers in Grand County. Anglers can also access several public stretches of rivers in the county, as well as many lakes. In 2007, the total economic impact of fishing activity in Grand County by residents and visitors amounted to almost $34.2 million (BBC 2008).

In 2007, Grand County contained 229 farms encompassing about 208,500 acres of land (about 18% of total Grand County acreage). Cattle and calves were the top livestock category in the county and forage was the top crop item. Ranches realized crop and livestock sales of almost $9.4 million in that year, with livestock sales making up about 84% of total sales. About 40% of Grand County farms reported less than $1,000 in total sales. Of the almost 11,500 people employed in Grand County in 2007, only 245, or about 2%, were employed in agricultural production (USDA 2007).

Public Facilities and Services

Unincorporated areas of Grand County are served by the Grand County Sheriff's office, which also operates the Grand County Jail. Three municipal police departments also provide law enforcement services to county residents. Five fire protection districts, including the East

[1]Visitor spending includes all purchases made by visitors during their trip, including activities, food, lodging, and other purchases, but does not include secondary effects related to the additional spending of businesses and employees.

[2]Employer establishments are those that include paid employees; non-employer establishments have no paid employees, such as real estate agents and independent contractors.

[3]Retail trade includes businesses that provide goods and services to residents as well as visitors.

[4]Visitor data for the Winter Park Ski Resort and Rocky Mountain National Park include both Grand County residents and other visitors. Rocky Mountain National Park is also a part of other counties; visitors to the park may or may not visit Grand County.

Grand County Fire Protection District, which serves the Fraser valley, serve Grand County. The East Grand County and West Grand County school districts provide educational services. Several medical clinics and the Kremmling Memorial Hospital are located in Grand County, but many residents travel to Denver for medical services. The Grand County Library District provides services to county residents through five branch libraries. The Granby and Kremmling landfills are available to county residents. All these providers offer an adequate level of service to county residents.

In addition to a growing population of year round residents, Grand County water and wastewater providers must serve a significant seasonal population in summer and winter months. Several water providers in popular tourist areas obtain their water from the Fraser River. Although they have adequate supplies to meet demands under Current Conditions (2006), these water providers are concerned about their ability to meet future demands as additional demands are placed on the river. Wastewater treatment providers that discharge into the Fraser River or tributaries are identified in Sections 3.2.5.1 and 5.2.1.2. A regional plant, in operation since 2004, serves Grand County Water and Sanitation District #1, Winter Park West Water and Sanitation District, and the Fraser Sanitation District. This facility has undergone recent upgrades to provide additional treatment of effluent before discharge. The Granby wastewater treatment facility has been approved for expansion and other facilities have the capability of future expansion if necessary. These wastewater treatment providers are concerned about future operations and future compliance with their NPDES discharge permits, which depend, in part, on Fraser River flows.

Fiscal Conditions

Total county revenues and operating expenditures increased by about 5.7% and 4.9% respectively per year between 2001 and 2008 reaching $40 million and $28 million, respectively, in 2008 (DOLA 2001-2008; BLS 1990-2011). Capital outlay expenditures ranged from $1.7 million to $14.5 million during this period, averaging $ 4.5 million (DOLA 2001-2008; BLS 1990-2011). Retail sales in the county more than doubled between 2001 and 2008, and sales and use tax revenues were about $3.3 million in 2008 (CDOR 2001, 2008; BLS 1990-2011).

3.19.5.7 Jefferson County

Jefferson County is part of the SIA for the following components: Leyden Gulch Reservoir site (Alternative 1c), Conduit O (Alternatives 8a and 13), and Conduit M (Alternative 10a).

Demographic and Economic Conditions

Jefferson County averaged population growth of less than 1% per year between 2000 and 2010, exceeding 534,000 people by 2010 (U.S. Census Bureau 2000, 2010a, 2010b). Annual population growth was higher between 1990 and 2000, but slowed dramatically since 2000, remaining below the Statewide growth rate through 2010 (U.S. Census Bureau 2000, 2009, 2010c). About 80% of Jefferson County residents are White, which is higher than the Statewide average of 70%. The county percentage of White residents decreased by about 5% between 2000 and 2010 (U.S. Census Bureau 2000, 2010a, 2010b). The median Jefferson County age is about 40 years, higher than the Statewide median age (U.S. Census

Bureau 2010c). About half the county residents commute outside Jefferson County to jobs elsewhere in the Denver area (U.S. Census Bureau 2010c).

Jefferson County vacancy rates have historically been lower than in Colorado and other Denver Metropolitan area counties. This trend continues, as in 2010 the county housing vacancy rate was 5.1%, less than half the Statewide rate for the same year (U.S. Census Bureau 2010a, 2010b). The median home value of about $259,000 in 2010 was about 9% higher than the Statewide median home value (U.S. Census Bureau 2010a, 2010b). In 2010, the median household income was more than 15% greater and the per capita income was almost 13% greater than in Colorado (U.S. Census Bureau 2010a, 2010b). Jefferson County residents are relatively affluent compared to Colorado residents, as a whole.

The Jefferson County unemployment rate of 9.6% in 2010 is similar to the State rate of 9.9%. About 98% of residents are employed in white-collar occupations (U.S. Census Bureau 2010a, 2010b). The Jefferson County economy is both robust and healthy. In 2009, the county included over 16,000 businesses and in 2007, the county generated $23.4 billion in sales (U.S. Census Bureau 2007, 2009).

Public Facilities and Services

The Jefferson County Sheriff's office serves unincorporated areas of the county and operates the County Jail. Eight municipal police departments also provide law enforcement services in the county. Fire protection is provided by 17 fire protection districts or fire departments. The R-1 school district provides educational services to the entire county. The county receives health services from the Jefferson County Department of Health and Environment, Exempla Lutheran Medical Center in Wheat Ridge, and private physicians. The Jefferson County Public Library serves the county with 10 branches. Water and wastewater services are provided by various municipal and rural agencies or through private wells and septic systems. The BFI Foothills Landfill is available to county residents. These service providers all offer an adequate level of services to county residents.

Fiscal Conditions

Total county operating expenditures grew faster than revenues between 2001 and 2008 and were $235 million and $339 million, respectively, in 2008 (DOLA 2001-2008; BLS 1990-2011). Capital outlays declined steadily between 2001 and 2008 and in 2008 were nearly half of what they had been in 2001 (DOLA 2001-2008; BLS 1990-2011). Retail sales nearly doubled over the period, and sales and use tax revenues were $33 million in 2008 (CDOR 2001, 2008; BLS 1990-2011).

3.19.5.8 Weld County

Weld County is part of the SIA for the Water Rights Acquisition Area (Alternative 13a).

Demographic and Economic Conditions

Weld County's population grew considerably between 2000 and 2010, averaging 3.3% annually, and reaching nearly 253,000 by 2010 (U.S. Census Bureau 2000, 2010a, 2010b). The median age of Weld County residents was 3 years younger than the Colorado median

age in 2010 (U.S. Census Bureau 2010c). The Hispanic population increased from 27 to 28.5% and the White representation dropped from 70 to 68%, between 2000 and 2010 (U.S. Census Bureau 2000, 2010a, 2010b). About a third of Weld County residents commute to other counties in Colorado for work (U.S. Census Bureau 2010c). In many respects, Weld County characteristics continue to be in line with Colorado averages.

Housing vacancy rates were less than the State average, but grew steadily between 2000 and 2010 (U.S. Census Bureau 2000, 2010a, 2010b). Between 1990 and 2000, median home values grew faster in Weld County compared with the State, however between 2000 and 2010 both county and Statewide growth slowed substantially (U.S. Census Bureau 1990, 2000, 2010a, 2010b; BLS 1990-2011). Weld County's 2010 median home value was $182,000, almost 30% less than the Statewide figure for the same year (U.S. Census Bureau 2010a, 2010b). Per capita income, both in the county and the State, decreased between 2000 and 2010. While per capita income was 27% less than the State average as of 2000, the 2010 county per capita income was only 25% less than the State (U.S. Census Bureau 2000, 2010a, 2010b; BLS 1990-2011). The county unemployment rate was 9.1%, slightly lower than that of the State for 2010. In 2000, blue-collar workers accounted for a high percentage of employees in Weld County; however, by 2010 the county was more comparable to the State with the majority of the employees working in white-collar professions (U.S. Census Bureau 2000, 2010c). In 2009, there were more than 5,000 business establishments in Weld County and in 2007, total sales reached $8.3 million (U.S. Census Bureau 2007, 2009).

Public Facilities and Services

The Weld County Sheriff's Department serves unincorporated areas of the county and municipal police departments provide law enforcement services to cities and towns in Weld County. There are 16 other police departments providing law enforcement to incorporated areas in the county. Weld County is served by 21 fire protection districts and fire departments. The Northern Colorado Medical Center in Greeley is the only full service hospital in Weld County. Additional health services are provided by the Weld County Department of Health and Environment. The Weld Library District serves the majority of county residents with four branches; several communities operate separate libraries. Water and wastewater services are provided by various municipal and rural agencies or through private wells and septic systems. The Buffalo Ridge Landfill, North Weld Sanitary Landfill, Denver Regional Landfill, and Front Range Landfill are all located in Weld County, as are several composting facilities and tire recyclers. There are 12 school districts responsible for providing educational services to the county.

Fiscal Conditions

Between 2001 and 2008, Weld County revenues grew faster than operating expenditures (DOLA 2001-2008; BLS 1990-2011). Total revenues were higher than total expenditures in any given year during that period. Annual capital expenditures averaged $17.9 million between 2001 and 2008, almost doubling during that period (DOLA 2001-2008; BLS 1990-2011). Retail sales more than tripled between 2001 and 2008 (CDOR 2001, 2008; BLS 1990-2011).

3.20 HAZARDOUS MATERIALS

3.20.0 Overview

Hazardous materials are defined in various ways under a number of State and Federal regulatory programs. Sites with recognized environmental conditions of concern are sites where known, existing, or past releases of hazardous substances, including petroleum products and other organic substances, metals, and other inorganic substances have been released to soil or groundwater. Risks to human health and the environment may occur when these materials are not managed properly.

Methodology

The methodology used to assess the presence of hazardous material sites within or adjacent to the Moffat Collection System Project (Moffat Project or Project) area consisted of a search of Federal, State, and local databases, and site visits. The criteria and search distances established for the database search are presented in Table 3.20-1. The search criteria meet the American Society for Testing and Materials (ASTM) standards for environmental assessment records review (ASTM E1527-05).

Table 3.20-1
Hazardous Material Site Database Search Criteria

Database	ASTM Approximate Minimum Search Distance (mile)
Federal National Priorities List (NPL) The U.S. Environmental Protection Agency's (EPA's) database of uncontrolled or abandoned hazardous waste sites identified for priority remedial actions under the Superfund Program.	1.0
Federal Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Compilation by the EPA of sites at which the potential exists for contamination originating from on-site hazardous substance storage or disposal. Sites designated as NFRAP indicate that No Further Remedial Action is Planned.	0.5
Federal Resource Conservation and Recovery Act (RCRA) treatment, storage, and disposal (TSD) facilities. RCRA permitted TSD facilities.	0.5
Federal Resource Conservation and Recovery Information System (RCRIS) Facilities that are regulated based on current hazardous waste generation management activities.	Site and Adjoining Properties
Federal RCRA Corrective Action (CORRACTS) facilities Sites identified as needing Corrective Action after a release of a hazardous waste or constituent into the environment from a RCRA facility.	1.0
Federal/State Emergency Response Notification System (ERNS) List Database of public complaints and reports of unverified releases or incidents.	Site
State Voluntary Cleanup Program (VCUP) sites Sites being addressed under the Colorado Department of Public Health and Environment (CDPHE) VCUP.	0.5

Table 3.20-1 (continued)
Hazardous Material Site Database Search Criteria

Database	ASTM Approximate Minimum Search Distance (mile)
State Historical Landfill Sites Inactive landfill sites (including sites known to generate methane) and illegal dumpsites.	0.5
State Above Ground Storage Tank (AST)/Underground Storage Tank (UST) List of sites that registered the presence of ASTs/USTs with the Colorado Department of Labor and Employment Division of Oil and Public Safety (OPS).	Site and Adjoining Properties
State Leaking Underground Storage Tanks (LUST) List of closed or un-remediated reported LUSTs.	0.5

Source: ASTM, 2000.

3.20.1 Reservoirs

3.20.1.1 Gross Reservoir

Database Search

No hazardous material sites were identified from the database search within the Gross Reservoir study area. Two hazardous material sites, however, were identified approximately 2,000 feet southeast of the Gross Reservoir study area near the mouth of Nineteen Gulch. At one time, the Gross Reservoir Maintenance Facility housed three underground storage tanks (USTs), two for storage of gasoline and one smaller tank for used oil in this area. The tanks were operational from the mid-1950s until they were removed in 1989. Subsequent sampling of soil and groundwater indicated low-level hydrocarbon contamination in soil and groundwater downgradient of the site in 1991. No BETX (benzene, ethylbenzene, toluene or xylene) compounds typically associated with fuel releases were identified. A No Further Action letter from the Colorado Department of Public Health and Environment (CDPHE) was issued in 1995.

Groundwater monitoring wells located hydraulically downgradient of a chemical storage shed and the loading dock of the maintenance facility were tested for soil and groundwater contaminants in 1994. Benzene was detected in a single well at a concentration of 520 micrograms per liter (µg/L), two orders of magnitude greater than the Colorado Drinking Water Standard. This contamination was attributed to spills associated with the release/spill of paint. File information at CDPHE did not indicate any remediation of the chemical storage shed occurred.

Because the distance of the maintenance facility is more than 2,000 feet hydraulically downgradient of the proposed enlarged Gross Reservoir boundary and more than 3,600 feet downgradient of the existing reservoir itself, the site is considered to have a low potential for concern.

Site Visit

A site visit at the base of the Gross Reservoir Dam and the Gross Reservoir Maintenance Facility was conducted in June 2006. A summary of the hazardous material sites identified at and near Gross Reservoir is presented in Table 3.20-2.

Table 3.20-2
Hazardous Material Sites Identified within the Gross Reservoir Study Area in 2006

Hazardous Material Sites	Description
Former UST Sites at Maintenance Facility (tanks removed)	More than 2,000 feet distant and hydraulically downgradient of reservoir site.
Former Chemical Storage Shed at Maintenance Facility	More than 2,000 feet distant and hydraulically downgradient of reservoir site.

Source: Satisfi, 2005a; CDPHE and OPS file review.
Note:
UST = underground storage tank

3.20.1.2 Leyden Gulch Reservoir Site

Database Search

No hazardous material sites were identified from the database search within the Leyden Gulch site. The southernmost boundary of the U.S. Department of Energy Rocky Flats site is located less than a mile northeast of the Leyden Gulch site. Samples of both soil and groundwater at Rocky Flats have been extensively analyzed for radioactive isotopes and other contaminants. Plutonium (Pu 239) concentrations located on land adjacent to the Leyden Gulch site ranged from less than 0.1 picocuries per gram (pCi/g) to less than 1.0 pCi/g. Extensive remediation has also been conducted at Rocky Flats with site closure completed in 2006. No information was found regarding soil or groundwater sampling in the Leyden Gulch study area.

The Foothills Landfill, which has been operated by BFI since 1986, is located east of State Highway (SH 93) and adjacent to the Leyden Gulch site. Immediately north of the Foothills Landfill is the site of the former Jefferson County Landfill, which has been closed since the opening of the Foothills Landfill. Extensive groundwater monitoring occurs on a quarterly basis at the Foothills Landfill and no violations have been recorded. The groundwater system at the Foothills Landfill consists of an unconfined watertable that occurs within the saturated bedrock aquitard of the Laramie Formation. Depth to groundwater ranges from 0 to 50 feet. Groundwater flow at the Foothills Landfill is to the south-southeast, indicating that the landfills are downgradient of the proposed reservoir. The horizontal groundwater flow rate ranges from 1.3 to 5.2 feet per year. The flow rate for February 2006 was estimated to be 3.26 feet per year. Based on the bedrock materials present at the site, the vertical groundwater flow rate is expected to be much slower.

A leachate collection system is in place, and leachate is stored in a permanent storage tank located on the former Jefferson County Landfill. A landfill gas extraction system is in operation at the former Jefferson County Landfill and collects both gas and gas condensate.

The presence of an underground coal mine (Leyden Coal Mine) located approximately 600 to 800 feet below the Foothills Landfill was documented in CDPHE files. This former coal

mine is now used as an emergency water storage source by Arvada. Water quality testing has been performed at this site; no significant quantities of gas or coal products were detected (City of Arvada 2008).

Site Visit

A site visit to the Ralston Reservoir Maintenance Facility located south of the proposed Leyden Gulch was conducted in June 2006. The Board of Water Commissioners (Denver Water) Ralston Reservoir site manager identified the location of two former UST sites. He indicated that two USTs were removed in the 1990s and that no release of contaminants was observed or reported after tank removal. No record of those USTs or their removal was found in the Division of Oil and Public Safety records. Two aboveground storage tanks (ASTs) that store gasoline and diesel fuel were also identified on the property. These tanks are hydraulically unrelated to the Leyden Gulch site.

The Union Pacific rail line has been present for many years. Rail corridors often have heavy metal and semi-volatile organic contamination in soils and ballast located adjacent to and under the track. Semi-volatile compounds typically include polyaromatic hydrocarbons (PAHs) derived from combustion of coal previously used to power trains and contamination from the rail ties coated with creosote used as a railroad tie preservative. Because the Union Pacific rail line is located immediately adjacent to the northern edge of the proposed Leyden Gulch Reservoir, there is a high potential for contaminated soil to be present in this area. A potential for heavy metals present in soils along SH 93 exists from the long use of leaded fuels along the highway. PAHs, a byproduct associated with the combustion of fuels, is also a potential contaminant that may be present in soils.

Several old electric utility lines with wooden poles traverse the Leyden Gulch site. These wooden poles may have been treated with a creosote preservative that could contaminate surrounding soils.

An isolated concrete slab (9 feet by 6 feet) containing a skull and crossbones etched on its surface was noted in 2005 during a site visit in T 2S, R 70 W, SW ¼, NE ¼, NE ¼, SW ¼ of Section 33. This slab may be related to Ralston Reservoir construction and the date range is approximately 1935 to 1940. It was located near a building/machinery foundation from the 1930s. This slab is located in an area where construction disturbance from the South Tunnel Portal or access road to South Tunnel Portal may occur.

A summary of potential hazardous material sites identified at the Leyden Gulch site is presented in Table 3.20-3.

Table 3.20-3
Hazardous Material Sites Identified Adjacent to and within the Leyden Gulch Reservoir Site in 2006

Hazardous Material Sites	Description
Rocky Flats	The southern-most boundary of the Rocky Flats site is located near the Leyden Gulch Reservoir site. No soil testing has been conducted in the area where the reservoir would be located.
Foothills Landfill	Site is located hydraulically downgradient of the Leyden Gulch Reservoir site and is located in the Pierre Shale with little hydraulic connection.
Jefferson County Landfill	Closed landfill with a leachate collection system and gas extraction system in place. Located hydraulically downgradient of the Leyden Gulch Reservoir site.
Former UST site	The Leyden Gulch Reservoir site is located more than 2,000 feet away from the UST site and is hydraulically unrelated to proposed reservoir.
Concrete Slab	The slab is located in Section 33 (SW ¼, NE ¼, NE ¼, SW ¼) T2S, R70W in an area where construction disturbances from the proposed South Tunnel Portal or access road to South Tunnel Portal may occur.
Union Pacific Rail Corridor	High potential for contaminated soil and ballast very close to the northern boundary of the Leyden Gulch Reservoir site along the rail line.
State Highway 93	Potential for heavy metals in soils due to long history of leaded fuels along roadway.
Utility Poles	Potential for creosote contamination in soil near poles.

Source: Satisfi, 2005b; CDPHE and OPS file reviews; field observations.
Note:
UST = underground storage tank

3.20.2 Conveyance Systems

The conveyance systems were not evaluated for hazardous material releases due to the expected high number of hazardous waste sites associated with the urban location of large portions of these alternative components. Potential hazardous sites would be identified prior to construction activity if Alternative 10a is permitted.

3.20.2.1 Conduit M

Conduit M was not evaluated for hazardous material releases due to the expected high number of hazardous waste sites associated with the urban location of large portions of these alternative components. Potential hazardous sites would be identified prior to construction activity if Alternative 10a is permitted.

3.20.2.2 Conduit O

Conduit O was not evaluated for hazardous material releases due to the expected high number of hazardous waste sites associated with the urban location of large portions of this alternative component. Potential hazardous sites along Conduit O would be identified prior to construction activity if Alternative 8a is permitted.

3.20.3 South Platte River Facilities

Database Search

A database search of the South Platte River Facilities study area was conducted in August 2006. Hazardous material sites identified from the database search are presented in Table 3.20-4.

Table 3.20-4
Hazardous Material Sites Identified Near the Worthing, South Tower, and Challenger Gravel Pits in 2006

Hazardous Material Sites	Description
Albert Frei & Sons 13205 Brighton Boulevard	The first report in this file is a 1983 inspection from a citizen's complaint. EPA did not find evidence of hazardous waste dumping at that time. A 1985 inspection noted "wood and metal" in Pit #4 approximately 50 yards from a pond. The address was noted as 11521 Brighton Boulevard. In 1987, a Tri-County Health Department (TCHD) memo indicated that Pit #2 was almost full. A 1988 inspection indicated inert material was being placed in the Pit #4. In 1989, TCHD indicated that Pit #4 was filled and was awaiting final cover and contour work. Filling of a pit near the entrance had begun and some asphalt had been placed in water in the pit. The site address had changed to 13205 Brighton Boulevard. The final inspection was conducted in 1993 by TCHD at Pit #2 (Hazeltine Pit) where some concrete conduit and metal rebar were incorrectly disposed of in the pit.
E-470 Public Highway Authority Maintenance Support Site E 14152 N E470 Pkwy	1,000-gallon AST containing diesel. No violations or leak reports. Site remains open. It is located hydrologically upgradient of the South Tower Pit.
Bromley Dump 130th and Old Brighton Road	This site was identified from older file information in 1998 by the TCHD. File indicates "organic material" may be present. A 1972 complaint of dump on fire was noted. This site may be located two blocks south of the Worthing Pit although the precise location is not certain.
Unnamed Dump 144th Avenue and Riverdale Road	Potential for a methane-emitting landfill was noted in Denver Regional Council of Governments (DRCOG) potential methane study data from circa 1981. Ranked low as apparent location on west side of South Platte River results in hydraulic separation.
Adams County Landfill	A sludge landfill identified from the early 1980s and contained in Solid Waste Historical Data at CDPHE offices. Precise location not noted.
Brighton SL. (Riverdale) NW	A refuse landfill identified from the early 1980s and contained in Solid Waste Historical Data at CDPHE offices. Precise location not noted.
Big R Construction – Henderson Pit US 85 and 124th Avenue	Based on location description, site is 0.5 mile from the South Tower Pit. Confidence in actual location of the pit is low. TCHD file suggests potential for disposal of asbestos wastes and petroleum-contaminated soils as well as the presence of USTs. Hydrologically separated from Worthing Pit.
Oil and Gas Production Wells	Oil and gas production from deep formations dot the landscape in the vicinity of the proposed water storage sites. Pumping units and associated facilities.
Sand and Gravel Operations	Sand and gravel operations with on-site tanks, production buildings, and heavy equipment operation with a potential for an environmental release were noted in the site visit.

Table 3.20-4 (continued)
Hazardous Material Sites Identified Near the Worthing, South Tower, and Challenger Gravel Pits in 2006

Hazardous Material Sites	Description
ENSCO Field Services 16315 N. Tucson Street Brighton, CO 80601	One time only generator status. No violations noted. Site is located approximately 800 feet south of the Challenger Pit.
Bestway Concrete Company 11723 Weld County Road #2 Brighton, CO 80601	Site is located due north of Challenger Pit. Site contains two 12,000-gallon ASTs for diesel. No violations noted. Site remains open with the Colorado Division of Oil and Public Safety.

Source: Satisfi, 2006; CDPHE, TCHD, and OPS file review.
Notes:
AST = aboveground storage tank
CDPHE = Colorado Department of Public Health and Environment
TCHD = Tri-County Health Department
UST = underground storage tank

Site Visit

A site visit of the existing Worthing, South Tower, North Tower, and Challenger pits was conducted in August 2006. No additional hazardous material sites were identified from the site reconnaissance. However, oil and gas production operations and associated surface facilities (i.e., ASTs) were noted throughout the area located between East 132nd Avenue and East 168th Avenue and between Riverdale Road and Brighton Road. These production wells are not considered hazardous material sites and are exempted from regulation by the U.S. Environmental Protection Agency. However, these sites may contain hazardous constituents that could contaminate drinking water supplies. Production wells are generally sealed from overlying aquifers, but releases may occur from these types of facilities. The precise location of these oil and gas production wells in relation to the proposed pits was not identified due to access limitations.

Sand and gravel mining has been in practice in the Brighton area for many years. Multiple active sites were noted during the site visit in August 2006. These facilities were noted to contain on-site tanks, a variety of structures, and use of a variety of heavy equipment. Hazardous materials associated with the sand and gravel-mining operations are likely to be present and a potential for release of these materials exists.

Worthing Pit

This pit is located south of E-470 and east of Riverdale Road east of and adjacent to the South Platte River. Eight sites listed in Table 3.20-4 were identified from the database search of hazardous material sites and from the site visit. Multiple dumpsites were documented during the database search, although the precise locations of the sites were not always available. Many of the dumps were used in the 1970s and 1980s, and the locations are uncertain. The pits typically received solid wastes of construction debris and “inert” material.

South Tower Pit

This pit is located north of E-470 east of Riverdale Road. As this pit is located close to the Worthing Pit, the same hazardous material sites identified at the Worthing Pit were identified near the South Tower Pit. These sites are listed in Table 3.20-4.

North Tower Pit

The North Tower Pit is located north of E-470 and is adjacent to the South Platte River. No hazardous material sites were identified in the vicinity of the North Tower Pit.

Challenger Pit

Two hazardous material sites were identified in the vicinity of the Challenger Pit and are listed in Table 3.20-4. In addition, two suspected construction debris landfill sites are documented in CDPHE files. These sites are reported to be located on the east side of the South Platte River and are not likely to be hydrologically connected to the proposed Challenger Pit. However, the exact location of these sites is not known. A 1977 memorandum from the TCHD expressed low confidence in the location of these sites.

3.20.4 Denver Basin Aquifer Storage Facilities

The Denver Basin aquifer storage facilities were not evaluated for hazardous material releases due to the expected high number of hazardous waste sites associated with the urban location of large portions of these alternative components. Potential hazardous sites would be identified prior to construction activity if Alternative 10a is permitted.