MOFFAT
COLLECTION SYSTEM PROJECT
FINAL ENVIRONMENTAL IMPACT STATEMENT

Chapter 5:
Moffat Project Effects

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5.0 INTRODUCTION

Chapter 5 describes the direct and indirect impacts expected to occur as a result of implementing each alternative described in Chapter 2, Proposed Action and Alternatives. These are impacts for which the Board of Water Commissioners (Denver Water) would be accountable should an alternative be constructed and operated. Unless otherwise stated, comparisons in Chapter 5 are between Full Use of the Existing System and Full Use with a Project Alternative, both of which include reasonably foreseeable future actions (RFFAs) (2032).

An environmental impact is defined as a modification or change in the existing environment as a result of actions taken. Impacts may be beneficial or adverse, may be assessed based on their duration, severity, or relation to the Moffat Collection System Project (Moffat Project or Project), and may vary in severity from only a slight discernable impact to a drastic impact.

The level of impact is based on regulatory standards, criteria and ordinances, available scientific documentation, and professional judgment of the technical evaluator. Denver Water would implement certain environmental protection measures, design features, and procedures to avoid or reduce adverse impacts of the action alternatives, as described in Chapter 2 and in Appendix M. Based on the impact analyses, additional mitigation measures to minimize potential adverse impacts are identified in this chapter. Mitigation measures may be included as conditions of a Section 404 Permit or other State or local permits.

An impact analysis was conducted for each resource described in Chapter 3, Affected Environment. Within each resource section, a discussion of potential environmental consequences includes: (1) anticipated impacts and issues raised during scoping, (2) impacts analysis, (3) mitigation of impacts, and (4) a summary of unavoidable adverse impacts (i.e., those impacts that are unavoidable and cannot be mitigated). The following time frames were compared in this Environmental Impact Statement (EIS) to isolate the impacts associated with each action alternative (Alternative 1a – Proposed Action, and Alternatives 1c, 8a, 10a, and 13a) and the No Action Alternative from other past, present, and RFFAs.

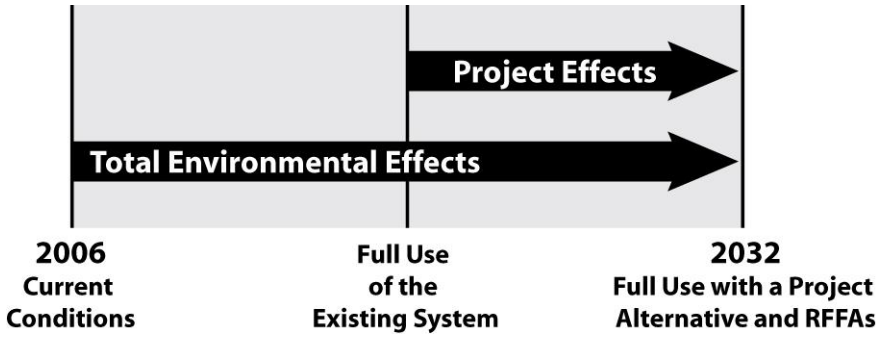
Comparison of Full Use of the Existing System and Full Use with a Project Alternative (2032)

- **Full Use of the Existing System** reflects the operation of Denver Water's existing system and water rights at an average annual demand of 345,000 acre-feet per year (AF/yr), since this is the point when a Moffat Project is anticipated to come on-line. "Full Use" of the existing system means Denver Water would maximize yield of their existing water supplies using their existing facilities and infrastructure, independent of a future Moffat Project. Based on Denver Water's demand forecast, this condition would occur in 2022 (see Chapter 1, Figure 1-5). The Full Use of the Existing System does not include the proposed Moffat Project being considered, but does include RFFAs.

- **Full Use with a Project Alternative (2032)** reflects conditions in Denver Water's system when the Moffat Project is completed and in Full Use in 2032. Under this scenario, Denver Water's demand would be 363,000 AF/yr and the Moffat Project would be providing 18,000 AF/yr of new firm yield through construction and operation of a Moffat Project alternative.

Both Full Use of the Existing System and Full Use with a Project Alternative (2032) scenarios include proposed water-related projects that were identified as RFFAs. The hydrologic effects associated with RFFAs, including Denver Water's growth in demand prior to a Moffat Project alternative coming on-line, are not caused by the Moffat Project. The only difference between the Full Use of the Existing System and Full Use with a Project Alternative (2032) scenarios is the inclusion of a Moffat Project alternative, which provides an additional 18,000 AF/yr of new firm yield. Therefore, the comparison of these two scenarios isolates the hydrologic effects that are attributable to a Moffat Project alternative.

The following graphic represents the timelines by which impacts associated with each Project alternative are evaluated.



Types of Impacts

Impacts may be direct or indirect in nature and may be temporary (short term) or permanent (long term). A direct impact is a direct result of the Moffat Project, and occurs at the same time and in the same place as the actions associated with each alternative. Direct impacts associated with the Moffat Project would result from construction of facilities (e.g., dams, pipelines, and Advanced Water Treatment Plants [AWTPs]), and inundation by reservoirs and gravel pits). An indirect impact is a secondary or subsequent impact of the Project, and occurs later in time or at a distance from the action. The primary indirect impacts would result from Project-induced operational flow changes to the streams in the overall study area. Temporary impacts generally occur during construction activities and are considered short-term disturbances that can be reclaimed (e.g., construction and placement of pipelines) or would cease upon completion of construction activities (e.g., construction noise). Permanent impacts are created by construction or operational changes and are considered long term, sometimes remaining for the life of the Project (e.g., dams), or that might occur intermittently over the life of the Moffat Project (e.g., reservoir inundation).

Impact thresholds are defined as changes in intensity in terms of the degree, level, or strength of an impact. The following thresholds are used to determine the change in intensity of impacts resulting from a Project alternative:

- *No impact*: no discernable effect
- *Negligible*: effect is at the lowest level of detection and causes very little or no disturbance
- *Minor*: effect that is slight, but detectable, with some perceptible effects of disturbance
- *Moderate*: effect is readily apparent and has measurable effects of disturbance
- *Major*: effect is readily apparent and has substantial effects of disturbance

Short-Term Versus Long-Term Productivity of Resources

Council on Environmental Quality regulations specify that the description of impacts should identify how short-term uses of the environment would affect long-term productivity of resources. Short term is defined as the construction period through final reclamation, which is assumed to take up to 5 years. Long-term productivity refers to the period after the Moffat Project is completed and mitigation measures are in place. The short-term and long-term impacts relative to each resource are described under each resource section in this chapter.

Irreversible or Irretrievable Commitment of Resources

National Environmental Policy Act of 1969, as amended, requires a discussion of irreversible or irretrievable commitment of resources that would result from implementing the alternatives. The irreversible or irretrievable commitment of resources associated with the Moffat Project is discussed in Section 5.21. Irreversible commitment of resources would occur if a resource or its productivity or utility is forever consumed or committed. These resources are permanently lost due to Project implementation. For instance, fossil fuel resources used during construction activities would represent an irreversible commitment of resources. Irretrievable commitment of resources would result from resources used, consumed, destroyed, or degraded during construction, operation, and abandonment of the Project and could not ever be retrieved or replaced. For instance, habitat covered by a dam or inundated by a reservoir would be an irretrievable commitment unless the dam is breached and the habitat is restored.

Approach for Assessing Representative Components of Alternatives

Alternatives 8a, 10a, and 13a are based on scenarios developed for this EIS that represent possible storage concepts and additional water sources. The proposed facilities are presented in Chapter 2 of the EIS as “typical” for purposes of the EIS analysis; exact locations and design details would be developed during later design phases if one of the alternatives is chosen.

Approach for Evaluating the Proposed Action with the Environmental Pool for Mitigation

Under the Proposed Action, a 77,000 acre-feet (AF) enlargement would be constructed at Gross Reservoir. Of the 77,000 AF enlargement, 72,000 AF would be utilized to provide new firm yield to Denver Water’s system and 5,000 AF would be an Environmental Pool for mitigation. The estimated ground disturbance for the Proposed Action conservatively

assumed the proposed inundation area (i.e., the area between elevation 7,282 and 7,400 feet), plus 10 feet above the expanded reservoir pool to account for potential tree removal and other construction-related activities. The additional area of inundation associated with the Environmental Pool (i.e., the area between elevation 7,400 and 7,406 feet) is within this impact area. Thus, the impact analysis of ground-disturbance associated with the Proposed Acton with or without the Environmental Pool is the same. The environmental effects discussed for surface water correspond with the 72,000 AF enlargement whereas the operations and effects associated with the 5,000 AF Environmental Pool are discussed in Appendices H-22 and M-2, and were independently evaluated by the U.S. Army Corps of Engineers (Corps). Additional analyses conducted by the Corps for recreation and aquatic biological resources associated with the Environmental Pool are also presented in Appendices H-22 and M-2. The environmental effects of a 77,000-AF expansion are expected to be similar to the 72,000-AF expansion.

- **Gravel Pit Storage Facilities (Alternatives 8a and 13a)** – As discussed in Chapter 3, the baseline conditions for the South Platte River storage facilities are not the existing conditions; rather each site is considered a reclaimed gravel pit storage facility. It is assumed Denver Water would acquire similar gravel pits after they have been mined and reclaimed by the aggregate owner for use as a water storage facility (i.e., slurry walls and reclaimed side slopes would be in place). Thus, when Denver Water takes ownership, the gravel pits would be empty, although not necessarily operationally ready to manage stored water.
- **Advanced Water Treatment Facilities (Alternatives 8a, 10a, and 13a)** – As discussed in Chapter 2, it is assumed that a new AWTP would be located adjacent to the Worthing Pit (Alternatives 8a and 13a) or near the existing Denver Water Recycling Plant (Alternative 10a). The temporary and permanent impacts associated with constructing the AWTPs in these locations is analyzed in Chapter 5 (i.e., approximately 7 acres of temporary impacts and 4 acres of permanent impacts). The AWTP facility would also require approximately 60 to 70 acres of evaporation pond and drying beds, the specific location of which, because of their speculative nature, remains to be determined. A buried pipeline would also be needed to deliver the waste stream or brine from the AWTP to the disposal site.
- **Agricultural Water Rights and Land Dry-up (Alternative 13a)** – Alternative 13a represents a scenario of acquiring existing South Platte River agricultural water rights. For purposes of this EIS analysis, a combination of four agricultural ditches that divert from the South Platte River between the Metro Wastewater Reclamation District Plant (Metro Wastewater Treatment Plant [WWTP]) and Fort Lupton were identified as potential sources of firm water supply. The four ditches used in the EIS analysis are Fulton, Brantner, Brighton, and Lupton Bottom ditches. In addition, the lands historically irrigated by these ditches would be affected by the loss of irrigation. Based on review of transfer decrees and pending applications for transfers, it is estimated that approximately 3,900 acres of agricultural land may need to be taken out of irrigation to provide the required dry-year yield; however, the specific parcels and their locations are unknown. The actual area would depend on what agricultural shares would be purchased and the historical practice on those lands if Alternative 13a is the alternative permitted by the Corps.

Since specific sites for these facilities have not been determined, the impacts of these facilities are not analyzed for each resource in Chapter 5. However, if Alternatives 8a, 10a, or 13a are chosen, Denver Water would locate the disposal facility on an upland site in a commercial, industrial, or other area compatible with surrounding land uses, in close proximity to the AWTP. The location would be evaluated to avoid or minimize interferences with sensitive environmental areas, including wetlands, threatened and endangered species habitat, migratory birds, and cultural resources. Denver Water would conduct the appropriate level of analyses and obtain all necessary permits prior to constructing and operating the AWTP. Types of potential impacts or issues to be addressed during the permitting process may include permanent loss of vegetation and soil, air quality concerns, temporary construction traffic and noise, temporary disturbance associated with installation of the pipeline, visual impacts, and change in land use.

River Segments

In Chapter 3, resources that may be affected by an increase or decrease in stream flow directly related to an EIS alternative were described. In Chapter 5, the potential flow-related impacts on the following resources are evaluated for the affected river segments:

- Section 5.1 Surface Water
- Section 5.2 Water Quality
- Section 5.3 Channel Morphology
- Section 5.4 Groundwater
- Section 5.8 Riparian and Wetland Areas
- Section 5.9 Wildlife
- Section 5.10 Special Status Species
- Section 5.11 Aquatic Biological Resources
- Section 5.15 Recreation
- Section 5.17 Visual Resources
- Section 5.19 Socioeconomics

Refer to Section 3.0 for a discussion of the geographic scope of the study areas for these flow-related resources. The remaining non-flow-related resource areas do not include a description of impacts to river segments since no ground-disturbing activities would occur in the overall river segment study area.

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5.1 SURFACE WATER

This section describes the changes in surface water hydrology (stream flows, reservoir volumes, surface areas and levels, and floodplains) that are specifically related to the Moffat Collection System Project (Moffat Project or Project). A description of Platte and Colorado Simulation Model (PACSM), which is the model used to generate hydrologic information associated with each of the scenarios evaluated, is provided in Section 4.6.1. Hydrologic impacts directly or indirectly related to implementing an action alternative are based on a comparison of data for Full Use of the Existing System and each of the action alternatives. Full Use of the Existing System was used as the basis against which Moffat Project effects were compared because it reflects hydrologic conditions at the time the Moffat Project would come on-line. It is appropriate to compare the action alternatives to Full Use of the Existing System as opposed to Current Conditions (2006) to identify effects that are specifically due to the alternatives since there will be effects attributable to other reasonably foreseeable future actions (RFFAs) that are anticipated to occur between Current Conditions (2006) and when a Moffat Project would come on-line.

Several issues related to surface water resources were raised during public scoping including the following:

- Impacts of changes in the flow regime (quantity and timing of water) in the Fraser River, Williams Fork River, Blue River, Colorado River, South Boulder Creek, North Fork South Platte River, and South Platte River basins particularly in dry years.
- Impact of changes in stream flow on water availability for other users.
- Impacts on other water rights and diversions (including agricultural and municipal water users) if the frequency and duration of calls from the Colorado River is increased.
- Impacts of reducing Fraser River bypass flows, including the ability of downstream water districts to meet wastewater treatment discharge permit limits and water quality standards, and the ability of local water districts to meet municipal water supply demands.
- Impacts of changes in operations at Wolford Mountain, Dillon, and Williams Fork reservoirs.
- Impacts of increased flows on the 100-year floodplain and stream channel along South Boulder Creek due to trans-basin diversions via the Moffat Tunnel.
- Impacts of changes in evaporative losses at the Board of Water Commissioners' (Denver Water's) reservoirs.
- Impacts on other ongoing projects including the Windy Gap Firming Project and the South Boulder Creek floodplain study.

Summary of Major Conclusions

Due to the complexities of the hydrological analyses presented in this section, a summary of the major conclusions of the surface water impact analyses is provided below. The analysis leading to the major conclusions is presented in detail starting in Section 5.1.1.

Surface Water Hydrology

- For all action alternatives, additional Denver Water diversions would occur in average and wet years and would be highly concentrated during the runoff months primarily in May, June, and July. Typically additional diversions would be greatest in wet years following dry year sequences. On average, *additional* diversions would be greatest from the Fraser and Williams Fork river basins than from the Blue River Basin, and least from the South Platte River and South Boulder Creek.
- For all action alternatives, there would be no additional diversions in dry years because Denver Water will divert the maximum amount physically and legally available under their existing water rights without additional storage in their system.
- For all action alternatives, changes in stream flow would be greatest in average and wet years during the runoff months, which coincide with the period that Denver Water's additional diversions would be greatest.
- On the West Slope, flows would decrease on average due primarily to Denver Water's additional diversions. On the East Slope, there would be both flow increases and decreases due primarily to the combined impacts of Denver Water's additional diversions, a shift in seasonal operations between Denver Water's northern (Moffat) and southern (Foothills and Marston) Water Treatment Plants (WTPs), additional effluent returns at the Littleton-Englewood (Bi-City) Wastewater Treatment Plant (WWTP) and the Metro Wastewater Reclamation District Plant (Metro WWTP), and additional return flows accruing to the river due to Denver Water's outdoor water usage. Changes in stream flow in each affected river basin are generally described below:
    1. Flows in the Fraser and Williams Fork river basins would decrease in average and wet years during the runoff months due to Denver Water's additional diversions.
    2. Flows in the Blue River Basin would decrease in average and wet years during summer months and increase slightly during winter months due to differences in Roberts Tunnel diversions and spills at Dillon Reservoir. Flow changes in the Blue River Basin would be driven primarily by the seasonal shift in WTP operations. Under all action alternatives there would be a reduction in winter operations of Foothills and Marston WTPs because the Moffat WTP would operate at a minimum level during the winter.
    3. Flows along the Colorado River would decrease in average and wet years during the runoff months due to changes in surface water flows in the Fraser, Williams Fork, and Blue river basins which would be translated downstream and into the Colorado River.
    4. Flows in South Boulder Creek upstream of Gross Reservoir would increase in average and wet years during the runoff months due to Denver Water's additional diversions through the Moffat Tunnel. While flows would increase on average,

there would be no change in the maximum flows experienced in this reach because the capacity of South Boulder Creek above Gross Reservoir is limited to approximately 1,200 cubic feet per second (cfs). During high runoff, Denver Water must limit Moffat Tunnel deliveries in order to meet this constraint. From Gross Reservoir to the South Boulder Canal diversion structure, changes in flow reflect Gross Reservoir operations. In general, flows would be higher during winter months as water would be moved out of Gross Reservoir and into Ralston Reservoir in response to the WTP load shift from the southern WTPs to the Moffat WTP. Increases in outflow from Gross Reservoir would generally be greatest in dry years because Denver Water would typically draw more water from their North System storage as a drought begins. Flows during the summer would be lower on average because Foothills and Marston WTPs would meet a greater portion of the overall demand during these months and as a result, Gross Reservoir releases would decrease. Downstream of the South Boulder Diversion Canal, flows would generally decrease in wet years because Denver Water would divert more native South Boulder Creek water.

5. Flows in the North Fork South Platte River would decrease on average during winter months and increase during summer months. While flows would increase on average during summer months, there would be no change in the maximum flows experienced because Denver Water operates their system in a manner to keep the average daily flow in the North Fork South Platte River below 680 cfs at Grant and below 980 cfs above the confluence with the mainstem (Yevdjerick and Simons 1966/1967). Flow changes in the North Fork South Platte River would be driven primarily by the load shift in WTP operations. Diversions through the Roberts Tunnel during winter months would be lower on average, which results in equivalent lower flows in the North Fork South Platte River in these months. Summer diversions through Roberts Tunnel would generally be higher, and consequently flows in the North Fork South Platte River would be higher on average from May through September.
6. Flow changes along the South Platte River would be relatively minor and vary depending on the location. In general, flows would change due to additional direct diversions and exchanges to Strontia Springs Reservoir and Conduit 20, changes in Moffat WTP operations, and the load shift between Denver Water's northern and southern WTPs. In addition, the demand that would be met with additional storage on-line is higher under the action alternatives; therefore, effluent returns at Bi-City WWTP and Metro WWTP and return flows accruing to the river due to Denver Water's outdoor water usage would increase. As a result, average annual flows would be higher at the South Platte River at Henderson gage.

- The hydrologic impacts of the Proposed Action and Alternative 1c would be similar. The water source for Alternative 1c would be the same as the Proposed Action, except that a portion of the additional Moffat Collection System diversions would be stored in a new Leyden Gulch Reservoir.
- Hydrologic impacts of Alternatives 8a, 10a, and 13a would be slightly less on the West Slope and slightly greater on the East Slope compared to the Proposed Action. These

alternatives include reusable water (Alternatives 8a and 10a) and transferred agricultural water rights (Alternative 13a) for a portion of the new supply. As a result, diversions from the Moffat Collection System would be slightly lower on average under these alternatives. However, changes in surface water hydrology under these alternatives would still be similar to the Proposed Action because reusable supplies or agricultural supplies would be pumped back to the Moffat Collection System infrequently and only as needed to supplement Denver Water's Moffat supplies during a drought.

- Hydrologic impacts of the No Action Alternative would be less than the action alternatives in the Fraser and Williams Fork river basins and greater in the Blue River Basin. Under the No Action Alternative, Roberts Tunnel diversions would increase substantially compared to the action alternatives because Denver Water would rely more heavily on their Blue River supplies and Strategic Water Reserve to meet a higher demand, particularly during droughts. Increases in Moffat Tunnel and Gumlick Tunnel diversions under the No Action Alternative would be substantially less than increases under the action alternatives. Flows in South Boulder Creek above and below Gross Reservoir would be less on average than the action alternatives due primarily to differences in Moffat Tunnel diversions and storage at Gross Reservoir. Flows in the North Fork South Platte River would increase on average compared to the action alternatives due to additional Roberts Tunnel imports from the Blue River Basin. Flows along the South Platte River would generally be slightly less under the No Action Alternative than the action alternatives because Denver Water would rely more heavily on their South Platte supplies and Strategic Water Reserve to meet a higher demand.
- The No Action Alternative would result in shortages in meeting customer demands for both treated and raw water deliveries, would require use of the Strategic Water Reserve, would cause Gross Reservoir to frequently be at the minimum pool level, and would prohibit the ability to use the Moffat WTP about half of every year. These impacts apply to using the Strategic Water Reserve and may be less if restrictions are also imposed (Combination Strategy).

Floodplains

- Generally, floodplain extent would be the same or smaller by implementation of any of the action alternatives. One exception, however, is on the Blue River between Dillon Reservoir and Green Mountain Reservoir. Annual peak flows associated with return intervals of 5 years or more increase slightly (< 5 percent [%] for a given return interval) for the alternatives, relative to Full Use of the Existing System conditions.
- In the Fraser and Williams Fork river basins, annual peak flows tend to be unaffected in driest and wettest years, and reduced in average years. As a result, flows associated with recurrence intervals generally between 2 and 10 years tend to be smaller under the alternatives than under Full Use of the Existing System conditions. Flows associated with lower frequency (higher return intervals) in the alternatives tend to be similar to flows under Full Use of the Existing System.

- Floodplains in North Fork South Platte River and South Boulder Creek above Gross Reservoir are unchanged by alternatives because imports through Roberts Tunnel and Moffat Tunnel are managed to stay within the channel. Floods can occur in these basins due to local snowmelt or precipitation, but not due to the changes in the Moffat Collection System.
- Effects on floodplains tend to be the same across all action alternatives, except on South Boulder Creek below Gross Reservoir. All alternatives have the effect of reducing flows associated with specified return intervals. This effect is greatest for the largest Gross Reservoir enlargement alternative (Proposed Action), and generally decreases in proportion to the smaller reservoir capacity enlargements.

5.1.1 Proposed Action (Alternative 1a)

Under the Proposed Action, a 77,000 acre-feet (AF) enlargement would be constructed at Gross Reservoir. Of the 77,000 AF enlargement, 72,000 AF would be utilized to provide new firm yield to Denver Water's system and 5,000 AF would be an Environmental Pool for mitigation. The environmental effects discussed for surface water correspond with the 72,000 AF enlargement whereas the operations and effects associated with the 5,000 AF Environmental Pool are discussed in Appendices H-22 and M-2. Using existing collection infrastructure, primarily average to wet-year Fraser River, Williams Fork River, and South Boulder Creek water would be diverted and delivered via the Moffat Tunnel and South Boulder Creek to the existing Gross Reservoir. Existing facilities would be used to deliver water from the enlarged Gross Reservoir to the Moffat WTP, including the South Boulder Diversion Canal and Conduits 16 and 22. In general, the majority of "new" water diverted to Gross Reservoir would be kept in storage until a dry year or sequence of below average years occur.

5.1.1.1 Reservoir Evaporation and Fluctuation

Reservoir evaporation, contents, and elevations under the Proposed Action were compared to the Full Use of the Existing System scenario to evaluate surface water impacts. The following reservoirs are evaluated:

- Williams Fork Reservoir
- Dillon Reservoir
- Wolford Mountain Reservoir
- Gross Reservoir
- Antero Reservoir
- Eleven Mile Canyon Reservoir
- Cheesman Reservoir
- Strontia Springs and Chatfield Reservoirs

Williams Fork Reservoir

Williams Fork Reservoir contents would generally be lower under the Proposed Action, primarily due to additional diversions at Gumlick Tunnel and exchanges to reservoirs in the Denver Water system. Average differences in end-of-month content would range from approximately 500 to 1,000 AF (2% or less), which translates to a drop in water elevation of less than 1 foot in any month. The biggest difference in content would occur in May. Typically, the reservoir would not be full yet in May, and additional diversions at Gumlick Tunnel would reduce inflow to the reservoir. The incremental Gumlick Tunnel diversions would be greatest in June, but by then, in many years, the reservoir would fill, and reservoir outflow (that is, spills or pre-emptive releases) would be more affected than end-of-month content. Increases in Gumlick Tunnel diversions would be greatest in wet years following dry years, when Denver Water's East Slope storage is drawn down. The additional exports from the basin would occasionally result in substantially lower (on the order of -10,000 AF) late summer reservoir contents, but make little difference in most years because there would typically be enough water to keep the reservoir nearly full despite the exports. A small increase in the average amount of exchange to Dillon Reservoir in late summer partially accounts for greater outflows in August, September, and October, so that Williams Fork Reservoir would typically enter the winter with 650 AF less in storage, on average. Then, since the water level in Williams Fork must be lower than the bottom of the spillway gate by mid-December, not as much water would need to be released in the early winter.

In dry years, there would be almost no difference in Williams Fork Reservoir contents because Gumlick Tunnel diversions would be the same under the Proposed Action and Full Use of the Existing System. In particular, reservoir contents would be relatively unaffected under the Proposed Action, during the critical period. Figure 4.6.1-1 shows the drawdown that would occur at Williams Fork Reservoir under the Proposed Action through the critical period from 1953 to 1957.

In wet years, Williams Fork Reservoir's contents under the Proposed Action would be lower by 1,300 to 2,100 AF on average from October through May. While exchanges to Dillon Reservoir would be somewhat higher in October and November under the Proposed Action, they account for only part of this difference. The rest of the difference is attributable to conditions in the preceding years. There would be almost no difference in reservoir content from June through September of wet years, because Williams Fork Reservoir would fill and stay fairly full.

The largest change in average monthly end-of-month contents under the Proposed Action would be a 1,000 AF or 2% decrease in average years and a 2,100 AF or 3% decrease in wet years (Table H-2.1). There would be virtually no change in a dry year. The maximum monthly average end-of-month water elevation change would be a decrease of 1 foot in average years and a decrease of 2 feet in wet years (Table H-2.2). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the Proposed Action is 8 and 18 feet, respectively. The average annual evaporative loss would be 3,331 AF compared to 3,355 AF under Full Use of the Existing System, as shown in Table H-8.1.

Dillon Reservoir

In the Full Use of the Existing System scenario, Denver Water shuts down the Moffat WTP from October through March and winter demand is met entirely by Foothills and Marston WTPs. Under the Proposed Action, the Moffat WTP would operate at a minimum of 30 million gallons per day (mgd) through the winter, which shifts a significant portion of the winter treatment load away from Foothills and Marston WTPs. Since Denver Water's South System primarily uses Blue River rather than South Platte River water in the winter, the shift would affect Roberts Tunnel diversions and Dillon Reservoir levels.

From October to April, Roberts Tunnel diversions would be 9,800 AF less on average under the Proposed Action. From May through September diversions would increase by 14,600 AF on average, for a net average increase in Roberts Tunnel diversions of 4,800 AF annually. As a result of the shift in the timing of Roberts Tunnel diversions, Dillon Reservoir would enter the runoff season with 1,700 AF (1%) more in storage on average at the end of April. From May through September, Dillon Reservoir contents would be lower and the difference in contents would widen through the summer because diversions through Roberts Tunnel would generally increase due to a higher demand that would be met under the Proposed Action. By the end of September, Dillon Reservoir would have 7,800 AF (4%) less in storage on average under the Proposed Action. Because of the additional summer time Roberts Tunnel diversions, Dillon Reservoir would spill less. After September, differences in reservoir contents under the Proposed Action would start to decrease, and contents would be 1,100 AF higher on average by the end of March. The largest positive average monthly difference in end-of-month contents would occur in April, when Dillon Reservoir content would be 1,700 AF or 1% greater (Table H-2.4). The corresponding difference in water elevation would be an increase of 1 foot on average (Table H-2.5). The largest decrease in contents would occur in September, when Dillon Reservoir contents would be 7,800 AF or 4% less on average. The corresponding difference in end-of-month water elevation would be a reduction of 3 feet on average. The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the Proposed Action is 16 feet and 11 feet, respectively. The average annual evaporative loss would be 5,368 AF compared to 5,494 AF under Full Use of the Existing System, as shown in Table H-8.1.

In dry years, average monthly contents differences between the Proposed Action and Full Use of the Existing System for Dillon Reservoir would increase from January through May and decrease from June through December. The increases are largely related to conditions prior to the five designated dry years. These are such that at the beginning of the designated dry years, Dillon Reservoir contents would be about 4,000 AF less (compared with a difference of 7,800 AF less on average). Reductions in Roberts Tunnel diversions through the winter would result in higher contents than under Full Use of the Existing System by January. From May through August, end-of-month contents would decrease relative to Full Use of the Existing System because Roberts Tunnel would divert more water under the Proposed Action. In dry years, the largest increase in contents would occur in April, when Dillon Reservoir content would be 5,300 AF or 4% greater on average (Table H-2.4). The corresponding difference in water elevation would be an increase of 3 feet on average (Table H-2.5). The largest decrease would occur in August, when Dillon

Reservoir content would be 4,700 AF or 4% less on average. The corresponding difference in water elevation would be a reduction of 3 feet on average. Figure 4.6.1-2 shows the drawdown that would occur at Dillon Reservoir under the Proposed Action through the critical period from 1953 to 1957.

In wet years, Dillon Reservoir contents are less on average under the Proposed Action in every month. This is partially due to the average difference in contents prior to the five designated wet years. Contents prior to the designated wet years would be 9,500 AF lower under the Proposed Action (compared with a difference of 7,800 AF less on average). The winter reduction in Roberts Tunnel diversions would not be enough to overcome this difference. In wet years, the largest monthly difference in contents would occur in October, when Dillon Reservoir contents would be 8,500 AF or 3% less on average (Table H-2.4). The corresponding difference in water elevation would be a reduction of 3 feet on average (Table H-2.5).

Wolford Mountain Reservoir

There would be very few and relatively small differences in operations at Wolford Mountain Reservoir in most months. Wolford Mountain Reservoir contents under the Proposed Action would be slightly lower on average in every month. Differences would be 70 to 270 AF on average from May through September. During the winter months, reservoir contents would gradually increase relative to Full Use of the Existing System until May, when they would be 70 AF lower. The differences from August through May would be due primarily to slight differences in substitution releases from Wolford Mountain Reservoir. Under the Proposed Action, Denver Water's substitution obligation to Green Mountain Reservoir is slightly higher because diversions are higher. As a result, there are differences in substitution releases from Wolford Mountain Reservoir to meet historic user's pool and Green Mountain Reservoir contract demands. Differences in average water elevation would be less than 1 foot throughout the year.

The biggest difference in contents and levels at Wolford Mountain Reservoir would occur due to differences in the amounts released for substitution. In some Septembers of substitution years, Wolford Mountain Reservoir would release between 1,300 and 2,500 AF more water under the Proposed Action for substitution. During these months, and generally until the reservoir "catches up" the following winter or spring, the water elevation would be 2 to 5 feet lower. Figure 4.6.1-3 shows the drawdown that would occur at Wolford Mountain Reservoir under the Proposed Action through the critical period from 1953 to 1957.

The largest change in average monthly end-of-month contents under the Proposed Action would be a less than 1% decrease in average, dry, and wet years (Table H-2.7). The maximum monthly average end-of-month water elevation change would be a decrease of less than 1 foot in average, dry, and wet years (Table H-2.8). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45 year study period between Full Use of the Existing System and the Proposed Action is 0 and 5 feet, respectively. The average annual evaporative loss would be 2,570 AF compared to 2,574 AF under Full Use of the Existing System, as shown in Table H-8.1.

Gross Reservoir

Under the Proposed Action with the Environmental Pool, Gross Reservoir's volume would increase by 77,000 AF to 118,811 AF, which is more than twice its current volume. The surface water area at normal high water would change by a factor of two, from approximately 418 acres to 824 acres and the water level would increase by 124 feet. Of the 77,000 AF enlargement, 72,000 AF would be utilized to provide new firm yield to Denver Water's system and 5,000 AF would be an Environmental Pool for mitigation. The effects discussed in this section correspond with the 72,000 AF enlargement. The environmental effects of a 77,000 AF expansion are expected to be similar to the 72,000 AF expansion. Additional discussion specific to the operations and effects associated with the 5,000 AF Environmental Pool is provided in Appendices H-22 and M-2.

From April through November, the annual pattern of fluctuation in level and content would be similar to that under Full Use of the Existing System: the reservoir would be at its lowest at the end of April, reach its highest level in August, and would be drawn down through the fall and winter. Under Full Use of the Existing System, the Moffat WTP does not operate in the winter months; therefore, contents increase on average from December through February. However, under the Proposed Action, Gross Reservoir contents would drop steadily by approximately 4,000 AF per month during these months mostly because the Moffat WTP would be operating at a minimum of 30 mgd. Differences in reservoir contents under the Proposed Action are greatest in wet years following a drought, when the enlarged capacity of Gross Reservoir would be able to fill. Figure 4.6.1-4 shows the drawdown that would occur at Gross Reservoir under the Proposed Action through the critical period from 1953 to 1957.

Average monthly contents would be greatest at the end of July at 102,500 AF and lowest at the end of April at 69,500 AF (Table H-2.10). In dry years, monthly contents during summer months would be lower than average because the reservoir would be drawn on more heavily during a drought. Whereas, in wet years, monthly contents during summer months would be higher than average. Monthly average, dry, and wet end-of-month water elevations are shown in Table H-2.11. The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45 year study period between Full Use of the Existing System and the Proposed Action is 156 feet and 9 feet, respectively. The average annual evaporative loss would be 991 AF compared to 477 AF under Full Use of the Existing System, as shown in Table H-8.1.

Antero Reservoir

Under the Proposed Action, there would be little to no difference in Antero Reservoir contents in most years. Antero Reservoir contents would be lower under the Proposed Action by several hundred acre-feet, on average. In general, Denver Water uses Antero Reservoir in a prolonged drought. Therefore, during the majority of the study period, reservoir contents would be similar, because Antero Reservoir is maintained full. The average differences reflect differences in the timing of isolated drawdowns and subsequent refills that occur in droughts. The differences are manifest in years that are neither wet nor dry, because Antero Reservoir is not used until a drought has significantly lowered the water level in Cheesman Reservoir. Generally, it is after the first year of a dry period that

drawdown and differences in water level would occur. Figure 4.6.1-5 shows the drawdown that would occur at Antero Reservoir under the Proposed Action during the critical period from 1953 to 1957. There would be little to no change in a wet year.

The largest change in average monthly end-of-month contents under the Proposed Action would be a 340 AF or 2% decrease in average years and a 270 AF or less than 1% decrease in dry years (Table H-2.13). There would be little to no change in a wet year. The maximum monthly average end-of-month water elevation change would be a decrease of less than 1 foot in average and dry years (Table H-2.14). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the Proposed Action is 9 feet and 7 feet, respectively. The average annual evaporative loss would be 3,602 AF compared to 3,625 AF under Full Use of the Existing System, as shown in Table H-8.1.

Eleven Mile Canyon Reservoir

Similar to Antero Reservoir, Eleven Mile Canyon Reservoir is drawn upon in multi-year droughts. As a result, contents of Eleven Mile Canyon Reservoir under the Proposed Action would be very similar to those under Full Use of the Existing System in most years. Average monthly contents would be 200 to 600 AF (1% or less) greater under the Proposed Action, for every month of the year. These averages reflect changes in operations (greater or less use of the reservoir and/or slower refilling) in the year or years following droughts. Figure 4.6.1-6 shows the drawdown that would occur at Eleven Mile Canyon Reservoir under the Proposed Action during the critical period from 1953 to 1957. There would be little to no change in a wet year.

The largest change in average monthly end-of-month contents under the Proposed Action would be a 560 AF or 1% increase in average years, and a 190 AF or less than 1% decrease in dry years (Table H-2.16). The maximum monthly average end-of-month water elevation change would be an increase of less than 1 foot in average years and a decrease of less than a foot in dry years (Table H-2.17). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the Proposed Action is 4 feet and 3 feet, respectively. The average annual evaporative loss would be 5,856 AF compared to 5,838 AF under Full Use of the Existing System, as shown in Table H-8.1.

Cheesman Reservoir

The shift in treatment plant operations during the winter and the higher demand level met under the Proposed Action would affect Cheesman Reservoir contents. Under the Proposed Action, Cheesman Reservoir would enter the runoff season at about the same level on average as under Full Use of the Existing System. Cheesman Reservoir would be used more heavily through the summer because Denver Water's demand would be higher under the Proposed Action. By the end of September, contents would be 1,300 AF (2%) lower on average. Under all alternatives, some of the winter demand met by Foothills and Marston WTPs would shift to the Moffat WTP, such that the average draft on Cheesman Reservoir from October through March would be less than it is under Full Use of the Existing System. As a result, differences in reservoir contents would decrease until in March, Cheesman Reservoir contents would be approximately 250 AF (less than 1%) more on average.

In dry years, differences are partly related to conditions prior to the five designated dry years. The antecedent content differences are not as great as they are on average. In other words, end of September contents for the water years preceding the designated dry years would be approximately 700 AF, rather than 1,300 AF, less than Full Use of the Existing System. As winter progresses, less water would be needed under the Proposed Action from Denver Water's South System, so Cheesman Reservoir contents would be higher under the Proposed Action by the end of December. Contents under the Proposed Action would remain higher than Full Use of the Existing System through June. From July through September, the monthly draft on Cheesman Reservoir would be between 1,200 and 1,700 AF more under the Proposed Action; therefore, by the end of September, dry year average end-of-month contents would be 2,700 AF (6%) lower. Figure 4.6.1-7 shows the drawdown that would occur at Cheesman Reservoir under the Proposed Action during the critical period from 1953 to 1957.

In wet years, differences are also partly related to conditions prior to the five designated wet years, however, the trends and reasons for differences throughout the year are similar to average and wet years. From May through September, Cheesman Reservoir contents would be up to 150 AF lower under the Proposed Action. From October through April, Cheesman Reservoir's contents would be up to 700 AF (1% or less) higher under the Proposed Action.

The largest change in average monthly end-of-month contents under the Proposed Action would be a 1,300 AF or 2% decrease in average years, a 2,700 AF or 6% decrease in dry years, and a 700 AF or 1% increase in wet years (Table H-2.19). The maximum monthly average end-of-month water elevation change would be a decrease of 3 feet in average years and 3 feet in dry years, and an increase of less than 1 foot in wet years (Table H-2.20). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the Proposed Action is 6 and 61 feet, respectively. The average annual evaporative loss would be 1,058 AF compared to 1,074 AF under Full Use of the Existing System, as shown in Table H-8.1.

Strontia Springs and Chatfield Reservoirs

Reservoir evaporation, contents, and water elevation changes at Strontia Springs and Chatfield reservoirs under the Proposed Action would be negligible.

5.1.1.2 River Segments

The analysis of environmental consequences focused on the overall study area river segments as described in Section 3.0 in Chapter 3.

Fraser River

For the purpose of analyzing changes in surface water hydrology in the Fraser River Basin due to the action alternatives, modeled diversions and stream flows were evaluated at the locations of interest shown in Table 4.6.1-2. These locations coincide with the primary sections of Denver Water's Moffat Collection System, which include:

- St. Louis Creek

- Vasquez Creek
- Jim Creek
- Ranch Creek Section

As described in Section 3.1.5.1, Denver Water has 31 primary diversion points in the Fraser River Basin, which are listed in Table 3.1-6. In the PACSM, several of the smaller tributaries that Denver Water diverts from are combined and modeled jointly. This approach is reasonable because the tributaries are located in close proximity, diversions are of similar magnitude and timing, and there is little or no gage data which could be used to model them separately. See Section 4.6.1.1.2 for information on which tributaries were combined and modeled jointly.

Changes in Fraser River flows under the Proposed Action are directly related to the increase in storage capacity at Gross Reservoir, which would enable Denver Water to store more water brought through the Moffat Tunnel. With increased storage capacity on the East Slope, Denver Water would be able to divert flows that it is unable to capture without additional storage.

Bypass Flow Reductions

The reductions in minimum bypass flows in the Fraser River Basin under the Proposed Action are similar to those under Full Use of the Existing System. The Proposed Action would not increase the conditions under which Denver Water would reduce bypass flows in the Fraser River Basin; therefore, additional diversions in dry years due to bypass flow reductions are not anticipated between Full Use of the Existing System and the Proposed Action. However, additional diversions under the Proposed Action would result in more days that flows would be reduced to minimum summer bypass requirements and tributaries without bypass requirements would be dried up for a longer duration. Differences compared to Full Use of the Existing System would be similar but slightly less than compared to Current Conditions. On average, flows would be reduced to minimum summer bypass requirements at the Fraser River at Winter Park gage and below Denver Water's diversions from St. Louis Creek, Vasquez Creek, and Ranch Creek as a result of additional diversions approximately 8 more days a year and a maximum of 60 more days in one year. On Elk Creek and tributaries, Cub Creek, Buck Creek, Cooper Creek, and Jim Creek, which are tributaries that do not have bypass requirements, flows would be reduced to 0 cfs as a result of additional diversions during the summer approximately 4 more days a year on average and a maximum of 26 more days in one year. On the Middle, South, and North Forks of Ranch Creek, Dribble Creek, King Creek, Little Vasquez Creek, and St. Louis Creek tributaries, flows would be reduced to 0 cfs as a result of additional diversions during the summer about 9 more days a year on average and a maximum of 64 more days in one year. These flow reductions would generally occur primarily in June, and May and July to a lesser degree in above average and wet years. During winter months tributaries that do not have bypass requirements are already dried up. This occurs because diversion head gates are set in November or December and are not changed until April of the following year. This typically results in 100% of the flow being diverted during the winter from tributaries without bypass requirements. In general, there was zero flow from October through March under Current Conditions (2006) except in two wet years during the

study period for all smaller tributaries that do not have bypass requirements at Denver Water's diversion points.

Moffat Tunnel Diversions

Additional Moffat Tunnel diversions would occur in average and wet years and would be highly concentrated during runoff primarily in May, June, and July. Typically, additional diversions through the Moffat Tunnel would be greatest in wet years following dry year sequences. As shown in Tables H-7.4 and H-7.6, average annual Moffat Tunnel diversions would increase by 10,300 AF or 15% and 11,800 AF or 19% in average and wet years, respectively. Diversions would increase in 33 years out of the 45-year study period and additional diversions would range up to 65,400 AF/yr (33,600 AF per month). There would be no additional diversions in dry years and below average years when Denver Water already diverts the maximum amount physically and legally available under their existing water rights without additional storage in their system.

Table H-3.1 summarizes average monthly diversions through the Moffat Tunnel for average, dry, and wet conditions. Additional diversions through the Moffat Tunnel occur primarily in May, June, and July. There would be virtually no additional diversions from late summer through early spring except in infrequent, very wet years. The maximum monthly average increase in diversions would occur in June, with a 105.9 cfs or 31% increase. In wet years, the maximum monthly average increase in diversions would also occur in June, with a 125.8 cfs or 74% increase. Figures H-4.1 and H-4.2 show average daily Moffat Tunnel diversions for average and wet conditions.

Table H-6.18 shows the percentage of days from May through July that Moffat Tunnel diversions would change. There would be little to no change in diversions (flow change less than 1 cfs) about 71% of the time. Increases in diversions up to 100 cfs would be most common and occur approximately 11% of the time. The maximum daily increase in diversions would be 843 cfs in June (this includes 95 cfs delivered from the Williams Fork River Basin).

As described above, changes in flow due to additional diversions in the Fraser River Basin would occur primarily during the runoff season from May through July; however, there would be some changes in flow due to additional diversions in winter months. Additional diversions during winter months would occur in 2 years during the 45-year study period. Additional diversions would occur during those months because Gross Reservoir would not be full under the Proposed Action in which case there would be additional space in Gross Reservoir to store water diverted through the Moffat Tunnel. Since most of the diversion dams in the Moffat Collection System cannot be adjusted in the wintertime because they are snowed in, Denver Water has the ability to release all or a portion of water diverted by that system rather than allowing it to flow through the Moffat Tunnel if Gross Reservoir is full. In winter months when additional diversions take place, the flow below the diversion structure would be equal to or higher than the average winter flow at that location. While there was an increase in diversions in two winters during the study period, there would generally be no flow in tributaries that do not have bypass requirements during the winter. Under Current Conditions (2006), Denver Water typically diverts 100% of the flow during the winter from tributaries that do not have bypass requirements at its diversion points.

Fraser River Mainstem

Below Denver Water's mainstem Fraser River diversion, average annual flows would decrease by 1,400 AF or 30% and 2,100 AF or 22% in wet years. Monthly average flows would decrease by a maximum of 17.3 cfs or 45% in June (Table H-3.2). In wet years, monthly average flows would decrease by a maximum of 26.0 cfs or 29% in June. The Fraser River at Winter Park gage is located downstream of Denver Water's mainstem Fraser River diversion and their tributary diversions from Jim Creek, Cub Creek, Buck Creek, and Cooper Creek. Average annual flows at this location would decrease by 1,900 AF or 24% and 3,000 AF or 20% in wet years. Monthly average flows would decrease by a maximum of 22.6 cfs or 43% in June (Table H-3.6). This coincides with the month when Moffat Tunnel diversions would increase most. In wet years, monthly average flows would decrease by a maximum of 35.9 cfs or 28% in June.

Continuing downstream, the Fraser River would be affected by Denver Water's diversions from Vasquez, Elk Creek, St. Louis, and Ranch creeks. Generally, the reduction in flow due to additional diversions rises in the downstream direction however; reductions would be smaller relative to the total stream which is growing. For some reaches, however, flows at locations downstream of Denver Water' Moffat Collection System would be less at certain times of the year if gains do not exceed the amount diverted for irrigation and municipal use. This is primarily an issue following runoff in July and August along the Fraser River mainstem downstream of the confluence of Vasquez Creek and upstream of the confluence with St. Louis Creek, and along St. Louis and Vasquez creeks. As a result, the percentage reduction in flow caused by Denver Water's diversions would be higher at some downstream locations; however, Denver Water's additional diversions in July and August are typically low because the amount physically and legally available is limited.

Below the confluence with Vasquez Creek, annual flows would decrease by 4,200 AF or 26% on average, and 5,800 AF or 17% on average in wet years. Monthly average flows would decrease by a maximum of 46.4 cfs or 38% in June (Table H-3.11). In wet years, monthly average flows would decrease by a maximum of 67.5 cfs or 24% in June.

Downstream of the confluence with St. Louis Creek, average annual flows would decrease by 6,600 AF or 21% and 8,400 AF or 13% in wet years. Monthly average flows would decrease by a maximum of 70.2 cfs or 31% in June (Table H-3.17). In wet years, monthly average flows would decrease by a maximum of 93.8 cfs or 18% in June.

Downstream of the confluence with Crooked Creek, which is located downstream of all of Denver Water's Fraser River Basin diversions, average annual flows would decrease by 8,400 AF or 10% and 10,400 AF or 7% in wet years. Monthly average flows would decrease by a maximum of 88.7 cfs or 19% in June (Table H-3.22). In wet years, monthly average flows would decrease by a maximum of 114.1 cfs or 11% in June.

At the Fraser River at Granby gage, which is located close to the confluence with the Colorado River, average annual flows would decrease by 8,400 AF or 9% and 10,400 AF or 6% in wet years. Monthly flows would decrease in 33 years out of the 45-year study period and decreases would range up to 29,100 AF. Monthly average flows would decrease by a maximum of 88.9 cfs or 17% in June (Table H-3.23). In wet years, monthly average flows would decrease by a maximum of 114.4 cfs or 10% in June. As discussed in Section 4.6.1, water supplies are adequate to meet existing demands for water providers in the Fraser

River Basin. Only Grand County Water and Sanitation District (GCWSD) would experience an additional shortage due to the Moffat Project. As shown in Table 4.3.1-3, GCWSD would experience an additional shortage of 6 AF/yr on average under the Proposed Action compared to Full Use of the Existing System. GCWSD's additional shortage under the Proposed Action would largely be caused by Denver Water's additional diversions from Vasquez Creek and Little Vasquez Creek compared to Full Use of the Existing System. Information provided by GCWSD staff indicates they would avoid potential shortages as their demand increases through infrastructure investments (see Section 4.6.1).

Jim Creek

Below Denver Water's Jim Creek diversion, average annual flows would decrease by 370 AF or 51% and 720 AF or 30% in wet years. Monthly average flows would decrease by a maximum of 4.0 cfs or 46% in June (Table H-3.3). In wet years, monthly average flows would decrease by a maximum of 7.5 cfs or 27% in June.

Cooper Creek

Below Denver Water's diversion from Cooper Creek, average annual flows would decrease by 20 AF or 31% and 30 AF or 37% in wet years. Monthly average flows would decrease by a maximum of 0.3 cfs or 66% in June (Table H-3.5). In wet years, monthly average flows would decrease by a maximum of 0.5 cfs or 59% in June.

Cub and Buck Creeks

Below Denver Water's diversions from Cub and Buck creeks, average annual flows would decrease by 90 AF or 31% and 160 AF or 27% in wet years. Monthly average flows would decrease by a maximum of 1.0 cfs or 52% in June (Table H-3.4). In wet years, monthly average flows would decrease by a maximum of 1.9 cfs or 30% in June.

Vasquez Creek and Tributaries

Denver Water's diversions from the Williams Fork River Basin are delivered into Vasquez Creek above the Moffat Collection System via the Gumlick and Vasquez tunnels. Below the outfall from the Gumlick Tunnel, annual flows would increase by 1,900 AF or 12% on average and 1,400 AF or 9% in wet years. Monthly average flows would increase by a maximum of 17.9 cfs or 21% in June (Table H-3.7). In wet years, monthly average flows would increase by a maximum of 13.1 cfs or 21% in June.

Below Denver Water's diversion from Vasquez Creek, average annual flows would decrease by 2,000 AF or 27% and 2,400 AF or 16% in wet years. Monthly average flows would decrease by a maximum of 20.0 cfs or 37% in June (Table H-3.8). In wet years, monthly average flows would decrease by a maximum of 26.7 cfs or 21% in June.

Below Denver Water's diversion from Little Vasquez Creek, average annual flows would decrease by 320 AF or 61% and 290 AF or 38% in wet years. Monthly average flows would decrease by a maximum of 3.8 cfs or 60% in June (Table H-3.9). In wet years, monthly average flows would decrease by a maximum of 4.9 cfs or 50% in June.

At the Vasquez Creek gage, average annual flows would decrease by 2,300 AF or 32% and 2,700 AF or 17% in wet years. Monthly average flows would decrease by a maximum of

23.8 cfs or 37% in June (Table H-3.10). In wet years, monthly average flows would decrease by a maximum of 31.6 cfs or 22% in June.

Elk Creek and Tributaries

Below Denver Water's diversions from Elk Creek, West and East Elk creeks, and the East and West forks of Main Elk Creek, average annual flows would decrease by 240 AF or 28% and 260 AF or 16% in wet years. Monthly average flows would decrease by a maximum of 2.5 cfs or 35% in June (Table H-3.12). In wet years, monthly average flows would decrease by a maximum of 2.7 cfs or 17% in June.

St. Louis Creek and Tributaries

Below Denver Water's diversion from St. Louis Creek, average annual flows would decrease by 990 AF or 17% and 1,100 AF or 10% in wet years. Monthly average flows would decrease by a maximum of 10.0 cfs or 26% in June (Table H-3.13). In wet years, monthly average flows would decrease by a maximum of 10.9 cfs or 13% in June.

Below Denver Water's diversion from tributaries to St. Louis Creek including West and East St. Louis creeks, Short Creek, Byers Creek, Iron Creek, and Fool Creek, average annual flows would decrease by 1,000 AF or 42% and 1,200 AF or 18% in wet years. Monthly average flows would decrease by a maximum of 10.7 cfs or 41% in June (Table H-3.14). In wet years, monthly average flows would decrease by a maximum of 12.0 cfs or 18% in June.

Below Denver Water's diversion from King Creek, average annual flows would decrease by 50 AF or 43% and 50 AF or 17% in wet years. Monthly average flows would decrease by a maximum of 0.5 cfs or 41% in June (Table H-3.16). In wet years, monthly average flows would decrease by a maximum of 0.5 cfs or 18% in June.

At St. Louis Creek near the Fraser gage, average annual flows would decrease by 2,000 AF or 13% and 2,400 AF or 9% in wet years. Monthly average flows would decrease by a maximum of 20.8 cfs or 21% in June (Table H-3.15). In wet years, monthly average flows would decrease by a maximum of 23.0 cfs or 12% in June.

Ranch Creek and Tributaries

Downstream of Denver Water's Englewood Ranch Gravity System, which includes diversions from North and South Trail creeks, Hurd Creek, Hamilton Creek, Cabin Creek, and Little Cabin Creek, average annual flows would decrease by 250 AF or 3% and 340 AF or 3% in wet years. Monthly average flows would decrease by a maximum of 1.4 cfs or 2% in June (Table H-3.18). In wet years, monthly average flows would decrease by a maximum of 2.9 cfs or 12% in May.

Downstream of Denver Water's North Fork Ranch Creek and Dribble Creek diversions, average annual flows would decrease by 340 AF or 24% and 330 AF or 11% in wet years. Monthly average flows would decrease by a maximum of 3.5 cfs or 23% in June (Table H-3.19). In wet years, monthly average flows would decrease by a maximum of 3.6 cfs or 11% in June.

Downstream of Denver Water's Main Ranch Creek diversion, average annual flows would decrease by 390 AF or 14% and 370 AF or 7% in wet years. Monthly average flows would

decrease by a maximum of 4.3 cfs or 21% in June (Table H-3.20). In wet years, monthly average flows would decrease by a maximum of 4.2 cfs or 10% in June.

Downstream of Denver Water's Middle and South Fork of Ranch Creek diversions, average annual flows would decrease by 810 AF or 37% and 820 AF or 15% in wet years. Monthly average flows would decrease by a maximum of 8.6 cfs or 35% in June (Table H-3.21). In wet years, monthly average flows would decrease by a maximum of 8.7 cfs or 15% in June.

Fraser River Native Stream Flow

Tables H-12.1 through H-12.5 and H-12.7 through H-12.15 show the native flow and the amount and percent diverted at Denver Water's diversion points in the Fraser River Basin under Current Conditions (2006), Full Use of the Existing System, No Action and each of the action alternatives. Additional native flow diversions would occur primarily in average and wet years during the runoff season from May through July. Under Full Use of the Existing System, the average annual percentage of native flow diverted ranges from 20% at the Englewood Ranch Gravity System up to 90% at Denver Water's Jim Creek diversion. Under the Proposed Action, the average annual percentage of native flow diverted would range from 22% at the Englewood Ranch Gravity System up to 95% at Denver Water's Jim Creek diversion. The average annual percentage of native flow diverted would increase by 2% at the Englewood Ranch Gravity System up to 14% at Denver Water's diversions from the Middle and South Fork of Ranch Creek compared to Full Use of the Existing System. In general, the average annual percentage of native flow diverted by Denver Water would increase by about 10% compared to Full Use of the Existing System. There would be little to no increase in the percentage of native flow diverted in winter months. The increase in the percentage of native flow diverted would be greatest in June at almost all locations in the Fraser River Basin. In June, the average annual percentage of native flow diverted under the Proposed Action would increase by about 15% compared to Full Use of the Existing System at most locations with a maximum increase of 20% at Denver Water's diversions from the Middle and South Fork of Ranch Creek.

Table H-12.6 shows the native flow and the amount and percentage added to Vasquez Creek due to Denver Water's additional diversions from the Williams Fork River Basin, which are delivered to Vasquez Creek via the Gumlick and Vasquez tunnels. Under Full Use of the Existing System, average monthly flows would increase 48.1 cfs (129%) in June, whereas under the Proposed Action, flows would increase by 66.0 cfs (177%). The greatest increase in flows would occur in June of a dry year. In dry years, average monthly flows would increase by 71.7 cfs (427%) under both Full Use of the Existing System and the Proposed Action.

Fraser River Daily Flow Changes

Figures H-4.1 through H-4.69 show average daily diversions through the Moffat Tunnel and hydrographs at locations of interest in the Fraser River Basin for average, dry, and wet conditions.

Figures H-5.1 through H-5.11 present flow duration curves at several locations of interest in the Fraser River Basin. As shown by the flow duration curves, flow reductions resulting from the Proposed Action would occur at higher flow rates, which typically correspond with wet years.

Table H-6.10 shows the percentage of days from May through July that flow changes would occur at several locations of interest. There would be little to no change in flow (flow change less than 1 cfs) more than 80% of the time at all locations in the basin upstream of the confluence with St. Louis Creek. Below the confluence with St. Louis Creek there would be little to no change in flow (flow change less than 1 cfs) between 70 and 80% of the time. Daily decreases in flow would be greatest along the Fraser River below St. Louis Creek and range up to 733 cfs. Table H-6.20 summarizes maximum daily flow reductions at several locations throughout the Fraser River Basin.

Figures H-6.1 through H-6.6 show daily flows at several locations in the Fraser River Basin from October 1953 through September 1957. These figures demonstrate the flow reductions that would occur in a wet year following a series of dry years. Denver Water's additional diversions during the critical period (1954, 1955, and 1956) would be attributable to reductions in bypass flows under both Full Use of the Existing System and the Proposed Action. Denver Water's Moffat Tunnel diversions in the wet year following the drought would increase by 65,400 AF or 139% under the Proposed Action. This includes an additional 7,800 AF diverted from the Williams Fork River Basin. The increase in diversions would be significant because Denver Water would divert more water to refill the additional firming storage at Gross Reservoir under the Proposed Action.

In some wet years following a drought, flows below Denver Water's diversion points would be more consistent with a dry year or below average year due to additional diversions under the Proposed Action. The reduction in flows in the year following the drought would increase the frequency and duration of dry year conditions. The change in dry year frequency and duration was evaluated at six locations in the Fraser River Basin including: (1) Fraser River at Winter Park gage, (2) below Denver Water's Jim Creek diversion, (3) Vasquez Creek gage, (4) St. Louis Creek gage, (5) below Denver Water's main Ranch Creek diversion, and (6) Fraser River below Crooked Creek. These locations are dispersed throughout the Fraser River Basin and include both tributary and mainstem locations with and without bypass requirements. Annual flows for Current Conditions, Full Use of the Existing System, No Action and each of the action alternatives were ranked based on volume (see Tables H-15.1 through H-15.6). The bottom 25th percentile was assumed to include dry and below average years. Under the Proposed Action, the greatest increase in the number of years with annual flows in the bottom 25th percentile would occur at Denver Water's Jim Creek diversion and the Vasquez Creek gage. At the Jim Creek diversion, the number of years in the bottom 25th percentile would increase by 6 years from 12 years to 18 years. At the Vasquez Creek gage, the number of years in the bottom 25th percentile would increase by 6 years from 23 years to 29 years. The increase in the frequency of dry year conditions would be greatest along the tributaries that Denver Water diverts from.

This analysis also shows the duration and recurrence of back-to-back dry years would increase under the Proposed Action. Under Full Use of the Existing System, there would be a total of 3 sets of at least 2 back-to-back dry or below average years, with the longest period being 3 years in a row at the Fraser River at Winter Park gage. Under the Proposed Action, there would be 4 sets of at least 2 back-to-back dry or below average years, with the longest period being 4 years in a row at that location. At the Vasquez Creek gage, there would be a total of 6 sets of at least 2 back-to-back dry or below average years under Full Use of the Existing System, with the longest period being 5 years in a row. Under the

Proposed Action, there would be 5 sets of at least 2 back-to-back dry or below average years, with the longest period being 6 years in a row at that location. Results at the other locations are more similar to the Fraser River at Winter Park gage.

Fraser River Peak Flow Changes

Denver Water's additional diversions under the Proposed Action would affect the magnitude, timing, frequency, and duration of peak flows below their diversion points. The Nature Conservancy's Indicators of Hydrologic Alteration (IHA) was used to evaluate changes in the flow regime at several locations in the Fraser River Basin. The IHA is a statistically based program for comparing hydrologic regimes before versus after a river has been altered by human activities. See Section 4.6.1.1.2 for a description of IHA and the methodology used to evaluate peak flow changes.

Tables H-14.6 through H-14.8 summarize changes in the magnitude, duration, and timing of high-flow pulses, small floods and large floods at each location analyzed. Tables H-14.9 and H-14.10 summarize changes in the magnitude and timing of the peak flow for an average year and wet year based on the average and wet year daily hydrographs included in Appendix H-4.

There would be little to no change in median monthly low flows at locations high in the Fraser River Basin compared to Full Use of the Existing System. There would be no decrease in the median low flows along the tributaries to the Fraser River that were evaluated. Below Denver Water's Fraser River diversion, the median monthly low flow would decrease 0.4 cfs in June. There would be no change in median monthly low flows at that location in other months. Further downstream along the Fraser River mainstem below the confluence with St. Louis Creek, the median monthly low flow would decrease 0.3 cfs in June. Below the confluence with Crooked Creek, there would be no decrease in median monthly low flows under the Proposed Action compared to Full Use of the Existing System.

At the locations evaluated, the magnitude of small flood peak flows would decrease up to 11 cfs (10%) along tributaries to the Fraser River and up to 55 cfs (8%) along the Fraser River mainstem below St. Louis Creek (Table H-14.6). At some locations, such as King Creek and the tributaries and mainstem of Ranch Creek, there would be little to no change in small flood peak flows. Throughout the basin there would be minimal change (± up to three days) in the timing of the small flood peak, which typically occurs in mid- to late June. There would be a significant decrease in the duration of a small flood along tributaries to the Fraser River. The duration of a small flood would decrease up to 21 days along tributaries to the Fraser River. The duration of a small flood would be reduced because it would typically take longer to fill an enlarged Gross Reservoir, in which case diversions would continue for a longer period during runoff under the Proposed Action. The reduction in the duration of a small flood generally decreases at locations further downstream in the basin and along the Fraser River mainstem.

There would be little change in the timing and magnitude of peak flows for large floods at the locations evaluated with the exception of the Fraser River below Crooked Creek. At the Fraser River below Crooked Creek the large flood peak flow would decrease by 391 cfs or 18% (Table H-14.7). This reduction is mainly due to changes in the timing and magnitude

of the peak of the large flood in one year of the study period at that location. There would be a significant decrease in the duration of large floods along the tributaries and mainstem of the Fraser River. The duration of a large flood would decrease from 7 days below Denver Water's King Creek diversion up to 45 days below Denver Water's main Ranch Creek diversion.

The magnitude of high flow pulses would increase or decrease by up to 7 cfs along tributaries to the Fraser River and up to 10 cfs along the Fraser River mainstem locations evaluated (Table H-14.8). There would be little change in the duration of high flow pulses (decrease by 1 day or less). In general there would be little change in the timing of high flows pulses (± up to 9 days).

As shown in Table H-14.9, the magnitude of the peak flow in an average year would decrease less than 1 cfs at the King Creek diversion up to 116 cfs at the Fraser River below Crooked Creek. In general, there would be little to no change (± up to 7 days) in the timing of the peak flow in an average year. As shown in Table H-14.10, the magnitude of the wet year peak flow would decrease less than 1 cfs at the tributary locations evaluated up to 91 cfs at the Fraser River below Crooked Creek. In general, the reduction in the average and wet year peak flows would be least at locations higher in the basin along tributaries and increase along the Fraser River mainstem lower in the basin. At most locations there would be little to no change in the timing of the wet year peak flow (± up to 2 days).

Changes in the frequency of peak flows for different flood recurrence intervals are discussed in the following section.

Fraser River Floodplain

The previous section on Fraser River flow explains that more water would be exported from the Fraser River Basin under the Proposed Action, as compared to Full Use of the Existing System. The additional diversions would occur in average and wet years, while dry year diversions would be unaffected. As a result, it is expected that flood flows would not be greater under the Proposed Action than they are under Full Use of the Existing System, and they would probably be smaller.

The maximum annual flow series for four different points in the Fraser River Basin were analyzed to verify this generalization. In all cases, peak flows for a given recurrence interval under the Proposed Action were equal to or less than peak flows for the same recurrence interval under Full Use of the Existing System. The following conclusions can be made:

- On the mainstem, annual peak flood flows would be reduced in all years in the study period.
- On the tributaries, the annual peaks associated with recurrence intervals above 6.6 years (St. Louis Creek) and 3.3 years (Ranch Creek) were unaffected by the proposed Moffat Project.

To summarize, areas of inundation would generally be reduced throughout the basin for the 2- and 5-year flood events. For less frequent floods, the floodplain along the Fraser River may be smaller than under Full Use of the Existing System, but have similar extents along the tributaries.

Williams Fork River

For the purpose of analyzing changes in surface water hydrology in the Williams Fork River Basin under the Proposed Action, modeled diversions and stream flows were analyzed at the Gumlick Tunnel, at the Williams Fork River below Steelman Creek gage and below Williams Fork Reservoir.

Gumlick Tunnel

As shown in Tables H-7.4 and H-7.6, average annual Gumlick Tunnel diversions would increase by 1,900 AF or 20% in average years and 1,400 AF or 20% in wet years. Diversions would increase in 34 years out of the 45-year study period and additional diversions would range up to 10,040 AF/yr (6,300 AF per month). There would be no additional diversions in below average and dry years compared to Full Use of the Existing System because Denver Water already diverts the maximum amount physically and legally available under their existing water rights without additional storage in their system. Additional diversions would occur primarily during the runoff season from May through July; however, there would be some changes in flow due to additional diversions in winter months. Additional diversions during winter months would occur in 2 years during the 45-year study period. Additional diversions would occur during those months because Gross Reservoir would not be full under the Proposed Action in which case there would be additional space in Gross Reservoir to store water diverted from the Williams Fork River Basin. In winter months when additional diversions take place, the flow below the diversion structure would be equal to or higher than the average winter flow at that location.

Table H-3.24 summarizes average monthly diversions through the Gumlick Tunnel for average, dry, and wet conditions. Additional diversions would occur primarily in May, June, and July. There would be virtually no additional diversions from late summer through early spring except in infrequent, very wet years. The maximum monthly average increase in diversions would occur in June, with a 17.9 cfs or 37% increase. In wet years, the maximum monthly average increase in diversions would also occur in June, with a 13.1 cfs or 143% increase on average. The increase in diversions in wet years is actually less than in average years because diversions are already high in most wet years and the opportunity to divert more water is limited given storage constraints at Gross Reservoir. Figures H-4.70 and H-4.71 show average daily diversions through Gumlick Tunnel for average and wet conditions.

Williams Fork River Mainstem and Tributaries

The Williams Fork River upstream of the Williams Fork Reservoir is directly affected by changes in Denver Water's diversions through the Gumlick Tunnel when additional storage is added to the Moffat Collection System. With increased storage capacity on the East Slope, Denver Water would be able to divert flows that it is unable to capture without additional storage. Increases in Gumlick Tunnel diversions would be concentrated in the runoff season, from May through July, and would be greatest in wet years following dry year sequences. Tables H-3.25 through H-3.30 summarize average monthly flows at the locations of interest in the Williams Fork River Basin for average, dry, and wet conditions. Note that flow reductions at tributary locations below Denver Water's diversion points are equivalent to the additional amount diverted at that location.

Denver Water diverts water for delivery through the Gumlick Tunnel from four headwater tributaries including Steelman Creek, Bobtail Creek, Jones Creek, and McQueary Creek. Below Denver Water's Steelman Creek diversion, average annual flows would decrease by 460 AF or 25% and 310 AF or 8% in wet years. At this location, monthly average flows would decrease by a maximum of 4.1 cfs or 21% in June (Table H-3.25). In wet years, monthly average flows would decrease by a maximum of 2.8 cfs or 8% in June. Below Denver Water's Bobtail Creek diversion, average annual flows would decrease by 850 AF or 27% and 680 AF or 9% in wet years. At this location, monthly average flows would decrease by a maximum of 8.3 cfs or 24% in June (Table H-3.26). In wet years, monthly average flows would decrease by a maximum of 6.3 cfs or 9% in June. Below Denver Water's Jones Creek diversion, average annual flows would decrease by 230 AF or 22% and 160 AF or 7% in wet years. At this location, monthly average flows would decrease by a maximum of 2.0 cfs or 18% in June (Table H-3.27). In wet years, monthly average flows would decrease by a maximum of 1.5 cfs or 8% in June. Below Denver Water's McQueary Creek diversion, average annual flows would decrease by 370 AF or 30% and 270 AF or 10% in wet years. At this location, monthly average flows would decrease by a maximum of 3.5 cfs or 28% in June (Table H-3.28). In wet years, monthly average flows would decrease by a maximum of 2.5 cfs or 10% in June.

Average annual flows at the Williams Fork River below Steelman Creek gage, which is located below Denver Water's Gumlick Tunnel diversions, would decrease by 1,900 AF or 22% and 1,400 AF or 8% in wet years. Monthly average flows would decrease by a maximum of 17.9 cfs or 21% in June, which coincides with the month when Gumlick Tunnel diversions would increase most (Table H-3.29). In wet years, monthly average flows would decrease by a maximum of 13.1 cfs or 8% in June. Moving downstream, the volume of change stays the same but the percentage reduction in flow is less because the stream is gaining.

Flows below Williams Fork Reservoir reflect differences in Gumlick Tunnel diversions and reservoir operations, including spills, substitution or exchange releases, and power releases to achieve operational goals. When more water is diverted through Gumlick Tunnel under the Proposed Action, that water is not available to fill Williams Fork Reservoir. Thus a "deficit" would develop in the reservoir to the extent of the increased diversions. Flow below the reservoir would usually be unaffected during runoff as long as the reservoir does not spill. The reservoir would bypass or release the same amount as under Full Use of the Existing System to satisfy downstream users. Flows below the reservoir during runoff would generally decrease in spill years because the reservoir would typically achieve fill later in the year and spill less.

In August, September, and October, releases from Williams Fork Reservoir would increase slightly on average because of a small increase in the average amount of exchange to the Moffat System and increased substitution releases out of Williams Fork Reservoir under the Proposed Action. Monthly average outflow would increase by 1 to 2 cfs during these months. If necessary, Denver Water would release water during the months of November and December so the water level in the reservoir would be below the bottom of the spillway gate to avoid icing. Releases to avoid icing would be less on average under the Proposed Action because reservoir contents would generally be lower at the end of October. Monthly average outflow would decrease by 3 cfs in November and 1 cfs in December.

As shown in Tables H-7.4 through H-7.6, average annual outflow from Williams Fork Reservoir would decrease by 1,700 AF or 2% in average years, 2,900 AF or 2% in wet years, and there would be minimal change in dry year outflow. Table H-3.30 summarizes average monthly outflow from Williams Fork Reservoir for average, dry, and wet conditions. Monthly average changes in outflow would range from a maximum decrease of 19.9 cfs or 13% in June to a maximum increase of 5.1 cfs or 6% in March. In wet years, monthly average changes in outflow would range from a maximum decrease 38.2 cfs or 8% in June to a maximum increase of 9.5 cfs or 7% in October. There would be little change in outflow in dry years.

Williams Fork River Native Stream Flow

Tables H-12.16 through H-12.19 show the native flow and the amount and percent diverted at Denver Water's diversions from the upper Williams Fork River tributaries under Current Conditions (2006), Full Use of the Existing System, No Action and each of the action alternatives. As discussed above, additional native flow diversions would occur primarily in average and wet years during the runoff season from May through July. Under Full Use of the Existing System, the average annual percentage of native flow diverted from the upper William Fork River Basin ranges from 55% at Denver Water's Jones Creek diversion up to 60% at their McQueary Creek diversion. Under the Proposed Action, the average annual percentage of native flow diverted would range from 65% at Denver Water's Jones Creek diversion up to 72% at their McQueary Creek diversion. The average annual percentage of native flow diverted would increase by approximately 11% compared to Full Use of the Existing System. There would be little increase in the percentage of native flow diverted in winter months. The increase in the percentage of native flow diverted from the upper Williams Fork River tributaries would be greatest in June. In June, the average percentage of native flow diverted by Denver Water from the upper Williams Fork River tributaries would increase by 12 to 15% compared to Full Use of the Existing System with a maximum increase of 15% at Denver Water's McQueary and Bobtail creeks diversions.

Williams Fork River Daily Flow Changes

Figures H-4.73 through H-4.90 show average daily hydrographs at the locations of interest in the Williams Fork River Basin. Figures H-5.12 through H-5.14 present flow duration curves for Steelman Creek below Denver Water's diversion, Williams Fork River below Steelman Creek, and Williams Fork Reservoir outflow, respectively. Flow duration curves for Bobtail, Jones, and McQueary creeks below Denver Water's diversion points were not developed since they are very similar to the flow duration curve for Bobtail Creek. As shown by the flow duration curves, flow reductions resulting from the Proposed Action would occur at higher flow rates, which typically correspond with wet years. Table H-6.11 shows the percentage of days from May through July that flow decreases would occur at these locations. About 85% of the time there would be little to no change in flow (flow change less than 1 cfs). Table H-6.20 summarizes maximum daily flow reductions at similar locations. The maximum flow reductions would occur in mid to late June and range from 51 cfs below Denver Water's Steelman Creek diversion to 873 cfs below Williams Fork Reservoir. The large flow reduction below Williams Fork Reservoir is due to changes in the timing of spills.

Figures H-6.7 and H-6.8 show daily flow changes below Denver Water's diversion from Steelman Creek and at the Williams Fork River below Steelman Creek gage during the critical period from October 1953 through September 1957. These figures demonstrate flow reductions that would occur in a sequence of dry years followed by a wet year. In the wet year following the drought (1957), Gumlick Tunnel diversions would increase by approximately 7,800 AF or 172% compared to Full Use of the Existing System. The increase in diversions would be significant in 1957 because Denver Water would divert more water to refill additional storage at Gross Reservoir. Additional diversions in 1957 are most significant in July after the peak flow occurs. Therefore, although there is a significant increase in the amount of water diverted in 1957, the peak flow that occurs at the end of June would be unaffected.

In some wet years following a drought, flows below Denver Water's diversion points would be more consistent with a dry year or below average year due to additional diversions under the Proposed Action. The reduction in flows in the year following the drought would increase the frequency and duration of dry year conditions. The change in dry year frequency and duration was evaluated at two locations in the Williams Fork River Basin including: (1) Steelman Creek below Denver Water's diversion, and (2) Williams Fork River below Steelman Creek gage. Annual flows for Current Conditions (2006), Full Use of the Existing System, No Action and each of the action alternatives were ranked based on volume. The bottom 25th percentile was assumed to include dry and below average years. At both locations analyzed, the number of years in the bottom 25th percentile would increase by 4 years from 13 years to 17 years, as shown in Tables H-15.7 and H-15.8.

This analysis also shows that the duration and recurrence of back-to-back dry years would increase under the Proposed Action. Under Full Use of the Existing System, below Denver Water's Steelman Creek diversion, there would be a total of 4 sets of at least 2 back-to-back dry or below average years, with the longest period being 3 years in a row. Under the Proposed Action, there would be 5 sets of at least 2 back-to-back dry or below average years, with the longest period being 4 years in a row at that location. At the Williams Fork River near Steelman Creek gage there would be 4 sets of at least 2 back-to-back dry or below average years under Full Use of the Existing System, with the longest period being 3 years in a row. Under the Proposed Action, there would be 5 sets of at least 2 back-to-back dry or below average years, with the longest period being 4 years in a row.

Williams Fork River Peak Flow Changes

The combined effect of Denver Water's additional diversions and other RFFAs would affect the magnitude, timing, frequency, and duration of peak flows in the Williams Fork River Basin. The Nature Conservancy's IHA was used to evaluate changes in the flow regime below Denver Water's diversion from Bobtail Creek and at the Williams Fork River above Darling Creek gage. See Section 4.6.1.1.2 for a discussion of IHA and the methodology used to evaluate changes in the flow regime. Appendix H-14 includes detailed output from the IHA analysis.

Tables H-14.6 through H-14.8 summarize changes in the magnitude, duration, and timing of high-flow pulses, small floods and large floods at the locations analyzed. Tables H-14.9 and H-14.10 summarize changes in the magnitude and timing of the peak flow for an average year and wet year based on the daily hydrographs included in Appendix H-4.

There would be little to no change in median monthly low flows at locations high in the Williams Fork River Basin. There would be no change in the median low flow below Denver Water's Bobtail Creek diversion. At the Williams Fork River above Darling Creek gage, the median monthly low flow would decrease less than 0.6 cfs during the summer and less than 0.2 cfs during the winter.

There would no change in the magnitude or timing of the small flood peak flow below the Bobtail Creek diversion, however, the duration of the small flood event would be reduced by 16 days. At the Williams Fork River above Darling Creek gage, the median small flood peak flow would increase by 5 cfs, the duration would decrease by 1.5 days, and the timing would shift less than one day earlier.

There would be no change in the timing and magnitude of the large flood peak flow at the locations evaluated, however, the duration of the large flood would decrease by 26 days at the Bobtail Creek diversion and 5 days at the Williams Fork River above Darling Creek gage.

The magnitude of high flow pulses would increase by 6 cfs and less than 1 cfs at the Bobtail Creek Diversion and Williams Fork River above Darling Creek gage, respectively. The duration of high flow pulses would decrease less than 1 day, however, the median timing of high flow pulses would shift 9 days and 4 days earlier at the Bobtail Creek Diversion and Williams Fork River above Darling Creek gage, respectively.

Tables H-14.9 and H-14.10 summarize changes in the magnitude and timing of the peak flow for an average year and wet year at the Bobtail Creek Diversion and the Williams Fork River above Darling Creek gage. The magnitude of the peak flow in an average year would decrease by 7 cfs at the Bobtail Creek Diversion and 14 cfs at the Williams Fork River above Darling Creek gage. There would be no change in the timing of the peak flow in an average year. There would be no change in the magnitude or timing of the wet year peak flow at the Bobtail Creek Diversion and Williams Fork River above Darling Creek gage.

Changes in the frequency of peak flows for difference flood recurrence intervals are discussed in the following section.

Williams Fork River Floodplain

Increases in diversions at the Gumlick Tunnel under the Proposed Action would generally diminish Williams Fork River flows above Williams Fork Reservoir in average and wet years. In dry years, there would be negligible impact to upper Williams Fork River flows. Downstream of Williams Fork Reservoir, flows would decrease during the peak runoff months of June and July, and increase slightly during August, September, and October.

Analysis of annual peak flows at two points in the basin upstream of Williams Fork Reservoir show that the annual flood flow would never be greater under the Proposed Action than under Full Use of the Existing System. The annual flood associated with recurrence intervals greater than 1.8 years is the same in the two scenarios, indicating that the Gumlick Tunnel would already be diverting as much as possible under the Full Use of the Existing System scenario during peak flow, and the diversion would not increase under the Proposed Action. Thus, the floodplain for high flow, low frequency events would be unchanged by implementation of the Proposed Action.

Generally, flows downstream of Williams Fork Reservoir during the high runoff months would be the same or smaller under the Proposed Action than under Full Use of the Existing System. Reservoir inflow would be reduced by virtue of greater Gumlick Tunnel diversions; therefore, spill volumes would generally be smaller and floodplains for any specified return interval would be no greater under the Proposed Action than they are under Full Use of the Existing System.

Colorado River

Colorado River Stream Flow

For the purpose of analyzing changes in surface water hydrology along the Colorado River under the Proposed Action, modeled diversions and stream flows were analyzed below the Windy Gap Diversion and at the Colorado River near the Kremmling gage. Hydrology of the Colorado River above the confluence with the Fraser River is virtually the same under all EIS alternatives.

Changes in Colorado River flows below Windy Gap under the Proposed Action would be due primarily to Denver Water's additional diversions from the Fraser River Basin in years that are average or wet, and in particular, in wet years following dry year sequences. Changes in surface water flows described above for the Fraser and Williams Fork river basins would be translated downstream and into the Colorado River, but the reductions in flow would be smaller relative to the total stream, which is gaining. Changes in flows in the Colorado River below Windy Gap would also depend on whether the Windy Gap Project is diverting. The reduction in flow at the mouth of the Fraser River may be reduced below the Windy Gap diversion if the Windy Gap Project is operating below its full capacity under the Full Use of the Existing System scenario, or if it is at capacity and bypassing a smaller amount than the reduction in inflow from the Fraser River Basin. In those instances, because Denver Water's Moffat Collection System water rights are senior to Windy Gap water rights, Denver Water's diversions under the Proposed Action could reduce the amount of water available for diversion at Windy Gap. In certain situations described above, Denver Water's additional diversions would result in a reduction in Windy Gap diversions. For example, the average annual flow reduction at the mouth of the Fraser River is 8,375 AF/yr under the Proposed Action whereas the average annual flow reduction on the Colorado River below Windy Gap is 7,918 AF/yr because Windy Gap's net diversions are reduced by 457 AF/yr on average due to Denver Water's additional diversions from the Fraser River Basin.

As shown in Tables H-7.4 and H-7.6, average annual flows below Windy Gap would decrease by 7,900 AF or 6% and 15,300 AF or 4% in wet years. Average annual flows below the confluence with the Williams Fork River would decrease by 9,600 AF or 4%, and 18,100 AF or 3% in wet years. Average annual flows at the gage near Kremmling would decrease by 14,400 AF or 2%, and 25,900 AF or 2% in wet years. At these locations, there would be no decrease in flows in dry years because Denver Water would not divert any additional water under the Proposed Action in dry years.

Tables H-3.31 through H-3.33 summarize average monthly flow changes in the Colorado River below Windy Gap, Colorado River below the confluence with Williams Fork River, and near Kremmling for average, dry, and wet conditions. At these locations, flow

reductions would occur in average and wet years and would be highly concentrated during the runoff months in May, June, and July when the majority of Denver Water's additional diversions would occur. There would be virtually no flow reductions from late summer through early spring except in infrequent, very wet years. Below Windy Gap, monthly average flows would decrease by a maximum of 82.6 cfs or 13% in June, which coincides with the month when Moffat Tunnel diversions would increase most. In wet years, monthly average flows would decrease by a maximum of 163.3 cfs or 7% in June. There would be no decrease in flows in dry years.

Moving downstream, the Colorado River is affected by tributary inflows from the Williams Fork River, Troublesome Creek, Muddy Creek, and the Blue River, and Denver Water's diversions and operations in those basins. The volume of change rises in the downstream direction, but the reductions in flow are smaller relative to the total stream, which is gaining. Below the confluence with Williams Fork River, monthly average flows would decrease by a maximum of 102.7 cfs or 12% in June. In wet years, monthly average flows would decrease by a maximum of 202.0 cfs or 7% in June. Near Kremmling, monthly average flows would decrease by a maximum of 127.0 cfs or 6% in June. In wet years, monthly average flows would decrease by a maximum of 272.4 cfs or 4% in June. Again, there would be no decrease in flows in dry years.

Colorado River Daily Flow Changes

Figures H-4.91 through H-4.99 show average daily hydrographs at locations of interest along the Colorado River. Figures H-5.15 through H-5.17 present flow duration curves for these locations. As shown by the flow duration curves, flow reductions resulting from the Proposed Action would occur at higher flow rates, which typically correspond with wet years. Table H-6.12 shows the percentage of days from May through July that flow decreases would occur at these locations. Below Windy Gap, about 75% of the time the flow change from May through July would be less than 1 cfs. About 11% of the time the flow would decrease up to 100 cfs. Below the confluence with Williams Fork River, about 66% of the time the flow change from May through July would be less than 1 cfs. About 14% of the time the flow would decrease up to 100 cfs. Near Kremmling, about 58% of the time the flow change from May through July would be less than 1 cfs. About 17% of the time the flow would decrease up to 100 cfs. Table H-6.20 summarizes maximum daily flow reductions at similar locations. The maximum daily flow reduction would occur in June and would range from 3,046 cfs below Windy Gap to 3,319 cfs near Kremmling. These large flow changes are primarily caused by changes in the timing of reservoir spills.

Figure H-6.9 shows daily flows below Windy Gap from October 1953 through September 1957. This figure demonstrates flow reductions that would occur in a sequence of dry years followed by a wet year. Denver Water and Windy Gap would divert additional water in the wet year following the drought to refill additional storage at Gross Reservoir and Chimney Hollow Reservoir (the Proposed Action for the Windy Gap Firming Project). Additional diversions by Denver Water and Windy Gap in 1957 would cause the peak flow of 2,371 cfs in early June to be reduced to 2,078 cfs.

The reduction in flows in the year following the drought would increase the frequency and duration of dry year conditions. The change in dry year frequency and duration was evaluated at the Colorado River below Windy Gap. Annual flows for Current Conditions

(2006), Full Use of the Existing System, No Action and each of the action alternatives were ranked based on volume. The bottom 25th percentile was assumed to include dry and below average years. Below Windy Gap, the number of years in the bottom 25th percentile would increase by 3 years from 19 years to 22 years. The duration and recurrence of back-to-back dry years would increase slightly under the Proposed Action compared to Full Use of the Existing System. Under both Full Use of the Existing System and the Proposed Action, there would be a total of 6 sets of at least 2 back-to-back dry or below average years below Windy Gap, with the longest period being 4 years in a row. However under the Proposed Action, 4 back-to-back dry or below average years would occur twice during the study period versus only once under Full Use of the Existing System, as shown in Table H-15.9.

Colorado River Peak Flow Changes

Tables H-14.9 and H-14.10 summarize changes in the magnitude and timing of the peak flow for an average year and wet year at the Colorado River below Windy Gap, the Colorado River below the confluence with Williams Fork River, and the Colorado River near Kremmling gage. As shown in Table H-14.9, the magnitude of the peak flow in an average year would decrease by 142 cfs below Windy Gap, 177 cfs below the confluence with Williams Fork River, and 257 cfs at the Kremmling gage. There would be little change in the timing of the peak flow at the locations analyzed (shift of up to 3 days later). As shown in Table H-14.10, the magnitude of the wet year peak flow would decrease by 184 cfs below Windy Gap, 120 cfs below the confluence with Williams Fork River, and 551 cfs at the Kremmling gage. The peak flow would shift up to 9 days later at these locations.

Changes in the frequency of peak flows for different flood recurrence intervals are discussed in the following section.

Colorado River Floodplain

Flows in the Colorado River reflect Denver Water's changed diversions and reservoir operations in the Fraser River, Williams Fork River, Muddy Creek, and Blue River basins. Annual flood flows were analyzed at two places on the river: in the vicinity of Hot Sulphur Springs, which reflects only Fraser River flow changes, and below the confluence with the Blue River. The latter flow integrates changes in all the tributaries discussed above.

Generally, annual flood flows for the Colorado River below Hot Sulphur Springs would be the same or lower under the Proposed Action than under Full Use of the Existing System. The differences, expressed either as an absolute amount or as a percent difference from the Full Use of the Existing System scenario flows, are more random with respect to the size of flows than in the Fraser and Williams Fork river basins. This may be due to the sometimes offsetting impacts of Windy Gap diversions, as described above. Based on an analysis of annual peak flood flows, it can be inferred that the floodplain extent for a specified return interval under the Proposed Action would be the same or smaller as the corresponding floodplain under Full Use of the Existing System.

Similar conditions apply to the Colorado River below the Kremmling gage. Generally, the floodplain extent for a specified recurrence interval along the Colorado River would be expected to be the same or smaller than the corresponding floodplain under Full Use of the Existing System. However, the PACSM output showed that under the Proposed Action, the

greatest difference in annual peak flow during the study period would be an increase of approximately 520 cfs, or 4% compared to Full Use of the Existing System. Therefore, occasionally the floodplain extent would increase under the Proposed Action for larger flood events.

Muddy Creek

Muddy Creek Stream Flow

For the purpose of analyzing changes in surface water hydrology in the Muddy Creek Basin under the Proposed Action, modeled diversions and stream flows were analyzed below Wolford Mountain Reservoir.

Changes along Muddy Creek below Wolford Mountain Reservoir under the Proposed Action would be minimal. Monthly differences in reservoir outflow rarely exceed several hundred acre-feet in any given month. As shown in Tables H-7.4 through H-7.6, average annual outflow from Wolford Mountain Reservoir would increase by 50 AF or less than 1%, while dry year and wet year average annual outflow from Wolford Mountain Reservoir would not change. Table H-3.34 summarizes average monthly outflow from Wolford Mountain Reservoir for average, dry, and wet conditions. Monthly changes in outflow would range from a maximum decrease of 1.4 cfs or 3% in January to a maximum increase of 2.8 cfs or 4% in September. The increase in outflow in September reflects additional substitution releases which would be made in some substitution years. Monthly changes in dry year and wet year average outflow would be 1 cfs or less

Muddy Creek Daily Flow Changes

Figures H-4.100 through H-4.102 show average daily hydrographs for Muddy Creek below Wolford Mountain Reservoir. Figure H-5.18 presents a flow duration curve for Muddy Creek below Wolford Mountain Reservoir. As shown by the flow duration curve, flow changes would be minimal throughout the range of flows that would occur.

Table H-6.13 shows the percentage of days flow changes would occur below Wolford Mountain Reservoir. About 98% of the time there would be minimal change in flows (± up to 1 cfs). As shown in Table H-6.20, the maximum daily flow reduction below Wolford Mountain Reservoir would occur in January and would be 180 cfs.

Muddy Creek Peak Flow Changes

Tables H-14.9 and H-14.10 summarize changes in the magnitude and timing of the peak flow for an average year and wet year for Wolford Mountain Reservoir outflow. There would be no change in the magnitude or timing of the average or wet year peak flow at that location under the Proposed Action compared to Full Use of the Existing System.

Changes in the frequency of peak flows for difference flood recurrence intervals are discussed in the following section.

Muddy Creek Floodplain

No impacts on the floodplain are anticipated because changes in the quantity and timing of flows under the Proposed Action would be infrequent and minor.

Blue River

Blue River Stream Flow

For the purpose of analyzing changes in surface water hydrology in the Blue River Basin under the Proposed Action, modeled diversions and stream flows were analyzed at Roberts Tunnel, and below Dillon and Green Mountain reservoirs.

The shift in seasonal operations between Denver Water's North and South WTPs would influence the flow regime in the Blue River. Under the Proposed Action, there would be a reduction in winter operations of Foothills and Marston WTPs (South System) because the Moffat WTP (North System) would operate at a minimum level of 30 mgd during the winter. More water would be kept in Dillon Reservoir during the winter months because the Moffat WTP would meet demand that would otherwise be met by Foothills and Marston WTPs under Full Use of the Existing System. Summer diversions through Roberts Tunnel would generally be higher due to an overall higher level of demand that would be met under the Proposed Action; however, the monthly differences are more variable than in the winter.

As shown in Tables H-7.4 through H-7.6, average annual Roberts Tunnel diversions would increase by 4,800 AF or 5%, dry year average annual diversions would decrease by 600 AF or less than 1%, and wet year average annual Roberts Tunnel diversions would increase by 1,900 AF or 3%. Table H-3.35 summarizes average monthly diversions through the Roberts Tunnel for average, dry, and wet conditions. Diversions through Roberts Tunnel would decrease on average during the winter months and increase on average during the summer months. Average monthly diversions through the Roberts Tunnel would be about 1,500 to 2,000 AF lower from November through March and about 1,400 to 4,000 AF higher from May through September. There is less variation in the decrease in diversions during winter months than the increase in diversions in summer months. Increases in diversions in summer months tend to be greatest in average and wet years and would depend on how Denver Water's Blue River supplies are used in conjunction with their South Platte River and Moffat system supplies, system-wide storage contents, and hydrologic conditions. Monthly changes in average diversions would range from a maximum decrease of 33.3 cfs or 35% in December to a maximum increase of 64.6 cfs or 37% in July. Monthly changes in dry year average diversions would range from a maximum decrease of 31.5 cfs or 27% in November to a maximum increase of 57.9 cfs or 18% in June. Monthly changes in wet year average diversions would range from a maximum decrease of 34.2 cfs or 43% in December to a maximum increase of 48.1 cfs or 586% in May. Note that in wet years, the difference in diversions in June would be relatively small because Denver Water's direct flow rights on the South Platte River would be available and would be taken ahead of Blue River water. Figures H-4.103 through H-4.105 show average daily diversions through Roberts Tunnel for average, wet, and dry conditions.

Flows below Dillon Reservoir reflect differences in Roberts Tunnel diversions and spills. In dry years, there would be minimal change in flows below Dillon Reservoir under the Proposed Action, because Denver Water would store all it could and bypass only what it must throughout the storage season. In average and wet years, flows below Dillon Reservoir would generally be lower primarily during June and July. June flows could

increase or decrease, depending on whether Dillon Reservoir has filled in a given year. If there is enough water to fill, and Dillon Reservoir enters the runoff season under the Proposed Action with more water in storage due to reduced winter exports through Roberts Tunnel, the flow below Dillon Reservoir would be higher because the spill would increase. The reverse is true in the less typical case, i.e., when Dillon Reservoir enters the runoff season with less water in storage under the Proposed Action. These two types of changes are apparently offsetting, as PACSM results shows that Dillon Reservoir would be full and spilling for approximately the same number of days under the Proposed Action as under Full Use of the Existing System. In many years during May and June, there would be no change in Dillon Reservoir outflow because Denver Water would bypass all the legally unavailable flow. There would also typically be little change in winter flows below Dillon Reservoir. The exceptions are generally during or just following wet years, in which Dillon Reservoir would stay close to full through the winter. In those instances, spills during the winter would be higher under the Proposed Action because contents are higher due to reduced releases through Roberts Tunnel during winter months.

Although Denver Water has the ability to reduce bypass flows below Dillon Reservoir, they have not exercised that right to date. Reductions in bypass flows below Dillon Reservoir were not included in the PACSM; however, there is no indication that reductions in Dillon Reservoir bypass flows would increase under the Proposed Action. See Section 4.6.1 for a discussion regarding how bypass flows at Dillon Reservoir are modeled in the PACSM in relation to actual operations.

As shown in Tables H-7.4 through H-7.6, average annual outflow from the reservoir would decrease by 4,800 AF or 5% and 7,900 AF or 4% in wet years. Table H-3.36 summarizes average monthly outflow from Dillon Reservoir for average, dry, and wet conditions. Monthly average outflow would decrease by a maximum of 45.6 cfs or 8% in June. In wet years, monthly average outflow would decrease by a maximum of 45.9 cfs or 7% in July.

Changes in Blue River flows below Green Mountain Reservoir are the result of the interaction between the seasonal shift in operations between Denver Water's northern and southern treatment systems and the resulting changes in flows below Dillon Reservoir. There would be very little difference in flows on average during the winter months from October through April. Note that flows in March, which are estimated by the PACSM, are higher than have historically occurred due to operating rules included in the model for Green Mountain Reservoir. In the PACSM, Green Mountain Reservoir is lowered to 50,000 AF, 60,000 AF, or 70,000 AF by April 1 based upon the most probable inflow conditions. While this is consistent with the U.S. Department of the Interior, Bureau of Reclamation's Annual Operating Plan, it does not always match historical operations. Historical operations show that the start of fill date for Green Mountain Reservoir has varied between April 1 and May 15 because snowpack and snowmelt conditions differ from year to year (particularly in wet years). Often the start of fill data is set retroactively months afterwards. While the PACSM accurately reflects Green Mountain Reservoir operations in a dry year, it is difficult to replicate the variability in operations in wet years since model operations are driven by defined operating rules and drawdown targets. The PACSM results for April and May show flows are lower than have occurred historically. This is also related to the operating rules for Green Mountain and the start of fill date of April 1. The bypass requirement below Green Mountain Reservoir is 60 cfs; therefore, the

flow below the reservoir is often no more than 60 cfs in the PACSM after April 1 until the reservoir fills. Since the start of fill date has historically varied between April 1 and May 15, the flows below Green Mountain Reservoir are often higher than 60 cfs if the reservoir is still being drawn down to target levels. The start of fill date affects the timing of flow below Green Mountain Reservoir but has little impact on the average annual volume of flow below the reservoir. For example, a later start-of-fill date results in spills later in the season, however, the volume of water spilled would be similar regardless of the start-of-fill date. In average and wet years, flows below Green Mountain Reservoir would generally be lower under the Proposed Action primarily during June and July. On average, differences in late summer flows would be roughly of the same magnitude as differences in outflow from Dillon Reservoir. Changes in flows below Green Mountain Reservoir are minimal in dry years. As shown in Tables H-7.4 through H-7.6, average annual outflow from the reservoir would decrease by 4,800 AF or 2% and 7,800 AF or 2% in wet years. Table H-3.37 summarizes average monthly outflow from Green Mountain Reservoir for average, dry, and wet conditions. Monthly average outflow would decrease by a maximum of 37.9 cfs or 5% in July and increase by a maximum of 4.4 cfs or 5% in May. In wet years, monthly average outflow would decrease by a maximum of 69.8 cfs or 3% in June and increase by a maximum of 5.5 cfs or 2% in May.

Blue River Daily Flow Changes

Figures H-4.106 through H-4.111 show average, wet and dry daily outflow from Dillon and Green Mountain reservoirs. Figures H-5.19 and H-5.20 present flow duration curves for Dillon Reservoir outflow and Green Mountain Reservoir outflow, respectively. As shown by the flow duration curves, flow reductions resulting from the Proposed Action would typically occur at higher flow rates. Table H-6.14 shows the percentage of days from June through August that flow decreases would occur at these locations. Below Dillon Reservoir, the flow change from June through August would be less than 1 cfs about 75% of the time. Flows would decrease up to 100 cfs about 9% of the time. Below Green Mountain Reservoir, the flow change from June through August would be less than 1 cfs about 66% of the time. Flows would decrease up to 100 cfs about 14% of the time. Table H-6.20 summarizes maximum daily flow reductions below Dillon and Green Mountain reservoirs. The maximum daily flow reduction would occur in June and would be 1,692 cfs below Dillon Reservoir and 3,385 cfs below Green Mountain Reservoir. These large flow decreases are primarily caused by changes in the timing and magnitude of reservoir spills.

Figure H-6.10 presents daily flows below Dillon Reservoir from October 1953 through September 1957. This figure demonstrates flow reductions that would occur in a sequence of dry years followed by a wet year. Denver Water would divert additional water in the wet year following the drought to refill Dillon Reservoir and deliver water through the Roberts Tunnel for storage in its South Platte River Basin reservoirs. The timing and magnitude of the peak flow in 1957 would be similar under both the Proposed Action and Full Use of the Existing System, however, the total duration and volume spilled would be greater under Full Use of the Existing System.

The reduction in flow in the year following the drought would increase the frequency and duration of dry year conditions. The change in dry year frequency and duration was evaluated for the Blue River below Dillon Reservoir. Annual flows for Current Conditions

(2006), Full Use of the Existing System, No Action and each of the action alternatives were ranked based on volume. The bottom 25th percentile was assumed to include dry and below average years. Below Dillon Reservoir, the number of years in the bottom 25th percentile would increase by 3 years from 21 years to 24 years, as shown in Table H-15.10.

This analysis also shows the duration and recurrence of back-to-back dry years would increase slightly under the Proposed Action. Under both Full Use of the Existing System and the Proposed Action, there would be 6 sets of at least 2 back-to-back dry or below average years below Dillon Reservoir, with the longest period being 5 years in a row. However under the Proposed Action, 5 back-to-back dry or below average years would occur twice during the study period versus only once under Full Use of the Existing System.

Blue River Peak Flow Changes

Tables H-14.9 and H-14.10 summarize changes in the magnitude and timing of the peak flow for an average year and wet year for the Blue River below Dillon and Green Mountain reservoirs compared to Full Use of the Existing System. The magnitude of the peak flow below Dillon Reservoir would decrease by 52 cfs and shift 4 days later in an average year. The magnitude of the peak flow below Green Mountain Reservoir would decrease by 23 cfs and shift 2 days earlier in an average year. The magnitude of the wet year peak flow below Dillon Reservoir would increase by 2 cfs but the timing would not change. The magnitude of the wet year peak flow below Green Mountain Reservoir would decrease by 47 cfs and shift 5 days later.

Changes in the frequency of peak flows for difference flood recurrence intervals are discussed in the following section.

Blue River Floodplain

Because Denver Water would not divert as much water through Roberts Tunnel in the winter months under the Proposed Action, as compared with Full Use of the Existing System, Dillon Reservoir would generally enter the runoff season with more water in storage under the Proposed Action. In wet years, the reservoir would spill sooner and more than it would under Full Use of the Existing System and this would occur during the high flow season. Frequency analysis of the annual floods below Dillon Reservoir during the study period showed that flood flows with recurrence intervals less than 5 years would decrease, meaning the floodplain would be smaller. At a recurrence interval of 5 years or greater, flood flows would increase. The increase in flood flows would be small, generally on the order of 2 to 4% of the Full Use of the Existing System flood flow with the same recurrence interval. Therefore, the floodplain extent would likely increase for larger flood events, within the area mapped by Federal Emergency Management Agency at and below Silverthorne.

There would be no significant differences in annual flood flows at the outflow from Green Mountain Reservoir, except for peak flows with recurrence intervals of about 2 to 3 years. Peak flows for these recurrence intervals would be reduced by about 10 to 15% compared to the Full Use of the Existing System.

South Boulder Creek

South Boulder Creek Stream Flow

For the purpose of analyzing changes in surface water hydrology in the South Boulder Creek Basin, modeled diversions and stream flows were analyzed at the South Boulder Creek at Pinecliffe gage, below Gross Reservoir, and at the South Boulder Creek near Eldorado Springs gage. Changes along South Boulder Creek were described with respect to three different sections of the creek: (1) from the Moffat Tunnel to Gross Reservoir, (2) from Gross Reservoir to the South Boulder Diversion Canal, and (3) below the South Boulder Diversion Canal.

In the uppermost reach, changes in flow are equivalent to changes in Moffat Tunnel deliveries. As shown in Tables H-7.4 and H-7.6, average annual flows at the Pinecliffe gage would increase by 10,300 AF or 9% and 14,400 AF or 13% in wet years. There would be no change in dry year flows, as shown in Table H-7.5. Note, that the combination of 5 years that were averaged to determine a wet and dry year average are different for the Moffat Tunnel versus South Boulder Creek because diversions into the Moffat Tunnel occur on the West Slope, whereas South Boulder Creek is located on the East Slope. Refer to Section 4.6.1 for a discussion of West Slope versus East Slope dry and wet year averages. As a result, the changes in wet and dry year annual averages are not comparable for the Moffat Tunnel and Pinecliffe gage. Table H-3.38 summarizes average monthly flows at the Pinecliffe gage for average, dry, and wet conditions. Flow increases would occur primarily in May, June and July, which corresponds with the months when additional diversions through Moffat Tunnel would be greatest. There would be virtually no flow increases from late summer through early spring except in infrequent, very wet years. There would be no increase in flows in dry years because Denver Water already diverts the maximum amount physically and legally available through the Moffat Tunnel under their existing water rights without additional storage in their system. Monthly average flows would increase by a maximum of 106.0 cfs or 17% in June. Monthly wet year average flows would increase by a maximum of 152.9 cfs or 32% in June.

From Gross Reservoir to the South Boulder diversion structure, changes in flow reflect Gross Reservoir operations. In general, flows would be consistently higher from October through February and April, as water would be moved out of Gross Reservoir and into Ralston Reservoir. Under the Proposed Action, the Moffat WTP would operate at a minimum of 30 mgd during the winter; therefore, more water would be released from Gross Reservoir during these months in response to the treatment load shift. In April, water would be proactively released from Gross Reservoir in anticipation of the runoff and to stage as much water as possible close to the Moffat WTP. Releases from Gross Reservoir during a drought would depend on storage conditions in Denver Water's North and South systems and hydrologic conditions. Increases in outflow from Gross Reservoir would be greatest in dry years because Denver Water would draw more water from their North System storage under the Proposed Action as a drought begins. In advanced stages of a drought, Denver Water's South System reservoirs would have more water and get drawn on more intensely. Thus, changes in stream flow in August, for example, would differ depending on storage conditions in Denver Water's North and South systems and hydrologic conditions. Flows in March, and May through August would be lower on

average because Foothills and Marston WTPs would meet a greater portion of the overall demand during these months under the Proposed Action and as a result, Gross Reservoir releases would decrease.

As shown in Tables H-7.4 through H-7.6, average, dry, and wet year average annual outflow from Gross Reservoir would increase by 9,700 AF or 8%, 14,000 AF or 16%, and 15,200 AF or 14%, respectively. Table H-3.39 summarizes average monthly outflow from Gross Reservoir for average, dry, and wet conditions. Monthly average flow changes would range from a decrease of 64.3 cfs or 23% in May to an increase of 88.0 cfs or 865% in January. Monthly dry year average flow changes would range from a decrease of 45.1 cfs or 13% in June to an increase of 85.1 cfs or 1,083% in January. Monthly wet year average flow changes would range from a decrease of 40.6 cfs or 20% in May to an increase of 84.5 cfs or 687% in January.

Below the South Boulder Diversion Canal, flows would generally decrease on average because Denver Water would divert more native South Boulder Creek water, either to storage at Gross Reservoir or under their direct diversion right at the South Boulder Diversion Canal. These additional diversions, which would occur only in wet years during peak runoff in May and June, would reduce flows below the canal. As shown in Tables H-7.4 through H-7.6, average annual flows at the Eldorado Springs gage would decrease by 1,000 AF or 2%, wet year average annual flows would decrease by 3,000 AF or 5%, and dry year average annual flows would increase by 150 AF or less than 1%. Table H-3.40 summarizes average monthly flows at the Eldorado Springs gage for average, dry, and wet conditions. Monthly average flows would decrease by a maximum of 11.4 cfs or 4% in June. Monthly dry year average flows would decrease by 0.3 cfs or 3% in March and 1% in July. Monthly wet year average flows would decrease by a maximum or 28.0 cfs or 17% in May.

South Boulder Creek Native Stream Flow

Native flows on South Boulder Creek are affected by Denver Water's trans-basin diversions from the Fraser and Williams Fork rivers. Table H-12.20 shows the native flow at the South Boulder Creek at Pinecliffe gage and the amount and percentage added due to additional Moffat Tunnel deliveries under Current Conditions (2006), Full Use of the Existing System, No Action and each of the action alternatives. The average annual Moffat Tunnel delivery to South Boulder Creek is 91.5 cfs under Full Use of the Existing System and 105.8 cfs under the Proposed Action, which is an increase of 157% and 181% of the native flow, respectively. The greatest increase in flow added to this river segment would be in June. The average Moffat Tunnel delivery is 345.4 cfs under Full Use of the Existing System and 451.3 cfs under the Proposed Action compared to an average native flow of 274.5 cfs. The greatest percentage increase in flow would be in September, when the average Moffat Tunnel delivery is approximately 76 cfs which is an increase of 425% under both Full Use of the Existing System and the Proposed Action. While, the amount of water 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.

South Boulder Creek Daily Flow Changes

Figures H-4.112 through H-4.120 show average daily hydrographs along South Boulder Creek for the locations of interest discussed above. Figures H-5.21 through H-5.23 present flow duration curves for South Boulder Creek at the Pinecliffe gage, outflow from Gross Reservoir and South Boulder Creek near the Eldorado Springs gage, respectively. As shown by the flow duration curve at the Pinecliffe gage, flow increases resulting from the Proposed Action would occur primarily at higher flow rates. The flow duration curve for Gross Reservoir outflow shows flow decreases would occur primarily at higher flow rates while flow increases would occur primarily at lower flow rates. The flow duration curve at the Eldorado Springs gage shows flow decreases would occur primarily at higher flow rates.

Table H-6.15 shows the percentage of days that flow increases and decreases would occur at these locations. About 70% of the time there would be little to no flow change from May through July at the Pinecliffe gage. Below Gross Reservoir, flow increases up to 100 cfs would occur about 73% of the time. Table H-6.20 summarizes maximum daily flow reductions below Gross Reservoir and at the Pinecliffe gage. The maximum daily flow reduction at the Pinecliffe gage would occur in June and would be 268 cfs. Daily increases in flow would be greatest at the Pinecliffe gage and range up to 833 cfs. Below Gross Reservoir and at the Eldorado Springs gage, the maximum daily flow reduction would be 489 cfs in March and 474 cfs in May, respectively.

South Boulder Creek Peak Flow Changes

Tables H-14.9 and H-14.10 summarize changes in the magnitude and timing of the peak flow for an average year and wet year at the Pinecliffe gage, below Gross Reservoir, and at the Eldorado Springs gage. At the Pinecliffe gage, the magnitude of the peak flow in an average year would increase by 117 cfs, whereas below Gross Reservoir and at the Eldorado Springs gage, the peak flow would decrease by 65 cfs and 24 cfs, respectively. The timing of the peak flow would shift 1 day later at the Pinecliffe gage, 18 days later below Gross Reservoir and not change at the Eldorado Springs gage. The magnitude of the wet year peak flow would increase by 252 cfs at the Pinecliffe gage and 26 cfs below Gross Reservoir and decrease by 25 cfs at the Eldorado Springs gage. The timing of the wet year peak flow would shift 14 days later at the Pinecliffe gage, 13 days earlier below Gross Reservoir and not change at the Eldorado Springs gage.

Changes in the frequency of peak flows for difference flood recurrence intervals are discussed in the following section.

South Boulder Creek Floodplain

Between the East Portal of Moffat Tunnel and Gross Reservoir, the channel has been improved to accommodate a flow of 1,200 cfs, and Denver Water operates the Moffat Tunnel such that this limit, including natural flows, is not exceeded. As a result, the only annual flood flows that increase significantly under the Proposed Action, relative to Full Use of the Existing System, are below approximately 920 cfs. During a major, rare flood event that exceeds channel capacity, the Moffat Tunnel would not be diverting water, and there would be no increase in floodplain boundaries that could be attributed to the Project.

Gross Reservoir is currently not operated to provide flood control along South Boulder Creek and that would not change under any of the alternatives. However, an enlarged Gross Reservoir would generally be able to capture flows that would be spilled under Full Use of the Existing System. As a result, annual flood flows below Gross Reservoir would consistently be smaller under the Proposed Action than under Full Use of the Existing System. For estimated recurrence intervals of 2 years or more, this reduction would be approximately 8 to 12% of the Full Use of the Existing System annual flood flow, indicating that the floodplain extent would decrease under the Proposed Action.

The City of Boulder is conducting a study of the floodplain along South Boulder Creek below Gross Reservoir beginning at Eldorado Springs. The study assumed that Gross Reservoir was full during the design storm. Given that assumption, there would be no change to the floodplain below Boulder Canyon, per the Boulder study, that can be attributed to the Moffat Project. It is possible that an enlarged Gross Reservoir would result in reductions in the floodplain size due to the ability to capture additional South Boulder Creek flows.

North Fork South Platte River

For the purpose of analyzing changes in surface water hydrology in the North Fork South Platte River under the Proposed Action, modeled diversions and stream flows were analyzed at the North Fork South Platte River below the Geneva Creek gage, which is just downstream of where the Roberts Tunnel discharges to the river.

North Fork South Platte River Stream Flow

The changes in flow in the North Fork South Platte River would be due to the shift in seasonal operations between Denver Water's northern and southern WTPs and are equivalent to changes in Roberts Tunnel deliveries. Monthly average diversions through the Roberts Tunnel from November through March would be about 1,500 to 2,000 AF lower on average under the Proposed Action. This results in equivalent lower flows in the North Fork South Platte River in these months. Flows during winter months would consistently be lower by about 30%. Summer diversions through Roberts Tunnel would generally be higher, and consequently flows in the North Fork South Platte River would be 1,300 AF to 3,800 AF higher on average from May through September. Flow changes at the Geneva Creek gage are slightly less than changes in diversions at the Roberts Tunnel due to transit losses.

As shown in Tables H-7.4 through H-7.6, average annual flows at the Geneva Creek gage would increase by 4,700 AF or 3%, dry year average annual flows would increase by 2,800 AF or 2%, and wet year average annual flows would decrease by 2,700 AF or 2%. Flows changes at the Geneva Creek gage are slightly less than changes in diversions at the Roberts Tunnel due to transit losses. The State Engineer's Office assesses a 5% transit loss on Denver Water's Roberts Tunnel deliveries to the North Fork South Platte River. The transit loss is intended to offset channel losses and evaporation losses from any additional water surface area that is caused by the delivery of water along the North Fork South Platte River from the outfall of the Roberts Tunnel to the Denver Water Intake/Conduit 20. Therefore, the average annual flows in the North Fork South Platte River are less by the 5% transit loss applied to Robert Tunnel deliveries. Table H-3.41 summarizes average monthly

flows in the North Fork South Platte River below Geneva Creek gage for average, dry, and wet conditions. Monthly average flow changes would range from a maximum decrease of 31.7 cfs or 28% in December to a maximum increase of 62.2 cfs or 20% in July. Monthly dry year average flow changes would range from a maximum decrease of 31.2 cfs or 23% in November to a maximum increase of 73.1 cfs or 18% in July. Monthly wet year average flow changes would range from a maximum decrease of 36.9 cfs or 37% in February to a maximum increase of 32.5 cfs or 14% in August. Note, that the combination of 5 years that were averaged to determine a wet and dry year average are different for the Roberts Tunnel versus the North Fork South Platte River because diversions at the Roberts Tunnel occur on the West Slope, whereas the North Fork South Platte River is located on the East Slope. Refer to Section 4.6.1 for a discussion of West Slope versus East Slope dry and wet year averages.

North Fork South Platte River Native Stream Flow

Native flows on the North Fork South Platte River downstream of the East Portal of the Robert Tunnel are affected by Denver Water's trans-basin diversions from the Blue River. Table H-12.21 shows the native flow and the amount and percentage added to the North Fork South Platte River below Geneva Creek gage due to Denver Water's additional Roberts Tunnel deliveries under Current Conditions (2006), Full Use of the Existing System, No Action and each of the action alternatives. The average annual Roberts Tunnel delivery to the North Fork South Platte River is 127.9 cfs under Full Use of the Existing System and 134.2 cfs under the Proposed Action, which is an increase of 182% and 191% of the native flow, respectively. The greatest increase in flow added to this river segment would be in July. The average Roberts Tunnel delivery is 166.5 cfs under Full Use of the Existing System and 228.7 cfs under the Proposed Action compared to an average native flow of 151.8 cfs. The greatest percentage increase in flow would be in September, when the average Roberts Tunnel delivery is 291.0 cfs (increase of 588%) and 312.9 cfs (increase of 632%) under Full Use of the Existing System and the Proposed Action, respectively. While, the amount of water 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.

North Fork South Platte River Daily Flow Changes

Figures H-4.121 through H-4.123 show average, wet and dry daily hydrographs at the North Fork South Platte River at Geneva Creek gage. Figure H-5.24 presents a flow duration curve for the North Fork South Platte River below Geneva Creek gage. As shown, flow increases resulting from the Proposed Action would occur at higher flow rates, while flow decreases occur at lower flow rates. Table H-6.16 shows the percentage of days that flow increases and decreases would occur at these locations. About 91% of the time there would be little to no flow change, or a flow increase or decrease up to 100 cfs would occur. Table H-6.20 summarizes maximum daily flow reductions at similar locations. The maximum daily flow reduction at the Geneva Creek gage would occur in January and would be 474 cfs. Maximum daily flow increases would be greatest at the Geneva Creek gage and range up to 530 cfs. The maximum daily flow reduction above Pine would also occur in January and would be 355 cfs.

North Fork South Platte River Peak Flow Changes

Tables H-14.9 and H-14.10 summarize changes in the magnitude and timing of the peak flow for an average and wet year at North Fork South Platte River below Geneva Creek gage. Below the Geneva Creek gage, the magnitude of the peak flow in an average year would increase by 38 cfs and the timing would shift 75 days earlier. A smaller peak of 386 cfs would occur earlier in the year on June 24 under Full Use of the Existing System, which is 48.6 cfs less and 2 days earlier than the peak that would occur under the Proposed Action. The magnitude of the wet year peak flow at that location would increase by 1 cfs but the timing would not change.

North Fork South Platte River Floodplain

Denver Water regulates Roberts Tunnel diversions in an effort to keep the average daily flow in the North Fork South Platte River below 680 cfs at Grant and below 980 cfs above the confluence with the mainstem (Yevdjerick and Simons 1966/1967). Under the Proposed Action, annual peak flows estimated for recurrence intervals of approximately 6 years and greater are all between 660 and 670 cfs. These annual flood flows reflect Roberts Tunnel delivering the maximum amount allowed by the channel capacity. Annual peak flows are virtually the same for both Full Use of the Existing System and the Proposed Action for all flood flows with an estimated recurrence interval of 2 years or more. During a major, rare flood event that exceeds channel capacity, Roberts Tunnel would not be importing substantial amounts of water, and there would be no increase in floodplain boundaries that could be attributed to the Moffat Project.

South Platte River

South Platte River Stream Flow

For the purpose of analyzing changes in surface water hydrology along the South Platte River under the Proposed Action, modeled diversions and stream flows were analyzed below Antero, Eleven Mile Canyon, Cheesman, and Chatfield reservoirs, and at the South Platte River at three U.S. Geological Survey (USGS) gages – Waterton, Denver, and Henderson.

Antero Reservoir to Cheesman Reservoir. In the upper South Platte River, above the confluence with the North Fork South Platte River, flows would be influenced by the seasonal shift in operations between the Moffat WTP (North System) and Marston and Foothills WTPs (South System). On average, there would be relatively little change in flows below Antero and Eleven Mile Canyon reservoirs since these reservoirs are operated more for drought protection. In general, flows below Cheesman Reservoir from October through March, would be lower on average because the Moffat WTP would operate in those months under the Proposed Action; therefore, releases of stored water to Strontia Springs would decrease. These differences would generally be consistent and amount to about 300 to 500 AF each month. During the summer months from April through September, more releases from Denver Water's South Platte reservoirs would generally be required to meet an overall higher level of demand under the Proposed Action. However, differences in flows would be highly variable; for instance, the difference in monthly flows below Cheesman Reservoir in August would range from a 7,300 AF decrease to a 6,100 AF increase. One reason the change in flows would be variable for any given summer month is

that Denver Water's mode of operation changes through the course of a drought. As a drought begins, Denver Water would draw more water from their North System storage under the Proposed Action, which may reduce demand on Antero, Eleven Mile Canyon, and Cheesman reservoirs. Consequently, less water would typically be used from Denver Water's South System storage in those years. In advanced stages of a drought, Denver Water's South System reservoirs would have more water and get drawn on more intensely. Thus, changes in stream flow in August, for example, would differ depending on storage conditions in Denver Water's North and South systems and hydrologic conditions.

Denver Water has the ability to reduce bypass flows below Eleven Mile Canyon and Cheesman reservoirs. Reductions in bypass flows below Eleven Mile Canyon and Cheesman reservoirs were not included in the PACSM; however, there is no indication that reductions in these bypass flows would increase under the Proposed Action.

As shown in Tables H-7.4 through H-7.6, average annual outflow and wet year average annual outflow from Antero, Eleven Mile Canyon, and Cheesman reservoirs changes by less than 1,000 AF or 1% or less, and dry year average annual outflow increases by 300 AF (3%), 600 AF (1%), and 2,600 AF (2%), respectively. Tables H-3.42 through H-3.44 summarize average monthly outflow from Antero, Eleven Mile Canyon, and Cheesman reservoirs for average, dry, and wet conditions. Monthly average, wet, and dry year flow changes below Antero and Eleven Mile Canyon reservoirs would be relatively small and would range up to 5.5 cfs. Monthly changes in average outflow from Cheesman Reservoir would range from a maximum decrease of 7.6 cfs or 6% in March to a maximum increase of 13.3 cfs or 4% in May. Monthly changes in dry year average outflow would range from a maximum decrease of 6.1 cfs or 4% in October to a maximum increase of 27.4 cfs or 9% in August. Monthly changes in wet year average outflow would range from a maximum decrease of 7.6 cfs or 6% in March to a maximum increase of 4.9 cfs or 1% in May.

Cheesman Reservoir to South Platte River at Waterton Gage. Denver Water's direct diversions and exchanges to Strontia Springs Reservoir and Conduit 20 would change under the Proposed Action primarily in response to changes in Moffat WTP operations and the shift in seasonal operations between Denver Water's northern and southern WTPs, as well as the overall higher level of demand that is met with additional storage on-line. As a result, South Platte River flows at the Waterton gage would decrease on average in the summer months. There would be little change in flows at the Waterton gage in most winter months from October through March; however, flow increases would occasionally occur. Increases in flows would be primarily due to increased load shifting between Denver Water's WTPs. Due to the load shift, water would be moved between Strontia Springs, Chatfield, and Marston reservoirs differently under the Proposed Action. While the amount moved would be comparable to the Full Use of the Existing System scenario, the timing would change.

In the summer, Foothills and Marston WTPs would operate at higher rates under the Proposed Action because of the overall higher level of demand that would be met. Therefore, Denver Water's direct diversions at Strontia Reservoir and Conduit 20 would increase in response to higher demand in summer months. The greatest increases in direct diversions would typically occur in the months of May, June, and July. In addition, exchanges to Conduit 20 would also increase in the summer months for similar reasons. Because summer diversions through Roberts Tunnel would generally be higher under the

Proposed Action, more reusable effluent at Metro WWTP and Bi-City WWTP would be available for exchange. The increase in available reusable effluent combined with the increased operation of Foothills and Marston WTPs in the summer, would result in increased exchanges to Conduit 20 on average. The majority of additional exchanges would occur from April through September.

Denver Water has the ability to reduce summer minimum fish flows downstream of Strontia Springs Dam at the Old Last Chance Ditch Diversion. Reductions in summer minimum flows below Strontia Springs Dam were not included in the PACSM; however, there is no indication that reductions in these minimum flows would increase under the Proposed Action.

Flows at the South Platte River at Waterton gage, which is below Strontia Springs and Conduit 20, were reviewed to evaluate changes in flows as a result of increased direct diversions and exchanges up to Conduit 20. As shown in Tables H-7.4 through H-7.6, average annual flows at the Waterton gage would decrease by 2,700 AF or 3%, dry year average annual flows would increase by 700 AF or 2%, and wet year average annual flows would decrease by 3,400 AF or 1%. Table H-3.45 summarizes average monthly flows at the Waterton gage for average, dry, and wet conditions. Monthly average flow changes would range from a maximum decrease of 22.2 cfs or 5% in June to a maximum increase of 3.1 cfs or 3% in April. Monthly dry year average flows would range from a maximum decrease of 0.7 cfs or 1% in June to a maximum increase of 7.6 cfs or 25% in April. Monthly wet year average flows would range from a maximum decrease of 23.7 cfs or 3% in July to a maximum increase of 5.4 cfs or 8% in November.

<u>South Platte River at Waterton Gage to Denver Gage</u>. In the reach along the South Platte River between the Waterton gage and Denver gage, flows would increase on average as compared to Full Use of the Existing System, due primarily to additional effluent returns at Bi-City WWTP and return flows accruing to the river due to Denver Water's outdoor water usage. The additional return flows in this reach would be approximately 1,600 AF/yr on average, which coincides closely with the average annual difference in flows between the Waterton and Denver gages of about 1,800 AF.

In addition to changes due to additional return flows in this reach, there would be slight differences in flows (approximately 300 AF/yr on average) between the Waterton gage and below Chatfield Reservoir due to the WTP load shift. Under the Proposed Action, water would be moved between Strontia Springs, Chatfield, and Marston reservoirs differently, which would result in some flow increases and decreases between the Waterton gage and Chatfield Reservoir. The amount moved between these reservoirs would be comparable to Full Use of the Existing System; however, the timing changes.

As shown in Table H-3.46 average monthly flows below Chatfield Reservoir would increase from November through April by up to 5.1 cfs. Average monthly flows in the remaining months would decrease by up to 14.8 cfs when the majority of Denver Water's additional exchanges and direct diversions occur. There are number of days under Current Conditions (2006) when there is zero flow below Chatfield Reservoir. This occurs almost exclusively during the winter from November through March ranging from 29% of the time in March to 57% of the time in January under Full Use of the Existing System. When Chatfield Reservoir does not have to bypass water for a senior downstream call or the call is

downstream of Denver Water's gravel pits, Denver Water is able to exchange water to Chatfield Reservoir leaving no outflow. The number of days of zero flow below Chatfield Reservoir increases from Current Conditions (2006) to Full Use of the Existing System because of Denver Water's higher demand, which results in more reusable effluent and increased exchanges to Chatfield Reservoir. The number of days of zero flow decreases under the Proposed Action to Current Conditions levels, because the Moffat Treatment Plant would be operating during the winter resulting in less reusable effluent to exchange upstream.

As shown in Tables H-7.4 through H-7.6, annual flows below Chatfield Reservoir would decrease by 2,400 AF or 2% on average, increase by 720 AF or 4% in dry years, and decrease by 3,600 AF or 1% in wet years. Table H-3.46 summarizes average monthly flows below Chatfield Reservoir for average, dry, and wet conditions. Monthly average flow changes would range from a decrease of 14.8 cfs or 3% in June to an increase of 5.1 cfs or 13% in November. Monthly dry year average flow changes would range from a decrease of 6.6 cfs or 15% in May to an increase of 12.5 cfs or 28% in April. Monthly wet year average flow changes would range from a decrease of 23.6 cfs or 3% in July to an increase of 9.1 cfs or 18% in November. Monthly flows at the Denver gage would increase on average during the winter months from October through April. In general, flows would increase in the winter months in this reach because there are additional indoor and outdoor return flows due to increased demand, and additional direct diversions and exchanges up to Strontia and Conduit 20 would be fairly minimal. Changes in flows from May through September would be more variable. On average, flows would decrease; however, monthly flow increases would range up to about 3,100 AF, and decreases would range up to about 8,100 AF. Increases and decreases from May through September would occur in both wet and dry years. The majority of the additional direct diversions and exchanges would occur from April through September. There would also be differences throughout the year due to the load shift and associated changes in the amount of water moved between Strontia Springs, Chatfield, and Marston reservoirs.

As shown in Tables H-7.4 through H-7.6, average annual flows at the Denver gage would decrease by 800 AF or less than 1%, dry year average annual flows would increase by 2,000 AF or 2%, and wet year average annual flows would decrease by 1,900 AF or less than 1%. Table H-3.47 summarizes average monthly flows at the Denver gage for average, dry, and wet conditions. Monthly average flow changes would range from a decrease of 13.2 cfs or 2% in June to an increase of 7.2 cfs or 7% in January. Monthly dry year average flow changes would range from a decrease of 6.3 cfs or 3% in May to an increase of 13.6 cfs or 10% in April. Monthly wet year average flow changes would range from a decrease of 21.7 cfs or 2% in July to an increase of 12.6 cfs or 8% in December.

<u>South Platte River at Denver Gage to South Platte River at Henderson Gage</u>. In the reach along the South Platte River between the Denver gage and Henderson gage, flows would increase on average due primarily to additional effluent returns at Metro WWTP and return flows accruing to the river due to outdoor water usage. The average annual difference in flows between the Denver gage and Henderson gage would increase by about 5,200 AF/yr, which coincides closely with the net return to the South Platte River in this reach. In addition, there would be an increase in the amount diverted through the Metro WWTP pumps for Farmer's Reservoir and Irrigation Company (FRICO) because more water is

available at the Metro WWTP at times when FRICO is short of water. There would also be a decrease on average in the amount diverted from the Metro WWTP to the non-potable project under Denver Water's junior right for the reuse project and exchanges from downstream gravel pits. These changes are relatively minor and are generally offsetting on an average annual basis.

Flows at the Henderson gage would increase on average during the winter months from October through April. In general, flows would increase in the winter months in this reach because there would be additional indoor and outdoor return flows attributable to Denver Water's and Arvada's increased demands and additional direct diversions and exchanges up to Strontia Springs Reservoir and Conduit 20 would be fairly minimal. The changes in flows from May through September are more variable for the same reasons indicated for the reach between the Waterton gage and Denver gage. Monthly flow increases would range up to about 3,000 AF and decreases would range up to about 7,100 AF.

As shown in Tables H-7.4 through H-7.6, average, dry year, and wet year average annual flows at the Henderson gage would increase by 4,300 AF or 2%, 3,700 AF or 3%, and by 6,600 AF or 1%, respectively. Table H-3.48 summarizes average monthly flows at the Henderson gage for average, dry, and wet conditions. Monthly average flow changes would range from a decrease of 11.4 cfs or 1% in June to an increase of 20.4 cfs or 8% in January. Monthly dry year flow changes would range from a decrease of 3.5 cfs or 1% in June to an increase of 18.2 cfs or 10% in January. Monthly wet year flow changes would range from a decrease of 9.4 cfs or less than 1% in May to an increase of 26.2 cfs or 4% in April.

South Platte River Daily Flow Changes

Figures H-4.124 through H-4.135 show average, wet and dry daily hydrographs below Cheesman Reservoir and at the Waterton, Denver and Henderson gages. Figures H-5.25 through H-5.30 present flow duration curves for outflow from the Antero, Eleven Mile Canyon, and Cheesman reservoirs, the South Platte River at the Waterton gage, Denver gage, and Henderson gage, respectively. As shown by the flow duration curves, flow changes would be relatively small the majority of time. Table H-6.17 shows the percentage of days that flow increases and decreases would occur for the South Platte River locations. About 96 to 99% of the time there would be little to no flow change, or a flow increase or decrease up to 100 cfs would occur. Table H-6.20 summarizes maximum daily flow reductions at similar locations. The maximum daily flow reductions would range from 210 cfs below Antero Reservoir up to 847 cfs below Cheesman Reservoir. Daily increases in flow would be greatest at the Henderson gage and range up to 727 cfs.

South Platte River Peak Flow Changes

Tables H-14.9 and H-14.10 summarize changes in the magnitude and timing of the peak flow for an average year and wet year at the Waterton gage and the Henderson gage compared to Full Use of the Existing System. The magnitude of the peak flow in an average year would decrease by 19 cfs at the Waterton gage and shift one day later. At the Henderson gage, the peak flow in an average year would decrease by 10 cfs but the timing would not change. The magnitude of the wet year peak flow would decrease by 27 cfs at

the Waterton gage and 19 cfs at the Henderson gage. There would be no change in the timing of the wet year peak at either gage.

South Platte River Floodplain

Changes in the floodplain along the South Platte River were analyzed below Cheesman Reservoir and at the Denver gage. Below Cheesman Reservoir, differences in flows during the summer would be variable under the Proposed Action. Although it is difficult to generalize about the tendency for monthly flows to increase or decrease under the Proposed Action, annual peak flows would generally be at the same level or smaller under the Proposed Action, for all recurrence intervals greater than or equal to 2 years. From this information, it can be inferred that the floodplain extent would not be significantly altered in the upper South Platte River, above the North Fork South Platte River.

At the Denver gage, the annual flood flows for the Proposed Action and Full Use of the Existing System are very similar, with almost all peak flows being within a percentage point of Full Use of the Existing System. Peak flows associated with more frequent flood events would occasionally increase between 1 and 3%; however, changes to the floodplain extent in this reach of the river are not considered significant.

5.1.2 Alternative 1c

Under Alternative 1c, a new 31,300-AF reservoir would be constructed at Leyden Gulch to complement a 40,700-AF enlargement at Gross Reservoir (total size 82,511 AF). The water source for Alternative 1c would be the same as the Proposed Action. A portion of the additional Moffat Collection System diversions would be stored in a new Leyden Gulch Reservoir. Water stored in Gross Reservoir would be released and delivered via the South Boulder Diversion Canal to Leyden Gulch Reservoir in an effort to keep Leyden Gulch Reservoir full. This would stage water closer to the Moffat WTP and maximize the space that would be available in Gross Reservoir for collection of Moffat Collection System supplies. Water would be released from Leyden Gulch Reservoir as needed to meet demands at Moffat WTP. In general, the majority of "new" water diverted to Gross and Leyden Gulch reservoirs would be kept in storage until a drought occurs. The additional water at Gross and Leyden Gulch reservoirs would typically only be used during a drought. Changes in surface water hydrology are very similar to the Proposed Action because the same amount of new storage would be added to the Moffat Collection System and the water source would be the same as the Proposed Action. Differences in hydrologic conditions compared to the Proposed Action would be focused at Gross Reservoir and on South Boulder Creek below Gross Reservoir. Minor changes in hydrology between the Proposed Action and Alternative 1c would be due to differences in evaporative losses at Gross Reservoir versus Leyden Gulch Reservoir, and the staging of water in Gross Reservoir versus Leyden Gulch Reservoir for example.

5.1.2.1 Reservoir Evaporation and Fluctuation

Williams Fork Reservoir

Changes in Williams Fork Reservoir operations, evaporation, contents, and water elevations under Alternative 1c are similar to the Proposed Action with the following differences.

Average, dry, and wet end-of-month contents under Alternative 1c would be within 100 to 200 AF of the Proposed Action. There would be about 1 foot decrease (average years), 2 foot decrease (wet years), and minimal to no change for dry years in reservoir elevations between Alternatives 1c and the Proposed Action. Differences in average monthly changes in content between Alternatives 1c and the Proposed Action are within 1%.

Dillon Reservoir

Changes in Dillon Reservoir operations, evaporation, contents, and elevations under Alternative 1c are similar to the Proposed Action with the following differences. Average, dry, and wet end-of-month contents under Alternative 1c are up to 700 AF lower than under the Proposed Action. This is primarily due to the fact that average annual Roberts Tunnel diversions would be about 400 AF higher on average under Alternative 1c than under the Proposed Action. This is mainly due to higher evaporation losses system-wide with Alternative 1c as compared to the Proposed Action. Differences in end-of-month reservoir elevations between Alternatives 1c and the Proposed Action are less than 1 foot. Differences in average monthly content between Alternatives 1c and the Proposed Action are within 1%.

Wolford Mountain Reservoir

Changes in reservoir operations, evaporation, contents, and water elevations under Alternative 1c are the same as the Proposed Action and no impacts are anticipated from Alternative 1c.

Gross Reservoir

Under Alternative 1c, Gross Reservoir's volume would be approximately twice its current volume. The surface area at normal high water level would increase from approximately 418 to 651 acres. Normal high water level would increase by 75 feet.

From April through November, the annual pattern of fluctuation in level and content would be similar to that under the Proposed Action. Gross Reservoir would be at its lowest level at the end of April, generally reach its highest levels in late summer, and be drawn down through the fall and winter. Average monthly contents would be greatest at the end of July at 72,500 AF and lowest at the end of April at 41,200 AF (Table H-2.10). In dry years, monthly contents during summer months would be lower than average because the reservoir would be drawn on more heavily during a drought. Whereas, in wet years, monthly contents during summer months would be higher than average. Monthly average, dry, and wet end-of-month water elevations are shown in Table H-2.11. The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and Alternative 1c is 107 feet and 27 feet, respectively. Average annual evaporative losses would be 769 AF compared to 477 AF under Full Use of the Existing System, as shown in Table H-8.1.

Leyden Gulch Reservoir

Leyden Gulch Reservoir would be maintained more or less at capacity except in an extended drought. Monthly average, dry, and wet end-of-month contents are approximately

28,000 to 31,000 AF or up to 3,000 AF below capacity (Table H-2.22). These averages reflect drawdowns that would occur in only a few years, which follow the designated five dry years, as drought persists. Leyden Gulch Reservoir would be completely emptied during the later stages of the critical period. Monthly average, dry, and wet end-of-month water elevations are shown in Table H-2.23. Average annual evaporation at Leyden Gulch Reservoir would be 623 AF, as shown in Table H-8.1.

Antero Reservoir/Eleven Mile Canyon Reservoir/Cheesman Reservoir/Strontia Springs Reservoir/Chatfield Reservoir

Changes in reservoir operations, evaporation, contents, and water elevations under Alternative 1c are similar to the Proposed Action.

5.1.2.2 River Segments

Fraser River

Fraser River Stream Flow

Because there is no difference in the amount of new storage added in the Moffat Collection System between Alternative 1c and the Proposed Action, changes in Fraser River stream flow under Alternative 1c are similar to the Proposed Action with the following minor differences. On average, Moffat Tunnel diversions would be approximately 200 AF/yr less under Alternative 1c than under the Proposed Action. Because there is little difference in Moffat Tunnel diversions under Alternative 1c compared to the Proposed Action, flow reductions in the Fraser River Basin would be similar to the Proposed Action. Average and wet year annual flow decreases in the Fraser River would be up to 100 AF and 600 AF less, respectively, under Alternative 1c than under the Proposed Action. Throughout the basin, differences in average monthly flow between Alternative 1c and the Proposed Action are within 1 to 2%. Differences in flows between Alternative 1c and the Proposed Action would primarily occur in June and July in wet years when Gross Reservoir or Leyden Gulch Reservoir fills. Differences in flow between these alternatives would not occur in dry years. On average, flows under Alternative 1c would be higher than the Proposed Action for 20 days in years there are differences.

Fraser River Floodplain

Changes in Fraser River flood flows and floodplain extents under Alternative 1c are similar to the Proposed Action.

Williams Fork River

Williams Fork River Stream Flow

Because there is no difference in the amount of new storage (77,000 AF) added in the Moffat Collection System between Alternatives 1c and the Proposed Action, changes in Williams Fork River stream flow under Alternative 1c are similar to the Proposed Action. Average annual Gumlick Tunnel diversions under Alternative 1c are virtually the same as the Proposed Action (Table H-7.4). As a result, reductions in flow downstream of the Gumlick Tunnel and changes in Williams Fork Reservoir outflow under Alternative 1c are essentially the same as the Proposed Action.

Williams Fork River Floodplain

Changes in Williams Fork River flood flows and floodplain extents under Alternative 1c are similar to the Proposed Action.

Colorado River

Colorado River Stream Flow

Changes in Colorado River stream flow under Alternative 1c are similar to the Proposed Action with the following minor differences. Average and wet year annual flow decreases in the Colorado River below the Windy Gap diversion would be about 100 and 500 AF less, respectively, under Alternative 1c than under the Proposed Action. Average and wet year annual flow decreases in the Colorado River near Kremmling would be about 200 and 300 AF less, respectively, under Alternative 1c than under the Proposed Action. At both locations, differences in average monthly flow between Alternatives 1c and the Proposed Action are within 1%.

Colorado River Floodplain

Changes in Colorado River flood flows and floodplain extents under Alternative 1c are similar to the Proposed Action.

Muddy Creek

Muddy Creek Stream Flow

Changes in Muddy Creek stream flow under Alternative 1c are the same as the Proposed Action.

Muddy Creek Floodplain

Changes in Muddy Creek flood flows and floodplain extents under Alternative 1c are similar to the Proposed Action.

Blue River

Blue River Stream Flow

Changes in Blue River stream flow under Alternative 1c are similar to the Proposed Action with the following minor differences. Under Alternative 1c, average annual Roberts Tunnel diversions are approximately 400 AF higher than the Proposed Action. As a result, average annual outflow from Dillon and Green Mountain reservoirs is approximately 400 AF less under Alternative 1c than the Proposed Action. Differences in average monthly flow between Alternatives 1c and the Proposed Action are within 1%.

Blue River Floodplain

Changes in Blue River flood flows and floodplain extents under Alternative 1c are similar to the Proposed Action.

South Boulder Creek

South Boulder Creek Stream Flow

Changes in South Boulder Creek stream flow under Alternative 1c are similar to the Proposed Action with the following differences. Above Gross Reservoir, average and wet year annual flow increases would be 200 and 300 AF less, respectively, under Alternative 1c than under the Proposed Action. These flow differences coincide with the differences in Moffat Tunnel diversions between Alternatives 1c and the Proposed Action. Differences in average monthly flow between Alternatives 1c and the Proposed Action are less than 1% in this reach.

From Gross Reservoir to the South Boulder Diversion Canal, differences in flow changes between Alternative 1c and the Proposed Action are greater because of the timing and quantity of water that would be released from Gross Reservoir for delivery to Leyden Gulch Reservoir under Alternative 1c. In general, more water would be released under Alternative 1c during the summer months and less during the winter months compared to the Proposed Action. The following changes in stream flow are based on a comparison with Full Use of the Existing System. In general, under Alternative 1c, flows would be consistently higher from October through February and April, as water would be moved out of Gross Reservoir and into Leyden Gulch and Ralston reservoirs. As shown in Tables H-7.4 through H-7.6, average, dry, and wet year annual outflow from Gross Reservoir would increase by 9,700 AF or 9%, 13,500 AF or 16%, and 15,100 AF or 13%, respectively. Table H-3.39 summarizes average monthly outflow from Gross Reservoir for average, dry, and wet conditions. Monthly average flow changes would range from a decrease of 56.0 cfs or 20% in May to an increase of 84.0 cfs or 825% in January. Monthly dry year average flow changes would range from a decrease of 48.2 cfs or 20% in July to an increase of 84.0 cfs or 1,069% in January. Monthly wet year average flow changes would range from a decrease of 37.0 cfs or 19% in May to an increase of 84.6 cfs or 688% in January.

Changes in South Boulder Creek stream flow below the South Boulder Diversion Canal under Alternative 1c are the same as the Proposed Action.

South Boulder Creek Floodplain

Changes in South Boulder Creek flood flows and floodplain extents under Alternative 1c are similar to the Proposed Action with the following differences. An enlarged Gross Reservoir would be able to capture some flows that were spilled under Full Use of the Existing System. However, because this alternative includes a smaller enlargement of Gross Reservoir than the Proposed Action, the impact on annual flood flows is smaller than under the Proposed Action. Annual flood flows for estimated recurrence intervals between 2 and 15 years are zero to 4% smaller under Alternative 1c than under Full Use of the Existing System. Lower frequency, higher return interval events would essentially be the same under Alternative 1c and Full Use of the Existing System, in which case, there would be no change in the floodplain extent for these large events under this alternative.

North Fork South Platte River

North Fork Stream Flow

Changes in the North Fork South Platte River stream flow under Alternative 1c are similar to the Proposed Action with the following minor differences. Under Alternative 1c, average annual Roberts Tunnel diversions are approximately 400 AF higher than the Proposed Action. As a result, average annual flow in the North Fork South Platte River is approximately 400 AF more than the Proposed Action. Differences in average monthly flow between Alternatives 1c and the Proposed Action are within 1%.

North Fork Floodplain

Changes in North Fork South Platte River flood flows and floodplain extents under Alternative 1c are similar to the Proposed Action.

South Platte River

South Platte River Stream Flow

Changes in South Platte River stream flow under Alternative 1c are similar to the Proposed Action with the following minor differences. Average, dry, and wet year annual flow changes along the South Platte River would differ by up to about 400 AF compared to the Proposed Action. Differences in average monthly flow between Alternatives 1c and the Proposed Action are within 1%.

South Platte River Floodplain

Changes in South Platte River flood flows and floodplain extents under Alternative 1c are similar to the Proposed Action.

5.1.3 Alternative 8a

Under Alternative 8a, Gross Reservoir would be expanded to approximately 93,811 AF in order to provide an additional 52,000 AF of storage. In addition, approximately 5,000 AF of gravel pit storage would be added along the South Platte River. The water source for the enlarged Gross Reservoir would be the same as the Proposed Action. The gravel pits would be supplied with reusable return flows diverted from the South Platte River below Metro WWTP. Diversions would be made from the South Platte River to the gravel pit lakes to the extent that reusable effluent is available and storage space exists in the gravel pit lakes. Water stored in the gravel pit lakes would generally be used for supply in dry years. In years when the stored water is not used, water would be diverted into the pits to replace evaporative losses.

Because the volume of new storage at Gross Reservoir is 20,000 AF less than the Proposed Action, additional diversions from the Moffat Collection System would be less under Alternative 8a. However, changes in surface water hydrology would still be similar to the Proposed Action because of the manner in which Denver Water would use their additional supplies at Gross Reservoir and the gravel pits. In general, the majority of "new" water diverted to Gross Reservoir would be kept in storage until a drought occurs. The additional water at Gross Reservoir would typically only be used during a drought. Reusable water

would be pumped back to the Moffat Collection System infrequently and only as needed to supplement Denver Water's Moffat supplies.

5.1.3.1 Reservoir Evaporation and Fluctuation

Williams Fork Reservoir

Changes in Williams Fork Reservoir operations, evaporation, contents, and elevations under Alternative 8a are similar to the Proposed Action with the following differences. Under Alternative 8a, the increase in Gumlick Tunnel diversions would be smaller on average than the increase under the Proposed Action because there is 20,000 AF less new storage at Gross Reservoir. Average annual Gumlick Tunnel diversions under Alternative 8a are approximately 280 AF less than the Proposed Action. There is a corresponding difference in Williams Fork Reservoir's contents: they would generally be lower under Alternative 8a than Full Use of the Existing System, with average monthly differences ranging from 260 to 800 AF (compared with differences ranging from 500 to 1,000 AF under the Proposed Action). Average monthly differences in water elevation between Alternatives 8a and the Proposed Action would be less than 1 foot. Differences in average monthly content between Alternatives 8a and the Proposed Action are within 1%.

Dillon Reservoir

Changes in Dillon Reservoir operations, evaporation, contents, and elevations under Alternative 8a would be similar to the Proposed Action with the following differences. Impacts of Alternative 8a on Dillon Reservoir contents are similar to impacts of the Proposed Action in dry years; however, average and wet year end-of-month contents under Alternative 8a are up to 600 and 1,800 AF higher, respectively, than under the Proposed Action. Dillon Reservoir contents would be higher under Alternative 8a on average because average annual Roberts Tunnel diversions would be about 500 AF less under Alternative 8a than under the Proposed Action. Roberts Tunnel diversions would be less under Alternative 8a because some of the additional demand would be directly met by reusable water pumped from the gravel pits. Differences in end-of-month water elevations between Alternatives 8a and the Proposed Action are less than 1 foot. The maximum increase and decrease in reservoir elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and this alternative is 15 feet and 8 feet, respectively. Differences in average monthly content between Alternatives 8a and the Proposed Action are within 1%.

Wolford Mountain Reservoir

Changes in reservoir operations, evaporation, contents, and water elevations under Alternative 8a are the same as the Proposed Action.

Gross Reservoir

Under Alternative 8a, Gross Reservoir's volume would be a little more than twice its volume as compared to Full Use of the Existing System. Surface area at normal high water level would be approximately 712 acres, compared with 418 acres under Full Use of the Existing System and normal high water level would increase by approximately 92 feet.

From April through November, the annual pattern of fluctuation in level and content would be similar to that under the Proposed Action. Gross Reservoir would be at its lowest at the end of April, generally reach its highest levels in late summer, and be drawn down through the fall and winter. Average monthly contents would be greatest at the end of June at 84,700 AF and lowest at the end of April at 52,400 AF (Table H-2.10). In dry years, monthly contents during summer months would be lower than average because the reservoir would be drawn on more heavily during a drought. Whereas, in wet years, monthly contents during summer months would be higher than average. Monthly average, dry, and wet end-of-month reservoir elevations are shown in Table H-2.11. The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and this alternative is 125 feet and 27 feet, respectively. Average annual evaporative losses would be 858 AF compared to 991 AF under the Proposed Action and 477 AF under Full Use of the Existing System, as shown in Table H-8.1.

Antero Reservoir/Eleven Mile Canyon Reservoir/Cheesman Reservoir/Strontia Springs Reservoir/Chatfield Reservoir

Changes in reservoir operations, evaporation, contents, and water elevations under Alternative 8a are similar to the Proposed Action.

Gravel Pit Storage

Alternative 8a includes approximately 5,000 AF of storage capacity in reclaimed gravel pits adjacent to the South Platte River. The pits would typically fill with reusable effluent from November through April, when unused reusable effluent is available. The gravel pits would generally only be depleted in advanced stages of a drought. Maximum end-of-month contents under Alternative 8a would be 4,000 AF in average years, 4,600 AF in dry years, and 3,800 AF in wet years (Table H-2.25). The change in average end-of-month water elevation across the year is 14 feet (Table H-2.26). Average annual evaporative losses would be 886 AF, as shown in Table H-8.1.

In wet years, there would be less reusable effluent available because less water would be imported from the Blue River. Accordingly, average wet year contents would be lower than average contents from October through May, and slightly higher from June through September. Wet year contents are lower than average during the winter months because less reusable effluent is available for storage and higher than average in summer months because reusable effluent would only be used during droughts.

Average dry year contents of the pits are higher than average for all months except September. Dry year contents are higher than average because the five designated dry years do not coincide with later stages of droughts when the water is typically released from the gravel pits for delivery to the Moffat Collection System delivery point.

5.1.3.2 River Segments

In general, flow changes under Alternative 8a would be very similar to the Proposed Action. For example, average annual flow decreases below Denver Water's diversion points in the Fraser and Williams Fork river basins would generally be about 100 AF less

than the Proposed Action. Similarly, differences in maximum monthly average flow decreases would be less than 1 cfs in those river basins.

Fraser River

Fraser River Stream Flow

Because the amount of new storage (52,000 AF) added in the Moffat Collection System is 20,000 AF less under Alternative 8a than the Proposed Action, Moffat Tunnel diversions and reductions in Fraser River stream flow would be less under Alternative 8a. On average, Moffat Tunnel diversions would be approximately 1,100 AF/yr or 1.5% less under Alternative 8a than under the Proposed Action. Moffat Tunnel diversions are less because a portion of the firm yield that would otherwise be provided by an enlargement of Gross Reservoir under the Proposed Action is provided by reusable supplies and gravel pit storage along the South Platte River under Alternative 8a.

As shown in Tables H-7.4 and H-7.6, average annual Moffat Tunnel diversions would increase by 9,200 AF or 14% while wet year average annual Moffat Tunnel diversions would increase by 11,500 AF or 18%. Diversions would increase in 33 years out of the 45-year study period and additional diversions would range up to 65,400 AF/yr (26,500 AF per month) as Gross Reservoir refills after a drought. Similar to the Proposed Action, there would be no additional diversions in dry years because Denver Water would divert the maximum amount physically and legally available under their existing water rights without additional storage in their system.

Because there is relatively little difference in Moffat Tunnel diversions under Alternative 8a compared to the Proposed Action, flow reductions in the Fraser River Basin would be similar to the Proposed Action. The difference in average monthly flows between Alternative 8a and the Proposed Action is generally less than 1 cfs on tributaries to the Fraser River mainstem. The maximum difference in average monthly flows between Alternative 8a and the Proposed Action is 6.7 cfs in July on the Fraser River mainstem below the confluence with Crooked Creek. Flows in the Fraser River Basin under Alternative 8a are higher on average compared to the Proposed Action because Moffat Tunnel diversions would be less. Differences in flows between Alternative 8a and the Proposed Action would primarily occur in June and July in wet years when Gross Reservoir fills. Differences in flow between Alternative 8a and the Proposed Action would not occur in dry years.

Fraser River Floodplain

Changes in Fraser River flood flows and floodplain extents under Alternative 8a are similar to the Proposed Action.

Williams Fork River

Williams Fork River Stream Flow

Because the amount of new storage (52,000 AF) added in the Moffat Collection System is 20,000 AF less under Alternative 8a than the Proposed Action, Gumlick Tunnel diversions and reductions in Williams Fork River stream flow would be less under Alternative 8a. On average, Gumlick Tunnel diversions would be approximately 280 AF/yr less under

Alternative 8a than under the Proposed Action. As shown in Tables H-7.4 and H-7.6, average annual Gumlick Tunnel diversions would increase by 1,600 AF or 17% while wet year average Gumlick Tunnel diversions would increase by 1,400 AF or 20%. Diversions would increase in 34 years out of the 45-year study period and additional diversions would range up to 7,600 AF/yr (5,800 AF per month). There would be no additional diversions in dry years or from late summer through early spring except in infrequent, very wet years.

Because there is little difference in Gumlick Tunnel diversions under Alternative 8a compared to the Proposed Action, flow reductions in the Williams Fork River Basin would be similar to the Proposed Action. The difference in average monthly flows between Alternative 8a and the Proposed Action is less than 1 cfs on all the upper tributaries to the Williams Fork River. The maximum difference in average monthly flows between Alternative 8a and the Proposed Action is 3.7 cfs in July below Williams Fork Reservoir. Flows in the Williams Fork River Basin under Alternative 8a are higher on average compared to the Proposed Action because Gumlick Tunnel diversions would be less.

Williams Fork River Floodplain

Changes in Williams Fork River flood flows and floodplain extents under Alternative 8a are similar to the Proposed Action.

Colorado River

Colorado River Stream Flow

The amount of new storage (52,000 AF) added in the Moffat Collection System is 20,000 AF less under Alternative 8a than the Proposed Action; therefore, reductions in Colorado River flows would be similar to but less under Alternative 8a primarily because additional Gumlick Tunnel and Moffat Tunnel diversions would be less. Flow changes described in the following paragraphs are based on comparisons with the Full Use of the Existing System scenario.

As shown in Tables H-7.4 and H-7.6, average annual flows below Windy Gap would decrease by 7,100 AF or 5% and 13,300 AF or 4% in wet years. Average annual flows below the confluence with Williams Fork River would decrease by 8,500 AF or 3% and 16,200 AF or 3% in wet years. Average annual flows at the gage near Kremmling would decrease by 12,700 AF or 2% and 21,900 AF or 2% in wet years. At those locations, there would be no decrease in flows in dry years because Denver Water would not divert any additional water under Alternative 8a in dry years.

Tables H-3.31 through H-3.33 summarize average monthly flow changes in the Colorado River below Windy Gap, below the confluence with Williams Fork River and near Kremmling for average, dry, and wet conditions. Changes in Colorado River flows below Windy Gap would be due primarily to Denver Water's additional diversions from the Fraser River. Below Windy Gap, monthly average flows would decrease by a maximum of 77.4 cfs or 12% in June, which coincides with the month when Moffat Tunnel diversions would increase most (Table H-3.31). In wet years, monthly average flows would decrease by a maximum of 145.3 cfs or 6% in June. There would be no decrease in flows in dry years.

Moving downstream, the Colorado River is affected by tributary inflows from the Williams Fork River, Troublesome Creek, Muddy Creek, and the Blue River and Denver Water's diversions and operations in those basins. The volume of change rises in the downstream direction, but the reductions in flow would be smaller relative to the total stream, which is growing. Below the confluence with Williams Fork River, monthly average flows would decrease by a maximum of 96.7 cfs or 12% in June (Table H-3.32). In wet years, monthly average flows would decrease by a maximum of 182.7 cfs or 6% in June. Near Kremmling, monthly average flows would decrease by a maximum of 117.8 cfs or 6% in June (Table H-3.33). In wet years, monthly average flows would decrease by a maximum of 228.2 cfs or 4% in June. Again, there would be no decrease in flows in dry years.

As shown by the flow duration curves (Figures H-5.15 through H-5.17), flow reductions resulting from Alternative 8a would occur at higher flow rates, which typically correspond with wet years. The percentage of days from May through July that flow decreases would occur would be similar to the Proposed Action (Table H-6.12).

Colorado River Floodplain

Changes in Colorado River flood flows and floodplain extents under Alternative 8a are similar to the Proposed Action.

Muddy Creek

Muddy Creek Stream Flow

Changes in Muddy Creek stream flow under Alternative 8a are the same as the Proposed Action.

Muddy Creek Floodplain

Changes in Muddy Creek flood flows and floodplain extents under Alternative 8a are similar to the Proposed Action.

Blue River

Blue River Stream Flow

Changes in Blue River stream flow under Alternative 8a are similar to the Proposed Action with the following differences. Under Alternative 8a, average annual Roberts Tunnel diversions are approximately 500 AF less than the Proposed Action because under Alternative 8a some of the demand is met from reusable water. As a result, average annual outflow from Dillon and Green Mountain reservoirs is approximately 500 AF higher under Alternative 8a than the Proposed Action. Differences in average monthly flow between Alternatives 8a and the Proposed Action are within 1%.

Blue River Floodplain

Changes in Blue River flood flows and floodplain extents under Alternative 8a are similar to the Proposed Action.

South Boulder Creek

South Boulder Creek Stream Flow

The amount of new storage (52,000 AF) added in the Moffat Collection System is 20,000 AF less under Alternative 8a than the Proposed Action; therefore, increases in South Boulder Creek flows would be less under Alternative 8a because additional Moffat Tunnel diversions would be less. Differences in South Boulder Creek flow increases between Alternatives 8a and the Proposed Action correspond with differences in Moffat Tunnel diversions. Flow changes in the following paragraphs are based on comparisons with the Full Use of the Existing System scenario.

In the uppermost reach above Gross Reservoir, changes in flow are equivalent to changes in Moffat Tunnel deliveries. As shown in Tables H-7.4 and H-7.6, average annual flows at the Pinecliffe gage would increase by 9,200 AF or 8% and 14,100 AF or 13% in wet years. There would be no change in dry year flows. Note, that the combination of 5 years that were averaged to determine a wet and dry year average are different for the Moffat Tunnel versus South Boulder Creek because diversions into the Moffat Tunnel occur on the West Slope, whereas South Boulder Creek is located on the East Slope. Refer to Section 4.6.1 for a discussion of West Slope versus East Slope dry and wet year averages. As a result, the changes in wet and dry year annual averages are not comparable for the Moffat Tunnel and Pinecliffe gage. Table H-3.38 summarizes average monthly flows at the Pinecliffe gage for average, dry, and wet conditions. Flow increases would occur primarily in May, June, and July, which corresponds with the months when additional diversions through the Moffat Tunnel would be greatest. There would be virtually no flow increases from late summer through early spring except in infrequent, very wet years. Monthly average flows would increase by a maximum of 100.3 cfs or 16% in June, which coincides with the month when Moffat Tunnel diversions would increase most. Monthly wet year average flows would increase by a maximum of 149.3 cfs or 31% in June.

From Gross Reservoir to the South Boulder Diversion Canal, changes in flow reflect Gross Reservoir operations. The annual pattern of reservoir releases would be similar to that under the Proposed Action. As shown in Tables H-7.4 through H-7.6, average, dry year, and wet year average annual outflow from Gross Reservoir would increase by 8,700 AF or 8%, 12,400 AF or 14%, and 15,400 AF or 14%, respectively. Table H-3.39 summarizes average monthly outflow from Gross Reservoir for average, dry, and wet conditions. Monthly average flow changes would range from a decrease of 64.3 cfs or 23% in May to an increase of 85.5 cfs or 839% in January. Monthly dry year average flow changes would range from a decrease of 46.6 cfs or 20% in July to an increase of 85.1 cfs or 1,083% in January. Monthly wet year average flow changes would range from a decrease of 40.6 cfs or 20% in May to an increase of 84.5 cfs or 687% in January. Changes in South Boulder Creek stream flow below the South Boulder Diversion Canal under Alternative 8a are virtually the same as the Proposed Action.

As shown by the flow duration curves (Figures H-5.21 through H-5.23) around Gross Reservoir, flow increases resulting from Alternative 8a would occur primarily at higher flow rates. The flow duration curve for Gross Reservoir outflow shows flow decreases occur primarily at higher flow rates while flow increases would occur primarily at lower

flow rates. The flow duration curve at the Eldorado Springs gage shows flow decreases would occur primarily at higher flow rates. The percentage of days that flow changes would occur would be similar to the Proposed Action (Table H-6.15).

South Boulder Creek Floodplain

Changes in South Boulder Creek flood flows and floodplain extents under Alternative 8a are similar to the Proposed Action with the following differences. An enlarged Gross Reservoir would be able to capture some flows that were spilled under Full Use of the Existing System. Because this alternative includes a smaller enlargement of Gross Reservoir than the Proposed Action, the reduction in annual flood flows is slightly smaller than under the Proposed Action for flood events with recurrence intervals greater than about 10 years. Reductions in flood flows under Alternative 8a would be similar to the Proposed Action for flood events with recurrence intervals less than 10 years.

North Fork South Platte River

North Fork South Platte River Stream Flow

Changes in the North Fork South Platte River stream flow under Alternative 8a are similar to the Proposed Action with the following minor differences. Under Alternative 8a, average annual Roberts Tunnel diversions are approximately 500 AF less than the Proposed Action. As a result, average annual flow in the North Fork South Platte River is approximately 500 AF less than the Proposed Action. Differences in average monthly flow between Alternatives 8a and the Proposed Action are within 1%.

North Fork South Platte River Floodplain

Changes in North Fork South Platte River flood flows and floodplain extents under Alternative 8a are similar to the Proposed Action.

South Platte River

South Platte River Stream Flow

Changes in South Platte River stream flow under Alternative 8a are similar to the Proposed Action with the following minor differences. Average, dry, and wet year annual flow changes along the South Platte River would differ by up to about 100 AF compared to the Proposed Action at all locations of interest except below the Metro WWTP. Differences in average monthly flow between Alternatives 8a and the Proposed Action are within 1% above the Metro WWTP.

For the reach below the Metro WWTP, flows are less under Alternative 8a than the Proposed Action because reusable effluent would be diverted for storage in gravel pits. Average annual diversions of reusable effluent to gravel pit storage would be 2,390 AF under Alternative 8a. Flow increases at the Henderson gage would be 1,600 AF less under Alternative 8a than the Proposed Action. The difference in the average annual flow increase at Henderson between Alternatives 8a and the Proposed Action does not coincide exactly with the average annual diversions of reusable effluent under Alternative 8a because of differences in the amount pumped by the Metro WWTP pumps. Differences are greatest during the winter months because reusable effluent would typically be diverted to storage in the gravel pits during those months.

The following flows changes are based on comparisons with the Full Use of the Existing System scenario. As shown in Tables H-7.4 through H-7.6, average annual flows at the Henderson gage would increase by 2,700 AF or 1%, dry year average annual flows would increase by 1,800 AF or 1%, and wet year average annual flows would increase by 4,800 AF or 1%. Table H-3.48 summarizes average monthly flows at the South Platte River at Henderson gage for average, dry, and wet conditions. Monthly average flow changes would range from a decrease of 11.2 cfs or 1% in June to an increase of 15.4 cfs or 6% in November and January,. Monthly dry year flow changes would range from a decrease of 4.6 cfs or 1% in June and 2% in July to an increase of 12.4 cfs or 7% in January. Monthly wet year flow changes would range from a decrease of 7.0 cfs or less than 1% in May to an increase of 22.7 cfs or 7% in January.

As shown by the flow duration curves (Figures H-5.25 through H-5.30) for the South Platte River, flow changes are relatively small the majority of time. The percentage of days that flow changes would occur would be similar to the Proposed Action (Table H-6.17).

South Platte River Floodplain

Changes in South Platte River flood flows and floodplain extents under Alternative 8a are similar to the Proposed Action.

5.1.4 Alternative 10a

Under Alternative 10a, Gross Reservoir would be expanded to approximately 93,811 AF in order to provide an additional 52,000 AF of storage. This is the same expansion scenario as Alternative 8a. The water source for the enlarged Gross Reservoir would be the same as the Proposed Action and Alternative 8a. In addition, approximately 20,000 AF of storage would be developed in the Denver Basin aquifers with an aquifer storage and recovery (ASR) system. The water source for the Denver Basin ASR system would be treated reusable return flow from the Denver Water Recycling Plant.

5.1.4.1 Reservoirs and River Segments

Stream Flow

There is no difference between Alternatives 8a and 10a in the amount of additional storage at Gross Reservoir. In addition, there is little difference in the timing and quantity of diversions of reusable effluent and the manner in which Denver Water would integrate use of their reusable supplies under Alternatives 8a and 10a. The primary difference between Alternatives 8a and 10a is the location of storage for reusable supplies. Under Alternative 8a, reusable supplies would be stored in gravel pits adjacent to the South Platte River, whereas under Alternative 10a, reusable effluent would be stored in the Denver Basin aquifer via injection wells. The difference in location where reusable effluent would be stored prior to delivery to the Moffat Collection System results in almost no difference in reservoir contents and elevations, and stream flows between Alternatives 8a and 10a throughout the Colorado and South Platte river basins downstream to the Metro WWTP. There is a slight difference in the amount of reusable effluent diverted because the gravel pits included in Alternative 8a would experience evaporative losses, whereas, there would be no evaporative losses associated with reusable effluent stored in the Denver Basin

aquifer. As a result, average annual diversions of reusable effluent are approximately 850 AF less under Alternative 10a (2,389 AF under Alternative 8a versus 1,540 AF under Alternative 10a). Because diversions of reusable effluent are less, the amount of reusable effluent in the South Platte River below the Metro WWTP is higher under Alternative 10a than 8a. As a result, the average annual flow at the South Platte River at Henderson gage is approximately 282,700 AF under Alternative 10a, which is approximately 600 AF higher than under Alternative 8a. Otherwise, differences in average, dry, and wet year average annual flows between Alternatives 8a and 10a are generally close to zero and always less than 100 to 200 AF at all other locations of interest. Therefore, the discussion of surface water impacts associated with Alternative 8a also applies to Alternative 10a.

Floodplain

Changes in flood flows and floodplain extents under Alternative 10a are the same as Alternative 8a, which are also similar to the Proposed Action.

5.1.5 Alternative 13a

Under Alternative 13a, Gross Reservoir would be expanded to approximately 101,811 AF in order to provide an additional 60,000 AF of storage. In addition, approximately 3,625 AF of gravel pit storage would be added along the South Platte River. The water source for the enlarged Gross Reservoir would be the same as the Proposed Action. The gravel pits would be supplied with transferred agricultural water rights diverted from the South Platte River. Diversions would be made from the South Platte River to the gravel pit lakes to the extent that water is available under the transferred water rights and storage space exists in the gravel pit lakes. Water stored in the gravel pit lakes would generally be used for supply in dry years. In years when the stored water is not used, water would be diverted into the pits to replace evaporative losses.

Alternative 13a is most similar to Alternative 8a. The volume of new storage at Gross Reservoir is 8,000 AF more than Alternative 8a; therefore, diversions from the Moffat Collection System would be slightly higher under Alternative 13a. However, changes in surface water hydrology would still be similar to Alternative 8a because of the manner in which Denver Water would use their additional supplies at Gross Reservoir and the gravel pits. In general, the majority of "new" water diverted to Gross Reservoir would be kept in storage until a drought occurs. The additional water at Gross Reservoir would typically only be used during a drought. Water would be pumped back to the Moffat Collection System from the gravel pits infrequently and only as needed to supplement Denver Water's Moffat supplies.

Unlike Alternative 8a, this alternative would require the conversion of agricultural water rights to municipal or other non-irrigation uses. Therefore, impacts to removal of return flows from irrigated lands may affect water quality and quantity.

5.1.5.1 Reservoir Evaporation and Fluctuation

Williams Fork Reservoir

Changes in Williams Fork Reservoir operations, evaporation, contents, and water elevations under Alternative 13a are similar to the Proposed Action. Average, dry, and wet year average end-of-month contents under Alternative 13a would be within 500 AF of the Proposed Action. There would be minimal to no change in water elevations between Alternatives 13a and the Proposed Action. Differences in average monthly content between Alternatives 13a and the Proposed Action are within 1%.

Dillon Reservoir

Changes in Dillon Reservoir operations, evaporation, contents, and water elevations under Alternative 13a are similar to the Proposed Action with the following differences. Average, dry, and wet year average end-of-month contents under Alternative 13a are up to 1,170 AF higher than under the Proposed Action. This is primarily due to the fact that average annual Roberts Tunnel diversions would be about 300 AF lower on average under Alternative 13a than under the Proposed Action. Differences in end-of-month reservoir elevations between Alternative 13a and the Proposed Action are less than 1 foot. Differences in average monthly content between Alternative 13a and the Proposed Action are within 1%.

Wolford Mountain Reservoir

Changes in reservoir operations, evaporation, contents, and water elevations under Alternative 13a are the same as the Proposed Action.

Gross Reservoir

Under Alternative 13a, Gross Reservoir's volume would be approximately 102,000 AF, or two and a half times its current volume. The surface area at normal high water level would be approximately 755 acres, compared with 418 acres and normal high water level would increase by approximately 103 feet.

From April through November, the annual pattern of fluctuation in level and content would be similar to that under the Proposed Action with the following differences. Average monthly contents would be greatest at the end of July at 91,800 AF and lowest at the end of April at 59,100 AF (Table H-2.10). In dry years, monthly contents during summer months would be lower than average because the reservoir would be drawn on more heavily during a drought. Whereas, in wet years, monthly contents during summer months would be higher than average. Monthly average, dry, and wet end-of-month water elevations are shown in Table H-2.11. The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and this alternative is 137 feet and 26 feet, respectively. Average annual evaporative losses would be 912 AF compared to 477 AF under Full Use of the Existing System, as shown in Table H-8.1.

Antero Reservoir/Eleven Mile Canyon Reservoir/Cheesman Reservoir/Strontia Springs Reservoir/Chatfield Reservoir

Changes in reservoir operations, evaporation, contents, and water elevations under Alternative 13a are almost the same as the Proposed Action.

Gravel Pit Storage

Alternative 13a includes approximately 3,625 AF of storage capacity in reclaimed gravel pits adjacent to the South Platte River. The pits would typically fill with agricultural water supplies during the summer months when it is available. The gravel pits would generally only be depleted in advanced stages of a drought. Maximum end-of-month contents under Alternative 13a would be 2,700 AF in average years and 3,000 AF in dry and wet years (Table H-2.25). The change in average end-of-month water elevation across the year is 3 feet (Table H-2.26). Average annual evaporative losses would be 656 AF, as shown in Table H-8.1.

5.1.5.2 River Segments

Fraser River

Fraser River Stream Flow

Changes in surface water hydrology would still be similar to the Proposed Action because of the manner in which Denver Water would use their additional supplies at Gross Reservoir and the gravel pits.

On average, Moffat Tunnel diversions would be approximately 500 AF/yr lower under Alternative 13a than under the Proposed Action. The differences in flow changes in the Fraser River Basin under Alternative 13a are commensurate with the changes in Fraser River diversions through the Moffat Tunnel. Average and wet year annual flow decreases in the Fraser River would be up to 300 AF and 200 AF less, respectively, under Alternative 13a than under the Proposed Action. Throughout the basin, differences in average monthly flow between Alternative 13a and the Proposed Action are less than 4 cfs.

Fraser River Floodplain

Changes in Fraser River flood flows and floodplain extents under Alternative 13a are similar to the Proposed Action.

Williams Fork River

Williams Fork River Stream Flow

On average, Gumlick Tunnel diversions would be approximately 100 AF/yr lower under Alternative 13a than under the Proposed Action. The differences in flow changes in the Williams Fork River Basin under Alternative 13a are commensurate with the changes in Gumlick Tunnel diversions. Average and wet year average annual flow decreases in the Williams Fork River would be up to 100 AF less under Alternative 13a than the Proposed Action. Throughout the basin, differences in average monthly flow between Alternative 13a and the Proposed Action are less than 5 cfs.

Williams Fork River Floodplain

Changes in Williams Fork River flood flows and floodplain extents under Alternative 13a are similar to the Proposed Action.

Colorado River

Colorado River Stream Flow

Changes in Colorado River stream flow under Alternative 13a are similar to the Proposed Action. Average and wet year average annual flow decreases in the Colorado River below the Windy Gap diversion would be about 400 AF and 1,200 AF less, respectively, under Alternative 13a than under the Proposed Action. Average and wet year average annual flow decreases in the Colorado River near Kremmling would be about 800 AF and 2,300 AF less, respectively, under Alternative 13a than under the Proposed Action. At both locations, differences in average, wet and dry monthly flow between Alternative 13a and the Proposed Action are less than 30 cfs.

Colorado River Floodplain

Changes in Colorado River flood flows and floodplain extents under Alternative 13a are similar to the Proposed Action.

Muddy Creek

Muddy Creek Stream Flow

Changes in Muddy Creek stream flow under Alternative 13a are the same as the Proposed Action.

Muddy Creek Floodplain

Changes in Muddy Creek flood flows and floodplain extents under Alternative 13a are similar to the Proposed Action.

Blue River

Blue River Stream Flow

Changes in Blue River stream flow under Alternative 13a are similar to the Proposed Action with the following differences. Under Alternative 13a, average annual Roberts Tunnel diversions are approximately 300 AF less than the Proposed Action. As a result, average annual outflow from Dillon and Green Mountain reservoirs is approximately 300 AF more under Alternative 13a than the Proposed Action. Differences in average monthly flow between Alternative 13a and the Proposed Action are less than 4 cfs.

Blue River Floodplain

Changes in Blue River flood flows and floodplain extents under Alternative 13a are similar to the Proposed Action.

South Boulder Creek

South Boulder Creek Stream Flow

Changes in South Boulder Creek stream flow under Alternative 13a are similar to the Proposed Action with the following differences. Above Gross Reservoir, average and wet year annual flow increases would be 500 AF and 200 AF less, respectively, under Alternative 13a than under the Proposed Action. Flow differences coincide with differences in Moffat Tunnel diversions between Alternative 13a and the Proposed Action. Differences in average monthly flow between Alternatives 13a and the Proposed Action are less than 5 cfs.

From Gross Reservoir to the South Boulder Diversion Canal, changes in flow between Alternatives 13a and the Proposed Action reflect Gross Reservoir operations. The annual pattern of reservoir releases would be similar to that under the Proposed Action. Average and wet year annual flow changes would be 400 AF less and 200 AF more, respectively, under Alternative 13a than under the Proposed Action. Differences in average monthly flow between Alternatives 13a and the Proposed Action are less than 2 cfs.

Changes in South Boulder Creek stream flow below the South Boulder Diversion Canal under Alternative 13a are virtually the same as the Proposed Action.

South Boulder Creek Floodplain

Changes in South Boulder Creek flood flows and floodplain extents under Alternative 13a are similar to the Proposed Action.

North Fork South Platte River

North Fork South Platte River Stream Flow

Changes in the North Fork South Platte River stream flow under Alternative 13a are similar to the Proposed Action with the following differences. The differences in flow changes in the North Fork South Platte River under Alternative 13a compared to the Proposed Action are commensurate with additional diversions through the Roberts Tunnel. Under Alternative 13a, average annual Roberts Tunnel diversions would be approximately 300 AF less than the Proposed Action. As a result, average annual flow in the North Fork South Platte River would be approximately 300 AF less than the Proposed Action. Differences in average monthly flow between Alternative 13a and the Proposed Action are less than 2 cfs.

North Fork South Platte River Floodplain

Changes in North Fork South Platte River flood flows and floodplain extents under Alternative 13a are similar to the Proposed Action.

South Platte River

South Platte River Stream Flow

Changes in South Platte River stream flow under Alternative 13a are similar to the Proposed Action with the following differences. Average, dry, and wet year annual flow changes along the South Platte River would differ by up to about 200 AF compared to the Proposed Action at all locations of interest except below the Metro WWTP. Differences in

average monthly flow between Alternative 13a and the Proposed Action are less than 2 cfs above the Metro WWTP.

For the reach downstream of the Metro WWTP, flows under Alternative 13a were compared to Full Use of the Existing System since the Proposed Action does not include transferred agricultural water rights, which affects flows in this reach. As compared to Full Use of the Existing System, flows at the Henderson gage would increase on average in all months except May and June. As shown in Tables H-7.4 through H-7.6, compared with the Full Use of the Existing System scenario, average, dry, and wet year average annual flows at the Henderson gage would increase by 5,700 AF or 2%, 4,700 AF or 4%, and 9,300 AF or 1%, respectively. Monthly average flow changes would range from a decrease of 7.6 cfs or 1% in May to an increase of 21.5 cfs or 9% in January. Monthly dry year flow increases would range up to 18.0 cfs or 10% in January. Monthly wet year flow changes would range from a decrease of 7.7 cfs or less than 1% in May to an increase of 33.4 cfs or 5% in April.

South Platte River Floodplain

Changes in South Platte River flood flows and floodplain extents under Alternative 13a are similar to the Proposed Action.

5.1.6 No Action Alternative

Under the No Action Alternative, Denver Water would continue to operate their existing system, with full utilization of the system projected to occur by the year 2022. At that time, the amount of available water supply is projected to equal the customer demand on the system, while maintaining a 30,000-AF Strategic Water Reserve (i.e., Safety Factor). While the action alternatives would meet an additional 18,000 AF/yr of demand beyond 2022, the No Action Alternative would have to rely on some combination of utilizing the Strategic Water Reserve and imposing more frequent mandatory restrictions to meet additional demands during drought sequences.

It is impossible to quantitatively predict when or to what degree Denver Water would negotiate a balance of depleting the Strategic Water Reserve versus imposing mandatory restrictions. To evaluate this scenario, first a quantitative analysis using PACSM output was made to evaluate depletions of the Strategic Water Reserve, and then a qualitative analysis was made of a combination of using both the Strategic Water Reserve and imposing mandatory restrictions.

5.1.6.1 Depletion of Strategic Water Reserve Strategy

To determine hydrologic changes to stream flow and reservoir operations as a result of the No Action Alternative, use of the Strategic Water Reserve Strategy was portrayed using the PACSM to provide the hydrology needed to compare the No Action Alternative with the action alternatives. In general, use of the Strategic Water Reserve creates greater hydrologic impacts than would occur if some level of restrictions were also imposed. The following sections describe in detail the hydrologic impacts of using the Strategic Water Reserve strategy.

As described below, the No Action Alternative (Depleting the Strategic Water Reserve, no restrictions) would result in the following:

- Shortages in meeting both treated and raw water customer demands
- Depletion of the Strategic Water Reserve in droughts
- Frequent drawdown of Gross Reservoir to the minimum pool level
- Increased overall system vulnerability, reduced water supply reliability, and reduced operational flexibility
- Reduced flexibility to react to droughts and emergencies

5.1.6.2 Reservoir Evaporation and Fluctuation

Under the No Action Alternative, Denver Water must rely on their Strategic Water Reserve to try to meet their demands during droughts. During the 45-year study period Denver Water would need to use their Strategic Reserve in 4 years. In those years, system wide storage (includes active capacity in Antero, Eleven Mile Canyon, Cheesman, Dillon, and Gross reservoirs) would be less than 120,000 AF and would be drawn down to a minimum of approximately 68,400 AF by the end of the critical period. These figures are based on not imposing mandatory restrictions during a drought. Denver Water's raw water and treated customers would also experience shortages. The maximum shortages to raw water and treated demands would occur during the critical period. Based on trying to meet an unconstrained demand, Denver Water's raw water customers would be short by approximately 9,600 AF and treated water demands would be short by approximately 600 AF during the critical period.

The hydrologic changes described in the following sections are based on a comparison of the Full Use of the Existing System scenario and the No Action Alternative.

Williams Fork Reservoir

Williams Fork Reservoir contents would be relatively unaffected by the increased demand under the No Action Alternative. Average differences in end-of-month content would range up to 300 AF, which translates to change in water elevation of less than 1 foot in any month. Average annual Gumlick Tunnel diversions under the No Action Alternative would increase by 400 AF compared to Full Use of the Existing System, which decreases inflow to the reservoir by that amount. Gumlick Tunnel diversions would be higher in average or wet years when water can be diverted either directly to demand or stored in Gross Reservoir. At a higher demand level under the No Action Alternative, there would be more space available in Gross Reservoir at times for additional diversions from the Moffat Collection System. On average, March and April would be the most affected months, when contents would be approximately 300 AF less on average. In all other months the differences in content are slightly positive or slightly negative (<0.5%).

In dry years, there would be little change in Williams Fork Reservoir's contents under the No Action Alternative compared to Full Use of the Existing System. In wet years, Williams Fork Reservoir's contents under the No Action Alternative would be lower by 1,300 to 1,800 AF (2% to 3%) on average from October through May. There would be

almost no difference in reservoir content from June through September of wet years, because Williams Fork Reservoir would fill and stay fairly full. Differences in contents are attributable to various conditions in the years preceding the five designated wet years and are highly influenced by a single year, which may not be generally representative of wet year conditions.

The largest change in average monthly end-of-month contents under the No Action Alternative would be a 300 AF or 1% decrease in average years and a 1,800 AF or 3% decrease in wet years (Table H-2.1). There would be little change (less than 1%) in a dry year. The maximum monthly average end-of-month water elevation change would be a decrease of 1 foot in average years and a decrease of 2 feet in wet years (Table H-2.2). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the No Action Alternative is 9 and 22 feet, respectively. The average annual evaporative loss would be 3,353 AF compared to 3,355 AF under Full Use of the Existing System, as shown in Table H-8.1.

Dillon Reservoir

Reductions in Dillon Reservoir contents under the No Action Alternative would almost always be greater than the reductions associated with all other alternatives, for all months and for average, dry, and wet conditions. This is because without additional storage on-line, Denver Water would rely heavily on their Blue River supplies and Strategic Water Reserve to meet a higher demand, particularly during droughts.

Under the No Action Alternative, Roberts Tunnel diversions would be 10,300 AF/yr higher on average. From January through June and October through December, monthly average diversions would be about 300 to 900 AF higher than Full Use of the Existing System. In July, August, and September, the additional diversions would be between 1,600 and 1,900 AF per month on average. Accordingly, at the beginning of runoff (end of April) Dillon Reservoir contents would be 12,700 AF (7%) less on average. During May and June, Dillon Reservoir would spill less on average, because it enters high runoff months with more space, and would come to within 7,200 AF (3%) of the Full Use of the Existing System content by the end of July. From September through April, Dillon Reservoir would decline more quickly under the No Action Alternative, until it reaches the April levels mentioned above. The largest average monthly difference in end-of-month contents would occur in April, when Dillon Reservoir content would be 12,700 AF or 7% less (Table H-2.4). The corresponding difference in end-of-month water elevation would be a decrease of 7 feet on average (Table H-2.5). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the No Action Alternative is 0 and 45 feet, respectively. The average annual evaporative loss would be 5,296 AF compared to 5,494 AF under Full Use of the Existing System, as shown in Table H-8.1.

In dry years, Dillon Reservoir contents are consistently lower than Full Use of the Existing System, and the differences are greater than average; they reach a maximum of 13,300 AF or 10% less in July. The corresponding difference in water elevation would be a decrease of 8 feet on average (Table H-2.5). During droughts, Dillon Reservoir would be used more

heavily than under Full Use of the Existing System and the action alternatives. During the critical period, Dillon reservoir would be drained to a minimum active content of 6,500 AF.

In wet years, Dillon Reservoir levels under the No Action Alternative would be more similar to Full Use of the Existing System scenario than they are on average. This is particularly true during and after the runoff, when the reservoir would generally be full or nearly full. The largest average monthly difference in end-of-month contents would occur in March, when Dillon Reservoir content would be 12,100 AF or 5% less (Table H-2.4). The corresponding difference in water elevation would be a decrease of 4 feet on average (Table H-2.5).

Wolford Mountain Reservoir

There would be very few and relatively small differences in operations at Wolford Mountain Reservoir in most months. Wolford Mountain Reservoir contents under the No Action Alternative would be slightly lower on average in every month. Differences would be up to 350 AF on average. The largest change in average monthly end-of-month contents under the No Action Alternative would be a less than 1% decrease in average, dry, and wet year years (Table H-2.7). The maximum monthly average end-of-month reservoir water elevation change would be a decrease of less than 1 foot in average, dry, and wet years (Table H-2.8). The average annual evaporative loss would be 2,568 AF compared to 2,574 AF under Full Use of the Existing System, as shown in Table H-8.1.

The biggest difference in contents and levels at Wolford Mountain Reservoir would occur in September due to differences in the amounts released for substitution. The decrease in content in September reflects additional substitution releases in years that are neither particularly wet nor dry. The average decrease in contents would be slightly greater for the No Action Alternative than for any other alternative because Denver Water would be more dependent on Dillon Reservoir under the No Action Alternative, in which case substitution releases from Wolford Mountain Reservoir would be higher.

Gross Reservoir

The No Action Alternative is the only alternative in which Gross Reservoir would have lower contents than the Full Use of the Existing System scenario because Gross Reservoir is enlarged in all other scenarios and has greater capacity. Gross Reservoir average end-of-month contents would be consistently lower in all months. Average monthly differences would be between 900 and 1,000 AF (2% to 3% lower) for June, July, August, and September. From November to February, the difference would hold steady at approximately 1,300 AF, because the South Boulder Diversion Canal would be shut down for winter. Average monthly differences in content would be greatest in March and April, when contents would be 1,800 AF lower.

In dry years, Gross Reservoir's contents would be 2,000 to 2,700 AF (7% to 11%) less on average from March through September. Fall and early winter differences would be more or less as described above for average years. Gross Reservoir would be drained to the minimum pool more frequently under the No Action Alternative than Full Use of the Existing System and the action alternatives. Gross Reservoir would be drained to the minimum pool in 12 years out of the 45-year study period versus only 4 years under Full Use of the Existing System.

In wet years, there would be little change in contents in summer months because the reservoir would be full or nearly full. Wet year average monthly differences in content would be greatest in March and April, when contents would be 2,300 AF (9%) lower.

The largest change in average monthly end-of-month contents under the No Action Alternative would be a 1,800 AF or 8% decrease in average years, a 2,700 AF or 11% decrease in dry years, and a 2,300 AF or 9% decrease in wet years (Table H-2.10). The maximum monthly average end-of-month water elevation change would be a decrease of 7 feet in an average year, a decrease of 9 feet in a dry year, and a decrease of 9 feet in a wet year (Table H-2.11). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the No Action Alternative is 3 feet and 28 feet, respectively. The average annual evaporative loss would be 463 AF compared to 477 AF under Full Use of the Existing System, as shown in Table H-8.1.

Antero Reservoir

Reductions in Antero Reservoir contents under the No Action Alternative would be greater than reductions associated with all other alternatives, for all months on average. This is because without additional storage on-line, Denver Water would rely more heavily on their South Platte River supplies and Strategic Water Reserve to meet a higher demand, particularly during droughts. Under the No Action Alternative, Antero Reservoir average monthly contents would be lower by up to 900 AF.

The largest change in average monthly end-of-month contents under the No Action Alternative would be a 900 AF or 5% decrease in average years and a 150 AF or 1% increase in dry years (Table H-2.13). There is little to no change in a wet year. The maximum monthly average end-of-month water elevation change would be a decrease of less than 1 foot in average and dry years (Table H-2.14). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the No Action Alternative is 0 feet and 15 feet, respectively. The average annual evaporative loss would be 3,545 AF compared to 3,625 AF under Full Use of the Existing System, as shown in Table H-8.1.

Eleven Mile Canyon Reservoir

Similar to Antero Reservoir, reductions in Eleven Mile Canyon Reservoir contents under the No Action Alternative would be greater than reductions associated with all other alternatives, for all months on average. This is because without additional storage on-line, Denver Water would rely more heavily on their South Platte River supplies and Strategic Water Reserve to meet a higher demand, particularly during droughts.

Eleven Mile Canyon Reservoir's average end-of-month contents are lower under the No Action Alternative by 1,600 to 2,000 AF for every month of the year. Like Antero Reservoir, Eleven Mile Canyon Reservoir is used for drought supply. Under the No Action Alternative, Eleven Mile Canyon Reservoir would be drafted earlier in dry periods because of Denver Water's higher demand. As a result, the average dry year contents for July, August, and September would be lower by up to 1,900 AF under the No Action Alternative. There would be little to no change in a wet year.

The largest change in average monthly end-of-month contents under the No Action Alternative would be a 2,000 AF or 2% decrease in average years and a 1,900 AF or 2% decrease in dry years (Table H-2.16). There would be little to no change in a wet year. The maximum monthly average end-of-month water elevation change would be a decrease of less than 1 foot in average and dry years (Table H-2.17). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the No Action Alternative is 0 feet and 8 feet, respectively. The average annual evaporative loss would be 5,753 AF compared to 5,838 AF under Full Use of the Existing System, as shown in Table H-8.1.

Cheesman Reservoir

Similar to Antero and Eleven Mile Canyon reservoirs, reductions in Cheesman Reservoir contents under the No Action Alternative are greater than reductions associated with all other alternatives, for all months on average. This is because without additional storage on-line, Denver Water would rely more heavily on their South Platte River supplies and Strategic Water Reserve to meet a higher demand, particularly during droughts.

Cheesman Reservoir's average end-of-month contents would be lower under the No Action Alternative by 1,600 to 2,000 AF (2% to 3%) every month of the year. Under the No Action Alternative, Cheesman Reservoir would be used more heavily because of Denver Water's higher demand. The average dry year contents for July, August, and September would be lower by up to 8,500 AF under the No Action Alternative. Cheesman Reservoir storage would be depleted more frequently under the No Action Alternative than Full Use of the Existing System and the action alternatives. There would be little change in a wet year.

The largest change in average monthly end-of-month contents under the No Action Alternative would be a 2,000 AF or 3% decrease in average years, an 8,500 AF or 17% decrease in dry years and a 300 AF or less than 1% increase in wet years (Table H-2.19). The maximum monthly average end-of-month water elevation change would be a decrease of 4 feet in average years, a decrease of 17 feet in dry years, and less than a 1 foot increase in wet years (Table H-2.20). The maximum increase and decrease in water elevation (averaged over the month) for any month over the 45-year study period between Full Use of the Existing System and the No Action Alternative is 5 feet and 59 feet, respectively. The average annual evaporative loss would be 1,053 AF compared to 1,074 AF under Full Use of the Existing System, as shown in Table H-8.1.

Strontia Springs Reservoir/Chatfield Reservoir

Reservoir evaporation, contents, and water elevation changes at Strontia Springs and Chatfield reservoirs under the No Action Alternative would be very similar to Full Use of the Existing System. At both reservoirs, average end-of-month contents would generally be about 100 AF less on average.

5.1.6.3 River Segments

The hydrologic changes described in the following sections are based on a comparison of Full Use of the Existing System and the No Action Alternative.

Fraser River

Changes in Fraser River flows under the No Action Alternative are directly related to the increase in Moffat Tunnel diversions which would occur under a higher demand. However, additional Moffat Tunnel diversions under the No Action Alternative would be considerably less than under the action alternatives. As shown in Tables H-7.4 and H-7.6, average annual Moffat Tunnel diversions would increase by 2,300 AF or 3% and 3,100 AF or 5% in wet years. Diversions would increase in 33 years out of the 45-year study period and additional diversions would range up to 6,800 AF/yr. Model results indicate there would be no additional diversions in dry years because bypass flows were not reduced in the PACSM under the No Action Alternative further than they were under Full Use of the Existing System. The hydrologic effects of imposing restrictions and reducing bypass flows further are addressed qualitatively in Section 5.1.6.4. The No Action Alternative portrayed in the PACSM includes use of the Strategic Water Reserve without imposing restrictions.

Bypass Flow Reductions

The modeled reductions in minimum bypass flows in the Fraser River Basin under the No Action Alternative are the same as under Full Use of the Existing System; therefore, there are no modeled flow reductions due to increased reductions in bypass flows. However, additional diversions under No Action would result in more days that flows would be reduced to minimum summer bypass requirements and tributaries without bypass requirements would be dried up for a longer duration. Differences compared to Full Use of the Existing System would be similar but slightly less than compared to Current Conditions.

As discussed under the qualitative assessment of the combination of using mandatory restrictions in addition to depleting the Strategic Water Reserve, Denver Water can be expected to reduce minimum bypass flows on eastern and western slope streams as demand increases beyond existing supplies and restrictions are imposed. As a result, stream flows would decrease due to decreased bypass flows beyond what is reflected in the PACSM.

Moffat Tunnel Diversions

Table H-3.1 summarizes average monthly diversions through the Moffat Tunnel for average, dry, and wet conditions. Additional diversions through Moffat Tunnel occur primarily in May, June, and July. There would be virtually no additional diversions from late summer through early spring except in infrequent, very wet years. The maximum monthly average increase in diversions would occur in June, with a 22.7 cfs or 7% increase. In wet years, the maximum monthly average increase in diversions would also occur in June, with a 19.4 cfs or 11% increase.

Fraser River Mainstem Stream Flow

Below Denver Water's mainstem Fraser River diversion, average annual flows would decrease by 360 AF or 7% and 490 AF or 5% in wet years. Monthly average flows would decrease by a maximum of 4.5 cfs or 12% in June (Table H-3.2). In wet years, monthly average flows would decrease by a maximum of 5.1 cfs or 6% in June. The Fraser River at Winter Park gage is located downstream of Denver Water's mainstem Fraser River diversion and their tributary diversions from Jim Creek, Cub Creek, Buck Creek, and

Cooper Creek. At the Fraser River at Winter Park gage, average annual flows would decrease by 500 AF or 7% and 800 AF or 5% in wet years. Monthly average flows would decrease by a maximum of 6.3 cfs or 12% in June (Table H-3.6). This coincides with the month when Moffat Tunnel diversions would increase most. In wet years, monthly average flows would decrease by a maximum of 9.1 cfs or 7% in June. Continuing downstream, the Fraser River would be affected by Denver Water's diversions from Vasquez, St. Louis, and Ranch creeks. Changes in flows are discussed below for tributaries Denver Water diverts from in upstream to downstream order. Below the confluence with Vasquez Creek, average annual flows would decrease by 1,000 AF or 6% and 1,400 AF or 4% in wet years. Monthly average flows would decrease by a maximum of 11.8 cfs or 10% in June (Table H-3.11). In wet years, monthly average flows would decrease by a maximum of 14.2 cfs or 5% in June.

Below the confluence with St. Louis Creek, average annual flows would decrease by 1,500 AF or 5% and 2,100 AF or 3% in wet years. Monthly average flows would decrease by a maximum of 16.4 cfs or 7% in June (Table H-3.17). In wet years, monthly average flows would decrease by a maximum of 17.6 cfs or 3% in June.

Below the confluence with Crooked Creek, which is located below all of Denver Water's Fraser River Basin diversions, average annual flows would decrease by 1,900 AF or 2% and 2,600 AF or 2% in wet years. Monthly average flows would decrease by a maximum of 20.0 cfs or 4% in June (Table H-3.22). In wet years, monthly average flows would decrease by a maximum of 20.1 cfs or 2% in June.

At the Fraser River at Granby gage, which is located close to the confluence with the Colorado River, average annual flows would decrease by 1,900 AF or 2% and 2,600 AF or 2% in wet years. Monthly average flows would decrease by a maximum of 20.0 cfs or 4% in June (Table H-3.23). In wet years, monthly average flows would decrease by a maximum of 20.1 cfs or 2% in June.

Jim Creek Stream Flow

Below Denver Water's Jim Creek diversion, average annual flows would decrease by 130 AF or 18% and 260 AF or 11% in wet years. Monthly average flows would decrease by a maximum of 1.5 cfs or 18% in June (Table H-3.3). In wet years, monthly average flows would decrease by a maximum of 3.2 cfs or 12% in June.

Cub and Buck Creeks Stream Flow

Below Denver Water's diversions from Cub and Buck creeks, average annual flows would decrease by 20 AF or 8% and 40 AF or 7% in wet years. Monthly average flows would decrease by a maximum of 0.3 cfs or 13% in June (Table H-3.4). In wet years, monthly average flows would decrease by a maximum of 0.6 cfs or 9% in June.

Cooper Creek Stream Flow

Below Denver Water's diversion from Cooper Creek, average annual flows would decrease by 10 AF or 9% and 10 AF or 13% in wet years. Monthly average flows would decrease by a maximum of 0.1 cfs or 16% in June (Table H-3.5). In wet years, monthly average flows would decrease by a maximum of 0.2 cfs or 20% in June.

Vasquez Creek and Tributaries Stream Flow

Denver Water's diversions from the Williams Fork River Basin are delivered into Vasquez Creek above the Moffat Collection System via the Gumlick and Vasquez tunnels. Below the outfall from the Vasquez Tunnel, annual flows would increase by 420 AF or 3% on average and 410 AF or 3% in wet years. Monthly average flows would increase by a maximum of 3.2 cfs or 4% in June (Table H-3.7). In wet years, monthly average flows would increase by a maximum of 2.6 cfs or 8% in August.

Below Denver Water's diversion from Vasquez Creek, average annual flows would decrease by 420 AF or 6% and 510 AF or 3% in wet years. Monthly average flows would decrease by a maximum of 4.6 cfs or 9% in June (Table H-3.8). In wet years, monthly average flows would decrease by a maximum of 3.9 cfs or 3% in June. Below Denver Water's diversion from Little Vasquez Creek, average annual flows would decrease by 70 AF or 13% and 80 AF or 11% in wet years. Monthly average flows would decrease by a maximum of 0.8 cfs or 14% in June (Table H-3.9). In wet years, monthly average flows would decrease by a maximum of 1.1 cfs or 11% in June. At the Vasquez Creek gage, average annual flows would decrease by 500 AF or 7% and 600 AF or 4% in wet years. Monthly average flows would decrease by a maximum of 5.5 cfs or 8% in June (Table H-3.10). In wet years, monthly average flows would decrease by a maximum of 5.1 cfs or 3% in June.

Elk Creek and Tributaries Stream Flow

Below Denver Water's diversions from Elk Creek, West and East elk creeks, and the East and West forks of Main Elk Creek, average annual flows would decrease by 50 AF or 6% and 50 AF or 3% in wet years. Monthly average flows would decrease by a maximum of 0.5 cfs or 7% in June (Table H-3.12). In wet years, monthly average flows would decrease by a maximum of 0.3 cfs or 2% in June.

St. Louis Creek and Tributaries Stream Flow

Below Denver Water's diversion from St. Louis Creek, average annual flows would decrease by 210 AF or 3% and 300 AF or 3% in wet years. Monthly average flows would decrease by a maximum of 1.8 cfs or 5% in June (Table H-3.13). In wet years, monthly average flows would decrease by a maximum of 1.9 cfs or 10% in August. Below Denver Water's diversion from tributaries to St. Louis Creek including West and East St. Louis creeks, Short Creek, Byers Creek, Iron Creek, and Fool Creek, average annual flows would decrease by 210 AF or 9% and 370 AF or 5% in wet years. Monthly average flows would decrease by a maximum of 2.2 cfs or 8% in June (Table H-3.14). In wet years, monthly average flows would decrease by a maximum of 1.8 cfs or 3% in June. Below Denver Water's diversion from King Creek, average annual flows would decrease by 10 AF or 9% and 20 AF or 5% in wet years. Monthly average flows would decrease by a maximum of 0.1 cfs or 9% in June (Table H-3.16). In wet years, monthly average flows would decrease by a maximum of 0.1 cfs or 4% in June. At the St. Louis Creek near Fraser gage, average annual flows would decrease by 400 AF or 3% and 700 AF or 2% in wet years. Monthly average flows would decrease by a maximum of 3.9 cfs or 4% in June (Table H-3.15). In wet years, monthly average flows would decrease by a maximum of 4.2 cfs or 10% in August.

Ranch Creek and Tributaries

Downstream of Denver Water's Englewood Ranch Gravity System, which includes diversions from North and South Trail Creek, Hurd Creek, Hamilton Creek, Cabin Creek, and Little Cabin Creek, average annual flows would decrease by 80 AF or 1% and 90 AF or 1% in wet years. Monthly average flows would decrease by a maximum of 0.5 cfs or 1% in June and 3% in July (Table H-3.18). In wet years, monthly average flows would decrease by a maximum of 0.5 cfs or 1% in July and 6% in August. Below Denver Water's North Fork Ranch Creek and Dribble Creek diversions, average annual flows would decrease by 60 AF or 5% and 70 AF or 2% in wet years. Monthly average flows would decrease by a maximum of 0.5 cfs or 3% in June (Table H-3.19). In wet years, monthly average flows would decrease by a maximum of 0.5 cfs or 3% in July. Below Denver Water's Main Ranch Creek diversion, average annual flows would decrease by 80 AF or 3% and 60 AF or 1% in wet years. Monthly average flows would decrease by a maximum of 0.7 cfs or 3% in June (Table H-3.20). In wet years, monthly average flows would decrease by a maximum of 0.6 cfs or 3% in July. Downstream of Denver Water's Middle and South Fork of Ranch Creek diversions, average annual flows would decrease by 160 AF or 7% and 170 AF or 3% in wet years. Monthly average flows would decrease by a maximum of 1.4 cfs or 6% in June (Table H-3.21). In wet years, monthly average flows would decrease by a maximum of 1.1 cfs or 5% in July.

Fraser River Daily Flow Changes

As shown by the flow duration curves (Figures H-5.1 through H-5.11), flow reductions resulting from the No Action Alternative would occur at higher flow rates, which typically correspond with wet years. The percentage of days from May through July that flow decreases would occur is less than under the action alternatives. About 90% of the time there would be little to no change in flow (Table H-6.10) at most locations in the Fraser River Basin except for the mainstem below the confluence with St. Louis Creek. Below the confluence with St. Louis Creek and at the Granby gage there would be little to no change in flow about 79% and 76% of the time, respectively. As shown in Table H-6.20, the maximum daily flow reduction at the locations of interest in the Fraser River Basin would be less under the No Action Alternative compared to the action alternatives, particularly in July. In May, June, and July, the maximum daily flow reduction at the Fraser River at Granby gage would be 597 cfs, 686 cfs, and 196 cfs, respectively, compared to 710 cfs, 729 cfs, and 713 cfs, respectively, under the action alternatives.

Fraser River Floodplain

The annual flood flows for the No Action Alternative would be very similar to Full Use of the Existing System. Throughout the basin, and throughout the range of estimated recurrence intervals, there would be no increase in annual peak flood flows. Relative to the action alternatives, the reductions to the annual peak flows are fewer and smaller in magnitude and generally occur in average years as opposed to wet years.

Williams Fork River

Gumlick Tunnel Diversions

Changes in Williams Fork River flows under the No Action Alternative are directly related to the increase in Gumlick Tunnel diversions which would occur under a higher demand. Additional Gumlick Tunnel diversions under the No Action Alternative would be less than under the action alternatives. As shown in Tables H-7.4 and H-7.6, average annual Gumlick Tunnel diversions would increase by 400 AF or 4% and 400 AF or 6% in wet years. Diversions would increase in 32 years out of the 45-year study period and additional diversions would range up to 1,500 AF/yr. There would be no additional diversions in dry years.

Table H-3.24 summarizes average monthly diversions through the Gumlick Tunnel for average, dry, and wet conditions. Additional diversions would occur primarily in May, June, and July. There would be virtually no additional diversions from late summer through early spring except in infrequent, very wet years. The maximum monthly average increase in diversions would occur in June, with a 3.2 cfs or 7% increase. In wet years, the maximum monthly average increase in diversions would occur in August, with a 2.6 cfs or 15% increase on average.

Williams Fork River Mainstem and Tributaries Stream Flow

Denver Water diverts water for delivery through the Gumlick Tunnel from four headwater tributaries including Steelman Creek, Bobtail Creek, Jones Creek, and McQueary Creek. Below Denver Water's Steelman Creek diversion, average annual flows would decrease by 100 AF or 6% and 90 AF or 2% in wet years. At this location, monthly average flows would decrease by a maximum of 0.8 cfs or 4% in June (Table H-3.25). In wet years, monthly average flows would decrease by a maximum of 0.5 cfs or 2% in July and 12% in August. Below Denver Water's Bobtail Creek diversion, average annual flows would decrease by 180 AF or 6% and 220 AF or 3% in wet years. At this location, monthly average flows would decrease by a maximum of 1.4 cfs or 4% in June (Table H-3.26). In wet years, monthly average flows would decrease by a maximum of 1.5 cfs or 18% in August. Below Denver Water's Jones Creek diversion, average annual flows would decrease by 60 AF or 5% and 50 AF or 2% in wet years. At this location, monthly average flows would decrease by a maximum of 0.4 cfs or 4% in June (Table H-3.27). In wet years, monthly average flows would decrease by a maximum of 0.3 cfs or 12% in August. Below Denver Water's McQueary Creek diversion, average annual flows would decrease by 70 AF or 6% and 60 AF or 2% in wet years. At this location, monthly average flows would decrease by a maximum of 0.6 cfs or 4% in June (Table H-3.28). In wet years, monthly average flows would decrease by a maximum of 0.4 cfs or 15% in August.

Average annual flows at the Williams Fork River below Steelman Creek gage, which is located below Denver Water's diversions from the Williams Fork Basin, would decrease by 400 AF or 5% and 400 AF or 2% in wet years. Monthly average flows would decrease by a maximum of 3.2 cfs or 4% in June (Table H-3.29). In wet years, monthly average flows would decrease by a maximum of 2.6 cfs or 14% in August. Moving downstream, the volume and rate of change stays the same but the percentage reduction in flow is less because the stream is growing.

Flows below Williams Fork Reservoir reflect differences in Gumlick Tunnel diversions and reservoir operations, including spills, substitution, or exchange, and power releases to achieve operational goals. Differences in releases from Williams Fork Reservoir would generally follow the same pattern as the alternatives. As shown in Tables H-7.4 through H-7.6, average annual outflow from Williams Fork Reservoir would decrease by 200 AF or less than 1%, 1,100 AF or 1% in wet years, and there would be minimal change in dry year outflow. Table H-3.30 summarizes average monthly outflow from Williams Fork Reservoir for average, dry, and wet conditions. Monthly average changes in outflow would range from a maximum decrease of 10.5 cfs or 7% in June to a maximum increase of 5.3 cfs or 6% in March (Table H-3.30). In wet years, monthly average changes in outflow would range from a maximum decrease of 30.7 cfs or 6% in June to a maximum increase of 9.4 cfs or 7% in October. There would be little change in outflow in dry years.

Williams Fork River Daily Flow Changes

As shown by the flow duration curves (Figures H-5.12 through H-5.14), flow reductions resulting from the No Action Alternative would occur at higher flow rates, which typically correspond with wet years. The percentage of days from May through July that flow decreases would occur is less than under the action alternatives. About 90 to 97% of the time there would be little to no change in flow (Table H-6.11). As shown in Table H-6.20, the maximum daily flow reductions at the upper basin locations would be slightly less than the Proposed Action and the same as the Proposed Action below Williams Fork Reservoir. For example, the maximum daily flow reduction below Denver Water's diversion from Steelman Creek would be 42 cfs under the No Action Alternative compared with 51 cfs under the action alternatives.

Williams Fork River Floodplain

Annual peak flows under the No Action Alternative would be very similar to those under Full Use of the Existing System. Floodplain extents for floods of any specified recurrence interval would therefore be very similar.

Colorado River

Colorado River Stream Flow

Changes in Colorado River flows below Windy Gap under the No Action Alternative would be due primarily to Denver Water's additional diversions from the Fraser River Basin in years that are average or wet, and in particular, in wet years following dry year sequences. Changes in stream flows described above for the Fraser and Williams Fork river basins would be translated downstream and into the Colorado River, but the reductions in flow would be smaller relative to the total stream, which is growing.

As shown in Tables H-7.4 and H-7.6, average annual flows below Windy Gap would decrease by 1,800 AF or 1% and 5,100 AF or 1% in wet years. Average annual flows below the confluence with Williams Fork River would decrease by 2,000 AF or 1% and 6,200 AF or 1% in wet years. Average annual flows at the gage near Kremmling would decrease by 12,100 AF or 2% and 22,100 AF or 2% in wet years. At these locations, there would be no decrease in flows in dry years.

Tables H-3.31 through H-3.33 summarize average monthly flow changes in the Colorado River below Windy Gap, below the confluence with Williams Fork River and near Kremmling for average, dry, and wet conditions. At these locations, flow reductions would occur in average and wet years and are highly concentrated during the runoff months in May, June, and July when the majority of Denver Water's additional diversions would occur. There would be virtually no flow reductions from late summer through early spring except in infrequent, very wet years. Below Windy Gap, monthly average flows would decrease by a maximum of 19.1 cfs or 3% in June (Table H-3.31). In wet years, monthly average flows would decrease by a maximum of 48.9 cfs or 2% in June.

Moving downstream, the Colorado River is affected by tributary inflows from the Williams Fork River, Troublesome Creek, Muddy Creek, and the Blue River, and Denver Water's diversions and operations in those basins. The volume of change rises in the downstream direction, but the reductions in flow are smaller relative to the total stream, which is growing. Below the confluence with Williams Fork River, monthly average flows would decrease by a maximum of 29.5 cfs or 4% in June (Table H-3.32). In wet years, monthly average flows would decrease by a maximum of 79.5 cfs or 3% in June. Near Kremmling, monthly average flows would decrease by a maximum of 101.5 cfs or 5% in June (Table H-3.33). In wet years, monthly average flows would decrease by a maximum of 273.3 cfs or 4% in June. Again, there would be no decrease in flows in dry years.

Colorado River Daily Flow Changes

As shown by the flow duration curves (Figures H-5.15 through H-5.17), flow reductions resulting from the No Action Alternative would occur at higher flow rates, which typically correspond with wet years. About 85 to 95% of the time there would be little to no flow change or a decrease up to 100 cfs would occur along the Colorado River (Table H-6.12). As shown in Table H-6.20, the maximum daily flow reductions along the Colorado River would be considerably less than the action alternatives below Windy Gap and the confluence with the Williams Fork River but similar to the action alternatives near the Kremmling gage. The maximum daily flow reduction below Windy Gap would be 1,893 cfs in June under the No Action Alternative compared to 3,046 cfs under the Proposed Action.

Colorado River Floodplain

Annual flood flows for the Colorado River below Hot Sulphur Springs would be the same or lower under the No Action Alternative than under Full Use of the Existing System, for all years. Reductions in annual peak flows would be minor, and mainly for low recurrence interval flood events.

Annual flood flows for the Colorado River below Kremmling would be the same or lower under the No Action Alternative than under the Full Use of the Existing System scenario, for all years. Reductions in annual peak flows would be minor, and mainly for recurrence intervals between 2 and 5 years.

Muddy Creek

Muddy Creek Stream Flow

Changes along Muddy Creek and at Wolford Mountain Reservoir under the No Action Alternative would be minimal. Monthly differences in outflow rarely exceed several hundred acre-feet in any given month. As shown in Tables H-7.4 through H-7.6, average annual outflow from Wolford Mountain Reservoir would increase by 100 AF or less than 1%, while dry year and wet year average annual outflow from Wolford Mountain Reservoir would not change. Table H-3.34 summarizes average monthly outflow from Wolford Mountain Reservoir for average, dry, and wet conditions. Monthly changes in outflow would range from a maximum decrease of 1.4 cfs or 3% in January to a maximum increase of 3.3 cfs or 5% in September. Monthly changes in dry year and wet year average outflow would be 1 cfs or less.

Muddy Creek Daily Flow Changes

As shown by the flow duration curve (Figure H-5.18), flow reductions resulting from the No Action Alternative would occur at higher flow rates, which typically correspond with wet years. The percentage of days that flow decreases would occur compared to Full Use of the Existing System is very similar to the action alternatives (Table H-6.13). As shown in Table H-6.20, the maximum daily flow reduction below Wolford Mountain Reservoir is the same as the Proposed Action.

Muddy Creek Floodplain

Changes in flood flows and floodplain extents are not anticipated since changes in the quantity and timing of flows under the No Action Alternative would be infrequent and minor.

Blue River

Blue River Stream Flow

Changes in Blue River flows under the No Action Alternative would be due primarily to Denver Water's additional diversions through Roberts Tunnel. Roberts Tunnel diversions would increase substantially under the No Action Alternative compared to Full Use of the Existing System and the EIS alternatives because Denver Water would rely heavily on their Blue River supplies and Strategic Water Reserve to meet a higher demand, particularly during droughts. Unlike the action alternatives, monthly diversions would increase on average during the winter months because the Moffat WTP would be shut down during those months. Foothills and Marston WTPs would need to meet the entire demand through the winter, resulting in higher deliveries through Roberts Tunnel during those months.

As shown in Tables H-7.4 through H-7.6, average annual Roberts Tunnel diversions would increase by 10,300 AF or 11%, which is approximately double the increase under the action alternatives; dry year average annual diversions would increase by 4,900 AF or 3%; and wet year average annual Roberts Tunnel diversions would increase by 9,500 AF or 16%. Table H-3.35 summarizes average monthly diversions through the Roberts Tunnel for average, dry, and wet conditions. Diversions through Roberts Tunnel would increase on average in all months. Monthly average diversions would increase by a maximum of

30.3 cfs or 12% in August. Monthly changes in dry year average diversions would range from a maximum decrease of 22.9 cfs or 9% in September to a maximum increase of 20.6 cfs or 8% in October. Monthly wet year diversions would increase by a maximum of 24.5 cfs or 9% in September.

Flows below Dillon Reservoir primarily reflect differences in Roberts Tunnel diversions and spills. In dry years, there would be minimal change in flows below Dillon Reservoir under the No Action Alternative, because Denver Water would store all it could and bypass only what it must throughout the storage season. In average and wet years, flows below Dillon Reservoir would generally be lower primarily from May through August. Table H-3.36 summarizes average monthly outflow from Dillon Reservoir for average, dry, and wet conditions. Average annual outflow from the reservoir would decrease by 10,200 AF or 11% and 15,900 AF or 7% in wet years. Monthly average outflow would decrease by a maximum of 86.6 cfs or 15% in June. In wet years, monthly average outflow would decrease by a maximum of 108.4 cfs or 8% in June.

Changes in Blue River flows below Green Mountain Reservoir are roughly of the same magnitude as differences in outflow from Dillon Reservoir. Table H-3.37 summarizes average monthly outflow from Green Mountain Reservoir for average, dry, and wet conditions. Average annual outflow from the reservoir would decrease by 10,200 AF or 4% and 15,900 AF or 4% in wet years. Monthly average outflow would decrease by a maximum of 71.4 cfs or 11% in June. In wet years, monthly average outflow would decrease by a maximum of 193.1 cfs or 9% in June.

Blue River Daily Flow Changes

As shown by the flow duration curves (Figures H-5.19 and H-5.20), flow reductions resulting from the No Action Alternative would typically occur at higher flow rates. About 80 to 85% of the time there would be little to no flow change or a decrease up to 100 cfs would occur (Table H-6.14). The maximum daily flow reductions along the Blue River under the No Action Alternative would generally be similar to the action alternatives with differences due mainly to slight changes in the timing of reservoir releases. As shown in Table H-6.20, the maximum daily flow reductions along the Blue River under the No Action Alternative would be slightly higher than under the action alternatives. For example, the maximum daily flow reduction below Dillon Reservoir would be 1,774 cfs under the No Action Alternative and 1,692 cfs under the Proposed Action.

Blue River Floodplain

Under the No Action Alternative, annual peak flows below Dillon and Green Mountain reservoirs would be less than or equal to annual peak flows under Full Use of the Existing System, for a given recurrence interval. Accordingly, floodplain extents would be the same as or slightly smaller under the No Action Alternative, compared with Full Use of the Existing System.

South Boulder Creek

South Boulder Creek Stream Flow

In the uppermost reach above Gross Reservoir, changes in flow are equivalent to changes in Moffat Tunnel deliveries. As shown in Tables H-7.4 and H-7.6, average annual flows at the Pinecliffe gage would increase by 2,300 AF or 2% and 4,800 AF or 4% in wet years. There would be no change in dry year flows, as shown in Table H-7.5. Note, that the combination of 5 years that were averaged to determine a wet and dry year average are different for the Moffat Tunnel versus South Boulder Creek because diversions into the Moffat Tunnel occur on the West Slope, whereas South Boulder Creek is located on the East Slope. Refer to Section 4.6.1 for a discussion of West Slope versus East Slope dry and wet year averages. As a result, the changes in wet and dry year annual averages are not comparable for the Moffat Tunnel and Pinecliffe gage. Table H-3.38 summarizes average monthly flows at the Pinecliffe gage for average, dry, and wet conditions. Flow increases would occur primarily in May, June, and July, which corresponds with the months when additional diversions through Moffat Tunnel would be greatest. There would be virtually no flow increases from late summer through early spring except in infrequent, very wet years. There would be no increase in flows in dry years. Monthly average flows would increase by a maximum of 22.7 cfs or 4% in June. Monthly wet year average flows would increase by a maximum of 40.6 cfs or 9% in June.

From Gross Reservoir to the South Boulder Diversion Canal, changes in flow reflect Gross Reservoir operations. Unlike the action alternatives, the Moffat WTP would be shut down from mid-October to April or May depending on the year and the South Boulder Diversion Canal would be shut down from mid-December through mid-March. As a result, Gross Reservoir outflow would not change in January and February. During those months, Foothills and Marston WTPs would need to meet the entire demand. However, flows would be consistently higher from March through December as more water is released to meet additional demand. As shown in Tables H-7.4 through H-7.6, average, dry, and wet year annual outflow from Gross Reservoir would increase by 2,300 AF or 2%, 1,400 AF or 2%, and 4,200 AF or 4%, respectively. Increases in average annual releases are approximately 7,000 AF less compared with the action alternatives. Table H-3.39 summarizes average monthly outflow from Gross Reservoir for average, dry, and wet conditions. Monthly average outflow would increase by a maximum of 12.3 cfs or 3% in June. Monthly dry year outflow would increase by a maximum of 10.9 cfs or 9% in March. Monthly wet year outflow would increase by a maximum of 15.1 cfs or 4% in June.

Below the South Boulder Diversion Canal, flows would generally decrease on average under the No Action Alternative because Denver Water would divert slightly more native South Boulder Creek water, either to storage at Gross Reservoir or under their direct diversion right at the South Boulder Diversion Canal. As shown in Tables H-7.4 and H-7.6, average and wet year annual flows at the Eldorado Springs gage would decrease by 200 AF and 700 AF, respectively, which is approximately 1%.

South Boulder Creek Daily Flow Changes

As shown by the flow duration curves (Figures H-5.21 through H-5.23), flow increases above Gross Reservoir resulting from the No Action Alternative would occur primarily at

higher flow rates. The flow duration curve for Gross Reservoir outflow shows flow increases would be relatively small and occur primarily during the summer at higher flow rates. The flow duration curve at the Eldorado Springs gage shows flow decreases would occur primarily at higher flow rates. About 97 and 96% of the time there would be less than 100 cfs flow change from May through July at the Pinecliffe and Eldorado Springs gages, respectively. Below Gross Reservoir, there would be little to no change in flow, or flow increases or decreases up to 100 cfs about 98% of the time (Table H-6.15). As shown in Table H-6.20, maximum daily flow reductions along South Boulder Creek would be slightly more under the No Action Alternative than the action alternatives. Daily flow reductions would be greatest below Gross Reservoir and would range up to 492 cfs under the No Action Alternative versus 489 under the Proposed Action. Maximum daily flow increases would generally be similar to the action alternatives except below Gross Reservoir. Daily flow increases below Gross Reservoir would range up to 446 cfs, which is about 150 cfs higher than under the action alternatives.

South Boulder Creek Floodplain

Upstream of Gross Reservoir, the only differences in annual flood flows for the No Action Alternative would be small increases for flood events with recurrence intervals less than 2 years. These flood events are well below channel capacity. Below Gross Reservoir, the only differences in annual flood floods under the No Action Alternative would be small increases (5% or less) for flood events with recurrence intervals less than 2.5 years.

North Fork South Platte River

North Fork South Platte River Stream Flow

The changes in flow in the North Fork South Platte River are equivalent to changes in Roberts Tunnel deliveries. Under the No Action Alternative, monthly average diversions through the Roberts Tunnel from January through June and October through December would be about 300 to 900 AF higher, and approximately 1,600 to 1,900 AF higher from July through September. Unlike the action alternatives, monthly flows would increase on average during the winter months because the Moffat WTP would be shut down during those months. Foothills and Marston WTPs would need to meet the entire demand through the winter, resulting in higher deliveries through Roberts Tunnel during those months. Flow changes at the Geneva Creek gage are slightly less than changes in diversions at the Roberts Tunnel due to transit losses. The State Engineer's Office assesses a 5% transit loss on Denver Water's Roberts Tunnel deliveries to the North Fork South Platte River. The transit loss is intended to offset channel losses and evaporation losses from any additional water surface area that is caused by the delivery of water along the North Fork South Platte River from the outfall of the Roberts Tunnel to the Denver Water Intake/Conduit 20. Moving downstream, the volume of the change along the North Fork South Platte River stays the same, however, the percentage change in flow is smaller relative to the total stream, which is growing.

As shown in Tables H-7.4 through H-7.6, average, dry year, and wet year annual flows at the Geneva Creek gage would increase by 9,900 AF or 7%, 5,600 AF or 3%, and 7,700 AF or 7%, respectively. The average annual increase in flows is about two times the increase that would occur under the action alternatives. Note, that the combination of 5 years that

were averaged to determine a wet and dry year average are different for the Roberts Tunnel versus the North Fork South Platte River because diversions at the Roberts Tunnel occur on the West Slope, whereas the North Fork South Platte River is located on the East Slope. Refer to Section 4.6.1 for a discussion of West Slope versus East Slope dry and wet year averages. Table H-3.41 summarizes average monthly flows in the North Fork South Platte River below Geneva Creek gage for average, dry, and wet conditions. Monthly average flows would increase by a maximum of 29.5 cfs or 9% in August. Monthly dry year average flow changes would range from a maximum decrease of 21.1 cfs or 6% in September to a maximum increase of 21.6 cfs or 8% in October. Monthly wet year average flows would increase by a maximum of 24.3 cfs or 9% in September.

North Fork South Platte River Daily Flow Changes

As shown by the flow duration curve for the North Fork South Platte River below Geneva Creek gage (Figure H-5.24), flows consistently increase at all levels and particularly at higher flow rates, which generally correspond with summer months. About 97% of the time there would be little to no flow change, or a flow increase or decrease up to 100 cfs would occur (Table H-6.16). As shown in Table H-6.20, the maximum daily flow reduction at the Geneva Creek gage and above Pine would be less under the No Action Alternative than the Proposed Action. At the Geneva Creek gage the maximum flow reduction would be 273 cfs, which is similar to Alternatives 8a, 10a, and 13a, but about 200 cfs less than the Proposed Action and Alternative 1c. The maximum daily flow increases would be similar to the action alternatives.

North Fork South Platte River Floodplain

Changes in flood flows and floodplain extents under the No Action Alternative would be similar to the Proposed Action.

South Platte River

South Platte River Stream Flow

For the purpose of analyzing changes in surface water hydrology along the South Platte River under the No Action Alternative, modeled diversions and stream flows were analyzed below Antero, Eleven Mile Canyon, Cheesman, and Chatfield reservoirs, and at the South Platte River at three USGS gages – Waterton, Denver, and Henderson.

Antero Reservoir to Cheesman Reservoir

In the upper South Platte River, above the confluence with the North Fork South Platte River, changes in South Platte River flows under the No Action Alternative would be due primarily to Denver Water's additional diversions and reservoir releases. Reservoir releases would increase substantially under the No Action Alternative in dry years compared to Full Use of the Existing System and the action alternatives because Denver Water would rely more heavily on their South Platte River supplies and Strategic Water Reserve to meet a higher demand during droughts. In addition, the Moffat WTP is shut down during the winter months unlike the action alternatives; therefore, Foothills and Marston WTPs would need to meet Denver Water's entire demand though the winter, resulting in higher reservoir releases during the winter months.

As shown in Tables H-7.4 through H-7.6, average, wet, and dry year average annual outflow from Antero Reservoir changes less than 100 AF. There would still be relatively little change in Antero Reservoir releases under the No Action Alternative because of the infrequency that Denver Water uses Antero Reservoir. Releases are typically only made in the later stages of a drought. Average and wet year average annual outflow from Eleven Mile Canyon and Cheesman reservoirs increases by less than 400 AF or less than 1%. Dry year average annual outflow at Eleven Mile Canyon and Cheesman reservoirs increases by 2,100 AF or 2%, and 10,000 AF or 7%, respectively. Average annual releases from Cheesman Reservoir are approximately 7,300 AF more in dry years than under the EIS alternatives. Tables H-3.42 through H-3.44 summarize average monthly outflow from Antero, Eleven Mile Canyon, and Cheesman reservoirs for average, dry, and wet conditions. Monthly average, wet, and dry year average flow changes below Antero Reservoir would be relatively small and range up to about 3 cfs. Monthly average and wet year average flow changes below Eleven Mile Canyon Reservoir would also be relatively small (up to 4 cfs), however, monthly changes in dry year average outflow would range from a maximum decrease of 5.9 cfs or 4% in May to a maximum increase of 19.8 cfs or 10% in August. Monthly changes in average outflow from Cheesman Reservoir would range from a maximum decrease of 4.0 cfs or 1% in August to a maximum increase of 4.7 cfs or 1% in May. Monthly changes in dry year average outflow would range from a maximum decrease of 1.9 cfs or 1% in October to a maximum increase of 42.1 cfs or 14% in August. Monthly changes in wet year average outflow would range from a maximum decrease of 4.0 cfs or 3% in December to a maximum increase of 3.0 cfs or 2% in March.

Cheesman Reservoir to South Platte River at Waterton Gage

Denver Water's direct diversions and exchanges to Strontia Springs Reservoir and Conduit 20 would change under the No Action Alternative primarily in response to a higher demand. As a result, South Platte River flows at the Waterton gage would decrease on average in the summer months. There would be little change in flows at Waterton gage in most winter months from October through March; however, flow decreases would occasionally occur from October through December and March.

In the summer, Foothills and Marston WTPs would operate at higher rates under the No Action Alternative because of the overall higher level of demand. Therefore, Denver Water's direct diversions at Strontia Springs Reservoir and Conduit 20 would increase in response to higher demand in summer months. The greatest increases in direct diversions would typically occur in the months of May through August. In addition, exchanges to Conduit 20 would also increase in the summer months for similar reasons. Because summer diversions through Roberts Tunnel would generally be higher under the No Action Alternative, more reusable effluent at Metro WWTP and Bi-City WWTP would be available for exchange. The increase in available reusable effluent combined with the increased operation of Foothills and Marston WTPs in the summer, would result in increased exchanges to Conduit 20 on average. The majority of additional exchanges would occur from April through September.

As shown in Tables H-7.4 through H-7.6, average, dry year, and wet year average annual flows at the Waterton gage would decrease by 3,800 AF or 4%, 300 AF or 1%, and 5,100 AF or 2%, respectively. Table H-3.45 summarizes average monthly flows at the

South Platte River at Waterton gage for average, dry, and wet conditions. Monthly average flows would decrease by a maximum of 20.5 cfs or 4% in June. Monthly dry year average flows would decrease by a maximum of 3.6 cfs or 10% in November. Monthly wet year average flows would decrease by a maximum of 26.7 cfs or 7% in August.

South Platte River at Waterton Gage to South Platte River at Denver Gage

In the reach along the South Platte River between the Waterton and Denver gages, flows increase on average, as compared to Full Use of the Existing System, due primarily to additional effluent returns at Bi-City WWTP and return flows accruing to the river due to Denver Water's outdoor water usage. Under the No Action Alternative, the average annual decrease in flow in the South Platte River at Waterton gage is approximately 3,800 AF while the average annual decrease in flow at the South Platte at Denver gage is approximately 3,300 AF. Therefore, the average annual difference in flows between the Waterton and Denver gages decreases by about 500 AF compared with about 1,800 AF under the action alternatives.

As shown in Tables H-7.4 through H-7.6, average annual flows below Chatfield Reservoir would decrease by 4,200 AF or 4% on average, 1,400 AF or 7% in dry years, and 5,000 AF or 1% in wet years. Table H-3.46 summarizes average monthly flows below Chatfield Reservoir for average, dry, and wet conditions. Average monthly flows below Chatfield Reservoir would decrease in all months. Monthly average flows would decrease by a maximum of 15.6 cfs or 3% in June. Monthly dry year average flows would decrease by a maximum of 7.8 cfs or 22% in June. Monthly wet year average flows would decrease by a maximum of 26.5 cfs or 6% in August.

Monthly flows at the Denver gage would decrease on average in all months except January and February. In general, flows would decrease due to the increased demand and additional direct diversions and exchanges up to Strontia Springs Reservoir and Conduit 20. The changes in flows from May through September would be variable. On average flows would decrease, however, monthly flow increases would range up to about 2,800 AF and decreases would range up to about 14,700 AF. The majority of the additional direct diversions and exchanges would occur from April through September. There would also be differences associated with changes in the amount and timing of water moved between Strontia Springs, Chatfield, and Marston reservoirs.

As shown in Tables H-7.4 through H-7.6, average, dry year, and wet year annual flows at the Denver gage would decrease by 3,300 AF or 1%, 400 AF or less than 1%, and 3,600 AF or 1%, respectively. Table H-3.47 summarizes average monthly flows at South Platte River at Denver gage for average, dry, and wet conditions. Monthly average flows would decrease by a maximum of 13.9 cfs or 2% in June. Dry year monthly average flows would decrease by a maximum of 5.8 cfs or 3% in June. Wet year monthly average flows would decrease by a maximum of 19.0 cfs or 3% in August. Monthly average, wet, and dry year average flow increases would be less than 3 cfs or 2%.

South Platte River at Denver Gage to South Platte River at Henderson Gage

In the reach along the South Platte River between the Denver and Henderson gages, flows increase on average, as compared to Full Use of the Existing System, due primarily to additional effluent returns at Metro WWTP and return flows accruing to the river due to

outdoor water usage. As shown in Table H-7.4, the average annual flow at the Henderson gage increases by about 1,900 AF/yr. The average annual difference in flows between the Denver and Henderson gages increases by about 5,200 AF/yr.

Flows at the Henderson gage would increase on average in all months except May and June. In general, flows increase in the winter months in this reach because there are additional indoor and outdoor return flows attributable to Denver Water's increased demands and additional direct diversions and exchanges up to Strontia Springs and Conduit 20 are fairly minimal. The changes in flows from May through September would be more variable with monthly flow increases ranging up to about 4,400 AF and decreases ranging up to about 14,300 AF.

As shown in Tables H-7.4 through H-7.6, average annual flows at the Henderson gage would increase by 1,900 AF or 1%, dry year average annual flows would increase by 3,100 AF or 2%, and wet year average annual flows would increase by 4,800 AF or 1%. Table H-3.48 summarizes average monthly flows at the Henderson gage for average, dry, and wet dry conditions. Monthly average flow changes would range from a decrease of 9.8 cfs or 1% in June to an increase of 12.4 cfs or 5% in March. Monthly dry year flows would increase by a maximum of 12.8 cfs or 6% in February. Monthly wet year flow changes would range from a decrease of 9.8 cfs or less than 1% in May to an increase of 35.3 cfs or 5% in April.

South Platte River Daily Flow Changes

As shown by the flow duration curves for the South Platte River, flow changes are relatively small the majority of time (Figures H-5.25 through H-5.30). As shown in Table H-6.17, flow changes of 100 cfs or less would occur at least 97% of the time at all other locations of interest along the South Platte River. As shown in Table H-6.20, maximum daily flow reductions are generally higher than the action alternatives. The maximum daily flow reduction would range from 482 cfs below Antero Reservoir to 870 cfs below Eleven Mile Canyon Reservoir under the No Action Alternative. The maximum daily flow increase would range from 474 cfs below Eleven Mile Canyon Reservoir to 700 cfs below Antero Reservoir. The difference in maximum daily flow increases and reductions in comparison to the action alternatives is a function of reservoir releases extending a few days longer or shutting off a few days earlier.

South Platte River Floodplain

Changes in the floodplain along the South Platte River were analyzed downstream of Cheesman Reservoir and at the Denver gage. Under the No Action Alternative, Denver Water's additional demand would be met largely from Blue River and South Platte River supplies. As a result, there would be greater releases from Antero, Eleven Mile Canyon, and Cheesman reservoirs, particularly during dry years. These increases would not impact annual flood events with relatively high recurrence intervals. As with the other alternatives, there would be no significant increases in flood flows associated with recurrence intervals of 2 years or greater.

At the Denver gage, there would be no increases in annual peaks under the No Action Alternative compared with Full Use of the Existing System. Generally flood flows are the same for the No Action Alternative and Full Use of the Existing System for recurrence

intervals equal to or greater than 2 years. There are only two recurrence intervals for which flood flows decrease by 3% or more.

5.1.6.4 Combination Strategy

A qualitative assessment of the combination of using mandatory restrictions in addition to depleting the Strategic Water Reserve was conducted for the No Action Alternative. The following compares the hydrologic effects of the Combination Strategy with solely relying on the Strategic Water Reserve.

In dry years, Denver Water would divert the maximum amount physically and legally available under their existing water rights. Imposing restrictions would allow Denver Water to decrease bypass flows on the West Slope, which would increase the amount physically available for Denver Water to divert. If Denver Water diverts additional water due to decreased bypass flows, then stream flows would decrease on the West Slope. In addition, stream flow could slightly decrease in dry years if greater restrictions were imposed because less water would be released from storage.

Imposing restrictions would generally have the impact of preserving more of the Strategic Water Reserve; therefore, storage contents in Denver Water's reservoirs would likely be higher during a drought as compared to not imposing restrictions. Whether storage contents are higher depends on several factors. The amount and location of water reserved in storage would vary depending on the severity and duration of restrictions imposed, on storage conditions in Denver Water's North and South systems and on hydrologic conditions. Since storage contents could be higher with restrictions after a drought, Denver Water's diversions into storage could be less and stream flows could increase for a short duration after Denver Water's reservoirs refill. However, this would not occur if a reservoir is drained even with restrictions in place. Conversely, with greater restrictions, during a drought stream flows would be less in some streams as Denver Water would decrease its releases from storage and decrease bypass flows. In summary, if mandatory restrictions were imposed in combination with depleting the Strategic Water Reserve, the following hydrologic impacts are likely to occur:

- During a drought, stream flows could decrease in some streams because less water would be released from storage to meet demand. This applies to South Boulder Creek below Gross Reservoir, the North Fork South Platte River and South Platte River. Changes in stream flow between the two No Action Alternative strategies are not expected to be significant.
- Steam flows would also decrease if bypass flows are decreased. For example, Denver Water would divert additional water from the Fraser River in dry years if bypass flows are reduced. This applies to several locations in the Fraser River Basin, the Blue River below Dillon Reservoir, and along the South Platte River below Eleven Mile Canyon Reservoir and Cheesman Reservoir, and at the Old Last Chance Ditch Diversion.
- Stream flows would increase along South Boulder Creek above Gross Reservoir if bypass flows in the Fraser River Basin are decreased since more water would be diverted through the Moffat Tunnel.

- Stream flows could increase below Williams Fork Reservoir if additional releases are required to replace out-of-priority diversions at Dillon Reservoir or through the Moffat Tunnel if bypass flows are reduced.
- Following a drought, stream flows could be higher for a short duration if Denver Water refills its reservoirs sooner. However, this would not occur if a reservoir is drained even with restrictions in place.
- Reservoir contents would be higher during a drought and when the reservoirs refill if the reservoir is not drained.

5.1.7 Mitigation and Monitoring

No mitigation is proposed for surface water hydrology.

Floodplain

Due to the anticipated flow changes resulting from the action alternatives and the No Action Alternative, flows would generally be reduced during high flow periods on the West Slope. As a result, the potential for creating additional flood hazard is considered low.

On the East Slope, Denver Water operates the Moffat Tunnel and Roberts Tunnel such that specific flow rates are not exceeded as a result of Denver Water operations. Therefore, impacts on flood flows on the East Slope due to the alternatives would also be relatively minor. Due to the magnitude of impacts anticipated, mitigation and monitoring of impacts on floodplains is not recommended.

5.1.8 Unavoidable Adverse Impacts

Surface Water Hydrology

There would be unavoidable changes in stream flow in numerous streams on the East and West slopes, increased diversion of water from the West Slope to the East Slope drainages, increased evaporation from expanded or new storage reservoirs under the action alternatives, and greater fluctuations in reservoir levels compared to Full Use of the Existing System.

Floodplain

There are no unavoidable direct or indirect adverse impacts identified for floodplains on the East or West slopes due to the implementation of any of the alternatives proposed in this EIS. No additional mitigation measures are expected to be necessary for impacts.

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5.2 WATER QUALITY

This section describes possible changes in water quality of reservoirs and streams throughout the Project area that are specifically related to the Moffat Collection System Project (Moffat Project or Project) by comparing Full Use of the Existing System and Full Use with a Project Alternative (2032). The primary water quality issue raised during scoping pertained to the potential impacts of reducing Fraser River bypass flows, including the ability of downstream water districts to meet wastewater treatment discharge permit limits and water quality standards. This issue and other potential water quality impacts resulting from implementing a Moffat Project alternative are evaluated and described in the following sections.

Each of the Project alternatives involves changes in the hydrologic regime, including changes to the quantity and timing of flow and reservoir storage. This section evaluates changes in flow and storage that may affect water quality in streams and reservoirs in the Project area. Most of the impacts to water quality would be indirect through changes in stream flow (Appendix H-3) or reservoir operation (Appendix H-2).

Summary of Major Conclusions

A summary of major conclusions related to water quality impacts is provided below. The analysis supporting the major conclusions is provided in subsequent sections.

- **General** – Under the Proposed Action, most streams and reservoirs would experience negligible impacts in water quality changes. Gross Reservoir is an exception. Short-term changes to Gross Reservoir water quality are anticipated due to inundation of new areas with expansion of the reservoir under the Proposed Action. These include minor increases in organic carbon concentrations and minor to moderate increases in mercury concentrations in fish tissue. The duration of these short-term effects is uncertain. However, no long-term adverse effects on Gross Reservoir water quality, including trophic state, are anticipated. Additionally, Chatfield Reservoir would experience seasonal changes in phosphorus loading; however, annual loadings would remain similar to current levels.
- **Temperature Effects** – Potential water temperature changes are anticipated on the Fraser River, Ranch Creek, and the Colorado River as a result of Full Use of the Existing System whereas a negligible level of impact is expected from the Proposed Action based on the type of analysis that could be reasonably performed with available data and methods related to flow-related effects on stream temperatures. Changes in flow caused by the Proposed Action would occur primarily during runoff months when stream temperatures have not historically exceeded regulatory limits. Additionally, as described in Section 4.6.2, available data on stream flow and stream temperature did not support prediction of water temperature changes based solely on flow changes.
- Outflow temperatures from Gross Reservoir to South Boulder Creek are expected to be lower based on comparison of Full Use of the Existing System and the Proposed Action due to expansion of the hypolimnion. Similar or slightly less temperature effects are

anticipated for Alternatives 1c, 8a, 10a, and 13a. The effects of this reduction in temperature on aquatic life are discussed in Section 5.2.1.2.

- **Fraser River and Ranch Creek Nutrient Effects** – Potential nutrient impacts on the Fraser River and Ranch Creek would primarily result from the predicted flow changes under Full Use of the Existing System conditions. The Proposed Action is anticipated to have negligible to minor additional nutrient impact.
- **Three Lakes Area** – Potential impacts in the Three Lakes area (Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir) would primarily occur from the predicted flow changes with Full Use of the Existing System. The Proposed Action is anticipated to have little to no additional impact on the Three Lakes area.
- **North Fork South Platte River Metals Concentrations** – The North Fork South Platte River would experience changes in metals concentrations, as described in Section 4.6.2. A portion of these changes would result from the Proposed Action and the predicted changes in seasonal deliveries through Roberts Tunnel.
- **Alternative 1c** – The impacts under Alternative 1c would be similar to the Proposed Action. Water quality at Leyden Gulch Reservoir would have slightly higher concentrations of phosphorus and chlorophyll *a* than Gross Reservoir. Overall effects on Gross Reservoir would be slightly lessened, relative to the Proposed Action, due to the smaller reservoir size under Alternative 1c. Water quality impacts to all river segments under Alternatives 1c would be similar to those described for the Proposed Action.
- **Alternatives 8a, 10a, and 13a** – The expansion of Gross Reservoir under Alternatives 8a, 10a, and 13a would result in similar but smaller impacts to water quality than the Proposed Action due to the smaller reservoir sizes. Water quality impacts to all river segments under Alternatives 8a, 10a, and 13a would be similar to those described for the Proposed Action since the sources for additional water supply are the same as those described for the Proposed Action. Most of the additional surface water diversions would be collected in the upper reaches of the West Slope watersheds in the Fraser and Williams Fork river basins. However, portions of the water supply for Alternatives 8a, 10a, and 13a would come from other sources (reusable water and converted agricultural water rights in the South Platte River). As a result, diversions from the West Slope basins would be slightly less than the Proposed Action.
- **No Action Alternative** – Two water bodies would have greater impacts from the No Action Alternative than from the Proposed Action. The North Fork South Platte River would experience increased annual deliveries from Roberts Tunnel resulting in phosphorus loading to both the North Fork South Platte River and Chatfield Reservoir leading to a minor long-term impact.

Methods for Reservoir Water Quality Evaluation

Methods used to assess in-reservoir water quality for the reservoirs in the Project area are summarized below. Detailed descriptions of the methods can be found in Section 4.6.2.1.

Gross Reservoir

Under the Proposed Action, the depth and capacity of Gross Reservoir would increase significantly. For assessment of potential changes to in-reservoir water quality, results from the Gross Reservoir Temperature Model (Hawley et al. 2013 in Appendix E-5) were considered along with empirical relationships from Vollenweider (1976). The analysis is described in detail in Section 4.6.2.1.1. Current Conditions and the Proposed Action with reasonably foreseeable future actions (RFFAs) were evaluated and compared.

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

The Three Lakes have recently received considerable attention over possible water quality changes resulting from any activity. To evaluate potential impacts on this system, an existing water quality model was used. The Three Lakes Water-Quality Model (AMEC 2008) was developed over a period of several years with involvement and review by many stakeholders. This process-based model simulates nutrients, chlorophyll *a*, dissolved oxygen (DO), water clarity, and total suspended solids (TSS) on a daily basis for each of the three water bodies. The model is described further in Section 4.6.2.1.1. Current Conditions and each of the Project alternatives were evaluated and compared.

Other Reservoirs

Potential effects on the water quality of other reservoirs in the Project area were assessed on a qualitative basis consistent with the relatively limited changes that the alternatives would have on the inflow, outflow, reservoir level, and residence times for these reservoirs.

Methods for Stream Water Quality Evaluation

For each basin in the Project area, potential water quality changes resulting from the Moffat Project alternatives were evaluated based on one or more of the following categories depending on the ecological conditions and concerns in the basins and on existing and potential diversions and return flows:

- **Impaired Water Bodies** – Potential to cause exceedances or contribute to potential exceedances for: (1) Regulation 93 constituents (the Monitoring and Evaluation List, Impaired Water Body List [303(d) List]), or (2) Total Maximum Daily Loads (TMDLs).
- **Effects on Wastewater Treatment Plant Operations and Discharges** – Potential to affect the operations of existing Wastewater Treatment Plants (WWTPs) and for wastewater discharges to adversely affect stream water quality due to reductions in dilutive flows.
- **Effects on Source Waters for Potable Water Systems** – Potential to affect the quality of source waters used by potable water systems or other potential site-specific effects.
- **Effects on Water Bodies** – Potential to affect the quality of the water entering an existing water body (such as changes in the quality of water used imported from separate river basin affecting the quality of water in the receiving water bodies).

The methods used to assess these four categories of effects are presented in four subsections below. The following primary information sources were used to support these four types of effects assessments:

- Water quality data as presented in Section 3.2 for sampling sites that are near or exceed existing water quality standards listed in Colorado Department of Public Health and Environment (CDPHE) Regulations.
- Platte and Colorado Simulation Model (PACSM) results as presented in Appendix H and Section 4.6.1.
- Completed and draft TMDLs as published on CDPHE's website (CDPHE 2012b).
- Colorado's 303(d) and Monitoring and Evaluation Lists as presented in CDPHE Regulation 93 (CDPHE 2012a).
- National Pollutant Discharge Elimination System permitted discharges as listed in the U.S. Environmental Protection Agency's (EPA's) Enforcement and Compliance History Online and Envirofacts databases (construction-related permits are not evaluated, as these are temporary) (EPA 2007b, 2010a).
- Potable drinking water system information as published in EPA's Envirofacts database (EPA 2007c).

Impaired Water Bodies

Regulation 93 (CDPHE 2012a) lists impaired stream segments that identify parameter(s) of interest for each segment. See Section 3.2.0 of this Environmental Impact Statement (EIS) for explanations of the State of Colorado's Section 303(d) List and Regulation 93. For these stream segments, CDPHE does not identify sources of pollution nor does it specify potential methods for reducing parameter concentrations or loadings. For stream segments with TMDLs, the source of pollution is identified, as well as methods of reducing concentrations or removal of the pollutants. The source or potential source of identified pollutants is reviewed in terms of 2032 conditions where a potential change in pollutant concentration would occur as a result of the Moffat Project.

Regulation 93 identifies temperature as a concern in a number of stream segments in the upper Colorado River Basin. Water temperature in streams is influenced by many factors. For example, solar radiation directly affects heat exchanged between the water and the atmosphere. Tributary temperatures, groundwater inflow, and precipitation are also factors. A number of studies have indicated that air temperature/solar radiation have the greatest impact on stream water temperature. Additional factors include riparian vegetation (shading and insulation), topographic shading, relative humidity, wind velocity, streambed conductivity, and channel morphology (Katzenberger and Mason n.d.; Poole and Berman 2001; Bartholow 1989; Essig 1998; Amaranthus et al. 1989). Input data required by temperature models, such as Stream Segment Temperature Model (SSTEMP), include meteorological data (air temperature, humidity, wind speed, and cloud cover), a shade factor, and physical parameters such as flow and streambed dimensions (USGS 2010b). In sensitivity analyses using the Instream Water Temperature Model (SNTEMP), Bartholow determined that stream flow was the fourth most important variable affecting stream water temperature, after air temperature, percent shade, and relative humidity (Bartholow 1989).

Reductions in flow rates in a reach of stream affect stream temperatures primarily by increasing the surface area of a stream in relation to the volume of water in the reach. Riparian vegetation affects heat exchange through shading, reduces wind velocity at the water surface, and provides an insulating effect of air temperature at the water surface. Other influences on stream water temperature include reduction of shade (for example, through disturbance of riparian vegetation from livestock grazing or back erosion due to rapidly varying flow rates), increases in width-to-depth ratio due to increased sedimentation or reduced flows, reduced flow due to upstream diversions or storage, and changes in vegetation, land use or other conditions that alter groundwater flows.

A review of approved TMDLs for water temperature in mountainous streams (NMED 1999, 2002; UDEQ 2010) showed that loss of riparian vegetation, an increase in sedimentation, and reduction of late summer flows were identified as contributors to changes in water temperatures. In New Mexico, Best Management Practices (BMPs) to increase riparian shade and reduce sedimentation concluded that increasing riparian shade by 55 percent (%) to 60% could result in meeting the stream standards in that setting.

Although many factors affect stream temperatures, investigations were conducted in response to interaction with Cooperating Agencies to determine whether single-variable regression analyses could be used to develop relationships to predict changes in stream temperatures caused solely by changes in stream flows and changes in air temperature.

The following analyses were performed:

- Examination of the potential relationship between air temperature and water temperature at a number of stations.
- Examination of the potential relationship between flow and water temperature at a number of stations.
- Examination of historical data for water temperatures near or above the stream standard and associated flow at that time.

These analyses are expected to be supplemented by dynamic stream temperature modeling being performed in support of the Clean Water Act Section 401 water quality certification process administered by CDPHE separately from this EIS.

There are no predicted changes in geomorphology that are expected to directly affect stream temperature. Changes in channel morphology could result from development and other land use practices that could result in additional sediment loading in streams. In these cases, increased sediment loads would be the result of activities such as urbanization, bank instability, loss of riparian vegetation (and corresponding stream shading), and/or grazing practices. It is not anticipated that the Project alternatives would extend or increase these practices and conditions. Furthermore, sediment supply, which is related to flow rates, would decrease rather than increase as a result of the Project alternatives. Therefore, geomorphology as it relates to stream temperature is not discussed further.

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 evaluations 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 be feasible as part of this EIS.

Effects on Wastewater Treatment Plant Operations and Discharges

The Moffat Project could adversely affect the ability of wastewater plant operators to maintain compliance with current and future discharge regulations due to potential flow reductions and reduced dilutive capacity in the receiving streams. Furthermore, changes in stream flow could drive changes in permit conditions. Evaluation of potential impacts to wastewater dischargers was based on potential changes in low flows at the discharge point. Evaluation of water quality for altered stream flows was conducted in two ways. For the Fraser River, nutrient concentrations have been modeled under various conditions and are described in more detail later in this section. For the Fraser River and the remaining basins, the percentages of stream flows that would be comprised of treated effluent were estimated in accordance with CDPHE procedures and the impacts are discussed. For other basins, where potential for nutrient loading would not be significant, the loads were not evaluated explicitly, but the percent of the stream comprised of wastewater effluent was evaluated.

Regulatory changes currently being discussed would regulate nitrogen and phosphorus as numeric criteria rather than the current narrative criteria. The proposed regulation changes for nitrogen and phosphorus would likely result in more stringent discharge criteria for many WWTPs.

Effects on Source Waters for Potable Water Systems

Potable water providers could be impacted if changes in contaminant concentrations in regulated drinking water parameters result from potential water transfers. These impacts are discussed for potable water providers that use water sources from affected stream segments in water basins within the Project area. For all alternatives, historical operational patterns of water transfers through the Moffat and Roberts tunnels would be similar but the quantity of water transferred would change. There is also potential for transfer of organisms, including those pathogenic to humans, from importing surface waters. For Alternatives 8a, 10a, and 13a, additional transfer of water would occur from the South Platte River Basin, downstream of the Metro Wastewater Reclamation District Plant (Metro WWTP). To ensure potable water quality standards, these three alternatives were configured to include advanced water treatment to remove potential pathogenic organisms and chemical and physical contaminants.

Effects on Water Bodies

The quality of water bodies can be altered through changes in the quality of inflows to the water body (or "source" waters). These potential effects were evaluated based on the potential causes of change in source water quality. For increases or decreases in flows from an imported source (for example, a trans-basin diversion tunnel), guidance was used from the Antidegradation Significance Determination for New or Increased Water Quality Impacts Procedural Guidance (CDPHE 2001). Per the guidance document, "In order to be

'insignificant', the new or increased discharge may not increase the actual instream concentration by more than 15% of the available increment over the baseline." For purposes of this EIS, baseline is defined as ambient stream conditions as presented in Section 3.2. Ambient stream quality was determined using CDPHE guidance for data quality, specifically where data points covered multiple years with multiple samples per year. The procedures and criteria used include:

- **Guidance on Data Requirements and Data Interpretation Methods Used in Stream Standards and Classification Proceedings**. Water Quality Control Division (WQCD), July 1993 (CDPHE 1993).
- **Regulation No. 31. The Basic Standards and Methodologies for Surface Water**. Effective January 1, 2011 (CDPHE 2011a).
- **Antidegradation Significance Determination for New or Increased Water Quality Impacts. Procedural Guidance**. Version 1.0. December 2001 (CDPHE 2001).
- **Guidance on Data Requirements and Data Interpretation Methods Used in Water Quality Standards and Classification Proceedings**. WQCD. August 2004 (CDPHE 2004).

Stream water quality changes attributable to changes in tributary water quality inflows are presented for each basin. Discussion is presented for potentially affected basins where reservoir water quality changes would change water quality downstream of the reservoir.

In general, groundwater quality changes would be negligible to minor (Section 4.6.4) for the majority of the Project area. The South Platte River Basin received greater evaluation due to the alluvial aquifer along the river as it exits the foothills, which transverses the Denver Metropolitan area and continues across Colorado's eastern plains. The South Platte River Basin is highly urbanized from Chatfield Reservoir to Henderson downstream of Denver where the river flow increases (gains) during low flow periods and flow decreases (loses) during high flow periods. Potential impacts from water quality in low flow periods are discussed in relation to possible changes of groundwater flow through potentially contaminated areas. The "15% criteria" for determination of the significance of surface water quality changes stated above also applies groundwater quality changes.

5.2.1 Proposed Action (Alternative 1a)

5.2.1.1 Reservoir Water Quality

Williams Fork Reservoir

Williams Fork Reservoir water quality is influenced by upstream water quality from the Williams Fork River, changes in reservoir operations or water surface elevation, and evaporation. Flow into the Williams Fork Reservoir is projected to change very little between Full Use of the Existing System conditions and Full Use with a Project Alternative (2032). Additionally, releases from the Williams Fork Reservoir would change very little except in June of average years when flows would decrease 13% under Full Use with a Project Alternative (2032) conditions compared to Full Use of the Existing System. Therefore, changes in Williams Fork Reservoir water quality are not anticipated with the

Proposed Action, however, changes would occur between Current Conditions (2006) and Full Use of the Existing System conditions as described in Section 4.6.2.

Dillon Reservoir

Dillon Reservoir water quality is influenced by upstream water quality from the Blue River, changes in reservoir operations or water surface elevations, and evaporation. Water quality of the Blue River inflow or tributary inflow to Dillon Reservoir is not expected to change under the Proposed Action. Reservoir water surface elevation is expected to fluctuate approximately 3 feet (between Full Use of the Existing System and Full Use with a Project Alternative [2032] conditions) but water quality would not be significantly affected. Releases from Dillon Reservoir are projected to have minimal changes except in October of wet years when flows would decrease 27%, and in January of wet years when flows are expected to increase 12%. Due to the size of Dillon Reservoir, water quality would not be expected to change significantly during any single month. Therefore, the Proposed Action is not expected to change water quality in Dillon Reservoir.

Wolford Mountain Reservoir

Changes in outflow from Wolford Mountain Reservoir would be minor when comparing the Proposed Action to Full Use of the Existing System. Therefore, any water quality changes in Wolford Mountain Reservoir would be the result of changes between Current Conditions (2006) and Full Use of the Existing System, as described in Section 4.6.2.

Gross Reservoir

The Proposed Action would enlarge Gross Reservoir storage capacity from 41,811 acre-feet (AF) to 118,811 AF (with the Environmental Pool for mitigation) by increasing the dam height from 340 to 471 feet. RFFAs are not likely to have any cumulative effects on water quality at Gross Reservoir, beyond those associated with the Moffat Project alternatives, because no major actions that would impact water quality are planned in this area. Therefore, impacts and analyses presented in Chapter 4 (Section 4.6.2) for total environmental effects for Gross Reservoir water quality are also applicable as Moffat Project effects.

Short-term changes to reservoir water quality are anticipated due to inundation of new areas with expansion of the reservoir for the Proposed Action. These include minor increases in organic carbon concentrations, nutrient concentrations, and chlorophyll *a* concentrations. Short-term minor to moderate increases in mercury concentrations in fish tissue are also anticipated. The duration of these short-term effects is uncertain. No long-term adverse effects on Gross Reservoir water quality, including trophic state, are anticipated. Analyses supporting these statements are presented in Section 4.6.2.

Antero Reservoir

Changes in releases from Antero Reservoir would be similar between Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions. The predicted water quality changes would result from Full Use of the Existing System as contrasted with changes under Current Conditions (2006), as described in Section 4.6.2. Therefore, water quality in Antero Reservoir is not expected to change as a result of the Proposed Action.

Eleven Mile Canyon Reservoir

Changes in releases from Eleven Mile Canyon Reservoir would be similar between Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions. Predicted changes in water quality would occur between Current Conditions (2006) and Full Use with a Project Alternative (2032), as described in Section 4.6.2. Water quality changes would be the result of Full Use of the Existing System and not the result of the Proposed Action. Therefore, water quality in the Eleven Mile Canyon Reservoir is not expected to change as a result of the Proposed Action.

Cheesman Reservoir

Changes in releases from Cheesman Reservoir would be similar between Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions. Changes in water quality are predicted between Current Conditions (2006) and Full Use with a Project Alternative (2032), as described in Section 4.6.2. Water quality changes would not be the result of the Proposed Action, but would result from Full Use of the Existing System conditions. Therefore, water quality in Cheesman Reservoir is not expected to change as a result of the Proposed Action.

Strontia Springs and Chatfield Reservoirs

Water quality in both Strontia Springs and Chatfield reservoirs is influenced by upstream water quality from the South Platte River, water deliveries through the Roberts Tunnel, changes in reservoir operations or water surface elevation, and evaporation. As discussed in Section 4.6.2, the South Platte River below North Fork South Platte River would experience changes in concentrations of copper, iron, and nickel. River water quality changes upstream would occur seasonally with yearly reservoir loadings expected to remain similar between the Proposed Project and Full Use of the Existing System conditions. Thus, some changes would occur on a seasonal basis in both reservoirs, but changes on an annual basis with regard to loading are not expected to change between Full Use of the Existing System and Full Use with a Project Alternative (2032).

In Chatfield Reservoir, the total annual phosphorus loadings from the South Platte River would not be expected to change under the Proposed Action. Annual deliveries through the Roberts Tunnel would be similar to Full Use of the Existing System when compared to Full Use with a Project Alternative (2032) conditions. The seasonal loading of phosphorus may vary due to seasonal changes in deliveries through Roberts Tunnel.

Both reservoirs would continue operating within the same general range of water surface elevations; therefore, no water quality changes would be expected from operational changes associated with the Proposed Action. No impact is anticipated for Strontia Springs Reservoir resulting from the Proposed Action. The Proposed Action would result in negligible long-term impacts at Chatfield Reservoir due to change in timing of phosphorus loading.

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

Results of the Three Lakes modeling effort are summarized in Table 5.2-1. Although from a hydrologic standpoint throughout this document, years are categorized by ‘water year’ (October through September), the results in this subsection (including Table 5.2-1) are

reported on a calendar year basis (January through December). This is done because, from a water quality perspective, important dynamics that occur in the later part of the calendar year (into the October through December period) are generally a result of operations and hydrology that occurred in the earlier part of the calendar year. For example, in 1977, the minimum hypolimnetic DO in Grand Lake occurs in early October, before turnover. This minimum concentration is in response to low inflows in the spring/summer of 1977, though low runoff is typically set up by minimal snowfall the preceding winter. If the DO results were reported on a water-year basis, that minimum DO value would be associated with WY1978, an average hydrologic year. Reporting the results on a calendar-year basis maintains a better connection between the causes of the response and the response itself.

Table 5.2-1
Modeled Concentrations in the Three Lakes
(Modeled Hydrologic Years of 1975 to 1989[1])

Parameter	Grand Lake			Shadow Mountain Reservoir			Granby Reservoir		
	Full Use of the Existing System	Full Use with a Project Alternative (2032)	Percent Change	Full Use of the Existing System	Full Use with a Project Alternative (2032)	Percent Change	Full Use of the Existing System	Full Use with a Project Alternative (2032)	Percent Change
Epilimnetic Total Nitrogen (µg/L)									
Average Year	271	273	1%	295	298	1%	317	321	1%
Dry Year	289	292	1%	311	314	1%	317	321	1%
Wet Year	252	254	1%	278	280	1%	321	321	0%
Epilimnetic Total Phosphorus (µg/L)									
Average Year	8	8	1%	13	13	1%	13	13	2%
Dry Year	9	9	2%	13	13	2%	11	12	2%
Wet Year	7	7	2%	12	12	2%	14	14	0%
Minimum Dissolved Oxygen (mg/L) at Bottom									
Average Year	5.9	5.9	0%	7.1	7.1	0%	3.9	3.9	0%
Dry Year	6.4	6.4	0%	6.9	6.9	0%	4.7	4.7	-1%
Wet Year	5.2	5.2	0%	7.1	7.1	0%	4.0	4.0	0%
Epilimnetic Chlorophyll *a* (µg/L)									
Average Year	3.8	3.9	1%	4.3	4.3	0%	3.2	3.2	0%
Dry Year	3.9	4.0	1%	4.1	4.2	0%	3.3	3.3	0%
Wet Year	3.7	3.8	1%	4.3	4.4	1%	3.3	3.3	0%
Average of Annual Maximum Epilimnetic Chlorophyll *a* (µg/L)									
Average Year	5.5	5.6	1%	6.1	6.2	1%	4.8	4.8	0%
Dry Year	5.1	5.2	1%	5.7	5.8	2%	4.8	4.8	1%
Wet Year	5.0	5.1	2%	6.9	7.0	2%	5.1	5.1	0%
Epilimnetic Total Suspended Solids (mg/L)									
Average Year	1.8	1.8	0%	2.0	2.0	0%	2.4	2.5	1%
Dry Year	1.9	1.9	1%	2.1	2.1	1%	2.4	2.5	1%
Wet Year	1.9	1.9	0%	2.1	2.2	0%	2.6	2.6	0%
Secchi Disk Depth (meters)									
Average Year	3.2	3.2	0%	2.3	2.3	0%	3.9	3.9	0%
Dry Year	3.1	3.1	-1%	2.3	2.3	0%	3.8	3.8	0%
Wet Year	3.2	3.2	-1%	2.3	2.3	0%	3.7	3.7	0%

Notes:
[1]The PACSM for the Final Environmental Impact Statement used water years 1946-1990.
[2]Dissolved oxygen results for Shadow Mountain Reservoir represent the minimum of entire depth, since the reservoir is represented by a single layer in the model.
µg/L = micrograms per liter PACSM = Platte and Colorado Simulation Model
mg/L = milligrams per liter

Results for nutrients, chlorophyll *a*, DO, TSS, and water clarity are reported below. Using the Carlson Trophic State Index (Carlson 1977) and values in Table 4.6.2-14 for average chlorophyll *a*, all three water bodies would be considered mesotrophic under Full Use of the Existing System and Full Use with a Project Alternative (2032). For all three water bodies, changes in all reported water-quality parameters are less than 2%.

The modeling results indicate no impact or a negligible impact to Grand Lake, Shadow Mountain Reservoir, and Granby Reservoir from the Proposed Action, as compared to Full Use of the Existing System.

Shadow Mountain Reservoir is listed on the Section 303(d) List for DO. The modeling results indicate no change in DO for Shadow Mountain Reservoir (for the simulated full depth), as shown in Table 5.2-1. Additionally, only a 0% to 1% decrease in minimum DO would occur at the bottom of Granby, which affects Shadow Mountain Reservoir through Farr pumping. Based on this, changes to DO in Shadow Mountain Reservoir for Full Uses with a Project Alternative (2032) compared to Full Use of the Existing System would be negligible.

Granby Reservoir is listed on the Section 303(d) List for Aquatic Life Use due to mercury identified in fish tissue. Rates of mercury methylation in lakes and reservoirs have been tied to DO concentrations. Low DO can enhance methylation in the sediments, methylmercury (MeHg) fluxes from the sediment, and methylation in the water column. Model results indicate that a 0% to 1% decrease in annual minimum DO at the bottom of Granby Reservoir would occur under the Proposed Action as compared to Full Use of the Existing System. Based on this small anticipated difference, effects on mercury methylation would be expected to be negligible. Additionally, it is possible that small predicted increases in nutrients (less than or equal to 2%) could result in slightly higher biomass, which could lead to slight reductions in MeHg concentrations. Results from recent studies conducted in Colorado indicate that increases in nutrients can result in reductions in mercury concentrations in biota (Lepak 2013), as discussed in Section 4.6.2.1.1. Occurrence of this effect would further support the prediction of negligible net impacts to mercury in fish tissue.

5.2.1.2 River Segments

Fraser River

Changes in Concentrations of Constituents Potentially Exceeding Stream Standards (Copper, Iron, Lead, pH, and Aquatic Life Use)

The Fraser River is listed on the Monitoring and Evaluation List for copper from the Town of Fraser to the confluence of the Colorado River and for lead from the Town of Tabernash to the Town of Granby (CDPHE 2012a). As Table 3.2-5 shows, one monitoring station indicates an 85th percentile value for copper greater than the stream standard at the Town of Fraser. Additionally, two CDPHE stations and four U.S. Geological Survey stations have records on copper concentrations beginning in 2000. There have been two exceedances of the acute standard for copper on the Fraser River; those occurred on January 25, 2006 and May 5, 2010 at WQCD station 12166 (Hranac 2013). As discussed in Section 4.6.2, it is

not anticipated that Full Use with a Project Alternative (2032) conditions would cause or contribute to stream standard exceedances for copper or lead.

The mainstem of the Fraser River and Vasquez Creek are also provisionally listed on the 303(d) List for Aquatic Life Use (CDPHE 2012a). A discussion of the Aquatic Life Use listing is presented in Section 3.11.

Potential Changes in Water Temperature

The Fraser River and Ranch Creek are both listed on the 303(d) List for temperature but St. Louis Creek is not listed. Although, all three streams could be subject to potential increases in frequency of temperature standard exceedances under the Proposed Action, none of these streams are anticipated to experience an increase due to the Proposed Action. The potential for increased exceedances attributable to the Proposed Action are discussed below for the Fraser River and for Ranch Creek.

Fraser River. For sections 10b and 10c of the Fraser River, flow changes resulting only from the Proposed Action are not anticipated to cause increased frequency of stream temperature standard exceedances. Sections 10b and 10c would experience negligible impacts under the Proposed Action.

Section 4.6.2 presented analyses showing that, for the datasets available to support a single-variable regression analysis, stream flow in isolation from other factors known to affect water temperature could not be reliably used as a predictor of water temperature changes in these river sections. During the period of concern for potential exceedances to stream temperature standards, mid-July through August, no further impact attributable to the Proposed Action was identified. Although flow is not a good predictor of water temperature for the data available for these river sections, the number of days with low flows (days in which the modeled flow was less than 100 cubic feet per second [cfs]), would not change between Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions. This indicates that the Proposed Action is not anticipated to have any additional effect on stream temperature exceedances beyond the effects of Full Use of the Existing System. However, based on the historical record of daily maximum and maximum weekly average temperature exceedances in the Fraser River Basin, it is possible that such exceedances could occur in the future during periods when diversions related to the Proposed Action would be taking place. Because of this possibility, impacts to stream temperatures due to the Proposed Action are considered negligible to minor.

Ranch Creek. For Ranch Creek, changes in flow resulting only from the Proposed Action are not expected to cause increased frequency of stream temperature standard exceedances. Negligible impacts are anticipated under the Proposed Action.

Section 4.6.2 presented analyses showing that, for the datasets available to support a single-variable regression analysis, stream flow in isolation from other factors known to affect water temperature, could not be reliably used as a predictor of water temperature changes in these river sections. During the period of concern for potential exceedances to stream temperature standards, mid-July through August, no further impact attributable to the Proposed Action was identified. Although flow is not a good predictor of water temperature for the data available for this stream reach, the number of days with low flows (days in which the modeled flow was less than 6 cfs), would not change between Full Use

of the Existing System and Full Use with a Project Alternative (2032) conditions. This indicates that the Proposed Action is not anticipated to have any additional effect on stream temperature beyond the effects of Full Use of the Existing System.

St. Louis Creek. As noted in Section 4.6.2, this station is near the confluence of the Fraser River and the two occurrences of temperature approaching or exceeding the regulatory standard occurred on days that the air temperature was equal to or exceeded the historical 90th percentile. Based on this data, St. Louis Creek was not further evaluated for potential stream temperatures exceeding regulatory standards under the Proposed Action with RFFAs in Chapter 4. Since no potential exceedances of regulatory standards were identified under Full Use with a Project Alternative (2032) conditions, the Proposed Action is not expected to cause exceedances of stream temperature standards.

Permit Compliance for Moffat Railroad Tunnel Discharges

An issue with the Moffat Railroad Tunnel discharge is the potential for decreased dilution of the permitted discharge resulting in increases in contaminant concentrations to harmful levels. Section 4.6.2 describes impacts resulting from the Moffat Railroad Tunnel permitted discharge where the estimated acute and chronic low flows were the same for both Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions. There would be no projected impacts with regard to the Moffat Railroad Tunnel permitted discharge attributable to the Proposed Action.

Potential Changes in Nutrient Levels

Nutrient levels for total nitrogen and total phosphorus were modeled as described in Section 4.6.2. The results shown in Tables 5.2-2 and 5.2-3 compare Full Use of the Existing System and Full Use with a Project Alternative (2032). The modeled total nitrogen and total phosphorus would result in an increase of 5% or less at all four stations. This analysis indicates that the Proposed Action would have a negligible to minor impact on nutrient concentrations in the Fraser River Basin.

Table 5.2-2
Total Nitrogen Concentrations in the Fraser River Basin

Station	Average Annual Total Nitrogen Concentrations, µg/L		Percent Increase
	Full Use of the Existing System	Full Use with a Project Alternative (2032)	
Average Year			
Fraser River below Fraser Wastewater Treatment Plant (WWTP)	1,046	1,073	2.5%
Ranch Creek	230	238	3.6%
Crooked Creek	484	484	0.0%
Fraser River at Mouth	617	632	2.4%
Dry Year			
Fraser River below Fraser WWTP	1,236	1,236	0.0%
Ranch Creek	228	228	0.0%
Crooked Creek	515	515	0.0%
Fraser River at Mouth	707	707	0.0%

Table 5.2-2 (continued)
Total Nitrogen Concentrations in the Fraser River Basin

Station	Average Annual Total Nitrogen Concentrations, µg/L		Percent Increase
	Full Use of the Existing System	Full Use with a Project Alternative (2032)	
Wet Year			
Fraser River below Fraser WWTP	899	926	3.0%
Ranch Creek	233	241	3.6%
Crooked Creek	399	399	0.0%
Fraser River at Mouth	555	568	2.3%

Table 5.2-3
Total Phosphorus Concentrations in the Fraser River Basin

Station	Average Annual Total Phosphorus Concentrations, µg/L		Percent Increase
	Full Use of the Existing System	Full Use with a Project Alternative (2032)	
Average Year			
Fraser River below Fraser Wastewater Treatment Plant (WWTP)	70	73	4.8%
Ranch Creek	32	33	3.3%
Crooked Creek	82	82	0.0%
Fraser River at Mouth	49	50	3.4%
Dry Year			
Fraser River below Fraser WWTP	84	84	0.0%
Ranch Creek	33	33	0.0%
Crooked Creek	85	85	0.0%
Fraser River at Mouth	54	54	0.0%
Wet Year			
Fraser River below Fraser WWTP	59	62	4.5%
Ranch Creek	31	32	3.5%
Crooked Creek	69	69	0.0%
Fraser River at Mouth	46	47	3.1%

Potential Impacts to Wastewater Treatment Plant Dischargers

Concerns of WWTP dischargers are the potential for the Proposed Action to result in more stringent discharge permits and cause costly plant upgrades resulting from stream flow changes or water quality changes in the receiving water.

As discussed in Section 4.6.2, the projected impacts with regard to domestic WWTP permitted discharges are not attributable to the Proposed Action. As noted above, estimated

acute and chronic low flows (as shown in Table 4.6.2-11) would be the same for Full Use of the Existing System as for Full Use with a Project Alternative (2032) conditions, indicating that impacts would occur before the Proposed Action would be implemented.

Effects Due to Changes in Tributary Flows and Water Quality

Changes in tributary flows and water quality would cause impacts under Full Use of the Existing System (see Section 4.6.2), rather than being the result of Full Use with a Project Alternative (2032). It is not anticipated that the Proposed Action with RFFAs would result in an incremental increase in water quality impacts due to changes in tributary flows and water quality.

Effects on Vasquez Creek Caused by Increased Flows through the Gumlick Tunnel

Of concern are potential water quality changes in Vasquez Creek resulting from increased diversions from the Williams Fork Basin. As presented in Section 4.6.2, no impacts to water quality in Vasquez Creek would be anticipated as a result of the Proposed Action with RFFAs.

Williams Fork River

Assimilation Capacity for Climax Mine Discharges

Potential changes in flow and reduction in dilution of the Climax Mine discharge could result in increases in contaminant concentrations to harmful levels. Changes in flow would also potentially change conditions of the Climax Mine discharge permit. Impact to water quality changes would potentially result from changes in tributary contributions. As analyzed in Section 4.6.2, there would be no projected changes in water quality in the Williams Fork River due to influences from the Climax Mine discharge or from changes in flow. Additionally, there would be no expected impacts to the Climax Mine discharge permit due to projected changes in flow in the Williams Fork River under the Proposed Action.

Effects Due to Changes in Tributary Flows and Water Quality

Water quality impacts downstream of Williams Fork Reservoir resulting from flow changes would be potential temperature changes caused by changes in reservoir releases, and potential changes in water quality caused by changes in reservoir releases. As analyzed in Section 4.6.2, change in flow from each of the tributaries has the potential to change water quality in the Williams Fork River. However, water quality is not anticipated to change as a result of the Proposed Action because all parameters would be well below stream standards except dissolved copper and DO. Analysis further showed that copper concentration would not likely exceed the stream standards due to changes in flow.

Potential Effects on Dissolved Oxygen and Temperature Due to Changes in Reservoir Releases

As noted in Section 4.6.2, impacts to DO in the Williams Fork River may occur as a result of lower flows downstream of Williams Fork Reservoir. The majority of the potential impact would occur as a result of change between Current Conditions (2006) and Full Use of the Existing System. Projected flows under Full Use of the Existing System and Full

Use with a Project Alternative (2032) would be very similar for many conditions, particularly those during dry years.

Minimal water quality impacts would occur downstream of Williams Fork Reservoir as a result of the Proposed Action. Projected flows under Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions would be within 8% of one another for all modeled time periods, except in June of average years. The projected flow under Full Use with a Project Alternative (2032) in June of average years would be the same as Current Conditions (2006) flows. Thus, minimal water quality changes are anticipated downstream of Williams Fork Reservoir resulting from the Proposed Action.

Colorado River

Potential Changes in Water Temperature

Considerable analysis was conducted on temperature changes and discussion is presented in Section 4.6.2. Increased frequency of temperature standard exceedances is not anticipated as a result of the Proposed Action. On average, monthly flows under Full Use with a Project Alternative (2032) conditions would be within 6% of Full Use of the Existing System conditions, except in June of average years when they would be within 13%. At Hot Sulphur Springs, for 181 of 2,790 days modeled, flow decreased greater than 10% between Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions. At the Kremmling sampling site, flow decreased more than 10% on 284 of 2,790 days modeled. The model evaluated dry years between Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions and found no days where flow changed greater than 10%.

Flows would change very little in July and August, and it is not anticipated that there would be an increased frequency of the temperature standard exceedances. This portion of the Colorado River is listed on the 303(d) List, however, it is anticipated that impacts to water quality would occur between Current Conditions (2006) and Full Use with a Project Alternative (2032) conditions. Impacts directly associated with the Proposed Action are therefore not anticipated.

Potential Changes in Wastewater Treatment Plant Discharge Permit and Treated Wastewater Contributions

Hot Sulphur Springs WWTP is a minor discharger and has a greater than 1:100 dilution ratio. The current permitted discharge is 0.09 million gallons per day (mgd) (0.14 cfs). Changes in low flow would need to be extreme to have any impact to the Hot Sulphur Springs permit. Acute low flow was calculated using daily data from PACSM Node 1400, Colorado River at Hot Sulphur Springs. The lowest calculated acute low flow was 26.7 cfs, significantly more than a 1:100 dilution ratio. Therefore, impacts to the Hot Sulphur Springs WWTP discharge permit due to changes in flow between Full Use of the Existing System and Full Use with a Project Alternative (2032) are not anticipated. Because the Hot Sulphur Springs WWTP is such a small discharger, changes in water quality in the Colorado River are not anticipated due to projected changes in flow.

Potential Effects on Aquatic Life Use

The upper Colorado River from the outlet of Windy Gap Reservoir to the 578 Road Bridge is listed on the Monitoring and Evaluation List for Aquatic Life Use (CDPHE 2012a). A discussion of the Aquatic Life Use listing is presented in Section 3.11.

Potential Changes to Manganese Concentrations Downstream of 578 Road

Potential changes in manganese concentrations in this area would be the result of changes between Current Conditions (2006) and Full Use of the Existing System. The Proposed Action is not anticipated to affect manganese concentrations.

Blue River

Potential Changes in Discharge Permits

Potential exists for more stringent discharge permits for WWTPs, necessitating capital expenditures for upgrades. As shown in Section 4.6.2, the acute and chronic low flows are estimated to be the same under both Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions. Thus, any changes to the Joint Sewer Authority's WWTP discharge permit are not anticipated to be a result of the Proposed Action, but rather a result of changes from Full Use of the Existing System.

Potential Changes in Water Quality Due to Changes in Tributary Flows and Water Quality

As described in Section 4.6.2, potential changes in water quality caused by changes in tributary contributions are anticipated to be negligible. Changes in flow between Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions would be less than 10% except in October of wet years. Thus, under the Proposed Action, any water quality change resulting from changes in tributary contributions would be negligible and limited to the fall of wet years.

Potential Changes in Water Quality Related to Treated Wastewater Discharges

The only change in flow greater than 10% would be expected to occur in October of wet years when comparing Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions. A potential change in water quality could occur due to the predicted changes in treated wastewater contributions for these limited periods. The impact of this discharge on water quality is unknown. Acute low flows are not expected to be affected and therefore a change to permit limits is not anticipated. With only one month of one hydrologic condition identified as being affected, this impact is considered negligible to minor.

Potential Changes in Water Quality Due to Changes in Water Quality and/or Release Patterns of Dillon Reservoir and/or Green Mountain Reservoir

As noted above, under the Proposed Action, changes in Dillon Reservoir and Green Mountain Reservoir water quality are not anticipated, and therefore no changes are anticipated in water quality in the Blue River as a result of the Proposed Action.

The Blue River from the outlet of Dillon Reservoir to the confluence with North Rock Creek is listed on the Monitoring and Evaluation List for Aquatic Life Use (CDPHE 2012a). A discussion of the Aquatic Life Use listing is presented in Section 3.11.

Muddy Creek

Potential Increase in Temperature Standard Exceedances Downstream of Wolford Mountain Reservoir

Temperature in Muddy Creek below Wolford Mountain Dam would be influenced by the reservoir level from which water is released, as the reservoir has four outlet gates at twenty-foot intervals in elevation. Prior to modification of the Moffat Collection System, a number of operational and management issues would change temperatures in the future, as detailed in Section 4.6.2. Wolford Mountain Dam is not operated by the Board of Water Commissioners (Denver Water) and as shown by the analysis in Section 4.6.2, there would be no impact from operational changes of Wolford Mountain as a result of the Proposed Action.

Potential Impact to Wastewater Treatment Plant Permits

As shown by the analysis in Section 4.6.2, there would be sufficient remaining assimilative capacity under Full Use of the Existing System to avoid impact to the Kremmling WWTP discharge permit. There would be no significant additional impact to the assimilative capacity at this location due to the Proposed Action.

Potential Changes in Water Quality Caused by Changes in Treated Wastewater Volume

Analysis described in Section 4.6.2 showed that the percentages of wastewater flow in the months of note would be significantly less than the currently permitted conditions and there would be no anticipated impacts to Muddy Creek under the Proposed Action due to changes in discharge of treated effluent.

Potential Changes in Water Quality Caused by Changes in Releases from Wolford Mountain Reservoir

Water quality changes would potentially occur from changes in Wolford Mountain Reservoir releases if there are changes in proportional contributions between the dam and downstream tributaries. With the exception of temperature, changes are likely derived from soils in the Alkali Slough, a tributary to Wolford Mountain Reservoir (Stevens and Sprague 2001). Changes in reservoir releases would therefore not likely change parameter concentrations because the reservoir attenuates spikes in concentrations resulting from snowmelt or storm runoff. There would be no anticipated impact due to changes in releases from Wolford Mountain Reservoir. Projected changes in quantity and timing of flows between Full Use of the Existing System and Full Use with a Project Alternative (2032) conditions are anticipated to be infrequent and minor. As described in Section 4.6.2, any potential water quality impacts would be the result of changes between Current Conditions (2006) and Full Use of the Existing System. Potential water quality impacts in Muddy Creek as a result of the Proposed Action are therefore not anticipated.

South Boulder Creek

Changes in Concentrations of Contaminants in Source Water

Potential impacts to water quality in South Boulder Creek resulting from the Proposed Action are related to changes in source water and the Moffat Tunnel permitted discharge. As noted in Section 4.6.2, impacts to source water or to the permitted discharge under Full

Use with a Project Alternative (2032) conditions are not anticipated. Thus, impacts to water quality in South Boulder Creek are not anticipated as a result of the Proposed Action.

Potential Impacts Related to the Moffat Railroad Tunnel Discharge Permit

The Moffat Railroad Tunnel Discharge Permit allows for discharge of railroad tunnel seepage water to either the Fraser River or South Boulder Creek under permit number CO-0047554. Discharge to South Boulder Creek is limited to 0.5 mgd, or about 0.77 cfs. Because this flow is seepage water, the maximum flow is not expected to increase between Full Use of the Existing System and Full Use with a Project Alternative (2032).

The Moffat Railroad Tunnel discharge into South Boulder Creek occurs just downstream of the tunnel. To estimate Project impacts on dilution in South Boulder Creek, flow through the railroad tunnel was reviewed and the low flow deliveries through the tunnel were estimated. There would be no adverse impacts to water quality caused by changes in flow through the Moffat Railroad Tunnel when combined with potential discharges from the Moffat Railroad Tunnel between Full Use of the Existing System and Full Use with a Project Alternative (2032). No impacts are anticipated to the Moffat Railroad Tunnel Discharge Permit.

Potential Changes to South Boulder Creek below Gross Reservoir

Possible impacts to water quality in South Boulder Creek downstream of Gross Reservoir could result from changes in Gross Reservoir water quality. South Boulder Creek also has potential to impact drinking water providers through source water quality changes as well as potentially affecting WWTP dischargers.

As noted in Section 4.6.2, impacts are anticipated with regard to short-term increases in biological productivity downstream of Gross Reservoir in South Boulder Creek. Short-term impacts are also anticipated to affect operations of the Moffat Water Treatment Plant (WTP). These impacts would be directly related to enlargement of Gross Reservoir under the Proposed Action.

As noted in Section 4.6.2, impacts to wastewater dischargers downstream of Gross Reservoir are not anticipated.

Also as described in Section 4.6.2, outflow temperatures from Gross Reservoir are predicted to decrease with the Proposed Action due to expansion of the hypolimnion. Outflow temperature predictions of a hydrodynamic temperature model of Gross Reservoir (Hawley et al. 2013 in Appendix E-5) indicate that peak outflow water temperatures will decrease on the order of 4.0 to 6.6 degrees Celsius (˚C) (for the range of conditions simulated), resulting in outflow water which is cooler than 9˚C throughout the year. A discussion of any aquatic life effects related to these temperature predictions is presented in Section 5.11.

North Fork South Platte River

Water Quality Effects Related to Changes in Dillon Reservoir Water Quality

As previously described in Section 5.2.1.1, Dillon Reservoir water quality is not anticipated to change as a result of the Proposed Action.

Changes Downstream of Roberts Tunnel Caused by Altered Diversions through Roberts Tunnel

As described in Section 4.6.2, changes in the volume and timing of deliveries through the Roberts Tunnel would impact water quality. Changes in water quality as a result of changes in source water flows (natural flow versus Roberts Tunnel flow) would be attributed to both the Proposed Action and from changes between Current Conditions (2006) and Full Use of the Existing System. Any decreases in flow through Roberts Tunnel would be the result of the Proposed Action as flows under Full Use of the Existing System would increase when compared to Current Conditions (2006). The changes in percent contribution between Full Use of the Existing System and Full Use with a Project Alternative (2032) are discussed in the following subsection.

Changes in Source Water Contributions

In average years, Roberts Tunnel deliveries would decrease for all alternatives, (including the Proposed Action) by approximately 15 to 18% during the months of November through March. During spring runoff months of May through July, the Roberts Tunnel deliveries would increase. In May, the increase in Roberts Tunnel deliveries would be approximately 58 to 60%; in June, the increase would be approximately 30 to 31%; and in July, the increase would be approximately 18 to 19%. The annual deliveries would remain approximately the same under Full Use of the Existing System as compared to Current Conditions.

In dry years, Roberts Tunnel deliveries would change by more than 15% in two months as a result of the Proposed Action. November deliveries would decrease by approximately 16%, and March deliveries would decrease by approximately 17%. Annual deliveries would remain approximately the same under Full Use of the Existing System as compared to Current Conditions.

In wet years, Roberts Tunnel deliveries would change by more than 15% throughout winter months (decrease) and during spring runoff (increase) as a result of the Proposed Action. In November through March the decrease would range from 17% to 37%. In May through August the increase would range from 15 to 67%. The annual average Roberts Tunnel deliveries would be 14% less under the Proposed Action than under Full Use of the Existing System.

Impacts to Wastewater Treatment Plant Dischargers

The changes in Roberts Tunnel deliveries described above would result in minor impacts to concentrations of copper, iron, and nickel as described in Section 4.6.2. Analysis shows that impacts are not anticipated for drinking water providers or wastewater dischargers on the North Fork South Platte River. Additionally, minimal changes in phosphorus loading in Chatfield Reservoir are anticipated due to the change in annual flows ranging from -2 to 3%. Thus, depending on the changes in Roberts Tunnel deliveries, impacts from the Proposed Action are anticipated to slightly increase or decrease the concentrations of copper, iron, and nickel. Nickel and iron are anticipated to remain below regulatory standards. The regulatory standard for copper changes with hardness levels, and with existing concentrations at or above the regulatory standard, the effects on copper concentration from the Proposed Action are unknown with regard to the regulatory

standard. However, impacts to copper concentrations resulting from the Proposed Action are anticipated to be minimal.

South Platte River

Antero Reservoir to the Confluence with the North Fork South Platte River

As described in Section 4.6.2, water quality is anticipated to remain within stream standards and no impacts are expected. Additionally, with the exception of September of dry years, flows under Full Use with a Project Alternative (2032) conditions are anticipated to be within 10% of projected flows under Full Use of the Existing System conditions. Any change in the South Platte River would be a result of changes between Full Use of the Existing System condition and Current Conditions (2006) and not a result of the Proposed Action.

The South Fork South Platte River below Antero Reservoir is on the Monitoring and Evaluation List for Aquatic Life Use (CDPHE 2012a). A discussion of the Aquatic Life Use listing is presented in Section 3.11.

Confluence with the North Fork South Platte River to Chatfield Reservoir

As described in Section 4.6.2, water quality changes in this reach would primarily be attributable to Full Use of the Existing System. During periods when there are decreases in flow through Roberts Tunnel compared to Full Use of the Existing System, copper and nickel concentrations would increase. However, water quality is anticipated to remain within stream standards under Full Use with a Project Alternative (2032).

The South Platte River from the outlet of Cheesman Reservoir to the confluence with Fourmile Creek is on the Monitoring and Evaluation List for Aquatic Life Use (CDPHE 2012a). A discussion of the Aquatic Life Use listing is presented in Section 3.11.

Chatfield Reservoir to the Denver Gage

The South Platte River downstream of Chatfield Reservoir is highly regulated, with numerous withdrawals. Additionally, two major municipal wastewater treatment dischargers, Centennial Water and Sanitation District and the Littleton-Englewood (Bi-City) WWTP, are located in this section of the South Platte River.

No impacts are anticipated as a result of Full Use with a Project Alternative (2032) conditions except for a possible change in in groundwater flow (refer to Section 4.6.2), but this impact is not anticipated to be significant.

Denver Gage to Henderson Gage

As noted in Section 4.6.2, no impacts to water quality are anticipated under Full Use with a Project Alternative (2032) conditions.

Stream Segments Outside the Project Area Listed in Regulation 93 or Having a TMDL

As described in Section 3.2, portions of the Colorado River, South Boulder Creek, and the South Platte River are listed in Regulation 93 on Colorado's 303(d) and Monitoring and Evaluation Lists. Some downstream segments also have had TMDLs. Stream segments

downstream of the Project area which are listed in Regulation 93, or which have TMDLs, are discussed below.

Colorado River

As described in Section 4.6.2, no water quality changes are anticipated for the segments downstream of the Kremmling sample site under the Proposed Action.

South Platte River

As described in Section 4.6.2, no water quality changes are anticipated for the segments downstream of Henderson under the Proposed Action.

Boulder Creek

Boulder Creek from 107th Street to the confluence with Coal Creek is provisionally listed on the 303(d) List for Aquatic Life Use, and Boulder Creek from Coal Creek to St. Vrain Creek is on the Monitoring and Evaluation List for Aquatic Life Use (CDPHE 2012a). A discussion of the Aquatic Life Use listings is presented in Section 3.11.

As described in Section 4.6.2, no water quality changes are anticipated for the segments downstream of South Boulder Creek at Highway 93 under the Proposed Action.

5.2.2 Alternative 1c

5.2.2.1 Reservoir Water Quality

Williams Fork Reservoir

Changes to Williams Fork Reservoir water quality are not expected and it is anticipated that no impact would result from Alternative 1c.

Dillon Reservoir

Changes to Dillon Reservoir water quality are not expected and it is anticipated that no impact would result from Alternative 1c.

Wolford Mountain Reservoir

Changes in water quality would be the same as with the Proposed Action and no impacts are anticipated from Alternative 1c.

Gross Reservoir

The potential impacts to reservoir water quality under Alternative 1c would be similar to those described for the Proposed Action. The reservoir size would be smaller under Alternative 1c, as compared to the Proposed Action, and residence times would also be less. Due to the smaller reservoir size, as compared to the Proposed Action, less land would be inundated, possibly resulting in reduced short-term water quality impacts of increased organic carbon, nutrients, and mercury in fish tissue. Impacts to water quality in Gross Reservoir under Alternative 1c are expected to be minor to moderate for the short term and negligible for the long term.

Leyden Gulch Reservoir

A large portion of the water stored in Leyden Gulch Reservoir would be diverted during average and wet years when the inflow may have slightly elevated levels of total organic carbon (TOC) and turbidity. This diversion could affect reservoir water quality. Leyden Gulch Reservoir would have a greater water quality impact from storing additional water from Gross Reservoir than if that water were to remain in Gross Reservoir under the Proposed Action and fluctuate in elevation as needed. Summer destratification, exposure and oxidation of sediments, and stress to aquatic organisms would be expected to be greater in Leyden Gulch Reservoir.

Under Alternative 1c the reservoir may be operated near capacity for extended periods. Minor variances in water quality inflow to South Boulder Creek could have multi-year impacts. Water quality data to more fully evaluate this impact are not available, thus precise impacts and their magnitudes are not known. Impacts to water quality in Leyden Gulch Reservoir (compared to current water quality in Gross Reservoir) would be minor.

Antero Reservoir/Eleven Mile Canyon Reservoir/Cheesman Reservoir/Strontia Springs Reservoir/Chatfield Reservoir

Changes in water quality in these reservoirs under Alternative 1c would be similar to the Proposed Action.

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

Changes in water quality in the Three Lakes under Alternative 1c would be similar to the Proposed Action.

5.2.2.2 River Segments

Changes in water quality under Alternative 1c would be similar to the Proposed Action. Impacts to South Boulder Creek of reduced outflow temperatures from Gross Reservoir would be expected to be slightly less than those predicted for the Proposed Action due to the slightly smaller reservoir size and shorter residences times. Aquatic life effects associated with water temperatures in South Boulder Creek are discussed in Section 5.11.

5.2.3 Alternative 8a

5.2.3.1 Reservoir Evaporation and Fluctuation

Williams Fork Reservoir

Changes in reservoir water quality under Alternative 8a would be similar to the Proposed Action.

Dillon Reservoir

Changes in reservoir water quality under Alternative 8a would be similar to the Proposed Action.

Wolford Mountain Reservoir

Changes in reservoir water quality under Alternative 8a would be similar to the Proposed Action.

Gross Reservoir

The potential impacts to reservoir water quality under Alternative 8a would be similar to those described for the Proposed Action. The reservoir size would be slightly smaller under Alternative 8a, as compared to the Proposed Action, and residence times would also be shorter. Due to the smaller reservoir size, as compared to the Proposed Action, less land would be inundated, possibly resulting in slightly reduced short-term water quality impacts of increased organic carbon, nutrients, and mercury in fish tissue. Impacts to water quality in Gross Reservoir for Alternative 8a are expected to be minor to moderate for the short term and negligible for the long term.

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

Changes in water quality in the Three Lakes under Alternative 8a would be similar to the Proposed Action.

5.2.3.2 River Segments

Changes in water quality under Alternative 8a would be similar to the Proposed Action. The changes described in Section 4.6.2 regarding influent to the Moffat WTP would be attributable to Alternative 8a. Water quality impacts to river segments under Alternative 8a would be similar to those described for the Proposed Action since most of the additional surface water diversions would be collected in the upper reaches of the West Slope watersheds in the Fraser and Williams Fork river basins. However, portions of the water supply for Alternatives 8a would come from other sources and, as a result, diversions from the West Slope basins would be slightly less than the Proposed Action.

Impacts to South Boulder Creek of reduced outflow temperatures from Gross Reservoir would be expected to be slightly less than those predicted for the Proposed Action due to the slightly smaller reservoir size and shorter residences times for Alternative 8a. Aquatic life effects associated with water temperatures in South Boulder Creek are discussed in Section 5.11.

5.2.3.3 South Platte River Facilities

Operation of the South Platte River gravel pit facilities would not significantly alter river flows in relation to Full Use of the Existing System and AWTP facilities would control the potential for additional nutrient loading in Ralston Reservoir.

5.2.4 Alternative 10a

5.2.4.1 Reservoir Water Quality

Williams Fork Reservoir

Changes in reservoir water quality under Alternative 10a are the same as described for Alternative 8a.

Dillon Reservoir

Changes in reservoir water quality under Alternative 10a are the same as described for Alternative 8a.

Wolford Mountain Reservoir

Changes in reservoir water quality under Alternative 10a are the same as described for Alternative 8a.

Gross Reservoir

The potential impacts on water quality at Gross Reservoir under Alternative 10a would be the same as Alternative 8a.

Antero Reservoir/Eleven Mile Canyon Reservoir/Cheesman Reservoir/Strontia Springs Reservoir/Chatfield Reservoir

Changes in water quality under Alternative 10a would be the same as described for Alternative 8a.

Grand Lake, Shadow Mountain Reservoir, Granby Reservoir (The Three Lakes)

Changes in water quality in the Three Lakes under Alternative 10a would be the same as described for Alternative 8a.

5.2.4.2 River Segments

Water quality impacts to river segments under Alternative 10a would be similar to those described for the Proposed Action since most of the additional surface water diversions would be collected in the upper reaches of the West Slope watersheds in the Fraser and Williams Fork river basins. However, portions of the water supply for Alternative 10a would come from other sources and, as a result, diversions from the West Slope basins would be slightly less than the Proposed Action.

5.2.4.3 Denver Basin Aquifer Facilities

Operation of the Denver Basin Aquifer Facilities would not significantly alter river flows in relation to Full Use of the Existing System and CDPHE permit conditions would disallow degradation of the aquifer system.

5.2.5 Alternative 13a

5.2.5.1 Reservoir Water Quality

Williams Fork Reservoir

No change in water quality would be expected from surface hydrology changes and thus no impacts would result from Alternative 13a.

Dillon Reservoir

No change in water quality would be expected from surface hydrology changes and thus no impacts would result from Alternative 13a.

Wolford Mountain Reservoir

Changes in water quality under Alternative 13a would be the same as the Proposed Action.

Gross Reservoir

The potential impacts to reservoir water quality under Alternative 13a would be similar to those described for the Proposed Action and slightly greater than those anticipated for Alternatives 8a and 10a. The reservoir size (and residence times) would be between those of the Proposed Action and Alternatives 8a and 10a. This would directly affect the area of land to be inundated and the short-term water quality impacts of increased organic carbon, nutrients, and mercury in fish tissue. Impacts to water quality in Gross Reservoir for Alternative 13a are expected to be minor to moderate for the short term and negligible for the long term.

Antero Reservoir/Eleven Mile Canyon Reservoir/Cheesman Reservoir/Strontia Springs Reservoir/Chatfield Reservoir

Changes in water quality under Alternative 13a would be similar to the Proposed Action.

Grand Lake, Shadow Mountain Reservoir, Granby Reservoir (The Three Lakes)

Changes in water quality in the Three Lakes under Alternative 13a would be similar to the Proposed Action.

5.2.5.2 River Segments

Water quality changes would be similar to those described for the Proposed Action. Operation of the Alternative 13a facilities would not significantly alter river flows in relation to Full Use of the Existing System.

5.2.5.3 South Platte River Facilities

Operation of the South Platte River gravel pit facilities would not significantly alter river flows in relation to Full Use of the Existing System and AWTP facilities would control the potential for additional nutrient loading in Ralston Reservoir.

5.2.6 No Action Alternative

5.2.6.1 Depletion of Strategic Water Reserve Strategy

To determine hydrologic changes to stream flow and reservoir operations as a result of the No Action Alternative, use of the Strategic Water Reserve Strategy was portrayed using the PACSM to provide the hydrology needed to compare the No Action Alternative with the action alternatives. In general, use of the Strategic Water Reserve creates greater hydrologic impacts than would occur if some level of restrictions were also imposed. The following sections describe in detail the hydrologic impacts of using the Strategic Water Reserve strategy.

As described below, the No Action Alternative (Depleting the Strategic Water Reserve, no restrictions) would result in the following:

- Shortages in meeting both treated and raw water customer demands
- Use of the Strategic Water Reserve
- Frequent drawdown of Gross Reservoir to the minimum pool level
- Restrictions in the ability to use the Moffat WTP for about half of each year
- Increased overall system vulnerability, reduced water supply reliability, and reduced operational flexibility
- Reduced flexibility to react to droughts and emergencies

5.2.6.2 Reservoir Water Quality

Under the No Action Alternative, Denver Water must rely on their Strategic Water Reserve to try to meet their demands during droughts. During the 45-year study period Denver Water would need to use their Strategic Reserve in 4 years. In those years, system-wide storage (includes active capacity in Antero, Eleven Mile Canyon, Cheesman, Dillon, and Gross reservoirs) would be less than 120,000 AF and would be drawn down to a minimum of approximately 68,400 AF by the end of the critical period. These figures are based on not imposing mandatory restrictions during a drought. Denver Water's raw water and treated customers would also experience shortages. The maximum shortages to raw water and treated demands would occur during the critical period. Based on trying to meet an unconstrained demand, however, Denver Water's raw water customers would be short by approximately 9,600 AF and treated water demands would be short by approximately 600 AF during the critical period.

The hydrologic changes described in the following sections are based on a comparison of the Full Use of the Existing System scenario and the No Action Alternative.

Williams Fork Reservoir

Minor changes are predicted in flow into and out of the Williams Fork Reservoir between Full Use of the Existing System and No Action Alternative. Changes in flow into the reservoir would range from -2 to 0%, where changes in reservoir releases would range from -7 to 7%. Thus, change in water quality in the Williams Fork Reservoir would not be

expected to be caused by the No Action Alternative, rather by changes between Current Conditions (2006) and Full Use of the Existing System conditions.

Dillon Reservoir

Dillon Reservoir water quality is influenced by upstream water quality from the Blue River, changes in reservoir operations or water surface elevations, and evaporation. Blue River water quality is not expected to change as a result of any action alternative. Reservoir water surface elevation is expected to fluctuate but water quality would not be significantly affected. Therefore, water quality in Dillon Reservoir is not expected to change as a result of the No Action Alternative.

Wolford Mountain Reservoir

Wolford Mountain water quality is influenced by upstream water quality from Muddy Creek, changes in reservoir operations or water surface elevations, and evaporation. Muddy Creek water quality upstream of Wolford Mountain Reservoir is not expected to change as a result of the No Action Alternative. The reservoir would experience little change in water surface elevation. Therefore, water quality in Wolford Mountain Reservoir is not expected to change as a result of the No Action Alternative (2032).

Gross Reservoir

Gross Reservoir water quality under the No Action Alternative would be anticipated to be similar to Full Use of the Existing System due to similar inflow concentrations and residence times. Annual ranges of water levels would also be similar, though ranges would be slightly greater for the No Action Alternative. Unlike the action alternatives, there would not be a short-term increase in organic carbon, nutrient concentrations, or mercury concentrations in fish tissue, since no additional areas would be inundated from an enlarged reservoir. Impacts to water quality in Gross Reservoir would be negligible.

Antero Reservoir

Antero Reservoir water quality is influenced by upstream water quality from the South Platte River, changes in reservoir operations or water surface elevations, and evaporation. The reservoir would experience infrequent and small change in water surface elevation and contents under the No Action Alternative as compared to Full Use of the Existing System conditions. Therefore, water quality in Antero Reservoir is not expected to change due to the No Action Alternative.

Eleven Mile Canyon Reservoir

Water quality in Eleven Mile Canyon Reservoir is influenced by upstream water quality from the South Platte River, changes in reservoir operations or water surface elevations, and evaporation. Reductions to reservoir contents would be greater under the No Action Alternative than with other alternatives, but it is unlikely to affect water quality. Therefore, water quality in Eleven Mile Canyon Reservoir is not expected to change due to the No Action Alternative as compared to Full Use of the Existing System and no impacts are anticipated.

Cheesman Reservoir

Cheesman Reservoir water quality is influenced by upstream water quality from the South Platte River, changes in reservoir operations or water surface elevations, and evaporation. Reductions to reservoir content would be greater under the No Action Alternative than with other alternatives, but it is unlikely to affect water quality. Therefore, water quality in Cheesman Reservoir is not expected to change due to the No Action Alternative when compared to Full Use of the Existing System.

Strontia Springs Reservoir

Strontia Springs Reservoir water quality is influenced by upstream water quality from the South Platte River, changes in reservoir operations or water surface elevations, and evaporation. Water quality changes in the South Platte River are possible with regard to copper, iron, and nickel; however, increased Roberts Tunnel deliveries would result in less impact under No Action Alternative compared to Full Use of the Existing System conditions. The reservoir would operate within the same general range of water surface elevation and therefore water quality changes are not expected due to operational changes associated with No Action Alternative.

Chatfield Reservoir

Chatfield Reservoir water quality is influenced by upstream water quality from the South Platte River, changes in reservoir operations or water surface elevations, and evaporation. Roberts Tunnel would experience greater annual deliveries under the No Action Alternative compared to Full Use with a Project Alternative (2032) (refer to Table H-3.34), potentially resulting in greater annual phosphorus loadings to Chatfield Reservoir. Additionally, South Platte River inflow water quality changes are possible with regard to copper, iron, and nickel. The reservoir would operate within the same range of water surface elevation and minor water quality impacts would be expected from the No Action Alternative.

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

Changes in water quality in the Three Lakes under the No Action Alternative would be similar to the Proposed Action.

Shadow Mountain Reservoir is listed on the 303(d) List for DO. Modeling results for DO indicate no change would occur between Full Use of the Existing System Conditions and the No Action Alternative. Thus, the No Action Alternative is not anticipated to cause or contribute to the identified impairment of Shadow Mountain Reservoir.

5.2.6.3 River Segments

Fraser River

Slight flow changes are predicted between No Action and Full Use of the Existing System. Flow decreases are less than under Full Use with a Project Alternative (2032) conditions. Thus, impacts attributed to the Proposed Action would be less under No Action.

Williams Fork River

The No Action Alternative would result in less water diverted from the four headwater creeks compared to Full Use with a Project Alternative (2032) conditions. However, water quality data, as shown and discussed in the Proposed Action, indicate that changes are not expected.

Colorado River

Impacts from the No Action Alternative would be similar to the Proposed Action. For all Alternatives, PACSM results predict less than 15% change in flow with no change in dry years. The flow reduction in summer months would be less under the No Action Alternative. Impacts are anticipated to be negligible.

Muddy Creek

Changes in the quantity and timing of flows in Muddy Creek would be infrequent and minor; therefore, no changes in water quality are anticipated under the No Action Alternative.

Blue River

Most changes in Blue River flows under the No Action Alternative occur between Current Conditions (2006) and Full Use of the Existing System. Thus, negligible to minor additional impacts between Full Use of the Existing System and the No Action Alternative are anticipated. The exceptions are June and August of average years and October and April of wet years. To identify impacts between Full Use of the Existing System and the No Action Alternative, Tables 5.2-4 and 5.2-5 were developed. The percent treated wastewater for those periods in which flow decreases, on average, is shown in Table 5.2-4. Table 5.2-5 shows a projected change in October of wet years. Negligible impacts are anticipated as a result of the No Action Alternative.

Table 5.2-4
Estimated Percent Wastewater in the Blue River, Downstream of Dillon Reservoir

Alternative	Average Flow Released from Dillon Reservoir[1] (cfs)	2032		
		Estimated Wastewater Flow[2] (mgd)	River that is Wastewater[3] (%)	Difference in River Content that is Wastewater (%)
June, Average Years				
Full Use of the Existing System	561	8.7	1.5	--
Full Use with No Action (2032)	474	5.6	1.8	0.3
August, Average Years				
Full Use of the Existing System	123	8.7	7.1	--
Full Use with No Action (2032)	99	8.7	8.8	1.7
October, Wet Years				
Full Use of the Existing System	68	8.7	12.8	--
Full Use with No Action (2032)	50	8.7	17.3	4.5

Table 5.2-4 (continued)
Estimated Percent Wastewater in the Blue River, Downstream of Dillon Reservoir

Alternative	Average Flow Released from Dillon Reservoir[1] (cfs)	2032		
		Estimated Wastewater Flow[2] (mgd)	River that is Wastewater[3] (%)	Difference in River Content that is Wastewater (%)
April, Wet Year				
Full Use of the Existing System	133	8.7	6.5	--
Full Use with No Action (2032)	112	8.7	7.7	1.2

Notes:
[1]Per PACSM.
[2]Calculated using projected population change and 80% of existing permitted capacity.
[3]One-hundred times the wastewater flow divided by the released flow.
-- = no difference
% = percent
cfs = cubic feet per second
mgd = million gallons per day

Tributary influences compared to releases from Dillon Reservoir are estimated using the PACSM information at the node just downstream of Boulder Creek as shown in Table 5.2-5. There would be less than 10% overall difference in the wastewater percentage of river flows. A substantial change occurs in October of wet years but as noted in Section 4.6.2, no impact is anticipated on wastewater dischargers permits because of the higher flows and assimilative capacity in these wetter years.

Table 5.2-5
Estimated Influences of Tributaries to the Blue River

Scenario	Average Flow Released from Dillon Reservoir[1] (cfs)	Average Flow Downstream of Boulder Creek (cfs)	River from Dillon Reservoir (%)[2]	Difference in River Content that is Wastewater (%)
June, Average Years				
Full Use of the Existing System	561	834	67	--
Full Use with No Action (2032)	474	748	63	5.8
August, Average Years				
Full Use of the Existing System	123	227	54	--
Full Use with No Action (2032)	99	203	49	10.0
October, Wet Years				
Full Use of the Existing System	68	119	57	--
Full Use with No Action (2032)	50	101	49	13.4
April, Wet Years				
Full Use of the Existing System	133	196	68	--
Full Use with No Action (2032)	112	176	64	6.2

Notes:
[1]Per PACSM.
[2]Average flow from Dillon divided by the average flow downstream of Boulder Creek.
-- = no difference
% = percent
cfs = cubic feet per second

South Boulder Creek

Average monthly flows are not predicted to change by more than 10% between Full Use of the Existing System and the No Action Alternative. Effects related to Gross Reservoir water quality (outflow to South Boulder Creek) are expected to be negligible, since no significant effects are anticipated in the reservoir for the No Action Alternative relative to Full Use of the Existing System. Additionally, Moffat WTP is projected to operate at minimal capacity or be off-line for an average of 6 months per year (mid-October to mid-April) under the No Action Alternative.

North Fork South Platte River

In general, more water would be diverted through Roberts Tunnel to the North Fork South Platte River under the No Action Alternative than under Full Use of the Existing System conditions. Water quality changes in the North Fork due to increased diversions through Roberts Tunnel are described in Section 4.6.2. Some of these changes would result from Full Use of the Existing System independent of the No Action Alternative.

South Platte River

As noted in Section 4.6.2, for purposes of water quality analysis, the South Platte River was divided into four sections based on the available data from gage stations. The following four sections of the South Platte River are discussed below: (1) Antero Reservoir to the confluence of the North Fork South Platte River, (2) the confluence of the North Fork South Platte River to Chatfield Reservoir, (3) Chatfield Reservoir to the Denver gage, and (4) the Denver gage to Henderson gage.

Antero Reservoir to the Confluence with the North Fork South Platte River

Changes in flow would be similar (within 3 cfs) to the Proposed Action. Thus, as no changes are anticipated with the Proposed Action, no changes are anticipated under the No Action Alternative.

Confluence of the North Fork South Platte River to Chatfield Reservoir

Releases from Cheesman Reservoir would be similar to the Proposed Action. Annual deliveries through Roberts Tunnel, however, would be greater with the No Action Alternative than under the Proposed Action, and impacts described in Section 5.2 are primarily attributable to the changes resulting from Full Use of the Existing System.

The South Platte River from the outlet of Cheesman Reservoir to the confluence with Fourmile Creek is on the Monitoring and Evaluation List for Aquatic Life Use (CDPHE 2012a). A discussion of the Aquatic Life Use listing and potential impacts related to the Proposed Action is presented in Section 5.11.

Chatfield Reservoir to the Denver Gage

Under the No Action Alternative, water quality changes in the South Platte River downstream of Chatfield Reservoir to the Denver gage would be similar to the Proposed Action.

Denver Gage to Henderson Gage

As noted in Section 4.6.2, no impacts to water quality are anticipated under the No Action Alternative.

Stream Segments Outside the Project Area Listed in Regulation 93 or Having a TMDL

As described in Section 3.2, portions of the Colorado River, South Boulder Creek, and the South Platte River are listed in Regulation 93 on Colorado's 303(d) and Monitoring and Evaluation Lists, or have had TMDLs developed. These segments are discussed below.

Colorado River

As described in Section 4.6.2, no changes are anticipated for the segments downstream of Kremmling.

South Platte River

As noted in Section 4.6.2, no changes are anticipated for the segments downstream of Henderson as a result of the No Action Alternative.

Boulder Creek

Boulder Creek from 107th Street to the Confluence with Coal Creek is provisionally listed on the 303(d) List for Aquatic Life Use, and Boulder Creek from Coal Creek to St. Vrain Creek is on the Monitoring and Evaluation List for Aquatic Life Use (CDPHE 2012a). A discussion of the Aquatic Life Use listings and potential impacts related to the Proposed Action is presented in Section 5.11.

As noted in Section 4.6.2, no changes are anticipated for the segments downstream of South Boulder Creek at State Highway 93 as a result of the No Action Alternative.

5.2.6.4 Combination Strategy

No additional water quality impacts would result from implementing the Combination Strategy. During a drought, stream flows could decrease in some streams because less water would be released from storage.

5.2.7 Mitigation and Monitoring

Denver Water would be required to implement a stormwater management plan for construction activities, which would be prepared in compliance with CDPHE's General Permit for Stormwater Discharges Associated with Construction Activities. The plan and permit would specify BMPs and inspection requirements to reduce pollutants in stormwater runoff from the construction sites. Additional water quality requirements may be part of the 401 Certification process.

Denver Water intends to continue its present water quality monitoring program, subject to annual reviews as follows:

1. Inflow and outflow quantity and water level in Gross Reservoir.

2. Inflow water quality in South Boulder Creek, during the range of flow conditions, capturing four high flow time periods and four low flow time periods. Parameters to continue monitoring include alkalinity, conductivity, pH, TSS, turbidity, metals, phosphorus, hardness, and DO.
3. Outflow water quality in South Boulder Creek during the range of flow conditions, capturing at least four high flow time periods and four low flow time periods. Parameters to continue monitoring include alkalinity, conductivity, pH, TSS, turbidity, metals, phosphorus, hardness, DO, coliforms, total kjeldahl nitrogen, ammonia, and TOC.
4. Reservoir water quality over the depth profile of the photic zone with three samples in the photic zone at two locations. Photic zone samples will be combined into one composite sample of the photic zone and monitored for phosphorus and chlorophyll *a*. Additionally, water quality at the same two locations would be sampled in the hypolimnion for DO, temperature, turbidity, pH, and specific conductance.
5. Water clarity (by Secchi disk) from the surface of the reservoir will be assessed periodically throughout the periods when the reservoir surface is not frozen.

Mitigation actions would be planned in response to possible water quality issues, and might include:

1. Use of hypolimnetic aeration may be considered if DO issues occur, however, it is not anticipated that DO issues will develop for the anticipated reservoir releases.
2. Limitation of access as it relates to activities with potentially negative influence on water quality. Examples would include continued prohibitions on body contact, prohibitions on all boating beyond non-motorized car-top boats, and prohibitions on animal contact. Additional limitations, if warranted by water quality concerns, may include prohibitions on all boating and ice fishing and restriction of access to the shoreline.

5.2.8 Unavoidable Adverse Impacts

Unavoidable impacts include:

- Short-term increases in phosphorus, chlorophyll *a*, and mercury in fish tissue in Gross Reservoir due to inundation of new areas with reservoir expansion. Removal of vegetation prior to inundation would reduce these effects.
- Decrease in outflow temperatures from Gross Reservoir due to expansion of the volume of the hypolimnion. Outflow temperatures to South Boulder Creek are discussed in Section 5.11 relative to aquatic life concerns.
- Seasonal changes in phosphorus loading are expected in Chatfield Reservoir resulting from increases in Roberts Tunnel deliveries. Annual loadings are anticipated to remain similar.
- Changes in metal concentrations are expected in the North Fork South Platte River with increases expected during periods of reduced Roberts Tunnel deliveries.

5.3 CHANNEL MORPHOLOGY

This section presents predicted potential changes in stream morphology and sedimentation resulting from the Moffat Collection System Project (Moffat Project or Project) alternatives as compared to Full Use of the Existing System. One potential issue was documented related to channel morphology during scoping:

- Impacts of changes in the flow regime on sediment loads, channel stability, and geomorphology.

Channel morphology would not be impacted by construction activities at Gross Reservoir, Leyden Gulch Reservoir, various conveyance structures (Conduit M, Conduit O, and gravel pit pipelines), the South Platte River Facilities, or the Denver Basin Aquifer Facilities. Thus, Project impacts to channel morphology associated with these alternative components were not evaluated. Rather, analysis focused on potential impacts to channel morphology associated with stream flow changes between Full Use of the Existing System and implementation of a Project alternative.

5.3.1 Geomorphologic Impacts at Representative Reaches

As described in Section 3.3.5, the Project area encompasses several river basins; therefore, it was impractical to collect and analyze detailed geomorphological data on every potentially affected river reach. Instead, detailed data were collected at 16 Representative sites (refer to Figure 3.0-2, Figure 3.0-3, and Figures E-4.1 through E-4.6 in Appendix E-4). 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. Anticipated impacts were quantified at the 16 Representative sites using the numeric approaches outlined in Section 4.6.3. Annual sediment transport capacity and supply, the threshold for and frequency of Phase 2 sediment transport, magnitude of peak flood events, and effective discharge calculations were calculated for Project alternatives. Results are presented below with numeric values for all Project alternatives compared with Full Use of the Existing System to assess potential impacts.

The Moffat Project alternatives would result in different flow conditions throughout the Project area. Differences in flows have the potential to result in changes in stream morphology. Anticipated flows for each of the Project alternatives were evaluated for the stream morphology assessment. All calculations were based on the daily flow data derived from the 45 years of daily Platte and Colorado Simulation Model (PACSM) output. Daily data was then compiled in a variety of manners as required for the specific calculations performed. Different uses of the hydrology data for the channel morphology assessment are described in this section.

Based on PACSM output for the alternatives, hydrologic changes would be similar for certain alternatives. Flow duration curves and flood analyses for each of the alternatives showed little difference between the Proposed Action (Alternative 1a) and Alternative 1c,

and between Alternatives 8a, 10a, and 13a. The Proposed Action and Alternative 1c both include 77,000 acre-feet (AF) of new storage in the Moffat Collection System, with the only difference being the location of new storage on the East Slope (i.e., Gross Reservoir and Leyden Gulch Reservoir). As a result, there is very little difference in hydrologic output between these alternatives. Alternatives 8a, 10a, and 13a have the same or similar quantities of new storage at Gross Reservoir and rely on South Platte River supplies (reusable effluent or transferred agricultural water) to generate 3,000 to 5,000 acre-feet per year (AF/yr) of new firm yield. There is also very little difference in hydrologic output between these alternatives. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Annual Sediment Transport Capacity

Annual bedload sediment transport capacity was determined at the Representative sites using the four transport equations. Calculations based on bedload exclude suspended sediment, which typically comprises a majority of the total sediment transported. Given the uncertainty in numeric results from any of the individual transport equations, comparing results derived from the four different equations is intended to provide an indication of the range of transport capacity expected for each Project alternative. Results of annual bedload transport capacity for Full Use of the Existing System, the No Action Alternative, the Proposed Action (Alternative 1a), and Alternative 8a are presented in Table 5.3-1. Figures showing transport capacity at the Representative sites are provided as Figures H-10.1 to H-10.16 in Appendix H-10.

Table 5.3-1
Calculated Annual Bedload Transport Capacity (Tons/Year)

Site	Equation	Full Use of the Existing System	No Action Alternative	Proposed Action (Alternative 1a)	Alternative 8a
FR1	Parker	180	152	84	87
	W-C	544	458	253	272
	Yang	5,497	4,957	3,496	3,591
	MPM	23,127	21,697	17,736	18,006
FR2	Parker	1,220	1,129	779	802
	W-C	1,674	1,561	1,037	1,060
	Yang	17,106	16,296	13,046	13,292
	MPM	61,520	59,142	51,077	51,996
FR3	Parker	1,133	1,078	734	763
	W-C	1,248	1,200	844	865
	Yang	1,363	1,293	965	1,002
	MPM	12,170	11,541	8,462	8,797
FR4	Parker	2,178	2,081	1,499	1,574
	W-C	1,440	1,406	1,177	1,204
	Yang	3,263	3,128	2,521	2,609
	MPM	177,150	173,027	156,028	159,025

Table 5.3-1 (continued)
Calculated Annual Bedload Transport Capacity (Tons/Year)

Site	Equation	Full Use of the Existing System	No Action Alternative	Proposed Action (Alternative 1a)	Alternative 8a
FR5	Parker	252	222	128	132
	W-C	282	249	145	149
	Yang	606	526	292	306
	MPM	1,733	1,537	939	973
FR6	Parker	0	0	0	0
	W-C	1	1	0	0
	Yang	77	63	38	39
	MPM	1,466	1,242	772	793
FR7	Parker	142	154	216	202
	W-C	126	136	182	172
	Yang	3,176	3,250	3,515	3,469
	MPM	12,815	13,097	14,106	13,932
WF1	Parker	1,225	1,178	956	985
	W-C	4,617	4,497	3,911	3,979
	Yang	10,563	10,274	9,166	9,360
	MPM	26,705	26,054	23,572	24,018
WF2	Parker	1,396	1,341	1,077	1,116
	W-C	1,384	1,353	1,196	1,215
	Yang	5,302	5,078	4,211	4,357
	MPM	37,691	35,953	29,908	31,082
CR1	Parker	36	35	30	31
	W-C	50	48	42	43
	Yang	13,339	13,091	12,141	12,262
	MPM	60,717	60,039	57,346	57,740
CR2	Parker	576	547	492	508
	W-C	616	589	530	547
	Yang	6,662	6,494	6,014	6,073
	MPM	117,869	116,276	111,073	111,798
BR1	Parker	0	0	0	0
	W-C	0	0	0	0
	Yang	2,764	2,398	2,594	2,613
	MPM	91,783	79,887	86,041	86,618
NF1	Parker	52	68	92	91
	W-C	179	222	277	274
	Yang	41,562	44,584	44,417	44,300
	MPM	144,472	151,463	151,384	151,089
NF2	Parker	96	112	139	137
	W-C	401	472	569	562
	Yang	38,553	41,839	41,809	41,626
	MPM	73,340	79,567	80,300	79,938

Table 5.3-1 (continued)
Calculated Annual Bedload Transport Capacity (Tons/Year)

Site	Equation	Full Use of the Existing System	No Action Alternative	Proposed Action (Alternative 1a)	Alternative 8a
SBC1	Parker	6	6	10	9
	W-C	12	13	20	20
	Yang	26,088	26,861	29,581	29,214
	MPM	187,714	189,486	197,204	196,282
SBC3	Parker	3,023	3,380	1,343	1,383
	W-C	374	417	178	183
	Yang	22,999	23,680	22,232	22,105
	MPM	506,938	517,575	573,402	569,868

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Large disparities in the calculated bedload transport capacity utilizing the different equations illustrate significant uncertainty in defining actual capacity. The following conclusions can be drawn from the calculated transport results shown in the table:

- The order of magnitude of transport capacity calculated using the Parker and Wilcock and Crowe (2003) equations are generally the same.
- Transport capacity calculated using the Yang equation is typically an order of magnitude greater than that calculated using the Parker or Wilcock and Crowe equation.
- Transport capacity calculated using the 1948 Meyer-Peter and Müller (MPM) equation is the largest, often exceeding values calculated using the Yang equation by an order of magnitude.
- Transport capacity calculated using the Parker and Wilcock and Crowe equations often produce results which are unreasonably low and which contradict observed conditions. Extreme examples of this include BR1 where results indicate that the stream has the capacity to move less than 2 ton per year of bedload, CR1 (< 50 tons/year), NF1 (< 75 tons/year), and SBC1 (<15 tons per year). Were these results to be accurate, large amounts of sediment would be accumulating and bed deposition would have occurred, neither of which has been observed based on direct observation or results of aerial and gage data analysis. For these reasons results of the Parker and Wilcock and Crowe equations are believed to underestimate sediment transport for at least some locations.

Given the range of results obtained from this numeric analysis and the uncertainty associated with any one equation, it is difficult to accurately predict the absolute sediment transport capacity value at the Representative sites. It is, however, possible to use the numeric data to determine the relative change in calculated transport capacity as the percent change is generally independent of the specific equation used. The percent change in annual transport capacity was therefore calculated in relation to the capacity at Full Use of the Existing System as a means of quantifying potential impacts.

Percent change was determined for each of the four transport equations as the ratio of transport capacity for a given alternative with reasonably foreseeable future actions to the transport capacity for Full Use of the Existing System. The range, mean and standard deviation of the percent change from the different equations was also determined. This metric provides an indication of the change in transport capacity that is expected when Project alternatives are compared to Full Use of the Existing System. Values below present annual bedload transport capacity as a percentage of capacity calculated for Full Use of the Existing System. Results are presented in Table 5.3-2 and discussed by watershed. Note that in the case of sites FR6 and BR1, the Parker and Wilcock and Crowe equations predicted that annual bedload transport capacity for Full Use of the Existing System was an unrealistic value of one ton per year or less. These values were excluded from the calculations as indicated in the table below.

As results below indicate, the four different equations typically predict similar percent change in annual sediment transport capacity. In case sites where the percentage change predicted by the different equations results in a wider range of values, the wide range is usually attributable to one or more equation predicting a very low annual transport capacity.

Table 5.3-2
Calculated Annual Bedload Transport Capacity as a Percent of Full Use of the Existing System

Site	Equation	Full Use of the Existing System	No Action Alternative	Proposed Action (Alternative 1a)	Alternative 8a
FR1	Parker	100%	84%	47%	48%
	W-C	100%	84%	47%	50%
	Yang	100%	90%	64%	65%
	MPM	100%	94%	77%	78%
	Range	N/A	84%-94%	47%-77%	48%-78%
	Average	N/A	88%	58%	60%
	St. Dev.	N/A	5%	15%	14%
FR2	Parker	100%	93%	64%	66%
	W-C	100%	93%	62%	63%
	Yang	100%	95%	76%	78%
	MPM	100%	96%	83%	85%
	Range	N/A	93%-96%	62%-83%	63%-85%
	Average	N/A	94%	71%	73%
	St. Dev.	N/A	2%	10%	10%
FR3	Parker	100%	95%	65%	67%
	W-C	100%	96%	68%	69%
	Yang	100%	95%	71%	74%
	MPM	100%	95%	70%	72%
	Range	N/A	95%-96%	65%-71%	67%-74%
	Average	N/A	95%	68%	71%
	St. Dev.	N/A	1%	3%	3%

Table 5.3-2 (continued)
Calculated Annual Bedload Transport Capacity as a Percent of Full Use of the Existing System

Site	Equation	Full Use of the Existing System	No Action Alternative	Proposed Action (Alternative 1a)	Alternative 8a
FR4	Parker	100%	96%	69%	72%
	W-C	100%	98%	82%	84%
	Yang	100%	96%	77%	80%
	MPM	100%	98%	88%	90%
	Range	N/A	96%-98%	69%-88%	72%-90%
	Average	N/A	97%	79%	81%
	St. Dev.	N/A	1%	8%	7%
FR5	Parker	100%	88%	51%	52%
	W-C	100%	88%	51%	53%
	Yang	100%	87%	48%	50%
	MPM	100%	89%	54%	56%
	Range	N/A	87%-89%	48%-54%	50%-56%
	Average	N/A	88%	51%	53%
	St. Dev.	N/A	1%	2%	2%
FR6	Parker	Excluded	Excluded	Excluded	Excluded
	W-C	Excluded	Excluded	Excluded	Excluded
	Yang	100%	82%	49%	51%
	MPM	100%	85%	53%	54%
	Range	N/A	82%-85%	49%-53%	51%-54%
	Average	N/A	83%	51%	52%
	St. Dev.	N/A	2%	2%	2%
FR7	Parker	100%	108%	152%	142%
	W-C	100%	108%	144%	137%
	Yang	100%	102%	111%	109%
	MPM	100%	102%	110%	109%
	Range	N/A	102%-108%	110%-152%	109%-142%
	Average	N/A	105%	129%	124%
	St. Dev.	N/A	3%	22%	18%
WF1	Parker	100%	96%	78%	80%
	W-C	100%	97%	85%	86%
	Yang	100%	97%	87%	89%
	MPM	100%	98%	88%	90%
	Range	N/A	96%-98%	78%-88%	80%-90%
	Average	N/A	97%	84%	86%
	St. Dev.	N/A	1%	5%	4%

Table 5.3-2 (continued)
Calculated Annual Bedload Transport Capacity as a Percent of Full Use of the Existing System

Site	Equation	Full Use of the Existing System	No Action Alternative	Proposed Action (Alternative 1a)	Alternative 8a
WF2	Parker	100%	96%	77%	80%
	W-C	100%	98%	86%	88%
	Yang	100%	96%	79%	82%
	MPM	100%	95%	79%	82%
	Range	N/A	95%-98%	77%-86%	80%-88%
	Average	N/A	96%	81%	83%
	St. Dev.	N/A	1%	4%	3%
CR1	Parker	100%	97%	83%	86%
	W-C	100%	96%	84%	86%
	Yang	100%	98%	91%	92%
	MPM	100%	99%	94%	95%
	Range	N/A	96%-99%	83%-94%	86%-95%
	Average	N/A	98%	88%	90%
	St. Dev.	N/A	1%	5%	4%
CR2	Parker	100%	95%	85%	88%
	W-C	100%	96%	86%	89%
	Yang	100%	97%	90%	91%
	MPM	100%	99%	94%	95%
	Range	N/A	95%-99%	85%-94%	88%-95%
	Average	N/A	97%	89%	91%
	St. Dev.	N/A	2%	4%	3%
BR1	Parker	Excluded	Excluded	Excluded	Excluded
	W-C	Excluded	Excluded	Excluded	Excluded
	Yang	100%	87%	94%	95%
	MPM	100%	87%	94%	94%
	Range	N/A	87%-87%	94%-94%	94%-95%
	Average	N/A	87%	94%	94%
	St. Dev.	N/A	0%	0%	0%
NF1	Parker	100%	131%	177%	175%
	W-C	100%	124%	155%	153%
	Yang	100%	107%	107%	107%
	MPM	100%	105%	105%	105%
	Range	N/A	105%-131%	105%-177%	105%-175%
	Average	N/A	117%	136%	135%
	St. Dev.	N/A	13%	36%	35%

Table 5.3-2 (continued)
Calculated Annual Bedload Transport Capacity as a Percent of Full Use of the Existing System

Site	Equation	Full Use of the Existing System	No Action Alternative	Proposed Action (Alternative 1a)	Alternative 8a
NF2	Parker	100%	117%	145%	143%
	W-C	100%	118%	142%	140%
	Yang	100%	109%	108%	108%
	MPM	100%	108%	109%	109%
	Range	N/A	108%-118%	108%-145%	108%-143%
	Average	N/A	113%	126%	125%
	St. Dev.	N/A	5%	20%	19%
SBC1	Parker	100%	100%	167%	150%
	W-C	100%	108%	167%	167%
	Yang	100%	103%	113%	112%
	MPM	100%	101%	105%	105%
	Range	N/A	100%-108%	105%-167%	105%-167%
	Average	N/A	103%	138%	133%
	St. Dev.	N/A	4%	33%	30%
SBC3	Parker	100%	112%	44%	46%
	W-C	100%	111%	48%	49%
	Yang	100%	103%	97%	96%
	MPM	100%	102%	113%	112%
	Range	N/A	102%-112%	44%-113%	46%-112%
	Average	N/A	107%	75%	76%
	St. Dev.	N/A	5%	35%	34%

Notes:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.
N/A = not applicable

5.3.1.1 Fraser River Basin

Results indicate that with the exception of Vasquez Creek (FR7), bedload transport capacity under the Project alternatives would generally decrease at all sites in the Fraser River Basin when compared to Full Use of the Existing System. Capacities would decrease by the greatest percentage at locations in close proximity to diversions and nearest the main stem of the Fraser River (FR1, FR5, and FR6). Reductions in bedload transport capacity are predicted to be less dramatic on tributary streams further downstream of Winter Park as evidenced by predicted capacity reductions on Ranch Creek (FR4) and St. Louis Creek (FR3) relative to predicted reductions on upper Fraser River (FR1 and FR5) and Jim Creek (FR6) sites. The Board of Water Commissioners' (Denver Water's) operation of the system, where more water is taken from diversions closest to the Moffat Tunnel, results in these areas having the greatest flow and transport capacity reductions. Capacities in Vasquez Creek are predicted to increase at the FR7 site as this is a location where additional flow is added to the system from diversions in the Williams Fork River.

When comparing the different alternatives, the No Action Alternative results in the smallest change in transport capacity when compared to Full Use of the Existing System. Under the No Action Alternative, calculated transport capacity at FR1 and FR5 are predicted to decrease by approximately 12 percent (%) based on the average of the four transport equations. Capacity in Jim Creek (FR6) is calculated to decrease by 17% while the capacity in Vasquez Creek above Denver Water's diversion (FR7) is predicted to increase by 5%. Transport capacities at all other sites are predicted to decrease by no more than 6% based on the average of the four transport equations.

Bedload transport capacity reductions resulting from the Proposed Action and Alternative 8a are generally similar and predicted to be the greatest of the alternatives. Calculated capacities at FR1, FR5, and FR6 are predicted to decrease by approximately 40%-50% based on the average of the four transport equations when compared to Full Use of the Existing System. Capacities at FR2, FR3, and FR4 are predicted to decrease by approximately 20%-35%. The capacity in Vasquez Creek above the diversion is predicted to increase by approximately 25%-30%.

5.3.1.2 Williams Fork River Basin

Results indicate that bedload transport capacity would decrease in the Williams Fork River for all Project alternatives when compared to Full Use of the Existing System. Capacities would decrease by the greatest percentage higher in the basin (WF2) than lower (WF1). This is due to inflows from additional tributaries muting flow and transport capacity reductions further downstream.

When comparing the different alternatives, the No Action Alternative results in the smallest change to transport capacity. Under the No Action Alternative, calculated transport capacity at WF1 and WF2 are predicted to decrease by approximately 3% and 4%, respectively when compared to Full Use of the Existing System based on the average of the four transport equations. Bedload transport capacity reductions resulting from the Proposed Action and Alternative 8a are generally similar and predicted to be the greatest of the alternatives. Calculated capacity at WF1 is predicted to decrease by approximately 15% when compared to Full Use of the Existing System; transport capacity at WF2 is predicted to decrease by approximately 18%.

5.3.1.3 Colorado River Basin

Results indicate that bedload transport capacity would decrease in the Colorado River for Project alternatives when compared to Full Use of the Existing System. Capacities would decrease by similar percentages at the upstream (CR1) and downstream (CR2) sites.

When comparing the different alternatives, the No Action Alternative results in the smallest change to transport capacity when compared to Full Use of the Existing System. Under the No Action Alternative, calculated transport capacities at CR1 and CR2 are predicted to be reduced by approximately 3% based on the average of the four transport equations. Bedload transport capacity reductions resulting from the Proposed Action and Alternative 8a are generally similar and predicted to be the greatest of the alternatives. Calculated capacities at CR1 and CR2 are predicted to decrease by between 9% and 12% when compared to Full Use of the Existing System.

5.3.1.4 Blue River Basin

Results indicate that bedload transport capacity under the different Project alternatives would be reduced in the Blue River when compared to Full Use of the Existing System. When comparing the different alternatives, the Proposed Action and Alternative 8a are predicted to change capacity by similar percentages. When compared to Full Use of the Existing System these alternatives are predicted to reduce bedload transport capacity by approximately 6% based on the average of the four transport equations. The No Action Alternative is expected to produce the greatest change in bedload transport with a decrease of approximately 13% when compared to Current Full Use of the Existing System.

5.3.1.5 North Fork South Platte River Basin

Results indicate that bedload transport capacity for the Project alternatives would increase in the North Fork when compared to Full Use of the Existing System. Capacities would increase by greatest greater percentage higher in the basin (NF1) than lower (NF2). This is due to inflows from additional tributaries muting flow augmentation effects further downstream.

When comparing the different alternatives, the No Action Alternative results in the smallest change to transport capacity when compared to Full Use of the Existing System. Under the No Action Alternative, calculated transport capacity at NF1 and NF2 are predicted to increase by approximately 17% and 13%, respectively based on the average of the four transport equations. Bedload transport capacity increases resulting from the Proposed Action and Alternative 8a are generally similar at NF1 and are predicted to increase by approximately 35% when compared to Full Use of the Existing System; transport capacity at NF2 is predicted to increase by approximately 25%.

5.3.1.6 South Boulder Creek Basin

Results indicate that bedload transport capacity would generally increase for Project alternatives in South Boulder Creek when compared to Full Use of the Existing System; however, decreases are expected below Gross Reservoir for some alternatives. Capacities below Gross Reservoir (SBC3) are predicted to increase for the No Action Alternative and decrease under the Proposed Action and Alternative 8a. Decreases in capacities for these alternatives are the result of the way releases from the reservoir would be managed. Under the Proposed Acton and Alternative 8a reservoir releases would increase during low flow periods and decrease during peak flow months when compared to Full Use of the Existing System. A reduction in releases during peak months, when the majority of bedload transport occurs, is the cause of the decrease in transport capacity.

When comparing the different alternatives, the No Action Alternative results in the smallest change to transport capacity when compared to Full Use of the Existing System both upstream and downstream of Gross Reservoir. Under the No Action Alternative, calculated transport capacity at SBC1 is predicted to increase by 3% while capacity at SBC3 is predicted to increase by 7% based on the average of the four transport equations. Bedload transport capacity increases at SBC1 resulting from the Proposed Action and Alternative 8a are generally similar and predicted to be approximately 35%. Calculated capacities at

SBC3 downstream of the reservoir are predicted to decrease by approximately 25% when compared to Full Use of the Existing System given the predicted release patterns.

5.3.1.7 Overall Bedload Transport Capacity Trends

Calculated bedload transport capacities follow anticipated trends. Capacities are predicted to reduce the most in areas where flow reductions are greatest and increase the most in areas with the largest increase in flows. Typically, changes in transport capacity are greatest under the Proposed Action and Alternative 8a and least for the No Action Alternative.

As discussed in Section 4.6.3, bedload sediment is in large part supplied from the channel bed and banks themselves during higher flow events. Decreases in flows predicted at different locations for the different Project alternatives therefore reduce both bedload supply and transport capacity. Similarly, areas where flows and transport capacity increases are predicted would also have increases in bedload sediment supply.

5.3.2 Sediment Supply

The bedload component of sediment supply is largely derived from sediment from within the channel that is mobilized in response to larger flow events. Changes in flow resulting from the different Project alternatives would therefore change bedload sediment in the streams. Changes in sediment transport were estimated using the supply equations presented in Section 4.6.3 for the Representative sites and the predicted flow durations data of the various alternatives. Changes in supply within the different basins are presented in this section. Table 5.3-3 shows calculated sediment supply at the Representative sites for the various Project alternatives. Changes in sediment supply for each alternative as a percent of Full Use of the Existing System are given in Table 5.3-4. Sediment supply curves are provided in the graphs in Figures H-10.1 to H-10.16 in Appendix H-10.

Table 5.3-3
Calculated Annual Sediment Supply (Tons/Year)

Site	Full Use of the Existing System	No Action Alternative	Proposed Action (Alternative 1a)	Alternative 8a
FR1	246	226	173	177
FR2	3,251	3,162	2,850	2,887
FR3	493	477	415	423
FR4	124	119	99	102
FR5	147	134	95	98
FR6	29	25	18	18
FR7	946	962	1,023	1,012
WF1	585	569	503	514
WF2	68	65	53	53
CR1	5,915	5,832	5,509	5,551
CR2	10,884	10,769	10,684	10,441
BR1	1,063	996	1,031	1,034

Table 5.3-3 (continued)
Calculated Annual Sediment Supply (Tons/Year)

Site	Full Use of the Existing System	No Action Alternative	Proposed Action (Alternative 1a)	Alternative 8a
NF1	7,586	8,269	8,200	8,174
NF2	8,911	9,967	10,704	10,621
SBC1	3,476	3,582	3,958	3,907
SBC3	4,504	4,609	4,705	4,676

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Table 5.3-4
Calculated Sediment Supply as Percent of Full Use of the Existing System

Site	Full Use of the Existing System	No Action Alternative	Proposed Action (Alternative 1a)	Alternative 8a
FR1	100%	92%	70%	72%
FR2	100%	97%	88%	89%
FR3	100%	97%	84%	86%
FR4	100%	96%	80%	82%
FR5	100%	91%	65%	67%
FR6	100%	86%	62%	62%
FR7	100%	102%	108%	107%
WF1	100%	97%	86%	88%
WF2	100%	96%	78%	78%
CR1	100%	99%	93%	94%
CR2	100%	99%	98%	96%
BR1	100%	94%	97%	97%
NF1	100%	109%	108%	108%
NF2	100%	112%	120%	119%
SBC1	100%	103%	114%	112%
SBC3	100%	102%	104%	104%

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

5.3.2.1 Fraser River Basin

Results indicate that with the exception of Vasquez Creek (FR7), sediment supply is predicted to decrease at all Representative sites for all Project alternatives when compared to Full Use of the Existing System. Similar to bedload transport capacity, supply would decrease by the greatest percentage at locations in closest proximity to diversions and nearest the main stem of the Fraser River (FR1, FR5, and FR6). Reductions in supply are predicted to be less dramatic on tributary streams further downstream of Winter Park as evidenced by supply reductions on Ranch Creek (FR4) and St. Louis Creek (FR3) relative to predicted reductions on the Fraser River (FR1 and FR5) and Jim Creek (FR6). Supply in

Vasquez Creek is predicted to increase at the FR7 site as this site is a location where additional flow is added to the system from diversions in the Williams Fork.

When comparing the different alternatives, the No Action Alternative results in the smallest change in supply when compared to Full Use of the Existing System. Under the No Action Alternative, calculated supply at FR1, FR5, and FR6 are predicted to decrease by approximately 8%-14%. Supply in Vasquez Creek above Denver Water's diversion (FR7) is predicted to increase by 2%. Supply at all other sites in the Fraser River Basin is predicted to decrease by no more than 4%.

Sediment supply reductions resulting from the Proposed Action and Alternative 8a are generally similar and predicted to be the greatest of the alternatives. Calculated capacities at FR1, FR5, and FR6 are predicted to decrease by approximately 28%-38% when compared to Full Use of the Existing System. Capacities at FR2, FR3, and FR4 are predicted to decrease by approximately 11%-20%. The capacity in Vasquez Creek above the diversion is predicted to increase by approximately 7%-8%.

5.3.2.2 Williams Fork River Basin

Results indicate that sediment supply would decrease in the Williams Fork for all Project alternatives when compared to Full Use of the Existing System. Supply would decrease by a greater percentage higher in the basin (WF2) than lower (WF1). This is due to inflows from additional tributaries muting flow and sediment supply reductions further downstream.

When comparing the different alternatives, the No Action Alternative results in the smallest change in sediment supply. Under the No Action Alternative, calculated supply at WF1 and WF2 are predicted to decrease by approximately 3% and 4%, respectively when compared to Full Use of the Existing System. Sediment supply reductions resulting from the Proposed Action and Alternative 8a are generally similar and predicted to be the greatest of the alternatives. Calculated supply at WF1 is predicted to decrease by approximately 12%-14% when compared to Full Use of the Existing System; supply at WF2 is predicted to decrease by approximately 22%.

5.3.2.3 Colorado River Basin

Results indicate that sediment supply would decrease in the Colorado River when compared to Full Use of the Existing System. Supply would decrease by a greater percentage higher in the basin (CR1) than lower (CR2). The Williams Fork River enters the Colorado River between CR1 and CR2, with additional inflows from the Williams Fork reducing changes to the existing flows and sediment supply.

When comparing the different alternatives, the No Action Alternative results in the smallest change in sediment supply when compared to Full Use of the Existing System. Under the No Action Alternative, calculated supply at CR1 and CR2 are predicted to decrease by 1% at each site when compared to Full Use of the Existing System. Sediment supply reductions resulting from the Proposed Action and Alternative 8a are generally similar and predicted to be the greatest of the alternatives. Calculated supply at CR1 is predicted to

decrease by approximately 6%-7% when compared to Full Use of the Existing System; supply at CR2 is predicted to decrease by approximately 2%-4%.

5.3.2.4 Blue River Basin

Results indicate that sediment supply given the different Project alternatives would be reduced in the Blue River when compared to Full Use of the Existing System as the result of lower flows. When comparing the different alternatives, the Proposed Action and Alternative 8a are predicted to change sediment supply by similar percentages. When compared to Full Use of the Existing System, each of these alternatives is predicted to reduce supply by approximately 3%. The No Action Alternative is expected to produce the greatest change in supply with a decrease of approximately 6% when compared to Full Use of the Existing System.

5.3.2.5 North Fork South Platte River Basin

Results indicate that sediment supply would increase in the North Fork South Platte River when compared to Full Use of the Existing System. Supply is predicted to increase by a greater percentage lower in the basin (NF2) rather than higher (NF1).

When comparing the different alternatives, the No Action Alternative results in the smallest change to sediment supply when compared to Full Use of the Existing System by a small amount. Under the No Action Alternative, calculated supply at NF1 and NF2 are predicted to increase by approximately 9% and 12%, respectively when compared to Full Use of the Existing System. Sediment supply increases resulting from the Proposed Action and Alternative 8a are generally similar at NF1 and are predicted to increase by approximately 8% when compared to Full Use of the Existing System); supply at NF2 is predicted to increase by approximately 20% at both locations when compared to Full Use of the Existing System.

5.3.2.6 South Boulder Creek Basin

Results indicate sediment supply would increase in South Boulder Creek when compared to Full Use of the Existing System. When comparing the different alternatives, the No Action Alternative results in the smallest change to sediment supply when compared to Full Use of the Existing System both upstream and downstream of the reservoir. Under the No Action Alternative, calculated supply at SBC1 is predicted to increase by 3% while supply at SBC3 is predicted to increase by 2%. Sediment supply increases at SBC1 resulting from the Proposed Action and Alternative 8a are generally similar and predicted to be approximately 12%-14%. Calculated supply at SBC3 downstream of the reservoir is predicted to increase by approximately 4% when compared to Full Use of the Existing System.

5.3.2.7 Overall Sediment Supply Trends

Calculated sediment supply follows anticipated trends related to flow changes. Supply is predicted to be reduced the most in areas where flow reductions are greatest and increased the most in areas with the largest increase in flows. Typically, changes in sediment supply are greatest under the Proposed Action and Alternative 8a and least for the No Action Alternative when compared to Full Use of the Existing System. Trends anticipated in

sediment supply generally mimic predicted changes in bedload transport capacity as both are influenced by flow changes in the same way.

5.3.3 Phase 2 Sediment Transport

The magnitude of flow required for the onset of Phase 2 sediment transport was determined at each Representative site. The required flow is a function of channel geometry and bed gradations and is not dependent on flow frequency; therefore, the flow required to initiate Phase 2 transport is the same for all alternatives. The recurrence interval, amount of the time flows equal or exceed the Phase 2 flow and maximum number of years between flow events large enough to cause Phase 2 transport were calculated based on the hydrology anticipated for each alternative using daily PACSM data. Results for the various alternatives were compared with results obtained for Full Use of the Existing System to assess how flow alternations would change the frequency and duration of Phase 2 transport.

Tables below present results calculated at the Representative site in each basin. Tabulated values include results calculated using both the Parker equation and the Wilcock and Crowe equation. Values in the text comparing results at the different sites and for the different alternatives are based on the average value derived from the Parker and Wilcock and Crowe equations. Figures showing transport for various flows and particle sizes are provided in Figures H-21.1 to H-21.32 in Appendix H-21.

5.3.3.1 Fraser River Basin

Flows required to initiate Phase 2 sediment transport were calculated for the Representative sites in the Fraser River based on the measured D_{16} material size observed at each of the sites. The calculated flow along with the recurrence interval, flow frequency and maximum number of years between Phase 2 flows were calculated and are presented below. Calculated values are presented on Table 5.3-5. Figures showing Phase 2 modeling results in the Fraser River Basin are presented in Figures H-21.1 to H-21.14 in Appendix H-21.

Table 5.3-5
Phase 2 Sediment Transport Calculations – Fraser River Basin

Site	D_{16} (mm) (Size Class)	$Q_{Phase\ 2}$ (cfs) (Parker / W-C)	Alternative	Recurrence Interval (yrs) (Parker / W-C)	Frequency Phase 2 Flow is Equaled or Exceeded (Parker / W-C)	Max. Duration between Phase 2 Flows (yrs) (Parker / W-C)
FR1	4 (fine gravel)	123 / 75	Full Use	1.9 / 1.8	1.8% / 2.7%	5 / 5
			No Action	2.1 / 1.8	1.6% / 2.2%	7 / 5
			Proposed Action	3.1 / 2.2	0.8% / 1.1%	8 / 6
			Alternative 8a	2.8 / 2.0	0.9% / 1.2%	8 / 6
FR2	12 (medium gravel)	417 / 337	Full Use	1.5 / 1.3	6.0% / 8.0%	2 / 2
			No Action	1.5 / 1.3	5.7% / 7.7%	2 / 2
			Proposed Action	1.6 / 1.4	4.5% / 6.7%	3 / 2
			Alternative 8a	1.6 / 1.4	4.7% / 6.9%	3 / 2
FR3	11 (medium gravel)	81 / 69	Full Use	1.4 / 1.4	5.8% / 6.2%	3 / 2
			No Action	1.5 / 1.4	5.4% / 5.8%	3 / 2
			Proposed Action	1.6 / 1.5	3.9% / 4.5%	3 / 3
			Alternative 8a	1.6 / 1.5	4.2% / 4.7%	3 / 3
FR4	12 (medium gravel)	31 / 34	Full Use	1.3 / 1.3	5.5% / 5.2%	2 / 2
			No Action	1.3 / 1.3	5.1% / 4.9%	2 / 2
			Proposed Action	1.4 / 1.4	3.7% / 3.5%	3 / 3
			Alternative 8a	1.4 / 1.4	3.9% / 3.7%	3 / 3
FR5	14 (medium gravel)	87 / 67	Full Use	1.8 / 1.8	2.2% / 2.5%	5 / 5
			No Action	1.8 / 1.8	1.8% / 2.1%	5 / 5
			Proposed Action	2.6 / 2.6	1.0% / 1.1%	8 / 6
			Alternative 8a	2.6 / 2.6	1.0% / 1.2%	8 / 6
FR6	22 (coarse gravel)	112 / 91	Full Use	34 / 9	0.01% / 0.12%	36 / 15
			No Action	36 / 11	0.01% / 0.10%	36 / 25
			Proposed Action	40 / 14	0.01% / 0.07%	36 / 26
			Alternative 8a	40 / 14	0.01% / 0.07%	36 / 26
FR7	19 (coarse gravel)	183 / 142	Full Use	1.2 / 1.1	3.1% / 6.1%	1 / 1
			No Action	1.2 / 1.1	3.4% / 6.4%	1 / 1
			Proposed Action	1.1 / 1.1	4.7% / 7.9%	1 / 1
			Alternative 8a	1.1 / 1.1	4.5% / 7.7%	1 / 1

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Results indicate that the seven representative sites can be considered as three different groups when describing the relative frequency of Phase 2 transport. One group includes sites FR2, FR3, FR4, and FR7. These sites include a site downstream on the main stem of the Fraser River (FR2), sites on St. Louis Creek (FR3), Ranch Creek (FR4) downstream of Denver Water's diversions, and one site on Vasquez Creek upstream of Denver Water's diversion (FR7). At all of these locations, Phase 2 transport is predicted to occur at a

recurrence interval between approximately 1.1 and 1.6 years for Full Use of the Existing System and all alternatives. In all cases, flow changes resulting from the various alternatives would change the recurrence interval of Phase 2 transport by no more than 0.2 year when compared to Full Use of the Existing System. The frequency of flows equal to or exceeding that required to initiate Phase 2 transport is predicted to decrease at FR2, FR3, and FR4 and increase at FR7. At FR2, FR3, and FR4 Phase 2 transport is predicted to occur on average at least 13 days per year. Phase 2 transport is expected to occur a maximum of 23 days per year for all alternatives at FR7. The maximum number of years between flows large enough to produce Phase 2 sediment transport at each of these sites remains similar for all alternatives based on daily PACSM results. At each site and for all alternatives, the greatest change predicted is one year or less.

The second group includes the Representative sites downstream of Denver Water's diversion on the Fraser River (FR1 and FR5). At both of these sites Phase 2 transport occurs with a recurrence interval of approximately 1.8-1.9 years under Full Use of the Existing System. Under the No Action Alternative, little change in the Phase 2 recurrence interval is anticipated. The Proposed Action and Alternative 8a are predicted to increase the recurrence interval of Phase 2 by approximately 0.5 year at these locations.

The frequency of flows equal to or exceeding that required to initiate Phase 2 transport is predicted to decrease at both FR1 and FR5 for all alternatives when compared to Full Use of the Existing System. Under Full Use of the Existing System, Phase 2 transport is predicted to occur approximately 8-9 days per year at these two locations. For the No Action Alternative, Phase 2 transport is predicted to occur an average of 7 days per year. Under the Proposed Action and Alternative 8a, Phase 2 transport is predicted to occur an average of approximately 3-4 days per year at these two sites. The maximum number of years between flows large enough to produce Phase 2 sediment transport at both of these sites is approximately 5 years for Full Use of the Existing System. The No Action Alternative is not predicted to result in any changes at FR5 while the maximum duration between events is predicted to increase to 6 years at FR1. Under the Proposed Action and Alternative 8a, the maximum interval between Phase 2 events is predicted to increase to approximately 7 years at both sites.

Site FR6, which is located downstream of the Jim Creek diversion, is dissimilar to the other sites in that Phase 2 transport is predicted to occur very infrequently. For Full Use of the Existing System, Phase 2 transport is predicted have a recurrence interval of approximately 22 years. The recurrence interval for the No Action Alternative is approximately 24 years while the calculated recurrence interval for the Proposed Action and Alternative 8a are approximately 27 years.

Phase 2 transport is not expected to occur often at this site under Full Use of the Existing System or any alternative. On average, it is predicted that Phase 2 transport only occurs an average of approximately 0.2 day per year; this is not expected to change significantly for any alternative. The maximum number of years between Phase 2 events is predicted to range between approximately 25 years for Full Use of the Existing System and 30 years for all alternatives.

5.3.3.2 Williams Fork River Basin

Flows required to initiate Phase 2 sediment transport were calculated for the Representative sites in the Williams Fork based on the measured D_{16} material size observed at each of the sites. The calculated flow along with the recurrence interval, flow frequency and maximum number of years between Phase 2 flows were calculated and are presented on Table 5.3-6. Figures showing Phase 2 modeling results in the Williams Fork River Basin are presented in Figures H-21.15 to H-21.18 in Appendix H-21.

Table 5.3-6
Phase 2 Sediment Transport Calculations – Williams Fork River Basin

Site	D_{16} (mm) (Size Class)	$Q_{Phase\ 2}$ (cfs) (Parker / W-C)	Alternative	Recurrence Interval (yrs) (Parker / W-C)	Frequency Phase 2 Flow is Equaled or Exceeded (Parker / W-C)	Maximum Duration between Phase 2 Flows (yrs) (Parker / W-C)
WF1	6 (fine gravel)	105 / 70	Full Use	1.1 / 1.1	7.3% / 9.6%	2 / 2
			No Action	1.2 / 1.1	6.9% / 9.2%	2 / 2
			Proposed Action	1.2 / 1.1	5.8% / 8.4%	2 / 2
			Alternative 8a	1.2 / 1.1	6.0% / 8.7%	2 / 2
WF2	10 (medium gravel)	65 / 60	Full Use	1.2 / 1.2	6.8% / 7.0%	2 / 2
			No Action	1.2 / 1.2	6.4% / 6.5%	2 / 2
			Proposed Action	1.3 / 1.3	4.9% / 5.0%	2 / 2
			Alternative 8a	1.3 / 1.3	5.1% / 5.2%	2 / 2

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Calculated flows required to initiate Phase 2 sediment transport are predicted to increase from upstream to downstream in the basin. Results for recurrence intervals and frequency are similar for the two Representative sites. At both locations, Phase 2 transport is predicted to occur at a recurrence interval of approximately 1.1-1.2 years for Full Use of the Existing System. For all Project alternatives, predicted flow changes would change the recurrence interval of Phase 2 transport by no more than 0.1 year when compared to Full Use of the Existing System. The frequency of flows equal to or exceeding that required to initiate Phase 2 transport is predicted to decrease at both Representative sites when compared to Full Use of the Existing System. Under Full Use of the Existing System, Phase 2 transport is calculated to occur approximately 25 days per year and 31 days per year at the upstream and downstream sites. For all Project alternatives, Phase 2 transport is predicted to occur a minimum of 18 days per year at the upstream site and 26 days per year at the downstream site. The maximum number of years between flows large enough to initiate Phase 2 sediment transport was calculated to be 2 years for both Full Use of the Existing System and all Project alternatives at both Representative sites.

5.3.3.3 Colorado River Basin

Flows required to initiate Phase 2 sediment transport were calculated for the Representative sites in the Colorado River based on the measured D_{16} material size observed at each of the sites. The relatively low frequency of the flows initiating Phase 2 transport calculated as part of this analysis shown below is believed to be heavily influenced by the use of the Parker and Wilcock and Crowe equations. As is indicated in Section 5.3.1, the Parker and Wilcock and Crowe equations result in unrealistically low estimates of sediment transport at some locations, including both sites on the Colorado River.

To account for the likely inaccuracies of the transport equations used for the Phase 2 analysis, the evaluation considered changes to the predicted frequency of the 1.5-year recurrent interval flood. The 1.5-year event is often used as an approximation for bankfull flow and provides an estimate for flows when Phase 2 transport threshold is typically exceeded (Ryan et al. 2002). While the 1.5-year event based on Full Use of the Existing System may not be the flow that initiates Phase 2 transport it provides a means to compare the relative frequency of a flow event that would be expected based on Full Use of the Existing System. The calculated flow along with the recurrence interval, flow frequency and maximum number of years between Phase 2 flows as well as for the 1.5-year flow based on Full Use of the Existing System hydrology were calculated and are presented on Table 5.3-7. Figures showing Phase 2 modeling results in the Colorado River are presented in Figures H-21.19 to H-21.22 in Appendix H-21.

Table 5.3-7
Phase 2 Sediment Transport Calculations – Colorado River Basin

Site	D_{16} (mm) (Size Class)	$Q_{Phase\ 2}$ (cfs) (Parker / W-C)	Alternative	Recurrence Interval (yrs) (Parker / W-C)	Frequency Phase 2 Flow is Equaled or Exceeded (Parker / W-C)	Maximum Duration between Phase 2 Flows (yrs) (Parker / W-C)
CR1	22 (coarse gravel)	3,500 / 2,440	Full Use	10 / 5	0.3% / 0.7%	24 / 11
			No Action	10 / 5	0.3% / 0.7%	24 / 11
			Proposed Action	9 / 6	0.3% / 0.6%	24 / 11
			Alternative 8a	9 / 6	0.3% / 0.6%	24 / 11
CR2	10 (medium gravel)	1,940 / 1,380	Full Use	4 / 3	1.7% / 3.1%	9 / 7
			No Action	4 / 3	1.6% / 3.0%	9 / 7
			Proposed Action	4 / 3	1.4% / 2.4%	9 / 8
			Alternative 8a	4 / 3	1.4% / 2.4%	9 / 8

Table 5.3-7 (continued)
Phase 2 Sediment Transport Calculations – Colorado River Basin

Site	Alternative	$Q_{1.5}$ Flow (cfs)	% Change from Full Use $Q_{1.5}$ Flow	Recurrence Interval for $Q_{1.5}$ Full Use Flow (yrs)	Frequency Q1.5 Full Use Flow is Equaled or Exceeded	Maximum Duration between $Q_{1.5}$ Full Use Flow (yrs)
CR1	Full Use	396	N/A	1.5	7.2%	3
	No Action	384	-3%	1.5	7.1%	3
	Proposed Action	382	-4%	1.5	6.8%	3
	Alternative 8a	382	-4%	1.5	6.8%	3
CR2	Full Use	868	N/A	1.5	5.5%	3
	No Action	894	+3%	1.5	5.3%	2
	Proposed Action	841	-3%	1.6	4.9%	3
	Alternative 8a	841	-3%	1.6	5.0%	3

Notes:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.
N/A = not applicable

Calculated flows required to initiate Phase 2 sediment transport were predicted to be higher above the confluence with the Williams Fork (CR1) than below (CR2) using the Parker and Wilcock and Crowe equations. This is the result of the larger D_{16} observed at CR1. Given the higher flows that are predicted to initiate Phase 2 transport upstream of the Williams Fork, the recurrence interval of Phase 2 transport is higher at the upstream site. At CR1, Phase 2 transport is predicted to occur at a recurrence interval of approximately 8 years for Full Use of the Existing System using the Parker and Wilcock and Crowe equations. No notable change in the recurrence interval of Phase 2 transport is predicted for any of the alternatives. Similar trends are observed for the frequency of flows equaling or exceeding Phase 2 transport and the maximum duration between Phase 2 flows based on the two equations. In all cases, differences in timing and frequency between Full Use of the Existing System and the Project alternatives are minimal. For Full Use of the Existing System and all Project alternatives, Phase 2 transport is expected to occur for an average of approximately 2 days per year; the longest interval between events causing Phase 2 transport is predicted to be 17-18 years for all alternatives.

The magnitude of flow predicted to occur with a recurrence interval of 1.5-years is predicted to decrease by between 3% and 4% for all alternatives when compared to Full Use of the Existing System at CR1 based on the flow frequency analysis. The Full Use of the Existing System 1.5-year flow of 396 cfs is predicted to occur approximately 26 days per year under Full Use of the Existing System and the No Action Alternative and 25 days per year for the Proposed Action and Alternative 8a. The longest interval between a flow of 396 cfs was found to be three years for Full Use of the Existing System and all Project alternatives.

At CR2, Phase 2 transport is predicted to occur at a recurrence interval of approximately 3-4 years for Full Use of the Existing System and all Project alternatives using the Parker and Wilcock and Crowe equations. For the Full Use of the Existing System and No Action Alternatives, flows causing Phase 2 transport are predicted to occur an average of 9 days per year. The Proposed Action and Alternative 8a would have approximately 7 days per year where flows equal or exceed those required for Phase 2 transport based on the Parker and Wilcock and Crowe equations. The longest interval between Phase 2 transport events is predicted to be approximately 8 years for Current Full Use of the Existing System; this value is predicted to range from approximately 8-9 years for the various Project alternatives.

The magnitude of flow predicted to occur with a recurrence interval of 1.5-years is predicted to increase by 3% for the No Action Alternative and decrease by 3% for the Proposed Action and Alternative 8a when compared to Full Use of the Existing System at CR2 based on the flow frequency analysis. The Full Use of the Existing System 1.5-year flow of 868 cfs is predicted to occur approximately every 1.5 to 1.6 years for the different Project alternatives. A flow of 868 cfs is predicted to occur approximately 20 days per year under Full Use of the Existing System verses roughly 19 days per year for the No Action Alternative and 18 days per year for the Proposed Action and Alternative 8a. The longest interval between a flow of 868 cfs was found to be three years for Full Use of the Existing System, two years for the No Action Alternative and three years for the Proposed Action and Alternative 8a.

5.3.3.4 Blue River Basin

Flows required to initiate Phase 2 sediment transport were calculated for the Representative sites on the Blue River based on channel geometry and the measured D_{16} material size. Calculated flow along with the recurrence interval, flow frequency and maximum number of years between Phase 2 flows were calculated and are presented on Table 5.3-8. Figures showing Phase 2 sediment transport modeling results in the Blue River are presented in Figures H-21.23 and H-21.24 in Appendix H-21.

Table 5.3-8
Phase 2 Sediment Transport Calculations – Blue River Basin

Site	D_{16} (mm) (Size Class)	$Q_{Phase\ 2}$ (cfs) (Parker / W-C)	Alternative	Recurrence Interval (yrs) (Parker / W-C)	Frequency Phase 2 Flow is Equaled or Exceeded (Parker / W-C)	Maximum Duration between Phase 2 Flows (yrs) (Parker / W-C)
BR1	30 (coarse gravel)	1,689 / 859	Full Use	2 / 1.5	2.0% / 5.4%	7 / 3
			No Action	3 / 1.7	1.8% / 4.5%	7 / 6
			Proposed Action	2 / 1.6	1.9% / 4.9%	7 / 3
			Alternative 8a	2 / 1.6	1.9% / 5.0%	7 / 3

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

At BR1, Phase 2 transport is predicted to occur with a recurrence interval of approximately 1.8 years for Full Use of the Existing System, the Proposed Action and Alternative 8a; a recurrence interval of approximately 2.4 years was predicted for the No Action Alternative. For Full Use of the Existing System, Phase 2 transport is expected to occur for an average of approximately 14 days per year. For all Project alternatives, Phase 2 transport flows are predicted to be equaled or exceeded an average of 11-13 days per year. The longest interval between Phase 2 transport events is predicted to be approximately 5 years for Full Use of the Existing System; this value is predicted to range from approximately 5-7 years for the various Project alternatives.

5.3.3.5 North Fork South Platte River Basin

Flows required to initiate Phase 2 sediment transport were calculated for the Representative sites of the North Fork based on the measured D_{16} material size observed at each of the sites. The calculated flow along with the recurrence interval, flow frequency and maximum number of years between Phase 2 flows were calculated and are presented on Table 5.3-9. Figures showing Phase 2 modeling results in the North Fork South Platte River are presented in Figures H-21.25 to H-21.28 in Appendix H-21.

Table 5.3-9
Phase 2 Sediment Transport Calculations – North Fork South Platte River Basin

Site	D_{16} (mm) (Size Class)	$Q_{Phase\ 2}$ (cfs) (Parker / W-C)	Alternative	Recurrence Interval (yrs) (Parker / W-C)	Frequency Phase 2 Flow is Equaled or Exceeded (Parker / W-C)	Maximum Duration between Phase 2 Flows (yrs) (Parker / W-C)
NF1	24 (coarse gravel)	612 / 415	Full Use	1.2 / 1	0.9% / 11.9%	6 / 0
			No Action	1.2 / 1	1.3% / 14.2%	3 / 0
			Proposed Action	1.2 / 1	2.1% / 16.4%	3 / 0
			Alternative 8a	1.2 / 1	1.9% / 16.2%	3 / 0
NF2	11 (medium gravel)	600 / 360	Full Use	1.3 / 1	2.8% / 22.1%	4 / 0
			No Action	1.1 / 1	3.6% / 24.4%	1 / 0
			Proposed Action	1.1 / 1	5.6% / 26.5%	1 / 0
			Alternative 8a	1.1 / 1	5.5% / 26.4%	1 / 0

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Calculated flows required to initiate Phase 2 sediment transport were predicted to be similar at both the upstream site (NF1) and the downstream site (NF2). The larger D_{16} observed at NF1 likely contributes to Phase 2 flow being similar to that of the downstream location despite lower peak flows at this location. At NF1, Phase 2 transport is predicted to occur with a recurrence interval approximately 1.1 years for Full Use of the Existing System and all Project alternatives. At NF2 Phase 2 transport is predicted to occur with a recurrence interval

of approximately 1.2 years for Full Use of the Existing System; for all Project alternatives Phase 2 transport is predicted to have a recurrence interval of approximately 1.1 year.

At NF1, Phase 2 transport is expected to occur for an average of approximately 23 days per year for Full Use of the Existing System. The frequency increases to approximately 28 days per year for the No Action Alternative. For the Proposed Action and Alternative 8a the frequency is predicted to increase to approximately 34 days per year. The longest interval between Phase 2 transport events is predicted to be approximately 3 years for Full Use of the Existing System; this value is predicted to be approximately 1.5 years for the various Project alternatives.

At NF2, Phase 2 transport is expected to occur for an average of approximately 45 days per year under Full Use of the Existing System. The frequency increases to approximately 51 days per year for the No Action Alternative. For the Proposed Action and Alternative 8a the frequency is predicted to increase to approximately 59 days per year. The longest interval between Phase 2 transport events is predicted to be approximately 2 years for Full Use of the Existing System; this value is predicted to range from approximately 0.5 year for the various Project alternatives.

5.3.3.6 South Boulder Creek Basin

Flows required to initiate Phase 2 sediment transport were calculated for the Representative sites in South Boulder Creek based on the measured D_{16} material size observed at each of the sites. The calculated flow along with the recurrence interval, flow frequency and maximum number of years between Phase 2 flows were calculated and are presented on Table 5.3-10. Figures showing Phase 2 modeling results in South Boulder Creek are presented in Figures H-21.29 to H-21.32 in Appendix H-21.

Table 5.3-10
Phase 2 Sediment Transport Calculations – South Boulder Creek Basin

Site	D_{16} (mm) (Size Class)	$Q_{Phase\ 2}$ (cfs) (Parker / W-C)	Alternative	Recurrence Interval (yrs) (Parker / W-C)	Frequency Phase 2 Flow is Equaled or Exceeded (Parker / W-C)	Maximum Duration between Phase 2 Flows (yrs) (Parker / W-C)
SBC1	48 (very coarse gravel)	N/A / 973	Full Use	N/A / 4	N/A / 0.26%	N/A / 17
			No Action	N/A / 4	N/A / 0.30%	N/A / 14
			Proposed Action	N/A / 3	N/A / 0.38%	N/A / 7
			Alternative 8a	N/A / 3	N/A / 0.38%	N/A / 7
SBC3	22 (coarse gravel)	385 / 385	Full Use	1 / 1	14.5% / 14.5%	0 / 0
			No Action	1 / 1	15.2% / 15.2%	0 / 0
			Proposed Action	1 / 1	8.7% / 8.7%	1 / 1
			Alternative 8a	1 / 1	8.7% / 8.7%	1 / 1

Notes:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.
N/A = not applicable

Using the Parker equation, the flow required to initiate Phase 2 transport was greater than the upper bound flow at SBC1 therefore the flow was undetermined. This is a result of the relatively large size of the D_{16} material. Flows, recurrence intervals and frequencies presented for SBC1 are therefore based solely on results from the Wilcock and Crowe equation.

Calculated flows required to initiate Phase 2 sediment transport were predicted to be greater at the upstream site (SBC1) than the lower site (SBC3). This is the result of the larger substrate size at SBC1. At SBC1 the recurrence interval for Phase 2 flows is estimated to be 4 years under Full Use of the Existing System. The recurrence interval of flows required to initiate Phase 2 transport is not expected to change for the No Action Alternative. Under the Proposed Action and Alternative 8a the recurrence interval is predicted to decrease to 3 years.

At SBC1 Phase 2 transport is expected to occur for an average of approximately 1 day per year under Full Use of the Existing System and all alternatives. The longest interval between Phase 2 transport events is predicted to be approximately 17 years for Full Use of the Existing System. This maximum interval is predicted to decrease to 14 years for the No Action Alternative and 7 years for the Proposed Action and Alternative 8a.

At SBC3, flows required to initiate Phase 2 transport are expected to occur with a recurrence interval of 1 year under Full Use of the Existing System; the recurrence interval is predicted to be unchanged by any of the Project alternatives. For Full Use of the Existing System, flow initiating Phase 2 transport is predicted to be equaled or exceeded approximately 53 days per year. The frequency increases to approximately 55 days per year for the No Action Alternative. For the Proposed Action and Alternative 8a the frequency is predicted to decrease to approximately 32 days per year. This decrease is a result of flow reductions during peak flow periods. For Full Use of the Existing System and the No Action Alternative, flows necessary for Phase 2 transport are predicted to occur every year. Under the Proposed Action and Alternative 8a, the longest interval between Phase 2 transport events is predicted to be approximately 1 year.

5.3.3.7 Overall Phase 2 Sediment Transport Trends

Changes to the predicted frequency and duration of flows causing Phase 2 sediment transport generally follow anticipated trends related to flow changes. Overall, the recurrence interval of flows required to initiate Phase 2 transport increases in areas where additional flow diversions are planned. The frequency of these flows occurring decreases in areas where flow decreases are predicted. Overall, changes in recurrence interval and frequency are more pronounced closer to the diversions location. Recurrence intervals for flows initiating Phase 2 transport are expected to decrease slightly in areas where flows would be increased. Increases in the frequency of these flows are predicted, in areas where flows would be increased, except below Gross Reservoir.

5.3.4 Five-Year and 10-Year Flood Events

Based on findings from Ryan, including work in the Fraser River Basin (Ryan 1997), observed changes to channel morphology downstream of diversions were generally limited to unconstrained, wide pool-riffle sections with cobble bars; changes were typically not

observed in other stream reaches. The absence of observed changes in channel morphology was attributed to the preservation of high magnitude, low frequency flood events such as the 5- and 10-year event (Ryan 1997). The magnitude of the 5- and 10-year peak flood event for the different Project alternatives was quantified and the recurrence interval of these flows were defined based on hydrology under Full Use of the Existing System to evaluate changes caused by the different Project alternatives. Results of this analysis are presented below. Flood frequency curves for each Representative site are provided in Figures H-20.1 to H-20.16 in Appendix H-20.

5.3.4.1 Fraser River Basin

Five- and 10-year flood events were calculated for the Representative site in the Fraser River Basin. The calculated flows for the Project alternatives are presented on Table 5.3-11. Presented results include the recurrence interval for each Project alternative based on Full Use of the Existing System hydrology. Results of the flood frequency analysis for sites in the Fraser River Basin are presented in Figures H-20.1 to H-20.7 in Appendix H-20.

Table 5.3-11
Five- and 10-Year Peak Flow Calculations – Fraser River Basin

Site	Alternative	Q_5 (cfs)	Q_{10} (cfs)	Recurrence Interval of Full Use Q_5 (yrs)	Recurrence Interval of Full Use Q_{10} (yrs)
FR1	Full Use	249	362	5	10
	No Action	235	330	6	12
	Proposed Action	212	274	8	23
	Alternative 8a	214	275	8	23
FR2	Full Use	1,211	1,652	5	10
	No Action	1,179	1,649	6	10
	Proposed Action	1,167	1,454	8	14
	Alternative 8a	1,167	1,455	8	14
FR3	Full Use	299	335	5	10
	No Action	296	335	6	10
	Proposed Action	278	335	6	10
	Alternative 8a	278	335	6	10
FR4	Full Use	101	126	5	10
	No Action	101	126	5	10
	Proposed Action	101	126	5	10
	Alternative 8a	101	126	5	10
FR5	Full Use	168	229	5	10
	No Action	159	229	6	10
	Proposed Action	149	175	8	18
	Alternative 8a	149	175	8	18
FR6	Full Use	66	98	5	10
	No Action	63	88	6	13
	Proposed Action	57	75	8	19
	Alternative 8a	58	75	8	19

Table 5.3-11 (continued)
Five- and 10-Year Peak Flow Calculations – Fraser River Basin

Site	Alternative	Q_5 (cfs)	Q_{10} (cfs)	Recurrence Interval of Full Use Q_5 (yrs)	Recurrence Interval of Full Use Q_{10} (yrs)
FR7	Full Use	306	333	5	10
	No Action	310	340	4	8
	Proposed Action	319	348	4	7
	Alternative 8a	319	340	4	8

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Results indicate that the seven Representative sites can be considered as three different groups when describing anticipated changes in 5- and 10-year peak flows. One group includes sites FR3, FR4, and FR7. These sites include sites on St. Louis Creek (FR3) and Ranch Creek (FR4) downstream of Denver Water's diversions and one site on Vasquez Creek upstream Denver Water's diversion (FR7). At all of these locations only minor changes are expected for the 5- and 10-year flood events when compared to Full Use of the Existing System. For all Project alternatives, flow changes are expected to cause the 5- and 10-year flood events to change by less than 7% when compared to Full Use of the Existing System. Slight peak flow decreases are predicted at FR3 for the 5-year event while no changes are predicted for the 10-year event. No changes for either flow event are predicted at FR4 while slight increases are predicted at FR7. For all alternatives the recurrence interval of the 5- year event with adjusted hydrology is between 4 and 6 years based on Full Use of the Existing System hydrology. The adjusted 10-year peak flows have a recurrence interval of between 7 and 10 years based on Full Use of the Existing System hydrology.

At FR2, the downstream site on the main stem of the Fraser River, predicted changes in flows may alter the peak 5-year flow by up to 4% and the 10-year flows by up to approximately 12% when compared to Full Use of the Existing System. Predicted changes are greatest for the Proposed Action and Alternative 8a. For all alternatives, the recurrence interval of the 5-year event with adjusted hydrology is between 5 and 8 years based on Full Use of the Existing System hydrology. The adjusted 10-year peak flows have a recurrence interval of between 10 and 14 years based on Full Use of the Existing System hydrology.

The greatest changes in peak 5- and 10-year flood flows is predicted at FR1, FR5, and FR6, the three Representative sites below Denver's highest priority diversions. In general, changes are least dramatic for the No Action Alternative with the Proposed Action and Alternative 8a having the greatest changes when compared to Full Use of the Existing System.

For all alternatives the recurrence interval of the 5-year event with adjusted hydrology is between 5 and 8 years based on Full Use of the Existing System hydrology. The adjusted 10-year peak flows have a recurrence interval of between 10 and 23 years based on Full Use of the Existing System hydrology. For these alternatives a small change in flow results in a large change in recurrence interval given the way the system is predicted to operate.

As an example, for the Proposed Action at FR1, a flow of 258 cfs is calculated to have a recurrence interval of 15 years while a flow of 361 cfs (increase of less than 1%) has a predicted recurrence interval of 23 years. This sensitivity influences the higher calculated recurrence intervals.

5.3.4.2 Williams Fork River Basin

Five- and 10-year flood events were calculated for the Representative sites in the Williams Fork River Basin. The calculated flows for the Project alternatives are presented on Table 5.3-12. Presented results include the recurrence interval for each Project alternative based on Full Use of the Existing System hydrology. Results of the flood frequency analysis for sites in the Williams Fork River Basin are presented in Figures H-20.8 and H-20.9 in Appendix H-20.

Table 5.3-12
Five- and 10-Year Peak Flow Calculations – Williams Fork River Basin

Site	Alternative	Q_5 (cfs)	Q_{10} (cfs)	Recurrence Interval of Full Use Q_5 (yrs)	Recurrence Interval of Full Use Q_{10} (yrs)
WF1	Full Use	414	463	5	10
	No Action	414	463	5	10
	Proposed Action	414	463	5	10
	Alternative 8a	414	463	5	10
WF2	Full Use	276	292	5	10
	No Action	276	292	5	10
	Proposed Action	276	292	5	10
	Alternative 8a	276	292	5	10

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Results show that no changes to the peak 5- and 10-year flood events are predicted at either WF1 or WF2 for any of the Project alternatives. Given the lower priority of diversions in the Williams Fork Basin, no additional water is predicted to be taken at these locations during peak flow periods.

5.3.4.3 Colorado River Basin

Five- and 10-year flood events were calculated for the Representative sites in the Colorado River. The calculated flows for the Project alternatives are presented on Table 5.3-13. Presented results include the recurrence interval for each Project alternative based on Full Use of the Existing System hydrology. Results of the flood frequency analysis for sites in the Colorado River are presented in Figures H-20.10 and H-20.11 in Appendix H-20.

Table 5.3-13
Five- and 10-Year Peak Flow Calculations – Colorado River Basin

Site	Alternative	Q_5 (cfs)	Q_{10} (cfs)	Recurrence Interval of Full Use Q_5 (yrs)	Recurrence Interval of Full Use Q_{10} (yrs)
CR1	Full Use	2,362	3,589	5	10
	No Action	2,254	3,581	6	10
	Proposed Action	2,235	3,629	6	10
	Alternative 8a	2,235	3,630	6	10
CR2	Full Use	2,572	4,062	5	10
	No Action	2,552	4,053	5	10
	Proposed Action	2,546	4,097	5	9
	Alternative 8a	2,547	4,098	5	9

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Results show that at both CR1 and CR2 the peak 5-year flood is predicted to decrease while the peak 10-year flood is predicted to increase for all Project alternatives except the No Action Alternative when compared to Full Use of the Existing System. For the 5-year event, peak flows are reduced by similar amounts for the No Action Alternative, the Proposed Action, and Alternative 8a. Predicted flow changes for the 10-year flood are predicted to be small for all alternatives when compared to Full Use of the Existing System. For all alternatives, the recurrence interval of the 5-year event with adjusted hydrology is between 5 and 6 years based on Full Use of the Existing System hydrology. The adjusted 10-year peak flows have a recurrence interval of between 9 and 10 years based on Full Use of the Existing System hydrology.

5.3.4.4 Blue River Basin

Five- and 10-year flood events were calculated for the Representative sites in the Blue River. The calculated flows for the Project alternatives are presented on Table 5.3-14. Presented results include the recurrence interval for each Project alternative based on Full Use of the Existing System hydrology. Results of the flood frequency analysis for the site in the Blue River are presented in Figure H-20.12 in Appendix H-20.

Table 5.3-14
Five- and 10-Year Peak Flow Calculations – Blue River Basin

Site	Alternative	Q_5 (cfs)	Q_{10} (cfs)	Recurrence Interval of Full Use Q_5 (yrs)	Recurrence Interval of Full Use Q_{10} (yrs)
BR1	Full Use	2,272	2,380	5	10
	No Action	2,242	2,304	6	16
	Proposed Action	2,282	2,402	5	9
	Alternative 8a	2,287	2,402	5	9

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Results indicate that the peak 5- and 10-year flood events are similar for Full Use of the Existing System, the Proposed Action, and Alternative 8a. The recurrence interval of the 5-year event with adjusted hydrology for the Proposed Action and Alternative 8a remains at 5 years based on Full Use of the Existing System hydrology. The adjusted 10-year peak flows have a recurrence interval of 9 years based on Full Use of the Existing System hydrology. The greatest change from Full Use of the Existing System is predicted for the No Action Alternative. Given the hydrology of this alternative, the adjusted 5-year flow has a recurrence interval of 6 years using Full Use of the Existing System hydrology; the 10-year peak flood with adjusted hydrology has a recurrence interval of 16 years. It should be noted that while the recurrence intervals show relatively large changes for the No Action Alternative, the actual change in the 5- and 10-year flows for this alternative are only approximately 1%-4% less than the same flows under Full Use of the Existing System.

5.3.4.5 North Fork South Platte River Basin

Five- and 10-year flood events were calculated for the Representative sites in the North Fork. The calculated flows for the Project alternatives are presented on Table 5.3-15. Presented results include the recurrence interval for each Project alternative based on Full Use of the Existing System hydrology. Results of the flood frequency analysis for sites in North Fork South Platte River are presented in Figures H-20.13 and H-20.14 in Appendix H-20.

Table 5.3-15
Five- and 10-Year Peak Flow Calculations – North Fork South Platte River Basin

Site	Alternative	Q_5 (cfs)	Q_{10} (cfs)	Recurrence Interval of Full Use Q_5 (yrs)	Recurrence Interval of Full Use Q_{10} (yrs)
NF1	Full Use	654	667	5	10
	No Action	656	666	5	10
	Proposed Action	656	668	5	10
	Alternative 8a	656	668	5	10
NF2	Full Use	763	838	5	10
	No Action	763	838	5	10
	Proposed Action	772	838	5	10
	Alternative 8a	773	838	5	10

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Results show that only minimal changes to the peak 5- and 10-year flood events are predicted and no changes to the recurrence interval of the 5- and 10-year flood events are anticipated for any alternative when compared to Full Use of the Existing System hydrology.

5.3.4.6 South Boulder Creek Basin

Five- and 10-year flood events were calculated for the Representative sites in South Boulder Creek. The calculated flows for the Project alternatives are presented on

Table 5.3-16. Presented results include the recurrence interval for each Project alternative based on Full Use of the Existing System hydrology. Results of the flood frequency analysis for sites in South Boulder Creek are presented in Figures H-20.15 and H-20.16 in Appendix H-20.

Table 5.3-16
Five- and 10-Year Peak Flow Calculations – South Boulder Creek Basin

Site	Alternative	Q_5 (cfs)	Q_{10} (cfs)	Recurrence Interval of Full Use Q_5 (yrs)	Recurrence Interval of Full Use Q_{10} (yrs)
SBC1	Full Use	985	1,003	5	10
	No Action	988	1,003	4	10
	Proposed Action	993	1,015	4	7
	Alternative 8a	993	1,015	4	7
SBC3	Full Use	766	834	5	10
	No Action	750	815	5	11
	Proposed Action	687	737	>45	>45
	Alternative 8a	690	735	>45	>45

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

Results show very slight increases in the magnitude of the 5- and 10-year event for the different Project alternatives are predicted at SBC1 when compared to Full Use of the Existing System. The recurrence interval of Full Use of the Existing System 5- and 10-year flows based on adjusted hydrology for the different alternatives either remains the same or decreases for all alternatives with changes in recurrence despite the minimal (approximately 1%) change in peak flows. Changes in recurrence intervals are the result of altered peak flows where similar high flow rates are achieved most years.

Changes in the 5- and 10-year flood event are predicted at SBC3 for the Proposed Action and Alternative 8a while little changes are predicted for the No Action Alternative when compared to Full Use of the Existing System hydrology. For the Proposed Action and Alternative 8a, the 5- and 10-year events based on Full Use of the Existing System hydrology would have a recurrence interval in excess of 45 years. The high recurrence interval predicted for the Proposed Action and Alternative 8a is based on planned operations of Gross Reservoir where less flow would be released during traditional peak flow periods.

5.3.4.7 Overall Flood Event Trends

The recurrence interval for the 5- and 10-year peak flow based on hydrology for Full Use of the Existing System is predicted to change at several locations in the Project area. The greatest changes are predicted within the Fraser River Basin where flows are projected to decrease at locations nearest diversions. Only minimal changes are predicted further downstream and the Colorado, Blue, Williams Fork or North Fork sites. Frequencies of these flows are predicted to decrease on South Boulder Creek upstream of Gross Reservoir and increase downstream of the reservoir.

5.3.5 Effective Discharge

Effective discharge refers to the flow that transports the most sediment over a prolonged period of time. While higher flows transport more sediment, the infrequent occurrence of extreme events results in less sediment transported on average than somewhat more frequent, lower magnitude flows. Effective discharge is a representative flow that has the ability to transport the most bed material over a period of years. Computation of effective discharge is thus a useful tool in assessing the potential for geomorphic change due to alterations in stream flow regime. Particularly in sediment-limited systems, however, changes to effective discharge do not necessarily correspond to changes in channel morphology.

Effective discharge was calculated at each of the Reference sites for all alternatives. The magnitude and recurrence interval of the effective discharge was quantified and compared to Full Use of the Existing System to evaluate changes caused by the different Project alternatives. Effective discharge values presented below are the average of the effective discharge values calculated using the four different transport equations. Results of the calculations are presented in Appendix H-9.

5.3.5.1 Fraser River Basin

The effective discharge was calculated for the Representative sites in the Fraser River Basin. The calculated flow and recurrence interval for each of the Project alternatives are presented on Table 5.3-17. Presented results include the recurrence interval for each Project alternative, the magnitude of effective discharge compared to Full Use of the Existing System and differences in the anticipated recurrence interval of effective discharge as compared to Full Use of the Existing System hydrology. Effective discharge curves for sites in the Fraser River Basin are presented in Figures H-9.17 to H-9.51 in Appendix H-9.

Table 5.3-17
Effective Discharge – Fraser River Basin

Site	Alternative	$Q_{effective}$ (cfs)	Recurrence Interval of $Q_{effective}$ (yrs)	$Q_{effective}$ as % of Full Use (%)	RI Change from Full Use (yrs)
FR1	Full Use	244	5	100%	0
	No Action	284	7	116%	2
	Proposed Action	284	12	116%	7
	Alternative 8a	284	12	116%	7
FR2	Full Use	1,302	6	100%	0
	No Action	1,041	3	80%	-3
	Proposed Action	1,080	4	83%	-2
	Alternative 8a	1,348	9	104%	3
FR3	Full Use	259	3	100%	0
	No Action	259	3	100%	0
	Proposed Action	259	4	100%	1
	Alternative 8a	259	4	100%	1

Table 5.3-17 (continued)
Effective Discharge – Fraser River Basin

Site	Alternative	$Q_{effective}$ (cfs)	Recurrence Interval of $Q_{effective}$ (yrs)	$Q_{effective}$ as % of Full Use (%)	RI Change from Full Use (yrs)
FR4	Full Use	90	3	100%	0
	No Action	102	5	113%	2
	Proposed Action	102	5	113%	2
	Alternative 8a	90	3	100%	0
FR5	Full Use	183	7	100%	0
	No Action	191	7	104%	0
	Proposed Action	183	12	100%	5
	Alternative 8a	191	13	104%	6
FR6	Full Use	87	8	100%	0
	No Action	83	9	95%	1
	Proposed Action	91	14	105%	6
	Alternative 8a	91	14	105%	6
FR7	Full Use	187	1.2	100%	0
	No Action	262	2	140%	0.8
	Proposed Action	262	1.5	140%	0.3
	Alternative 8a	191	1.1	102%	-0.1

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

At FR1, the effective discharge was calculated to be 244 cfs with a recurrence interval of 5 years for Full Use of the Existing System. For the No Action Alternative, the Proposed Action and Alternative 8a the effective discharge is predicted to increase to 284 cfs. Under the increased flow and predicted changes in the annual hydrograph, the recurrence interval of effective discharge is predicted to increase to 7 years for the No Action Alternative and 12 years for the Proposed Action and Alternative 8a.

At FR2, the effective discharge was calculated to be 1,302 cfs with a recurrence interval of 6 years for Full Use of the Existing System. The magnitude of effective discharge and its recurrence interval is different for the various Project alternatives. Decreases in the effective discharge flow are predicted for the No Action Alternative and the Proposed Action. For these alternatives the recurrence interval is predicted to range from 3-4 years. Flow and recurrence interval increases are predicted for the effective discharge for Alternative 8a (9 year recurrence interval).

The effective discharge for Full Use of the Existing System and all Project alternatives are predicted to be 259 cfs at FR3. For Full Use of the Existing System and the No Action Alternative the recurrence interval of this flow is 3 years. This same flow is predicted to have a recurrence interval of 4 years for the Proposed Action and Alternative 8a.

At FR4, the effective discharge was calculated to be 90 cfs with a recurrence interval of 3 years for Full Use of the Existing System. For Alternative 8a, the effective discharge and recurrence interval of this flow are unchanged when compared to Full Use of the Existing System. Effective discharge is predicted to be 102 cfs for the No Action Alternative and the Proposed Action, which corresponds to a recurrence interval of 4 years.

At FR5, the effective discharge was calculated to be 183 cfs with a recurrence interval of 7 years for Full Use of the Existing System. For the Proposed Action, the effective discharge is predicted to remain at 183 cfs while the recurrence interval increases to 12 years. Effective discharge is predicted to be 191 cfs for the No Action Alternative (7 year recurrence interval) and Alternative 8a (13 year recurrence interval).

At FR6, the effective discharge was calculated to be 87 cfs with a recurrence interval of 8 years for Full Use of the Existing System. Effective discharge is predicted to decrease slightly to 83 cfs for the No Action Alternative. A slight increase to 91 cfs is predicted for the Proposed Action and Alternative 8a. Recurrence intervals for effective discharge are predicted to range from a low of 8 years for Full Use of the Existing System to 14 years for the Proposed Action and Alternative 8a.

At FR7, the effective discharge was calculated to be 187 cfs with a recurrence interval of 1.2 years for Full Use of the Existing System. This discharge is generally unchanged for Alternative 8a where effective discharge is predicted to be 191 cfs which has a recurrence interval of 1.1 years. Effective discharge is predicted to increase to 262 cfs for the No Action Alternative (2 year recurrence interval) and the Proposed Action (1.5 year recurrence interval).

5.3.5.2 Williams Fork River Basin

The effective discharge was calculated for the Representative sites in the Williams Fork River Basin. The calculated flow and recurrence interval for each of the Project alternatives are presented on Table 5.3-18. Presented results include the recurrence interval for each Project alternative, the magnitude of effective discharge compared to Full Use of the Existing System and differences in the anticipated recurrence interval of effective discharge as compared to Full Use of the Existing System hydrology. Effective discharge curves for sites in the Williams Fork River Basin are presented in Figures H-9.52 to H-9.61 in Appendix H-9.

Table 5.3-18
Effective Discharge – Williams Fork River Basin

Site	Alternative	$Q_{effective}$ (cfs)	Recurrence Interval of $Q_{effective}$ (yrs)	$Q_{effective}$ as % of Full Use (%)	RI Change from Full Use (yrs)
WF1	Full Use	281	1.6	100%	0
	No Action	323	1.9	115%	0.3
	Proposed Action	323	2.0	115%	0.4
	Alternative 8a	281	1.8	100%	0.2
WF2	Full Use	182	1.4	100%	0
	No Action	233	3	128%	1.6
	Proposed Action	217	2	119%	0.6
	Alternative 8a	182	1.6	100%	0.2

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

At WR1, the effective discharge was calculated to be 281 cfs with a recurrence interval of 1.6 years for Full Use of the Existing System. No change is predicted in the magnitude of effective discharge for Alternative 8a. The recurrence interval of effective discharge is predicted to increase to 1.8 years for Alternative 8a. For the No Action Alternative and the Proposed Action the effective discharge is predicted to increase to 323 cfs. Under the increased flow and predicted changes in the annual hydrograph, the recurrence interval of effective discharge is predicted to increase to between 1.9 and 2 years for these Project alternatives.

At WR2, the effective discharge was calculated to be 182 cfs with a recurrence interval of 1.4 years for Full Use of the Existing System. No change is predicted in the magnitude of effective discharge for Alternative 8a. The recurrence interval of effective discharge is predicted to increase to 1.6 years for Alternative 8a. For the No Action Alternative and the Proposed Action the effective discharge is predicted to increase to 233 cfs and 217 cfs, respectively. Under the increased flow and predicted changes in the annual hydrograph, the recurrence interval of effective discharge is predicted to increase to between 2 and 3 years for these Project alternatives.

5.3.5.3 Colorado River Basin

The effective discharge was calculated for the Representative sites in the Colorado River. The calculated flow and recurrence interval for each of the Project alternatives are presented on Table 5.3-19. Presented results include the recurrence interval for each Project alternative, the magnitude of effective discharge compared to Full Use of the Existing System and differences in the anticipated recurrence interval of effective discharge as compared to Full Use of the Existing System hydrology. Effective discharge curves for sites in the Colorado River are presented in Figures H-9.62 to H-9.71 in Appendix H-9.

Table 5.3-19
Effective Discharge – Colorado River Basin

Site	Alternative	$Q_{effective}$ (cfs)	Recurrence Interval of $Q_{effective}$ (yrs)	$Q_{effective}$ as % of Full Use (%)	RI Change from Full Use (yrs)
CR1	Full Use	3,205	8	100%	0
	No Action	3,202	9	100%	1
	Proposed Action	3,342	9	104%	1
	Alternative 8a	2,926	8	91%	0
CR2	Full Use	3,628	7	100%	0
	No Action	3,813	8	105%	1
	Proposed Action	3,813	8	105%	1
	Alternative 8a	3,734	8	103%	1

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

At CR1, the effective discharge was calculated to be 3,205 cfs with a recurrence interval of 8 years for Full Use of the Existing System. Changes to the magnitude of effective discharges are predicted to be within 9% of Full Use of the Existing System for all Project alternatives. The recurrence interval of effective discharge is predicted to remain at 8 years for Alternative 8a. A recurrence interval of 9 years is predicted for effective discharge under the No Action Alternative and the Proposed Action.

At CR2, the effective discharge was calculated to be 3,628 cfs with a recurrence interval of 7 years for Full Use of the Existing System. Changes to the magnitude of effective discharges are predicted to be within 5% of Full Use of the Existing System for all Project alternatives. The recurrence interval of effective discharge is predicted to be 8 years for the No Action Alternative, the Proposed Action, and Alternative 8a.

5.3.5.4 Blue River Basin

The effective discharge was calculated for the Representative sites in the Blue River. The calculated flow and recurrence interval for each of the Project alternatives are presented on Table 5.3-20. Presented results include the recurrence interval for each Project alternative, the magnitude of effective discharge compared to Full Use of the Existing System and differences in the anticipated recurrence interval of effective discharge as compared to Full Use of the Existing System hydrology. Effective discharge curves for the site in the Blue River are presented in Figures H-9.72 to H-9.76 in Appendix H-9.

Table 5.3-20
Effective Discharge – Blue River Basin

Site	Alternative	$Q_{effective}$ (cfs)	Recurrence Interval of $Q_{effective}$ (yrs)	$Q_{effective}$ as % of Full Use (%)	RI Change from Full Use (yrs)
BR1	Full Use	2,260	5	100%	0
	No Action	2,298	9	102%	4
	Proposed Action	2,298	6	102%	1
	Alternative 8a	2,298	5	102%	0

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

At BR1, the effective discharge was calculated to be 2,260 cfs with a recurrence interval of 5 years for Full Use of the Existing System. Changes in the magnitude of effective discharges are predicted to increase by less than 2% when compared to Full Use of the Existing System for all Project alternatives. The recurrence interval of effective discharge is predicted to be 5 years for Alternative 8a. A recurrence interval of 9 years is predicted for effective discharge under the No Action Alternative and a recurrence interval of 6 years is predicted for the effective discharge under the Proposed Action.

5.3.5.5 North Fork South Platte River Basin

The effective discharge was calculated for the Representative sites in the North Fork. The calculated flow and recurrence interval for each of the Project alternatives are presented on Table 5.3-21. Presented results include the recurrence interval for each Project alternative, the magnitude of effective discharge compared to Full Use of the Existing System and differences in the anticipated recurrence interval of effective discharge as compared to Full Use of the Existing System hydrology. Effective discharge curves for sites in North Fork South Platte River are presented in Figures H-9.77 to H-9.86 in Appendix H-9.

Table 5.3-21
Effective Discharge – North Fork South Platte River Basin

Site	Alternative	$Q_{effective}$ (cfs)	Recurrence Interval of $Q_{effective}$ (yrs)	$Q_{effective}$ as % of Full Use (%)	RI Change from Full Use (yrs)
NF1	Full Use	515	1.1	100%	0
	No Action	592	1.2	115%	0.1
	Proposed Action	592	1.2	115%	0.1
	Alternative 8a	592	1.2	115%	0.1
NF2	Full Use	544	1.1	100%	0
	No Action	602	1.1	111%	0
	Proposed Action	602	1.1	111%	0
	Alternative 8a	602	1.1	111%	0

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

At NF1, the effective discharge was calculated to be 515 cfs with a recurrence interval of 1.1 years for Full Use of the Existing System. The magnitude of effective discharge is predicted to increase to 592 cfs with a recurrence interval of 1.2 years for the No Action Alternative, the Proposed Action, and Alternative 8a.

At NF2, the effective discharge was calculated to be 544 cfs with a recurrence interval of 1.1 years for Full Use of the Existing System. The magnitude of effective discharge is predicted to increase to 602 cfs, which has a recurrence interval of 1.1 years for the No Action Alternative, the Proposed Action, and Alternative 8a.

5.3.5.6 South Boulder Creek Basin

The effective discharge was calculated for the Representative sites in South Boulder Creek. The calculated flow and recurrence interval for each of the Project alternatives are presented on Table 5.3-22. Presented results include the recurrence interval for each Project alternative, the magnitude of effective discharge compared to Full Use of the Existing System and differences in the anticipated recurrence interval of effective discharge as compared to Full Use of the Existing System hydrology. Effective discharge curves for sites in South Boulder Creek are presented in Figures H-9.87 to H-9.96 in Appendix H-9.

At SBC1, the effective discharge was calculated to be 730 cfs with a recurrence interval of 1.5 years for Full Use of the Existing System. The magnitude of effective discharge is predicted to increase to 942 cfs for the No Action Alternative (3 year recurrence interval) and the Proposed Action (2 year recurrence interval). The magnitude of effective discharge is predicted to be 843 cfs, which has a recurrence interval of 1.4 years for Alternative 8a.

Table 5.3-22
Effective Discharge – South Boulder Creek Basin

Site	Alternative	$Q_{effective}$ (cfs)	Recurrence Interval of $Q_{effective}$ (yrs)	$Q_{effective}$ as % of Full Use (%)	RI Change from Full Use (yrs)
SBC1	Full Use	730	1.5	100%	0
	No Action	942	3	129%	1.5
	Proposed Action	942	2	129%	0.5
	Alternative 8a	843	1.4	115%	-0.1
SBC3	Full Use	536	1	100%	0
	No Action	512	1.1	96%	0.1
	Proposed Action	512	1.4	96%	0.3
	Alternative 8a	563	1.8	105%	0.8

Note:
Hydrologic changes would be similar for the Proposed Action and Alternative 1c, and between Alternatives 8a, 10a, and 13a. Therefore, the evaluation of impacts on channel morphology is presented for Full Use of the Existing System, the Proposed Action, Alternative 8a, and the No Action Alternative.

At SBC3, the effective discharge was calculated to be 536 cfs with a recurrence interval of 1 year for Full Use of the Existing System. The magnitude of effective discharge is predicted to remain within 5% of Full Use of the Existing System with the recurrence interval of effective discharge predicted to range from 1.1 to 1.8 years for all alternatives.

5.3.5.7 Overall Effective Discharge Trends

Given the sensitivity to flows rates and sediment transport calculations, significant variability was observed in effective discharge. As a general rule, the calculated effective discharge flow increased at both sites where diversions and flows are expected to increase. Trends in the recurrence interval of effective discharge generally suggest that effective discharge would occur less frequently in areas with decreased flows and more frequently in areas with increased flows, however there are many exceptions to the general trend.

5.3.6 Impact Summary

Predicted impacts to channel morphology were estimated based on a combination of observation of existing conditions, assessment of existing physical data and the numerical assessments presented above. Predicted impacts were made based on observed data trends amongst the various analyses. These predicted impacts are compared with Full Use of the Existing System and are presented for the different river basins below.

5.3.6.1 Fraser River Basin

Numerical analysis of Full Use of the Existing System quantifies various parameters related to the stream segments that describe the magnitude and frequency of different events that impact channel morphology and provide a basis for comparing impacts of Project alternatives.

Representative Sites FR1 and FR5

Representative sites FR1 and FR5 are located near the upper end of the Fraser River below Denver Water's diversion and modeled results for these sites were similar. Flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 1.8-1.9 years at both sites with Phase 2 transport occurring approximately 8 days per year at each location. Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 5 years at both locations. Effective discharge is predicted to occur with a recurrence interval of approximately 5-7 years at these sites. The relatively low recurrence interval of Phase 2 transport, the frequency at which flows reach this threshold, the number of years between Phase 2 events and the recurrence interval for effective discharge suggest that periods of sediment accumulation may occur, but long-term channel morphology at these stream segments is not expected to be impacted by diversions under Full Use of the Existing System.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Reduced flows resulting from the No Action Alternative are predicted to reduce the bedload sediment transport capacity at these locations by approximately 12% and sediment supply by 8%-9%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.8-2 years with flows above the threshold for Phase 2 transport occurring approximately 7-9 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be between 5 and 6 years at these locations. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence

interval of 5-6 years at these sites under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10-12 years for this alternative. Effective discharge is predicted to occur approximately once every 7 years at these locations under the No Action Alternative. Overall differences between Full Use of the Existing System and No Action Alternative are considered insignificant and no changes in channel morphology are predicted at these locations when compared to Full Use of the Existing System.

Reduced flows resulting from the Proposed Action are predicted to reduce the bedload sediment transport capacity at these locations by approximately 40%-50% and sediment supply by 30%-35%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.8-2.7 years with flows above the threshold for Phase 2 transport occurring approximately 4-7 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be between 8 and 9 years at these locations. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 8 years at these sites under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 18-23 years for this alternative noting that at higher flows, small changes in flows result in large changes in recurrence interval. Effective discharge is predicted to occur approximately once every 12 years at these locations under the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are predicted to be greater than the No Action Alternative. The recurrence interval of Phase 2 transport is predicted to be up to 1 year greater than for Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to occur for multiple days per year. Peak flood events and effective flows are predicted to occur less frequently for the Proposed Action. Based on results it is predicted that flow reductions would result in longer duration and additional locations where sediment may temporarily accumulate when compared to Full Use of the Existing System. Given the relative frequency of Phase 2 transport; however, sediment deposition is predicted to be temporary and no long-term changes in channel morphology are predicted at these locations when compared to Full Use of the Existing System.

Reduced flows resulting from Alternative 8a are predicted to reduce the bedload sediment transport capacity at these locations by approximately 40%-50% and sediment supply by about 30%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 2.4-2.6 years with flows above the threshold for Phase 2 transport occurring approximately 4 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 7 years at these locations. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 8 years at these sites under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 18-23 years for this alternative. Effective discharge is predicted to occur approximately once every 12-13 years at these locations under Alternative 8a. At these higher flow rates, small changes in flows result in large changes in recurrence interval. Overall impacts of Alternative 8a are predicted to be very similar to the Proposed Action. Based on results it is predicted that flow reductions would result in longer duration and additional locations where sediment may temporarily accumulate when compared to Full Use of the Existing System. Given the relative

frequency of Phase 2 transport; however, sediment deposition is predicted to be temporary and no long-term changes in channel morphology are predicted at these locations when compared to Full Use of the Existing System.

Representative Site FR2

Representative site FR2 is located on the Fraser River downstream of Tabernash. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 1.4 years with Phase 2 transport occurring approximately 26 days per year. Based on the modeled 45-year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 5 years. Effective discharge is predicted to occur with a recurrence interval of approximately 6 years. The relatively low recurrence interval of Phase 2 transport, the frequency at which flows reach this threshold, the number of years between Phase 2 events and the recurrence interval for effective discharge suggest that channel morphology at this stream segment is not expected to be impacted by diversions under Full Use of the Existing System.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Reduced flows resulting from the No Action Alternative are predicted to reduce the bedload sediment transport capacity at this location by approximately 6% and sediment supply by 3%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.4 years with flows above the threshold for Phase 2 transport occurring approximately 24 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 2 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 6 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 3 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and the No Action Alternative are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from the Proposed Action are predicted to reduce the bedload sediment transport capacity at this location by approximately 29% and sediment supply by 12%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.5 years with flows above the threshold for Phase 2 transport occurring approximately 20 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 2.5 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 8 years at this site under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 14 years for this alternative. Effective discharge is predicted to occur approximately once every 4 years at this location under the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are predicted to be greater than the No Action Alternative. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring less frequently

although they are still predicted to occur for multiple days per year. Peak flood events are predicted to occur less frequently for the Proposed Action while effective discharge is likely to occur more frequently. Based on results, it is predicted that flow reductions could result in more temporary sediment accumulation when compared to Full Use of the Existing System. Given that the recurrence interval of Phase 2 transport is relatively unchanged and Phase 2 transport is still predicted to occur for approximately 20 days per year, no long-term changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from Alternative 8a are predicted to reduce the bedload sediment transport capacity at this location by approximately 27% and sediment supply by 11%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.5 years with flows above the threshold for Phase 2 transport occurring approximately 21 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 2.5 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 8 years at these sites under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 14 years for this alternative. Effective discharge is predicted to occur approximately once every 9 years at this location under Alternative 8a. Overall differences between Full Use of the Existing System and Alternative 8a are predicted to be similar to the Proposed Action. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to occur for multiple days per year. Peak flood events and effective flows are predicted to occur less frequently for Alternative 8a. Based on analysis results, it is predicted that flow reductions could result in more temporary sediment accumulation when compared to Full Use of the Existing System. Under the recurrence interval of Phase 2 transport is relatively unchanged and Phase 2 transport is still predicted to occur for approximately 21 days per year, no long-term changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Representative Site FR3

Representative site FR3 is located on St. Louis Creek downstream of Denver Water's diversion. For Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 1.4 years with Phase 2 transport occurring approximately 22 days per year. Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 2.5 years. Effective discharge is predicted to occur with a recurrence interval of approximately 3 years. The relatively low recurrence interval of Phase 2 transport, the frequency at which flows reach this threshold, the limited number of years between Phase 2 events and the recurrence interval for effective discharge suggest that channel morphology at this stream segment is not expected to be impacted by diversions under Full Use of the Existing System.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Reduced flows resulting from the No Action Alternative are predicted to reduce the bedload sediment transport capacity at this location

by approximately 5% and sediment supply by 3%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.5 years with flows above the threshold for Phase 2 transport occurring approximately 20 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 2.5 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 6 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 3 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and No Action Alternative are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from the Proposed Action are predicted to reduce the bedload sediment transport capacity at this location by approximately 32% and sediment supply by 16%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.6 years with flows above the threshold for Phase 2 transport occurring approximately 15 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 3 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 6 years at this site under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 4 years at this location under the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are predicted to be greater than the No Action Alternative. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to occur for multiple days per year. Peak flood events and effective flows are predicted to occur slightly less frequently for the Proposed Action. Given that the recurrence interval of Phase 2 transport is relatively unchanged and Phase 2 transport is still predicted to occur for approximately 15 days per year, no long-term changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from Alternative 8a are predicted to reduce the bedload sediment transport capacity at this location by approximately 29% and sediment supply by 14%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.6 years with flows above the threshold for Phase 2 transport occurring approximately 16 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 3 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 6 years at this site under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 4 years at this location under Alternative 8a. Overall differences between Full Use of the Existing System and Alternative 8a are predicted to be similar to the Proposed Action. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to

occur for multiple days per year. Peak flood events and effective flows are predicted to occur slightly less frequently for Alternative 8a. Based on analysis results it is predicted that flow reductions could result in more temporary sediment accumulation when compared to Full Use of the Existing System. Given that the recurrence interval of Phase 2 transport is relatively unchanged and Phase 2 transport is still predicted to occur for approximately 15 days per year, no long-term changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Representative Site FR4

Representative site FR4 is located on Ranch Creek downstream of Denver Water's diversion. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 1.3 years with Phase 2 transport occurring approximately 20 days per year. Based on the modeled 45-year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 2 years. Effective discharge is predicted to occur with a recurrence interval of approximately 3 years. The relatively low recurrence interval of Phase 2 transport, the frequency at which flows reach this threshold, the limited number of years between Phase 2 events and the recurrence interval for effective discharge suggest that channel morphology at this stream segment is not expected to be impacted by diversions under Full Use of the Existing System.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Reduced flows resulting from the No Action Alternative are predicted to reduce the bedload sediment transport capacity at this location by approximately 3% and sediment supply by 4%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.3 years with flows above the threshold for Phase 2 transport occurring approximately 18 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 2 years. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 5 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and No Action Alternative are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from the Proposed Action are predicted to reduce the bedload sediment transport capacity at this location by approximately 21% and sediment supply by 20%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.4 years with flows above the threshold for Phase 2 transport occurring approximately 13 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 3 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at these sites under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every

5 years at this location under the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are predicted to be greater than the No Action Alternative. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to occur for multiple days per year. Peak flood events are predicted to occur at the same frequency as they do for Full Use of the Existing System and effective flows are predicted to occur less frequently for the Proposed Action. Given that the recurrence interval of Phase 2 transport is relatively unchanged and Phase 2 transport is still predicted to occur for approximately 13 days per year, no long-term changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from Alternative 8a are predicted to reduce the bedload sediment transport capacity at this location by approximately 19% and sediment supply by 18%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.4 years with flows above the threshold for Phase 2 transport occurring approximately 14 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 3 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at these sites under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 3 years at this location under Alternative 8a. Overall differences between Full Use of the Existing System and Alternative 8a are predicted to be similar to the Proposed Action. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to occur for multiple days per year. Peak flood events and effective flows are predicted to occur at the same frequency for Alternative 8a as they do for Full Use of the Existing System. Given that the recurrence interval of Phase 2 transport remains relatively unchanged and Phase 2 transport is still predicted to occur for approximately 14 days per year, no long-term changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Representative Site FR6

Representative site FR6 is located immediately downstream of Denver Water's diversion on Jim Creek. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 22 years with Phase 2 transport rarely occurring (approximately 0.2 day per year). Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 26 years. Effective discharge is predicted to occur with a recurrence interval of approximately 8 years for Full Use of the Existing System. The high recurrence interval for Phase 2 transport, the infrequency at which flows reach this threshold and the high recurrence interval for effective discharge suggest that this stream segment would be impacted by diversions and changes in channel morphology would occur under Full Use of the Existing System.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Reduced flows resulting from the No Action Alternative are predicted to reduce the bedload sediment transport capacity at this location by approximately 17% and sediment supply by 14%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 24 years with flows above the threshold for Phase 2 transport rarely occurring (approximately 0.2 day per year). The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 31 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 6 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 13 years for this alternative. Effective discharge is predicted to occur approximately once every 9 years at this location under the No Action Alternative. Predicted flows do not change significantly from Full Use of the Existing System and would not be sufficient to maintain equilibrium. Aggradation and/or vegetative encroachment expected under Full Use of the Existing System is likely to persist similar to Full Use of the Existing System.

Reduced flows resulting from the Proposed Action are predicted to reduce the bedload sediment transport capacity at this location by approximately 49% and sediment supply by 38%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 27 years with flows above the threshold for Phase 2 transport rarely occurring (approximately 0.1 day per year). The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 31 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 8 years at these sites under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 19 years for this alternative. Effective discharge is predicted to occur approximately once every 14 years at this location under the Proposed Action. It is predicted that the effective discharge for the Proposed Action would be slightly greater than the effective discharge for No Action Alternative, increasing to 91 cfs. Frequency and recurrence of Phase 2 transport flows are predicted to increase from 8 years to 14 years but are not likely to notably change the morphology at this location under the predicted low frequency of these events for Full Use of the Existing System. Reductions in the frequency of peak 5- and 10-year flood events when compared to Full Use of the Existing System suggest that existing aggradation and vegetative encroachment would accelerate.

Reduced flows resulting from Alternative 8a are predicted to reduce the bedload sediment transport capacity at this location by approximately 48% and sediment supply by 38%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 27 years with flows above the threshold for Phase 2 transport rarely occurring (approximately 0.1 day per year). The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 31 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 8 years at these sites under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 19 years for this alternative. Effective discharge is predicted to occur approximately once every 14 years at this location under Alternative 8a. Overall differences between Full Use of the Existing System and

Alternative 8a are predicted to be similar to the Proposed Action. Increases to the frequency and recurrence of Phase 2 transport flows are not predicted to notably change morphology at this location under the low frequency of these events predicted for Full Use of the Existing System. Reductions in the frequency of peak 5- and 10-year flood events when compared to Full Use of the Existing System suggest that existing aggradation and vegetative encroachment would accelerate.

Representative Site FR7

Representative site FR7 is located upstream of Denver Water's diversion on Vasquez Creek. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 1.2 years with Phase 2 transport occurring approximately 17 days per year. Based on the modeled 45 year daily PACSM results, flows large enough to initiate Phase 2 flows are expected to occur every year. Effective discharge is predicted to occur with a recurrence interval of approximately 1.2 years. The recurrence interval of Phase 2 transport, the frequency at which flows reach this threshold, the limited time between Phase 2 events and the recurrence interval for effective discharge suggest that channel morphology at this stream segment is not anticipated to be impacted by diversions under Full Use of the Existing System.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Increased flows resulting from the No Action Alternative are predicted to increase the bedload sediment transport capacity at this location by approximately 5% and sediment supply by 2%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.3 years with flows above the threshold for Phase 2 transport occurring approximately 18 days per year. Flow events large enough to initiate Phase 2 transport are predicted to occur every year. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 4 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 8 years for this alternative. Effective discharge is predicted to occur approximately once every 2 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and No Action Alternative are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Increased flows resulting from the Proposed Action are predicted to increase the bedload sediment transport capacity at this location by approximately 29% and sediment supply by 8%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.1 years with flows above the threshold for Phase 2 transport occurring approximately 23 days per year. Flow events large enough to initiate Phase 2 transport are predicted to occur every year. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 4 years at these sites under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 7 years for this alternative. Effective discharge is predicted to occur approximately once every 1.5 years at this location under the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are predicted

to be greater than the No Action Alternative. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring somewhat more frequently. Peak flood events are predicted to occur somewhat more frequency as they do for Full Use of the Existing System and effective flows are predicted to occur slightly less frequently for the Proposed Action. Given that the recurrence interval of Phase 2 transport is basically unchanged and Phase 2 transport is still predicted to occur a similar number of days per year, no long-term changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Increased flows resulting from Alternative 8a are predicted to increase the bedload sediment transport capacity at this location by approximately 24% and sediment supply by 7%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.1 years with flows above the threshold for Phase 2 transport occurring approximately 22 days per year. Flow events large enough to initiate Phase 2 transport are predicted to occur every year. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 4 years at this site under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 8 years for this alternative. Effective discharge is predicted to occur approximately once every 1.1 years at this location under Alternative 8a. Overall conditions for Alternative 8a are predicted to be similar to conditions for the Proposed Action. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring somewhat more frequently. Peak flood events are predicted to occur more frequently than they do for Full Use of the Existing System and effective flows are predicted to occur slightly more frequently for Alternative 8a. Given that the recurrence interval of Phase 2 transport remains relatively unchanged and Phase 2 transport is still predicted to occur a similar number of days per year, no long-term changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Overall Conclusions for the Fraser River Basin

Results generated from the Representative sites in the Fraser River Basin were used to predict impacts throughout the basin and compare impact anticipated as a result of Project alternatives with Full Use of the Existing System. Based on the results presented, a majority of the stream systems are expected to be stable from a channel morphology standpoint under Full Use of the Existing System. Altered flows resulting from the No Action Alternative are not expected to cause notable changes in morphology. Flow changes for the Proposed Action and Alternative 8a are in general, greater than the flow changes predicted for the No Action Alternative. It is expected that additional localized sediment deposition could occur under the Proposed Action and Alternative 8a; however, results indicate that remaining flows are sufficient to continue to cause Phase 2 transport and peak flood events to occur frequently therefore no long-term changes in channel morphology are predicted when compared to Full Use of the Existing System.

Streams below diversions with no bypass requirements were found to be an exception to the conclusions reached for the remainder of the drainage. Under Full Use of the Existing System, in areas with no bypass flows, peak flows are reduced to the point where Phase 2

sediment transport would not occur often enough and aggradation and/or channel encroachment is likely to occur. The No Action Alternative provides conditions that are generally similar to Full Use of the Existing System so no additional changes are expected under this alternative. Flow reductions resulting from the Proposed Action and Alternative 8a may cause aggradation and/or vegetative encroachment to accelerate.

5.3.6.2 Williams Fork River Basin

Numerical analysis of Full Use of the Existing System quantifies various parameters related to the stream segments that describe the magnitude and frequency of different events that impact channel morphology and provide a basis for comparing impacts of Project alternatives.

Representative Site WF1

Representative site WF1 is the downstream site on the Williams Fork River. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 1.1 years with Phase 2 transport occurring approximately 31 days per year. Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 2 years. Effective discharge is predicted to occur with a recurrence interval of approximately 1.6 years. The relatively low recurrence interval of Phase 2 transport, the frequency at which flows reach this threshold, the limited number of years between Phase 2 events and the recurrence interval for effective discharge suggest that channel morphology at this stream segment would not be impacted by diversions under Full Use of the Existing System.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Reduced flows resulting from the No Action Alternative are predicted to reduce the bedload sediment transport capacity at this location by approximately 3% and sediment supply by 3%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.2 years with flows above the threshold for Phase 2 transport occurring approximately 30 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 2 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 1.9 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and No Action Alternative are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from the Proposed Action are predicted to reduce the bedload sediment transport capacity at this location by approximately 16% and sediment supply by 14%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.2 years with flows above the threshold for Phase 2 transport occurring approximately 26 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 2 years at this location. The flow

categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at these sites under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 2 years at this location under Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are predicted to be slightly greater than the No Action Alternative. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to occur for multiple days per year. Peak flood events are not predicted to change when compared to Full Use of the Existing System and effective flows are predicted to occur slightly less frequently for the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from Alternative 8a are predicted to reduce the bedload sediment transport capacity at this location by approximately 14% and sediment supply by 14%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.2 years with flows above the threshold for Phase 2 transport occurring approximately 27 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 2 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at these sites under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 1.8 years at this location under Alternative 8a. Overall differences between Full Use of the Existing System and Alternative 8a are predicted to be similar to the Proposed Action. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to occur for multiple days per year. Peak flood events are not predicted to change when compared to Full Use of the Existing System and effective flows are predicted to occur slightly less frequently for Alternative 8a. Overall differences between Full Use of the Existing System and Alternative 8a are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Representative Site WF2

Representative site WF2 is the upstream site on the Williams Fork River located below Steelman Creek. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 1.2 years with Phase 2 transport occurring approximately 25 days per year. Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 2 years. Effective discharge is predicted to occur with a recurrence interval of approximately 1.4 years. The relatively low recurrence interval of Phase 2 transport, the frequency at which flows reach this threshold, the limited number of years between Phase 2 events and the recurrence interval for effective discharge suggest that

channel morphology at this stream segment is not expected to be impacted by diversions under Full Use of the Existing System.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Reduced flows resulting from the No Action Alternative are predicted to reduce the bedload sediment transport capacity at this location by approximately 4% and sediment supply by 4%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.2 years with flows above the threshold for Phase 2 transport occurring approximately 24 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 2 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 3 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and the No Action Alternative are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from the Proposed Action are predicted to reduce the bedload sediment transport capacity at this location by approximately 19% and sediment supply by 22%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.3 years with flows above the threshold for Phase 2 transport occurring approximately 18 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 2 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at these sites under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 2 years at this location under the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are predicted to be slightly greater than the No Action Alternative. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to occur for multiple days per year. Peak flood events are not predicted to change when compared to Full Use of the Existing System and effective flows are predicted to occur less frequently for the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from Alternative 8a are predicted to reduce the bedload sediment transport capacity at this location by approximately 17% and sediment supply by 22%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.3 years with flows above the threshold for Phase 2 transport occurring approximately 19 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 2 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at these sites under Alternative 8a; a Full Use of the Existing

System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 1.6 years at this location under Alternative 8a. Overall differences between Full Use of the Existing System and Alternative 8a are predicted to be similar to the Proposed Action. The recurrence interval of Phase 2 transport is predicted to be similar to that for Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to occur for multiple days per year. Peak flood events are not predicted to change when compared to Full Use of the Existing System and effective flows are predicted to occur slightly less frequently for Alternative 8a. Overall differences between Full Use of the Existing System and Alternative 8a are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Overall Conclusions for the Williams Fork River Basin

Results generated from the Representative sites in the Williams Fork River Basin were used to predict impacts throughout the basin and compare impact conditions anticipated under Full Use of the Existing System. Based on results, stream systems are expected to be stable from a channel morphology standpoint under Full Use of the Existing System. Altered flows resulting from the No Action Alternative are not expected to cause any notable changes in morphology. Flow changes for the Proposed Action and Alternatives 8a are in general, greater than the flow changes predicted for the No Action Alternative, however changes in the recurrence interval of Phase 2 transport and the frequency of Phase 2 transport are not predicted to change significantly. No changes to the recurrence of peak flood flows are expected for any alternative; therefore, no changes in channel morphology are predicted when alternatives are compared with Full Use of the Existing System.

5.3.6.3 Colorado River Basin

Numerical analysis of Full Use of the Existing System quantifies various parameters related to the stream segments that describe the magnitude and frequency of different events that impact channel morphology and provide a basis for comparing impacts of Project alternatives.

Representative Site CR1

Representative site CR1 is located on the Colorado River upstream of the confluence with the Williams Fork. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 8 years with Phase 2 transport occurring approximately 2 days per year based on results developed using the Parker and Wilcock and Crowe equations. Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 18 years. Under Full Use of the Existing System hydrology a flow of approximately 400 cfs occurs with a recurrence interval of 1.5-years and may be a better approximation of when Phase 2 transport actually occurs based on the questionable results obtained using the Parker and Wilcock and Crowe equations. Effective discharge is predicted to occur with a recurrence interval of approximately 8 years. Data suggests that sediment deposition is likely to occur during years between peak events under Full Use of

the Existing System. Sediment deposition is expected to be temporary with aggraded material removed during peak flow years.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Reduced flows resulting from the No Action Alternative are predicted to reduce the bedload sediment transport capacity at this location by approximately 2% and sediment supply by 1%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 8 years with flows above the threshold for Phase 2 transport occurring approximately 2 days per year based on the Parker and Wilcock and Crowe equations. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 18 years at this location from these equations. A flow of approximately 400 cfs which has a recurrence interval of 1.5 based on Full Use of the Existing System is expected to occur with a recurrence interval of 1.5 years under the No Action Alternative. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 6 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 9 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and the No Action Alternative are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from the Proposed Action are predicted to reduce the bedload sediment transport capacity at this location by approximately 12% and sediment supply by 7%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 8 years with flows above the threshold for Phase 2 transport occurring approximately 2 days per year based on the Parker and Wilcock and Crowe equations. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 18 years at this location from these equations. A flow of approximately 400 cfs which has a recurrence interval of 1.5 based on Full Use of the Existing System is expected to occur with a recurrence interval of 1.5 years under the Proposed Action. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 6 years at these sites under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 9 years at this location under the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from Alternative 8a are predicted to reduce the bedload sediment transport capacity at this location by approximately 10% and sediment supply by 6%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 8 years with flows above the threshold for Phase 2 transport occurring approximately 2 days per year based on the Parker and Wilcock and Crowe equations. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 18 years at this location from these equations. A flow of approximately 400 cfs which has a recurrence interval of 1.5 based on Full Use of the Existing System is expected to occur

with a recurrence interval of 1.5 years under Alternative 8a. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 6 years at these sites under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 8 years at this location under Alternative 8a. Overall differences between Full Use of the Existing System and Alternative 8a are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Representative Site CR2

Representative site CR2 is located on the Colorado River downstream of the confluence with the Williams Fork. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 3.5 years with Phase 2 transport occurring approximately 9 days per year based on results developed using the Parker and Wilcock and Crowe equations. Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 8 years. Under Full Use of the Existing System a flow of approximately 870 cfs occurs with a recurrence interval of 1.5-years and may be a better indicator of when Phase 2 transport actually occurs based on the questionable results obtained using the Parker and Wilcock and Crowe equations. Effective discharge is predicted to occur with a recurrence interval of approximately 7 years. Data suggests that sediment deposition may occur during years between peak events, but not to the extent of or for the duration anticipated upstream of the Williams Fork confluence under Full Use of the Existing System. Sediment deposition is expected to be temporary with aggraded material removed during peak flow years.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Reduced flows resulting from the No Action Alternative are predicted to reduce the bedload sediment transport capacity at this location by approximately 3% and sediment supply by 1%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 3.5 years with flows above the threshold for Phase 2 transport occurring approximately 9 days per year based on the Parker and Wilcock and Crowe equations. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 8 years at this location from these equations. A flow of approximately 870 cfs which has a recurrence interval of 1.5 based on Full Use of the Existing System is expected to occur with a recurrence interval of 1.5 years under the No Action Alternative. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 8 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and the No Action Alternative are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from the Proposed Action are predicted to reduce the bedload sediment transport capacity at this location by approximately 11% and sediment supply by

2%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 3.5 years with flows above the threshold for Phase 2 transport occurring approximately 7 days per year based on the Parker and Wilcock and Crowe equations. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 9 years at this location from these equations. A flow of approximately 870 cfs which has a recurrence interval of 1.5 based on Full Use of the Existing System is expected to occur with a recurrence interval of 1.6 years under the Proposed Action. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 9 years for this alternative. Effective discharge is predicted to occur approximately once every 8 years at this location under the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from Alternative 8a are predicted to reduce the bedload sediment transport capacity at this location by approximately 9% and sediment supply by 4%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 3.5 years with flows above the threshold for Phase 2 transport occurring approximately 7 days per year based on the Parker and Wilcock and Crowe equations. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 9 years at this location from these equations. A flow of approximately 870 cfs which has a recurrence interval of 1.5 based on Full Use of the Existing System is expected to occur with a recurrence interval of 1.6 years under Alternative 8a. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 9 years for this alternative. Effective discharge is predicted to occur approximately once every 8 years at this location under Alternative 8a. Overall differences between Full Use of the Existing System and Alternative 8a are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Overall Conclusions for the Colorado River Basin

Results generated from the Representative sites in the Colorado River were used to predict impacts along the river and compare impact conditions anticipated under Full Use of the Existing System. Based on results, stream systems appear to be stable from a channel morphology standpoint under Full Use of the Existing System, however sediment deposition likely occurs during years where peak flows are lower as the recurrence interval of Phase 2 transport is lengthened, particularly upstream of the Williams Fork confluence. Altered flows resulting from the No Action Alternative are not expected to cause any notable changes in morphology. Flow changes for the Proposed Action and Alternative 8a are in general, greater than the flow changes predicted for other Project alternatives; however, changes in the recurrence interval of Phase 2 transport and the frequency of Phase 2 transport are not predicted to change significantly when compared to Full Use of the Existing System. The analysis based in the 1.5-year recurrence interval flow for Full Use of the Existing System shows that this magnitude flood would still occur at

approximately the same frequency both upstream and downstream of the Williams Fork confluence for all Project alternatives. The recurrence interval of the 5-year flood based on Full Use of the Existing System hydrology is expected to increase upstream of the Williams Fork confluence given flow changes; however, the recurrence interval for the 10-year flood is expected to remain unchanged in this location and would decrease slightly downstream of Williams Fork for the Proposed Action and Alternative 8a. Given the slight differences calculated, no measurable changes in channel morphology are predicted for any of the alternatives when compared to Full Use of the Existing System.

5.3.6.4 Blue River Basin

Numerical analysis of Full Use of the Existing System quantifies various parameters related to the stream segments that describe the magnitude and frequency of different events that impact channel morphology and provide a basis for comparing impacts of Project alternatives.

Representative Site BR1

Representative site BR1 is located on the Blue River between Dillon and Green Mountain Reservoirs, downstream of Boulder Creek. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 1.8 years with Phase 2 transport occurring approximately 14 days per year. Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 5 years. Effective discharge is predicted to occur with a recurrence interval of approximately 5 years. The relatively low recurrence interval of Phase 2 transport, the frequency at which flows reach this threshold, the limited number of years between Phase 2 events and the recurrence interval for effective discharge suggest that channel morphology at this stream segment is not expected to be impacted by diversions under Full Use of the Existing System.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Reduced flows resulting from the No Action Alternative are predicted to reduce the bedload sediment transport capacity at this location by approximately 13% and sediment supply by 6%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 2.4 years with flows above the threshold for Phase 2 transport occurring approximately 12 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 6.5 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 6 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 16 years for this alternative. Effective discharge is predicted to occur approximately once every 9 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and No Action Alternative are greater than any other Project alternative. The recurrence interval of Phase 2 transport is predicted to be about 0.6 years greater than Full Use of the Existing System with Phase 2 transport flows occurring less frequently although they are still predicted to occur for multiple days per year. It is predicted that flow reductions would result in longer duration and additional locations where sediment may temporarily accumulate when compared to Full Use of the

Existing System. Given the relative frequency of Phase 2 transport; however, sediment deposition is predicted to be temporary and no long-term changes in channel morphology are predicted at these locations when compared to Full Use of the Existing System.

Reduced flows resulting from the Proposed Action are predicted to reduce the bedload sediment transport capacity at this location by approximately 6% and sediment supply by 3%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.8 years with flows above the threshold for Phase 2 transport occurring approximately 12 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 5 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at these sites under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 9 years for this alternative. Effective discharge is predicted to occur approximately once every 6 years at this location under the Proposed Action. Overall differences between Full Use of the Existing System and the Proposed Action are predicted to be insignificant; no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Reduced flows resulting from Alternative 8a are predicted to reduce the bedload sediment transport capacity at this location by approximately 6% and sediment supply by 3%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.8 years with flows above the threshold for Phase 2 transport occurring approximately 13 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be approximately 5 years at this location. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 9 years for this alternative. Effective discharge is predicted to occur approximately once every 5 years at this location under Alternative 8a. Overall differences between Full Use of the Existing System and Alternative 8a are predicted to be similar to those for the Proposed Action; no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Overall Conclusions for the Blue River Basin

Results generated from the Representative site on the Blue River were used to predict impacts along the river and compare impact conditions anticipated under Full Use of the Existing System. Based on these results, stream systems appear to be stable from a channel morphology standpoint under Full Use of the Existing System. Altered flows resulting from the Proposed Action and Alternative 8a are not expected to cause any notable changes in channel morphology when compared to Full Use of the Existing System. Flow changes for the No Action Alternative are in general, greater than the flow changes predicted for other Project alternatives; however, changes in the recurrence interval of Phase 2 transport and the frequency of Phase 2 transport are not predicted to change significantly. Peak flood events and effective flows are predicted to occur less frequently for the No Action Alternative with the current 5- and 10-year flows projected to occur once every 6 and 16 years, respectively. This data suggests that additional sediment deposition would likely

occur during years between peak events under the No Action Alternative as compared to Full Use of the Existing System. Sediment deposition is expected to be temporary with aggraded material removed during peak flow years.

5.3.6.5 North Fork South Platte River Basin

Numerical analysis of Full Use of the Existing System quantifies various parameters related to the stream segments that describe the magnitude and frequency of different events that impact channel morphology and provide a basis for comparing impacts of Project alternatives.

Representative Site NF1

Representative site NF1 is located on the North Fork downstream of the Roberts Tunnel outlet near the Town of Shawnee. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 1.1 years with Phase 2 transport occurring approximately 23 days per year. Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 3 years. Effective discharge is predicted to occur with a recurrence interval of approximately 1.1 years. The recurrence interval of Phase 2 transport and effective discharge are at the lower end of those calculated for other representative sites that were observed to be stable. Erosive forces which have led to the need for localized bank stabilization currently exist. Flows anticipated for Full Use of the Existing System are expected to cause additional localized instability.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Increased flows resulting from the No Action Alternative are predicted to increase the bedload sediment transport capacity at this location by approximately 17% and sediment supply by 9%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.1 years with flows above the threshold for Phase 2 transport occurring approximately 28 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 1.5 years. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 1.2 years at this location under the No Action Alternative. Overall flow increases are predicted to encourage additional transport slightly more than for Full Use of the Existing System. Based on results it is predicted that increased flows would continue to cause erosive forces that likely increase the need for localized bank stabilization to a similar extent predicted for Full Use of the Existing System.

Increased flows resulting from the Proposed Action are predicted to increase the bedload sediment transport capacity at this location by approximately 36% and sediment supply by 8%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.1 years with flows above the threshold for Phase 2 transport occurring approximately 34 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 1.5 years. The flow categorized as the 5-year flood event based

on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 1.2 years at this location under the Proposed Action. Overall flow increases are predicted to encourage additional transport slightly more than for the No Action Alternative. The recurrence interval of Phase 2 transport is predicted to remain unchanged when compared to Full Use of the Existing System with Phase 2 transport flows occurring more often. Peak flood events are predicted to occur with the same frequency and effective discharge at a similar frequency for the Proposed Action as compared to Full Use of the Existing System. Based on results it is predicted that increased flows would continue to cause erosive forces that may slightly increase the need for localized bank stabilization when compared to Full Use of the Existing System.

Increased flows resulting from Alternative 8a are predicted to increase the bedload sediment transport capacity at this location by approximately 35% and sediment supply by 8%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.1 years with flows above the threshold for Phase 2 transport occurring approximately 33 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 1.5 years. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 1.2 years at this location under Alternative 8a. Overall flow increases are predicted to encourage additional transport in a similar manner as the Proposed Action. The recurrence interval of Phase 2 transport is predicted to remain unchanged when compared to Full Use of the Existing System with Phase 2 transport flows occurring more often. Peak flood events are predicted to occur with the same frequency and effective discharge at a similar frequency for Alternative 8a as compared to Full Use of the Existing System. Based on results it is predicted that increased flows would continue to cause erosive forces that may slightly increase the need for localized bank stabilization when compared to Full Use of the Existing System.

Representative Site NF2

Representative site NF2 is located on the North Fork near the Town of Pine. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 1.2 years with Phase 2 transport occurring approximately 46 days per year. Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 flows is 2 years. Effective discharge is predicted to occur with a recurrence interval of approximately 1.1 years. The recurrence interval of Phase 2 transport and effective discharge are at the lower end of those calculated for other representative sites that were observed to be stable. Erosive forces which have led to the need for localized bank stabilization currently exist. Flows anticipated for Full Use of the Existing System are expected to cause additional localized instability.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Increased flows resulting from the No Action

Alternative are predicted to increase the bedload sediment transport capacity at this location by approximately 13% and sediment supply by 12%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.1 years with flows above the threshold for Phase 2 transport occurring approximately 51 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 1 year. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 1.1 years at this location under the No Action Alternative. Overall flow increases are predicted to encourage additional transport slightly more than for Full Use of the Existing System. The recurrence interval of Phase 2 transport is predicted to decrease slightly when compared to Full Use of the Existing System with Phase 2 transport flows occurring slightly more often. The recurrence interval of peak flood events and effective discharge are predicted to remain unchanged for the No Action Alternative. Based on results it is predicted that increased flows would continue to cause erosive forces that likely increase the need for localized bank stabilization to a similar extent predicted for Full Use of the Existing System.

Increased flows resulting from the Proposed Action are predicted to increase the bedload sediment transport capacity at this location by approximately 26% and sediment supply by 20%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.1 years with flows above the threshold for Phase 2 transport occurring approximately 59 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 1 year. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 1.1 years at this location under the Proposed Action. Overall flow increases are predicted to encourage additional transport more than for Full Use of the Existing System. The recurrence interval of Phase 2 transport is predicted to decrease slightly when compared to Full Use of the Existing System with Phase 2 transport flows occurring slightly more often. The recurrence interval of peak flood events and effective discharge are predicted to remain unchanged for the Proposed Action. Based on results it is predicted that increased flows would continue to cause erosive forces that likely increase the need for localized bank stabilization slightly more than predicted for Full Use of the Existing System.

Increased flows resulting from Alternative 8a are predicted to increase the bedload sediment transport capacity at this location by approximately 25% and sediment supply by 19%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 1.1 years with flows above the threshold for Phase 2 transport occurring approximately 58 days per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 1 year. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is

predicted to occur approximately once every 1.1 years at this location under Alternative 8a. Overall flow increases are predicted to encourage additional transport in a similar manner as the Proposed Action. The recurrence interval of Phase 2 transport is predicted to decrease slightly when compared to Full Use of the Existing System with Phase 2 transport flows occurring slightly more often. The recurrence interval of peak flood events and effective discharge are predicted to remain unchanged for Alternative 8a. Based on results, it is predicted that increased flows would continue to cause erosive forces that likely increase the need for localized bank stabilization slightly more than predicted for Full Use of the Existing System.

Overall Conclusions for the North Fork South Platte River Basin

Results generated from the Representative sites on the North Fork South Platte River were used to predict impacts along the river and compare impact conditions anticipated under Full Use of the Existing System. Based on the results of this analysis, the stream system is predicted to be susceptible to additional areas of localized instabilities under Full Use of the Existing System. Altered flows resulting from the Project alternatives would increase flows throughout this area. The Phase 2 sediment transport recurrence interval for all Project alternatives would be 1.1-1.2 years, which is consistent with that predicted for Full Use of the Existing System. Flows are expected to be at or above the threshold causing Phase 2 sediment transport up to approximately 50% more often for the different alternatives than they are for Full Use of the Existing System. The recurrence intervals for peak flood events and effective discharge are predicted to remain generally unchanged for all alternatives when compared to Full Use of the Existing System. Increased flows are predicted to encourage bank instabilities and additional localized bank stabilization may be required. Of the various Project alternatives, the No Action Alternative is predicted to have the least impact while the Proposed Action and Alternative 8a are predicted to have the greatest potential impacts.

5.3.6.6 South Boulder Creek Basin

Numerical analysis of Full Use of the Existing System quantifies various parameters related to the stream segments that describe the magnitude and frequency of different events that impact channel morphology and provide a basis for comparing impacts of Project alternatives.

Representative Site SBC1

Representative site SBC1 is located on South Boulder Creek upstream of Rollinsville. Under Full Use of the Existing System, flows required to initiate Phase 2 sediment transport are predicted to occur with a recurrence interval of approximately 4 years with Phase 2 transport occurring approximately 1 day per year. Based on the modeled 45 year daily PACSM results, the longest interval between flows large enough to initiate Phase 2 transport is 17 years. Effective discharge is predicted to occur with a recurrence interval of approximately 1.5 years. Recurrence interval of Phase 2 transport and effective discharge are similar to recurrence intervals for the same parameters at locations where flow depletions have occurred. The frequency of Phase 2 transport is less and the maximum

time period between Phase 2 flows is greater than unimpacted sites. Observations that the channel bed at this site is heavily armored likely impact these values.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Increased flows resulting from the No Action Alternative are predicted to increase the bedload sediment transport capacity at this location by approximately 3% and sediment supply by 3%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 4 years with flows above the threshold for Phase 2 transport occurring approximately 1 day per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 14 years. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 4 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 10 years for this alternative. Effective discharge is predicted to occur approximately once every 3 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and the No Action Alternative are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Increased flows resulting from the Proposed Action are predicted to increase the bedload sediment transport capacity at this location by approximately 38% and sediment supply by 14%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 3 years with flows above the threshold for Phase 2 transport occurring approximately 1 day per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 7 years. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 4 years at this site under the Proposed Action; a Full Use of the Existing System 10-year flood is predicted to occur every 7 years for this alternative. Effective discharge is predicted to occur approximately once every 2 years at this location under the Proposed Action. Overall flow increases are predicted to encourage additional transport slightly more than for Full Use of the Existing System or the No Action Alternative. The recurrence interval of Phase 2 transport is predicted to decrease slightly when compared to these alternatives although Phase 2 transport flows are expected to occur with the same, low frequency. Peak flood events and effective flows are predicted to occur somewhat more frequently. Based on results it is predicted that increased flows would continue to cause erosive forces that may increase the need for additional localized bank stabilization when compared to Full Use of the Existing System.

Increased flows resulting from Alternative 8a are predicted to increase the bedload sediment transport capacity at this location by approximately 38% and sediment supply by 14%. Phase 2 sediment transport is predicted to occur with a recurrence interval of 3 years with flows above the threshold for Phase 2 transport occurring approximately 1 day per year. The maximum duration between flow events large enough to initiate Phase 2 transport is predicted to be 7 years. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 4 years at this site under Alternative 8a; a Full Use of the Existing System 10-year flood is predicted to occur every 7 years for this alternative. Effective discharge is predicted to occur approximately once every 1.4 years at this location under Alternative 8a.

Overall flow increases are predicted to encourage additional transport in a similar manner as the Proposed Action. The recurrence interval of Phase 2 transport is predicted to decrease slightly when compared to Full Use of the Existing System although Phase 2 transport flows are expected to occur with the same, low frequency. Peak flood events and effective flows are predicted to occur somewhat more frequently. Based on results, it is predicted that increased flows would continue to cause erosive forces that may increase the need for additional localized bank stabilization when compared to Full Use of the Existing System.

Representative Site SBC3

Representative site SBC3 is located on South Boulder Creek downstream of Gross Reservoir. Under Full Use of the Existing System flows required to initiate Phase 2 sediment transport are predicted to occur every year with Phase 2 transport occurring approximately 53 days per year. Based on the modeled 45 year daily PACSM results, Phase 2 transport is predicted to occur every year. Effective discharge is predicted to occur every year. Recurrence interval of Phase 2 transport, the frequency at which flows reach this threshold, the limited time between Phase 2 events and the recurrence interval for effective discharge all suggest that high flows encourage transport at this location for Full Use of the Existing System.

Changes in flows resulting from the different Project alternatives would alter some of the parameters related to channel morphology. Increased flows resulting from the No Action Alternative are predicted to increase the bedload sediment transport capacity at this location by approximately 7% and sediment supply by 2%. Phase 2 sediment transport is predicted to occur every year with flows above the threshold for Phase 2 transport occurring approximately 55 days per year. Phase 2 transport is predicted to occur every year. The flow categorized as the 5-year flood event based on Full Use of the Existing System hydrology is expected to occur with a recurrence interval of 5 years at this site under the No Action Alternative; a Full Use of the Existing System 10-year flood is predicted to occur every 11 years for this alternative. Effective discharge is predicted to occur approximately once every 1.1 years at this location under the No Action Alternative. Overall differences between Full Use of the Existing System and the No Action Alternative are considered insignificant and no changes in channel morphology are predicted at this location when compared to Full Use of the Existing System.

Increased flows resulting from the Proposed Action are predicted to result in a decrease in the bedload sediment transport capacity at this location by approximately 25% while sediment supply is predicted to increase by 4%. Phase 2 sediment transport is predicted to occur every year with flows above the threshold for Phase 2 transport occurring approximately 32 days per year. The flows categorized as the 5-year flood and the 10-year flood event based on Full Use of the Existing System hydrology are not predicted to occur within the modeled 45 year period for this alternative. Effective discharge is predicted to occur approximately once every 1.4 years at this location under the Proposed Action. Overall sediment transported by this alternative is predicted to decrease despite flow increases given the planned timing of releases from the reservoir. Reductions in transport and the frequency of flows initiating Phase 2 transport are expected to decrease erosive

potential in the stream and potentially reduce the need for localized bank stabilization when compared to Full Use of the Existing System.

Increased flows resulting from Alternative 8a are predicted to result in a decrease in the bedload sediment transport capacity at this location by approximately 24% while sediment supply is predicted to increase by 4%. Phase 2 sediment transport is predicted to occur every year with flows above the threshold for Phase 2 transport occurring approximately 32 days per year. The flows categorized as the 5-year flood and the 10-year flood event based on Full Use of the Existing System hydrology are not predicted to occur within the modeled 45 year period for this alternative. Effective discharge is predicted to occur approximately once every 1.8 years at this location under Alternative 8a. Overall Alternative 8a is predicted to be very similar to the Proposed Action as sediment transported by this alternative is predicted to decrease despite flow increases under the planned timing of releases from the reservoir. Reductions in transport and the frequency of flows initiating Phase 2 transport are expected to decrease erosive potential in the stream and potentially reduce the need for localized bank stabilization when compared to Full Use of the Existing System.

Overall Conclusions for the North Fork South Platte River Basin

Results generated from the Representative sites on South Boulder Creek were used to predict impacts throughout the stream and compare impacts conditions anticipated under Full Use of the Existing System. Based on the results of this analysis the stream system is predicted to be stable from a channel morphology standpoint under Full Use of the Existing System, although past channel armoring activities indicate past bank erosion. Altered flows resulting from the Project alternatives would increase flows throughout this area. Channel segments both above and below Gross Reservoir are not expected to be impacted in terms of channel morphology for the No Action Alternative. Under the Proposed Action and Alternative 8a, it is predicted that increased flows would continue to cause erosive forces that may increase the need for localized bank stabilization when compared to Full Use of the Existing System for stream segments above the reservoir. Operations of the reservoir, which are planned to release less water during peak flow periods, are predicted to decrease erosive potential downstream of the reservoir under the Proposed Action and Alternative 8a when compared to Full Use of the Existing System.

5.3.7 Mitigation and Monitoring

Fraser, Williams Fork, Colorado, and Blue Rivers

Due to anticipated flow reductions resulting from the action alternatives and the No Action Alternative, additional localized sediment deposition is anticipated, particularly near diversion locations. Deposition that occurs should be limited in extent and magnitude but would likely persist for longer periods. Flow reductions, are not, however predicted to pose significant changes to long-term channel morphology. The exception is downstream of diversions in locations where no bypass flows occur. Sediment accumulation and/or vegetative encroachment currently exists in these areas and is expected to accelerate with Project alternatives. As a result the channel width may decrease and the amount and size of vegetation in the channel may increase.

Given that existing channel morphology is already impacted by past diversions at locations immediately downstream of diversions with no bypass flows, mitigating the incremental effects of the action alternatives and the No Action Alternative will not restore the natural sediment balance below these diversions. It is therefore believed that mitigation for these impacts would provide greater benefit if it were included as part of overall stream enhancement at other locations within the basin.

Muddy Creek

Flow changes in Muddy Creek are expected to be minimal under the No Action Alternative and action alternatives. Therefore, channel morphology impacts are predicted to be negligible and no mitigation is recommended.

South Boulder Creek and North Fork South Platte River

Due to anticipated flow increases resulting from the action alternatives and the No Action Alternative, minor amounts of localized bed and bank erosion may occur. Denver Water has an ongoing program to monitor and stabilize banks as needed. The bank stabilization programs per the FERC hydropower license for Gross Reservoir and Denver Water's ongoing maintenance activities would continue to mitigate Project-induced areas of instability and stabilize those areas as required.

South Platte River

Anticipated flow changes resulting from the action alternatives and the No Action Alternative, are very minor in nature. No significant changes to sediment deposition or bed or bank erosion are anticipated; therefore, no mitigation is recommended.

5.3.8 Unavoidable Adverse Impacts

Implementation of alternatives considered in the Environmental Impact Statement have the potential to temporarily increase localized sediment deposition in streams where additional diversions lead to decreased flows. These impacts, however, are expected to be temporary in nature with sufficient large flows remaining to maintain overall long-term balance in stream morphology. Aggradation and/or vegetative encroachment is currently occurring and would continue under the Project alternatives. Increased flows in the North Fork South Platte River and South Boulder Creek have the potential to cause additional channel instability. These impacts can be mitigated through stabilization. Since all anticipated impacts can be mitigated for, there are no foreseen unavoidable adverse impacts identified for channel morphology in the Project area.

5.4 GROUNDWATER

This section describes the direct and indirect groundwater impacts expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Potential groundwater issues documented during scoping include:

- Effects on groundwater quality for potable and recreational uses on the West Slope, particularly the combined impacts of larger stream diversions and future Wastewater Treatment Plant (WWTP) discharges.
- Effects on groundwater recharge caused by stream flow depletions in Fraser River Basin.
- Effects on habitats supported by groundwater systems on the East Slope (refer to Section 5.8).

These issues and other potential groundwater impacts resulting from implementing a Moffat Project alternative are evaluated and described in the following sections.

5.4.1 Proposed Action (Alternative 1a)

As described in Section 5.1, the expected water level changes in reservoirs would be relatively small, compared to the historical ranges for each of the potentially affected reservoirs on the West Slope. On the East Slope however, the water level in Gross Reservoir would rise substantially because the dam height will be raised as part of the Proposed Action.

5.4.1.1 Gross Reservoir

The increased storage proposed for Gross Reservoir to accommodate the additional water diverted from the Fraser River and the Williams Fork River would likely cause increased seepage from the reservoir to the groundwater system. Under the Proposed Action, the projected normal high water level in the reservoir would be about 124 feet higher than present. Higher reservoir levels would cause a consequent increase in groundwater levels adjacent to the reservoir. In areas upstream of the reservoir, this groundwater mounding effect would cause the eastward hydraulic gradients to decrease and thus reduce the eastward rate of groundwater flow toward the reservoir. Wetlands that currently exist along the edge of the reservoir would be inundated with water under the new storage scenario. However, new wetlands are likely to form in upstream fingers of the expanded reservoir, which would be sustained by shallow groundwater, similar to Current Conditions (2006).

Downstream of Gross Reservoir to the east, the higher reservoir seepage into groundwater would cause groundwater levels to rise slightly, and cause groundwater discharge into the creek to increase slightly.

River Segments

Section 3.4 describes the groundwater conditions in areas potentially affected by this Project. Stream flow changes were modeled using the Platte and Colorado Simulation

Model (PACSM) as described in Final Environmental Impact Statement (EIS) Sections 3.1 and 5.1.

Changes in flood extent, including changes in stream levels and inundation areas, were modeled using the U.S. Army Corps of Engineers (Corps) Hydrologic Engineering Centers-River Analysis System (HEC-RAS) computer software (version 4.0) for analysis of stream hydraulics. A HEC-RAS model was developed for each representative stream reach using data collected in the field, including stream discharge, velocity, slope, and channel geometry data. For more detailed information on the data collected, refer to the Moffat Collection System Project Existing Channel Conditions Report (ERC 2006). The HEC-RAS hydraulic models were used to generate water surface-profiles and other hydraulic output as a function of discharge for each reach. For each representative reach, the HEC-RAS modeled was simulated for the 1.5-, 2-, 5-, and 10-year flood events for each EIS scenario (Current Conditions, Full Use of the Existing System, No Action Alternative, and each EIS action alternative). Probability plotting was relied on to estimate the flood flow rates for the recurrence intervals evaluated. The probability plot flows are provided in Table 4.6.8-1 (refer to Section 4.6.8). HEC-RAS output was used to determine changes in water surface elevations and differences in the width of channel that would be inundated. The results for the Proposed Action are provided in Tables 5.8-4, 5.8-5, and 5.8-6 (refer to Section 5.8).

Fraser River

Groundwater conditions in the Fraser River Valley are described first because there are more hydrogeologic and stream flow data available in this valley, and also because the environmental effects will likely be larger here than for the other mountain watersheds. Under the Proposed Action, stream flows along the Fraser River are predicted to decrease during the seasonal high runoff period. The maximum reduction in peak flow would typically be in June or July. Changes in the level of the river would cause localized, minimal effects on the groundwater system in this watershed. Groundwater levels would decrease slightly, and the hydraulic gradient in groundwater near the river would increase slightly in response to the reductions in peak stream flows.

Throughout the blue and brown areas delineated on Figure 3.4-1, groundwater recharge rates would remain the same under the Proposed Action as for Current Conditions. Both the uplands and along the stream channels in the blue areas are upstream of the Board of Water Commissioners (Denver Water) diversion points. The brown areas delineate another part of the watershed in which the Proposed Action will not affect groundwater recharge rates. Both the uplands and the tributary channels in the brown area are upstream of any Denver Water diversion points. Based on information in Section 3.4, substantial groundwater recharge occurs throughout the blue and brown areas delineated on Figure 3.4-1.

The blue and brown areas of Figure 3.4-1 include the highest land surface elevations, precipitation rates, and snowpack amounts in these watersheds. Precipitation and snowmelt infiltrate though permeable soils and fractured rocks in the upland areas to become groundwater recharge. Groundwater flows generally downhill, away from recharge areas and toward discharge areas along the streams lower in the valley. Unaffected stream channel segments are depicted with light blue lines on these watershed maps. Along those

stream segments, groundwater recharge contributed by seepage through the bottom of stream beds would not change due to this Project at any time of year because those stream beds are not downstream of any Denver Water diversion point. Therefore, the Proposed Action would not impact groundwater recharge rates, groundwater flow, or availability of groundwater resources in any of those areas.

Within the white area delineated on Figure 3.4-1, groundwater recharge rates would also not change because this area lies outside the limits of the potentially-affected stream segments and so it is not downstream of any Denver Water diversion points. As is true for the blue and brown areas on Figure 3.4-1, none of the hydrogeologic factors controlling the infiltration of water below the ground surface would be altered by this Project.

In the remaining parts of this watershed that lie directly downstream of the diversions, the Proposed Action has the potential to slightly reduce groundwater recharge rates beneath the affected stream segments. Extending the seasonal duration of the stream flow diversions may cause a short-term minor decrease in the rate of groundwater recharge beneath these stream channel segments (golden brown lines). However, streambed seepage rates would slightly diminish only during the proposed diversions, which would be during the high-flow snowmelt season. The degree to which streambed seepage may decrease is related to the potential reduction in hydraulic gradient, which is determined by the difference in elevations between the stream level and the groundwater level beneath the stream during the proposed diversion period.

Groundwater recharge rates would only decline where: (1) the stream reach is losing water by seepage to groundwater under Current Conditions, and (2) the diverted stream flow causes a substantial decrease in the stream level and the wetted area of the stream bed. The potential change in groundwater recharge along those stream segments (the golden brown lines on Figure 3.4-1) would be minimal for reasons described in the following paragraphs.

Groundwater data and other hydrogeologic information presented in Section 3.4, combined with the stream flow modeling in Section 5.1, indicates there will be, at most, very small changes in groundwater recharge directly beneath potentially-affected stream segments. Streambed seepage rates would remain essentially the same as for Current Conditions because: (1) the high-flow stream levels and wetted areas of the channels would only change by a very small amount, (2) groundwater flows generally toward and into the streams, and (3) the hydraulic conductance (permeability) of the streambed materials would not be affected by the Proposed Action. At most, the streambed seepage rates in the potentially affected stream segments would decrease by an exceedingly small amount because the timing of the Proposed Action diversions would coincide with high runoff periods in wet or average years. Appendix H-9 provides a series of flow duration curves based on PACSM results for a number of locations along the Fraser River and tributaries downstream of the diversion points. The curves indicate that the potential changes in flow durations attributable to this Project would be minimal. As shown by the flow duration curves, flow reductions resulting from the Proposed Action would occur only when there are higher flow rates, which typically correspond with wet years.

As part of the impact assessment for wetland and riparian areas, Section 5.8 provides an analysis of the relationships between stream flow changes and inundated areas in the affected drainage. Table 5.8-4 provides predicted changes in stream levels and channel

widths for four selected sampling sites along streams in the Fraser River watershed. The modeling results indicate site FR1 near Winter Park would have the largest reduction in stream level due to the Denver Water diversions. In that reach of the river, the peak stream level during a 2-year flow event would drop about 8 inches. The wetted channel width would only change by about 3.2 feet, which is small in comparison to the existing channel width during the high flow period (i.e., the 2-year water profile).

In summary, the Proposed Action would have minimal impacts on groundwater levels in the Fraser River watershed. In wet and average years, the Proposed Action would not impact groundwater levels except downstream of Denver Water diversion points in areas immediately adjacent to those stream segments. Declining stream levels attributable to the Proposed Action would likely cause very minor short-term reductions in groundwater levels next to the streams and minimal decreases in streambed seepage rates. During snowmelt runoff, local recharge contributed by streambed seepage may be temporarily reduced by the proposed diversions in some reaches, but only very slightly. Overall, groundwater recharge rates would not change substantially during wet and average years. During dry years, there would be no additional water diversions, and thus, the Proposed Action would not impact groundwater levels or recharge rates.

The Fraser Sanitation District/Grand County Water and Sanitation District #1 WWTP is located in the upper reach of the Fraser River Basin and discharges effluent into the Fraser River. Project-related stream flow reductions could reduce the capacity of the river to assimilate the discharge from this WWTP. If the quality of the stream water downstream of the WWTP effluent discharge point is degraded, this may adversely impact groundwater quality. This indirect impact to groundwater quality would be localized to those reaches in which stream levels are substantially higher than the adjacent groundwater levels, where the stream currently loses water to the groundwater system. However, there are no known reaches of the river below any Denver Water diversion in which stream flow recharges groundwater during average or wet years. Natural attenuation of undesirable constituents in the stream water, and along the streambed-groundwater interface, would further minimize the impacts to groundwater quality and would probably result in a minimal impact to the groundwater system overall.

Williams Fork River

The additional stream flow removed from the Williams Fork River would be similar conditions to those described for the Fraser River Basin. Throughout the blue, white, and brown areas delineated on Figure 3.4-14, groundwater recharge rates would remain the same as for Current Conditions. Both the uplands and areas along the stream channels in the blue areas are upstream of the Denver Water diversion points. The brown areas delineate another part of the watershed in which the Proposed Action will not affect groundwater recharge rates because those areas are not downstream of any Denver Water diversion points.

None of the hydrogeologic factors controlling the infiltration of water below the ground surface would be altered by this Project. Thus, the flow changes will have no effect on groundwater recharge rates throughout the vast majority of the Williams Fork River watershed.

In the remaining parts of this watershed that lie directly downstream of the diversions, the Proposed Action has the potential to reduce groundwater recharge rates beneath the affected stream segments. Extending the seasonal duration of the stream flow diversions may cause a short-term minor decrease in the rate of groundwater recharge beneath these stream channel segments (golden brown lines). However, streambed seepage rates would slightly diminish only during the proposed diversions, which would be during the high-flow snowmelt season. The degree to which streambed seepage may decrease is related to the potential reduction in hydraulic gradient, which is determined by difference in elevations between the stream level and the groundwater level beneath the stream for the flow changes predicted to occur under the Proposed Action.

In summary, the proposed diversions are expected to have minimal impacts on groundwater levels in the Williams Fork watershed. In wet and average years, the Proposed Action would not impact groundwater levels except downstream of Denver Water diversion points in areas immediately adjacent to those stream segments. During snowmelt runoff, local recharge contributed by streambed seepage would be temporarily reduced by the proposed diversions, but only very slightly. Overall, groundwater recharge rates would not change substantially during wet and average years. During dry years, there would be no additional water diversions, and thus, the Proposed Action would not impact groundwater levels or recharge rates.

Colorado River

Flows in an average year in the Colorado River below the Windy Gap gage would decline under the Proposed Action, would result in slightly lower river water levels, narrower widths, and a potential for slight reductions in groundwater levels adjacent to the river. Impacts to groundwater would be minimal, similar to but less than those described above for the Fraser River.

Muddy Creek enters the north side of the Colorado River near Kremmling, just north of where the Blue River enters the Colorado River from the south. Flows in Muddy Creek would not be affected by the Project because it is not downstream of any potentially-affected river segments in the upper Colorado River Basin.

Blue River

Below Dillon Reservoir on the Blue River, flows would vary throughout the year with implementation of the Proposed Action. On average, there would be an increase in reservoir levels in winter months and a decrease in reservoir levels in the summer months and flows in the Blue River would be lower in the summer and slightly higher in the winter. The changes in flow below the Green Mountain Reservoir would be similar in nature and duration to the flow changes below the Dillon Reservoir. However, the flow changes would be less in the Blue River below Green Mountain Reservoir. Changes in the Blue River flow would cause similar changes in groundwater levels along the river. Impacts to groundwater would be minimal and localized, similar to those described above for the Fraser River.

There are several WWTPs in the upper reaches of the Blue River Basin; one of these WWTPs operated by the Silverthorne-Dillon Joint Sewer Authority discharges treated

water to the Blue River below Dillon Dam. Similar to the impacts described for the Fraser River Basin, the reductions in flow volumes could reduce the capacity of the Blue River and its tributaries to assimilate the discharge from these WWTPs. Nonetheless, because the Project would only divert surface water from Dillon Reservoir during the high flow periods in wet or average years, the reduction in assimilative capacity of the Blue River below Dillon Dam would be small. If the flow reductions diminish the natural attenuation capacity of the stream, this may result in local adverse impacts to surface water quality. For instance, discharges of WWTP effluent may not be attenuated as quickly as for Current Conditions. Seepage from the streambed into the adjacent groundwater in those areas could indirectly cause adverse impacts to the local groundwater quality next to the river. However, natural attenuation of undesirable constituents would continue in the Blue River and along the riverbed-groundwater interface. Overall, the Proposed Action would not impact groundwater quality.

South Boulder Creek

Along South Boulder Creek above Gross Reservoir, the flow changes are related to the changes in the Moffat Tunnel diversions from the West Slope basins. The flows increase in the summer months, and remain relatively unchanged during winter months of an average year when compared to Full Use of the Existing System. Below Gross Reservoir, the changes in stream flow would be in response to the increased storage and changes in releases from Gross Reservoir. During the winter months, the transfer of water from Gross Reservoir to Ralston Creek Reservoir would increase flows along South Boulder Creek. Downstream of the South Boulder Diversion Canal, flows would remain approximately the same as the Full Use of the Existing System scenario with slight decreases during the summer months of average and wet years.

The impacts of these flow changes on groundwater are expected to be negligible. Along South Boulder Creek above Gross Reservoir, the stream generally has a steep gradient typical of mountain streams. Thus, increasing stream flow would cause a relatively small increase in the elevation of the stream level. Even if the stream level increases during the summer months, the rise in groundwater levels would be limited to the area immediately adjacent to the stream and would not be more than the slight change in stream level caused by the flow increase. Downstream of Gross Reservoir, the flow changes during the winter months are expected to cause even smaller rises in groundwater levels, which would also be localized in areas immediately next to the creek.

North Fork South Platte River and South Platte River

On the North Fork South Platte River, changes in Roberts Tunnel diversions from the Blue River would cause a decrease in flows in the winter months and an increase in flows in the summer below the Geneva Creek gage.

Along the South Platte River, changes in flow vary depending on location. Below Chatfield Reservoir, flow rates increase in January and decrease in August and September, on average. At the Denver Water gage, the changes in stream flow are smaller in magnitude and range from an increase in January and decrease in June, July, and August on average.

The maximum expected increases and decreases in stream flow would only have minor impacts on groundwater. Because of the steep gradient and channel shape, the expected

change in stream flow would cause only a small change in the stream water level at any given point. Even as groundwater levels adjacent to the stream rise or fall slightly as a result of the changing stream levels, these groundwater level changes would not be any larger than the stream level elevation changes and would be limited to only the areas near the stream. These groundwater level fluctuations would be well within the range of normal seasonal fluctuations typical of aquifers along streams in mountainous terrain.

5.4.2 Alternative 1c

5.4.2.1 Gross Reservoir

The expansion of Gross Reservoir under Alternative 1c would cause similar but smaller impacts than the Proposed Action due to the smaller reservoir size (40,700 acre-feet [AF]). Reservoir seepage would be less, and the change in hydraulic gradients around the reservoir would be less under Alternative 1c.

5.4.2.2 Leyden Gulch Reservoir Site

The groundwater impacts due to the development of a new Leyden Gulch Reservoir along the South Boulder Diversion Canal would be, in general, similar to those described for the expansion of Gross Reservoir (refer to Section 5.4.1.1).

The southern boundary of the U.S. Department of Energy Rocky Flats site is near the proposed Leyden Gulch Reservoir. As described in Section 5.20, soil and groundwater at Rocky Flats has been extensively analyzed for radioactive isotopes and other contaminants. Remediation has also been conducted at Rocky Flats to address the risks posed by the contaminated soils found at the plant. Site closure was completed in 2006. During construction of a new reservoir, it is possible unknown contaminants could be remobilized from soil to groundwater. The increased recharge to groundwater from the proposed reservoir and influence of construction activities may increase the rate of contaminant mobility. However, natural recharge of the groundwater system from infiltration of precipitation is already occurring at the site. Additionally, seepage of good quality water out of the reservoir would provide natural attenuation by dilution. For example, the natural flushing action would reduce the content of salts in soils in which evapo-concentration of constituents in precipitation and rocks have naturally affected the surface soils within the proposed reservoir area.

Constructing the new Leyden Gulch Reservoir would inundate the terrestrial habitat for wildlife, including the location of seeps and wetlands, within the immediate area of the reservoir footprint. However, increased groundwater levels caused by seepage out of the reservoir would promote the development of new vegetation and habitat near the reservoir perimeter.

5.4.2.3 River Segments

The sources for additional water supply under Alternative 1c are the same as those described for the Proposed Action. Most of the additional surface water diversions would be collected in the upper reaches of the West Slope watersheds in the Fraser and Williams

Fork river basins. The impacts on groundwater resources due to these increased diversions of surface water on the West Slope are described in Section 5.4.1.2.

5.4.3 Alternative 8a

5.4.3.1 Gross Reservoir

The expansion of Gross Reservoir under Alternative 8a would cause similar but smaller impacts on groundwater than the Proposed Action due to the smaller reservoir size (52,000 AF). The smaller enlargement would decrease seepage and decrease the change in hydraulic gradients around the reservoir when compared to the Proposed Action.

5.4.3.2 South Platte River Facilities

Generally, the South Platte is a gaining river (i.e., receives groundwater) during the low flow time of year and a losing river during the high flow season. The removal of water under Alternative 8a would not affect the river flow volume, surface water level, groundwater levels near the river, or water quality during the high flow season. The amount of reusable return flow extracted from the river for this alternative would cause an immeasurable drop in river volume and level (i.e., less than 1 percent [%] of the total river flow) during the high flow season. During the low flow time of the year, the removal of additional water from the South Platte under Alternative 8a would decrease the surface water elevation of the river, which would slightly reduce the groundwater elevations near the river. Clearly, where there is an influx of better quality groundwater to the river, the quality of the river water improves.

The conveyance of the water to the gravel pits, and from the pits to the Moffat Project would not affect the groundwater resources because the water would be enclosed within pipelines or lined canals. Even if there were a total failure of the conveyance network, the water released would be of good quality and thus would cause negligible impacts to groundwater resources.

By design and regulation, the gravel pits used for storage of the additional water removed from the South Platte River would be surrounded by a slurry wall to restrict seepage from the storage pit to the groundwater system. The slurry walls would be keyed into the Pierre Shale, which underlies the alluvial aquifer in that area. While the Pierre Shale is known to contain naturally-elevated levels of selenium in some other areas, construction and operation of the South Platte River Facilities are not expected to cause impacts to groundwater quality. Mobilization and transport of selenium dissolved from the shale is unlikely to be significant in areas where the Pierre Shale has been exposed to stream erosion and weathering processes for thousands of years. Thus, natural flushing of selenium from the weathered shale by alluvial groundwater flow has likely reduced selenium levels at the proposed location of the gravel pits. Moreover, the extremely low permeability of the slurry walls and the Pierre Shale would restrict seepage out of the gravel pit storage areas and thus preclude any adverse impacts to groundwater levels and groundwater quality in the area of the gravel pits.

5.4.3.3 Conduit O

Conduit O would be designed as a closed pipeline. Over the Project life, the groundwater resources that could potentially be impacted by Conduit O are minimal, even if there is a total failure of the pipeline. If a catastrophic failure occurred along Conduit O, the impacts to the localized groundwater system could include: increased groundwater levels, addition of good quality water to the groundwater system, and short-lived changes to the groundwater gradients.

5.4.3.4 River Segments

The sources for additional water supply included under Alternative 8a are the same as those described for the Proposed Action. Most of the additional surface water diversion would be collected in the upper reaches of the West Slope watersheds in the Fraser and Williams Fork river basins. The impacts to groundwater resources expected to result from these increased surface water diversions from the West Slope are described in Section 5.4.1.2. However, a portion of the water supply for Alternative 8a would be from reusable water in the South Platte River. As a result, diversions from the West Slope basins would be slightly less than the Proposed Action, and thus would have smaller groundwater impacts than those described for the Proposed Action.

5.4.4 Alternative 10a

5.4.4.1 Gross Reservoir

The smaller expansion of Gross Reservoir under Alternative 10a (52,000 AF) would result in the same impacts as described for Alternative 8a. Seepage from Gross Reservoir would likely decrease as Gross Reservoir would have less water stored when compared to the Proposed Action.

5.4.4.2 Denver Basin Aquifer Facilities

Alternative 10a proposes to use the Denver Basin aquifers for storage and recovery of reusable return flows. Three injection and recovery wells would be installed at each well site, in the upper Arapahoe, lower Arapahoe, and Laramie-Fox Hills aquifers, with approximately 24 locations throughout the Denver Metropolitan area. The reusable water would be treated at a new AWTP prior to injection into the Denver Basin aquifers. The treated water must meet all established groundwater quality standards so the injected water would not degrade the existing groundwater quality. In addition, the injected water should be tested to establish compatibility with the aquifer water and aquifer host rock. If certain chemical characteristics of the injected water vary in quality from those in the aquifer, such as the oxidation-reduction potential of the water, naturally-occurring metals could be mobilized from the aquifer host rock. However, Denver Water would employ water treatment measures to preclude any such water quality impact to the recovered water or the native groundwater in the aquifers.

Water levels in existing water wells in the vicinity of the proposed Denver Water injection and recovery wells may fluctuate in response to injection and withdrawal pumping.

However, such pumping impacts would diminish exponentially with distance away from the Denver Water wells.

Through the State Engineers' Office permitting process, the distance between these injection and recovery wells and other water well users would be greater than 600 feet (CDWR 2008a). This permit-required separation distance would protect other water well users from groundwater level fluctuations that could otherwise be detrimental to existing water wells and current users if separation distances were smaller. Overall, the net long-term impact on groundwater levels due to the Denver Water wells would be minimal because Denver Water intends to only recover the amount of water injected into aquifer storage.

5.4.4.3 Conduit M

The potential impacts on the groundwater system due to transportation of water in Conduit M are similar to those described for Conduit O in Alternative 8a in Section 5.4.3.3.

5.4.4.4 River Segments

The sources for additional water supply included under Alternative 10a are the same as those described for the Proposed Action and Alternative 8a. Most of this additional surface water diversion would be collected in the upper reaches of the West Slope watersheds in the Fraser and Williams Fork river basins. The impacts to groundwater resources potentially caused by these increased diversions of surface water on the West Slope are described in Section 5.4.1.2. However, a portion of the water supply for Alternative 10a would be from reusable water in the South Platte River, as described above and from the Blue River, South Platte River, and South Boulder Creek. As a result, the Alternative 10a diversions from the West Slope basins would be slightly less than, and thus, would result in fewer impacts to groundwater than the diversions planned for the Proposed Action.

5.4.5 Alternative 13a

5.4.5.1 Gross Reservoir

The expansion of Gross Reservoir under Alternative 13a would cause similar but smaller impacts on groundwater than the Proposed Action due to the smaller expansion (60,000 AF). The smaller enlargement would cause smaller changes in seepage due to the smaller rises in groundwater levels around the reservoir.

5.4.5.2 South Platte River Facilities

The potential impacts to groundwater associated with South Platte River Facilities under Alternative 13a would be similar to those described for Alternative 8a in Section 5.4.3.2. This alternative, however, would require the conversion of agricultural water rights to municipal or other non-irrigation uses. Therefore, less groundwater recharge would occur in localized areas that are no longer irrigated. Reducing the amount of irrigation water may cause slight declines of the water table in these areas.

5.4.5.3 Conduit O

The potential impacts on the groundwater system due to transportation of water in Conduit O for Alternative 13a would be the same as those described for Alternative 8a in Section 5.4.3.3.

5.4.5.4 River Segments

The sources for additional water supply included under Alternative 13a are the same as those described for the Proposed Action. Most of this additional surface water diversion would be collected in the upper reaches of the West Slope watersheds in the Fraser and Williams Fork river basins. The impacts on groundwater resources due to these increased diversions of surface water on the West Slope are described in Section 5.4.1.2. However, a portion of the water supply for Alternative 13a would be from newly purchased agricultural water rights in the South Platte River and from the Blue River, South Platte River, and South Boulder Creek. As a result, diversions from the West Slope basins would be slightly less than, and thus, would cause smaller impacts than those described for the Proposed Action, which are expected to be minimal for groundwater.

5.4.6 No Action Alternative

The No Action Alternative does not include any new facilities being constructed in the Moffat Project area. The predicted future water demands would be met using current infrastructure and by withdrawing more stream runoff from the Denver Water diversion points on the West Slope up to the legal limit of Denver Water's water rights.

Downstream of the existing diversion structures on the West Slope, the creeks would be narrower and shallower primarily during runoff months from May through July due to the withdrawal of water to meet higher demands throughout the year. The width and depth of streams would vary annually depending on the amount of snowpack and summer precipitation. During low stream flow periods, groundwater levels would decline slightly near the creeks in those areas. In areas having an upward hydraulic gradient during these low flow periods, groundwater flow into the creeks would increase to compensate, in part, for the reduction in stream flow caused by the diversions. In stream reaches where a downward hydraulic gradient exists, the stream flow reduction would result in slightly lower rates of seepage from the stream into the groundwater system.

The slight increase in recharge to the groundwater system through the bottom of unlined diversion and conveyance canals due to increase duration of use would likely be less than the decrease in recharge through the streambeds downstream of the diversion structures. However, the overall effect of these small changes in groundwater recharge and discharge would create only minor impacts to groundwater levels near the West Slope stream segments.

On the East Slope, the Moffat Collection System components would remain the same as those currently in use. However, due to the higher future demands and without additional storage capacity, the water levels and volumes of water stored in the reservoirs would generally be lower than average. More frequent low reservoir levels would decrease the

seepage from the reservoirs and cause groundwater levels to decline, which could cause a long-term adverse impact to the local groundwater resource near the reservoir.

No additional impacts on groundwater would result from implementing the Combination Strategy. Changes in stream flow between the two No Action Alternative strategies as described in Section 5.1.6.3 are not expected to be significant.

5.4.7 Mitigation and Monitoring

Considering that the impacts to groundwater are minimal and short term in nature, no additional mitigation or monitoring is expected to be necessary for impacts identified in Sections 5.4.1 through 5.4.6.

5.4.8 Unavoidable Adverse Impacts

There are no unavoidable direct or indirect adverse impacts identified for the groundwater resources (e.g., groundwater quality, quantity, or availability) on the East or West slopes due to the implementation of any of the alternatives proposed in this EIS.

5.5 GEOLOGY

This section describes the direct and indirect impacts to geology expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Two potential geologic issues were documented during the scoping process:

- Impact of increased earthquake activity potential from water-lubricated faults due to the increased storage at the proposed reservoir sites.
- Impacts to geologic features (i.e., hogback) from possible relocations of State Highway (SH) 93 associated with the Leyden Gulch Reservoir alternative.

Other geologic issues addressed in this section include slope and reservoir rim instability, landslides, erosion, and seepage. Concerns raised during the Draft Environmental Impact Statement (EIS) comment period related dam safety are also addressed in this section. Potential geologic issues vary by alternative and are discussed by components, where applicable.

5.5.1 Proposed Action (Alternative 1a)

5.5.1.1 Gross Reservoir

Moderate direct impacts to geologic resources at Gross Reservoir include the loss of mineral resources such as sand, gravel, and bedrock that would be used as borrow material for dam construction. In addition, there would be a partial loss of unmined gravel and rock resources due to reservoir inundation. The majority of the aggregate required to construct the raised dam would be harvested on site in the reservoir area upstream of the dam, primarily on the southwest shore of the reservoir. In addition, sand-sized material would be imported from a commercial supplier.

Minor indirect, permanent geologic impacts at Gross Reservoir include reservoir rim instability, landslides, rock fall, and erosion due to operation of the facility. Analysis of geologic materials indicate much of the soils and underlying weathered to highly weathered and decomposed granite (i.e., Precambrian Boulder Creek Granodiorite) bedrock in the existing reservoir are subject to erosion. The highly weathered granite consists of medium-to coarse-grained, sometimes clayey, material that tends to lose cohesive strength when wet. Wave action would likely erode this material from the toes of slopes and cut benches along the reservoir rim, which may lead to reservoir rim instability. Additionally, water levels in the reservoir would fluctuate in response to operational changes. Altering changes in the moisture contents of the reservoir rim slopes may also increase instability. Wave cut benches would tend to form more rapidly in areas of the reservoir rim exposed to greater amounts of wave action, such as ridges. Reservoir rim instability associated with slope failures may result in landslides. If landslides do occur at Gross Reservoir, they are expected to be relatively small, local features since highly weathered granite is relatively free draining. More specifically, it is anticipated that a landslide would not contain sufficient volume to create a wave that could overtop the dam or significantly reduce its

storage volume. The potential also exists for rock fall in localized areas to be triggered by erosion associated with wave cut benches.

Seismicity

Gross Reservoir occurs in Seismic Zone 1, which means there is a one in ten chance that an earthquake with an active peak acceleration level of 0.1 g (one-tenth the acceleration of gravity) would occur within the next 50 years. Additionally, the Livingston Sheer Zone and Fault, the Copeland Fault, and the Rogers Fault are not mapped as potentially active and therefore unlikely to create earthquake activity near Gross Reservoir (Kirkham and Rogers 1981). In general, reservoirs with depths greater than 300 feet may potentially induce seismicity. Increased seismic activity associated with water-lubricated faults is typically related to the load of a reservoir on an area that creates changes in stress at depths of at least a few miles. The water loads at Gross Reservoir would not change the water content in faults at depths of a few miles, thus increased seismic activity from lubricated faults is not anticipated. However, stress on the faults located at or near the reservoir site may increase or change, and result in negligible seismic activity. In summary, the proposed dam raise and expansion of Gross Reservoir may increase the potential for reservoir-induced seismicity, but not at substantial levels. Potential issues related to geologic resources will be addressed through geotechnical and seismic studies in the design and construction phases. Intermittent blasting by explosives such as ANFO (Ammonium Nitrate Fuel Oil) would occur during the early phases of construction as aggregate supplies are needed for dam construction. Blasting would be designed specifically for Gross Dam and would create ground vibrations and land motion appropriate for the dam structure to sustain. A seismograph will be used to monitor the blasting operations to ensure that acceleration thresholds are not exceeded. The land motion created from blasting recedes rapidly from the source (i.e., the dam) and would be insufficient to collapse wells or cause other damage in the Project area.

Dam Safety

A dam safety analysis was conducted for the existing Gross Dam. Similarly, a dam safety analysis would be conducted for an enlarged Gross Reservoir during final design. Where appropriate, general safety features were incorporated into the conceptual dam design used for the EIS impact analysis. For example, Section 2.3.2.1 states: "In order to satisfy current dam safety criteria, the dam raise would necessitate an increased spillway capacity, improved dam safety condition, and would require the construction of a service spillway. The spillway could be located in the dam crest, a topographic saddle south of the dam or along the right abutment of the dam or some combination (Figure 2-3)."

If constructed, the enlargement of Gross Reservoir would be subject to a series of design reviews by several organizations including: the Board of Water Commissioners (Denver Water), the Colorado State Engineers Office (SEO), and the Federal Energy Regulatory Commission (FERC). FERC and the SEO conduct annual inspections of the existing Gross Dam and would continue to do so if the reservoir is enlarged. Daily inspections would also continue to be conducted at Gross Dam by Denver Water personnel. Additionally, Denver Water will update its current Emergency Preparedness Plan if Gross Reservoir is enlarged.

This plan provides a detailed description of who needs to be notified, and what areas are likely to be flooded, among other details, in the highly unlikely event of a dam failure.

5.5.2 Alternative 1c

5.5.2.1 Gross Reservoir

The potential geologic impacts at Gross Reservoir associated with Alternative 1c, are similar to those described for the Proposed Action, but less ground-disturbing activity would be necessary for the smaller expansion (40,700 acre-feet [AF]).

5.5.2.2 Leyden Gulch Reservoir Site

Moderate direct impacts at the Leyden Gulch Reservoir site include the loss of mineral resources such as sand, gravel, and bedrock that would be used as borrow material for dam construction. In addition, there would be a partial loss of unmined sand and gravel deposits, due to excavation, particularly north and west of the proposed reservoir rim. Borrow material would be extracted entirely from the reservoir pool area. Topography of the borrow areas would be permanently changed by removal of material. These areas would be covered by the reservoir pool.

Moderate, indirect, permanent geologic impacts may result at the Leyden Gulch Reservoir site related to the Pierre Shale, which is present under most of the proposed reservoir and dam. Seepage through weathered and fractured shale may create reservoir rim instability and subsequent erosion during operation. Geologic mapping conducted at the Leyden Gulch Reservoir site indicates the Pierre Shale contains a relatively thick upper or surficial weathered zone that consists of red-brown to green-gray, intensely to closely fractured, claystone and shale with numerous open fractures (URS 1999). The depth of weathering and extent of open fractures in the Pierre Shale appears to be related to depth and location of groundwater at the site (refer to Section 3.4.1.2). Shale in the valley bottom is relatively unweathered and contains no open fractures because groundwater levels are similar to the elevation of the intermittent stream that flows through this location. On the abutments of the proposed dam and reservoir rim, the shale is located 50 to 100 feet above the groundwater; therefore, the upper zone of the shale has become weathered, dried out, and open fractures have formed.

Seepage through the proposed dam is likely due to the presence of open fractures and a high gradient resulting from a sharp elevational change in the short distance between the reservoir and seepage exit points downstream of the right abutment. Seepage would form through the dam abutments and into the reservoir rim due to the presence of weathered Pierre Shale containing a 3-dimensional interconnected system of open fractures at this location. As seepage develops, some of the open fractures would likely swell and close, reducing seepage flow quantities and result in minor impacts.

Reservoir rim instability and erosion at the Leyden Gulch Reservoir site could create moderate impacts to the railroad located along the north rim of the proposed reservoir. Landslides have been mapped in the proposed reservoir area and are interpreted to have formed in the upper weathered Pierre Shale bedrock and overlying soils (URS 1999). Operation of the Leyden Gulch Reservoir would likely include periodic drawdown of the

reservoir that may initiate formation of landslides, especially along the rim of the reservoir in areas affected by the change of pore pressure.

The amount of time for landslides to develop is not known. Some may form with initial filling of the reservoir; however, it is common for landslides to develop after many seasons of filling and drawdown as the weathered shale is softened by reservoir water entering open fractures as the shale is loaded and unloaded by changes in pore pressure. Also, a failure surface in the weathered shale may take some time to form and for the shale to reach critical strength. After the failure surface develops and movement occurs, the strength of the shale rapidly reaches residual strength and can trigger a progressive mode of failure that results in the landslide extending further and further upslope and into areas surrounding the reservoir. Erosion along the reservoir rim by wave action can also create locally steep slopes that may initiate progressive landsliding in the slope. The railroad alignment is located in areas underlain by Pierre Shale that are relatively close to the reservoir rim; therefore, landslides that might develop have the potential to impact the railroad during periods of rapid drawdown, such as during a drought.

The Leyden Gulch Reservoir site is located in Seismic Zone 1 similar to Gross Reservoir. The potential impacts would be similar to those described for the Proposed Action. The hogback located east of the proposed Leyden Gulch dam contains clay mine workings that contribute to instability in and next to this geologic feature. Alternative 1c was re-configured to avoid the relocation of the railroad; however, approximately 4,000 feet of SH 93 would be relocated to the east between the toe end of the proposed dam and the hogback. (Refer to Section 5.17.2.2, for a discussion of the visual impacts of the hogback.) The highway relocation design and construction should include methods of stabilizing the existing workings and locating a stable embankment on top of the workings. Issues related to seepage, reservoir rim stability, seismic activity, and relocation of SH 93 would be addressed during design and construction.

5.5.3 Alternative 8a

5.5.3.1 Gross Reservoir

The potential geologic impacts at Gross Reservoir associated with Alternative 8a are similar to those described for the Proposed Action, but less ground-disturbing activity is necessary for the smaller expansion (52,000 AF).

5.5.3.2 South Platte River Facilities

For the purpose of this EIS, it was assumed that when Denver Water acquires the gravel pits, they would be completely mined, reclaimed for use as a water storage facility, and empty. Thus, it is assumed that all economically viable sand and gravel resources would be mined prior to the Denver Water acquisition. Once the gravel pits are filled and operating, they would experience fluctuating water levels associated with seasonal changes and return flow obligations resulting in a negligible impact.

Existing geologic hazards associated with the South Platte River Facilities may result indirectly from operation of the gravel pits and include weak sediment and soils, flooding, and collapsible soils. In the existing gravel pits, slopes may be marginally stable due to

weak materials, and could become unstable when water levels in storage reservoirs are drawn down. The weak materials may include loose and saturated sandy alluvium at gravel pit pipeline stream crossings, soft organic clays in abandoned stream channels, and soft weathered clayey bedrock and colluvium composed of weathered shale found in the Denver Formation. The potential also exists for alluvium to have a cover of wind-deposited loess that can collapse when wetted.

The gravel pits would be reclaimed for use as a water storage facility prior to Denver Water taking ownership. The side slopes of the mined pit would be backfilled with soil to create a stable slope; therefore, slope stability problems are not expected.

5.5.3.3 Conduit O

An analysis of geologic materials along the alignment indicates weak soils and alluvial sediment can result in temporary excavation instability during construction, including pipeline trench wall instability at stream crossings. If groundwater exists in the trenches excavated in the roads, unstable slopes may be problematic during construction activities. During construction, the conduit would be installed with adequate erosion control and excavation stability measures to avoid or minimize construction-related problems. Since Conduit O would be constructed within existing roads, it is assumed that no sand and gravel resources would be impacted.

5.5.4 Alternative 10a

5.5.4.1 Gross Reservoir

The potential impacts at Gross Reservoir associated with Alternative 10a are the same as those described for Alternative 8a.

5.5.4.2 Denver Basin Aquifer Facilities

The Denver Basin aquifer study area contains localized areas of granular, cohesionless materials, such as saturated gravels and sands, eolian deposited silty sands, and sand and gravel alluvium. These types of materials may create trench instability. Thus, the impacts for the Denver Basin aquifer distribution pipeline are similar to those described for Conduit O.

5.5.4.3 Conduit M

The potential geologic impacts for Conduit M are similar to those described for the Conduit O.

5.5.5 Alternative 13a

5.5.5.1 Gross Reservoir

The potential geologic impacts at Gross Reservoir associated with Alternative 13a are similar to those described for the Proposed Action, but less ground-disturbing activity is necessary for the smaller expansion (60,000 AF).

5.5.5.2 South Platte River Facilities

The potential geologic impacts at the South Platte River Facilities associated with Alternative 13a are similar to those described for Alternative 8a.

5.5.5.3 Conduit O

The potential geologic impacts for the Conduit O alignment under Alternative 13a are the same as those described for Alternative 8a.

5.5.6 No Action Alternative

No direct geologic impacts are anticipated to occur under the No Action Alternative, since there would be no ground-disturbing activities. However, operational activities at Gross Reservoir may create potentially unstable slopes and reservoir rim instability as a result of erosion, seepage, wave action, and water level fluctuations.

5.5.7 Mitigation and Monitoring

Potential impacts to geologic resources related to the construction and operation of the proposed Project would include erosion, seepage, slope and reservoir rim instability, and increased seismic activity. Possible mitigation and monitoring of geologic impacts may include:

- Various erosion mitigation measures should be implemented during construction and operation of the facilities, such as design of slopes with rolled erosion control products, vegetation, riprap, or a combination of these. Visual monitoring of the facilities may be conducted to evaluate the impact of erosion and the effectiveness of erosion protection measures.
- In the dam and reservoir construction areas, cut slopes should be designed to provide adequate slope stability for the temporary construction and long-term loading conditions at each site.
- Seepage associated with the proposed Leyden Gulch Reservoir may be mitigated with design of seepage reduction measures, such as cut off walls, grouting, etc. Monitoring of seepage reduction measures and changes in groundwater levels before, during, and after construction may be conducted using piezometers.
- Reservoir rim instability associated with Leyden Gulch Reservoir may be mitigated with design of slope stabilization measures, such as flattening slopes, installing drains, and constructing slope stabilization features. Monitoring of unstable slopes may include mapping, installation of survey monuments, periodic air photo review, and installation of slope movement instruments such as inclinometers and survey monuments.
- Erosion and stability of excavations associated with all pipelines may be mitigated with design of erosion control and excavation stability measures. This is especially necessary where pipelines cross drainageways.

- The relocation design and construction of SH 93 should include methods of stabilization and reclamation of the existing clay mine workings in order to protect the hogback feature located east of the proposed Leyden Gulch Reservoir. Issues related to seepage, reservoir rim stability, seismic activity, and relocation of SH 93 would be addressed during design and construction.
- Appropriate seismic analysis should be conducted, including deterministic and probabilistic methods, as part of design at the reservoir sites. A seismograph will be used to monitor the blasting operations at the dam site to ensure that acceleration thresholds are not exceeded.

5.5.8 Unavoidable Adverse Impacts

There would be an unavoidable loss of geologic resources (i.e., bedrock and sand and gravel deposits) and alteration of topography associated with the use of borrow materials.

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5.6 SOILS

This section describes the direct and indirect impacts to soils expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Two potential soils issues were documented during the agency and public scoping process:

- The impacts of proposed water level changes in Gross Reservoir on shoreline inundation and erosion.
- Consideration of soil testing at the proposed Leyden Gulch Reservoir site because of potential contaminants from previous Rocky Flats fires.

These issues are addressed in Sections 5.6.1.1 and 5.6.2.1, respectively.

Other soils issues addressed in this section include slope instability, landslides and slippage, expansive soils, flooding, erosion, sedimentation, and reclamation potential. Potential soils issues vary by alternatives and are discussed by components, where applicable.

Impacts from expansive soils are described only under the alternatives to which they pertain. Expansive soils alternately swell when wet and contract when dry, thereby potentially damaging structures. No expansive soils were identified in the Gross Reservoir study area, thus no impacts to the raised dam and other associated facilities are anticipated.

5.6.1 Proposed Action (Alternative 1a)

5.6.1.1 Gross Reservoir

Permanent Impacts to Soils

Expansion of the dam, reservoir, and related facilities would permanently affect approximately 465 acres of soils. The calculation of acres assumes disturbance between the current reservoir pool elevation (7,282 feet) and 10 feet above the expanded pool elevation of 7,400 feet (7,410 feet). This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet). Refer to Table F-1 in Appendix F for a description of soils that may be impacted in the Gross Reservoir study area. Soils that are covered by facilities would be permanently lost unless salvaged and used as embankment fill. Approximately 60 percent (%) of the total borrow material would be produced on site. Soils permanently inundated by the reservoir would become anaerobic and would have altered chemical and biological processes. Soils in the drawdown zone would experience alternating wet and dry cycles with associated fluctuations in water level during reservoir operations. This anaerobic/aerobic pattern may result in moderate chemical and physical changes in the soils (e.g., mottle features).

Erosion from Construction

Soil erosion can increase the sediment load in surface-receiving waters downstream of the construction site. Soil disturbing activities may result in compaction, which may lead to decreased infiltration rates and corresponding increased runoff and erosion rates. The magnitude, extent, and duration of construction-related impacts depend on the erodibility

rates of the soil; the proximity of the construction activity to receiving waters; and the construction methodologies, duration, and season. The mitigation measures outlined in Section 5.6.7 can reduce these impacts to soil resources.

Construction activities would temporarily disturb approximately 89 acres of soils primarily through earth-moving activities and construction equipment traffic. The soils identified in the construction areas are described in Table F-1. Some erosion is likely to occur and may adversely affect adjoining areas or deliver sediment to South Boulder Creek.

Stockpile areas located on the eastern boundary of reservoir (approximately 0.5 acre) would be necessary for temporary storage of soil during construction activities. Two potential spoil areas (approximately 5 acres total) would be located north and south of the dam (see Table D-1 in Appendix D for additional information). Post-construction, the stockpile and spoil areas would be situated entirely below the proposed high water level; however, they would be stabilized during construction to minimize erosion and sedimentation.

Additional impacts would occur from tree removal around the rim of the reservoir. Trees would be cleared from the inundation area and shoreline up to elevation 7,410 feet in elevation. Moderate impacts on soils include erosion resulting from disturbance and compaction during harvest. Several methods of tree removal may be used depending on slope, access and presence of rock outcrops, including ground-based harvest systems (hand felling/grapple skidder and feller/buncher), cable-based system, helicopter system, or hydro-ax. Tree harvesting and removal would use both existing and new access roads.

The amount of soil disturbance and compaction resulting from timber harvest varies depending on the method of harvest (EPA 2005a), with ground-based systems having the most disturbance (about 25 to 35% for clear cut), helicopter systems the least (1 to 5%). Disturbance of soil and litter would result in accelerated erosion, which would need to be controlled with erosion and timber harvest Best Management Practices (BMPs). Use of cable systems, helicopter, and hydro-ax on steeper slopes would also help control erosion. Stumps and roots would remain in place, providing some surface protection. Post-construction restoration of the cleared area not inundated would include establishing a mix of native grass, forb, and shrub species to further minimize erosion.

Shoreline Character

As described in Section 5.1, the annual pattern of fluctuation in level and content in Gross Reservoir (from April through November) would be similar to that under the Full Use of the Existing System. Average monthly volume for the reservoir would be at its lowest at the end of April (7,326 feet), reach its highest level in July (7,383 feet) and be drawn down through the fall and winter. Under the Proposed Action, Gross Reservoir contents would drop steadily by approximately 4,000 acre-feet (AF) per month on average during winter months because the Moffat Water Treatment Plant would be operating at a minimum of 30 million gallons per day.

Fluctuating water levels associated with operation of Gross Reservoir under the Proposed Action would create changes in the stresses in the slopes of the shoreline. The nature of the shoreline and exposed reservoir bottom would be determined by the type of soil, its stability and texture, the slope of the shoreline, and by the water level of the reservoir. As described in Section 3.6, the steep slopes combined with volatile weather patterns cause most soils at

Gross Reservoir to be potentially highly erosive or prone to landslides. During a field visit conducted in September 2005, the Gross Reservoir shoreline appeared relatively stable with evidence of minor erosion indicated by exposed roots, bank sloughing, and exposed bedrock. Removal of the soils' protective vegetative cover during construction would likely make them highly susceptible to erosion, unless otherwise stabilized.

Reclamation Potential

Soils would be temporarily disturbed by construction of the enlarged dam, reservoir, and associated facilities. In general, the limitations for soil reclamation in the study area are steep slopes, shallow depth to bedrock, and erosion.

5.6.2 Alternative 1c

5.6.2.1 Gross Reservoir

The potential permanent impacts to soils resulting from Alternative 1c (approximately 302 acres) are less than those described for the Proposed Action. Fluctuating water levels and associated shoreline impacts at Gross Reservoir would be substantially the same as described for the Proposed Action. Average monthly volume for the 82,511 AF reservoir would be greatest at the end of July (7,335 feet) and lowest at the end of April (7,275 feet). Temporary impacts to soils resulting from Alternative 1c (approximately 105 acres) construction activities at Gross Reservoir would be greater than the Proposed Action due to the larger amount of disturbed area that would remain exposed after inundation.

5.6.2.2 Leyden Gulch Reservoir Site

Permanent Impacts to Soils

Construction of the proposed dam, reservoir, and related facilities would permanently affect approximately 389 acres of soils (refer to Table F-2 in Appendix F). Soils that are covered by facilities would be permanently lost unless salvaged. All borrow material would be obtained from within the boundary of the proposed reservoir pool. Soils permanently inundated by the reservoir would become anaerobic with altered chemical and biological processes. Until the reservoir is full, soils would experience alternating wet and dry cycles with associated fluctuations in water level. This anaerobic/aerobic pattern would result in moderate chemical and physical changes in the soils (e.g., mottle features).

Erosion from Construction

Construction activities would temporarily disturb approximately 176 acres of soils primarily through earth-moving activities and construction equipment traffic. The soils identified in the construction areas are described in Table F-2; some of which have severe water erosion potential and moderate wind erosion potential. Some erosion is likely to occur during construction activities and may adversely affect adjacent areas, including any surface receiving waters. The mitigation measures outlined in Section 5.6.7 would reduce impacts to soil resources resulting from construction of the Moffat Project to less than significant levels.

Shoreline Character

The proposed Leyden Gulch Reservoir would be maintained at or near capacity (between 6,120 and 6,121 feet) except in an extended drought. Reservoir operations would cause the water level to fluctuate between 6,113 feet in April and 6,121 feet in August, September, October, and November. The proposed Leyden Gulch Reservoir would be completely emptied during the later stages of the critical period.

Filling and draining the reservoir would create changes in the stresses in the slopes of the shoreline. The nature of the shoreline and exposed reservoir bottom would be determined by the type of soil, its stability and texture, the slope of the shoreline, and by the water level of the reservoir. Topographic, geologic, and soils evidence of slope instability, slippage, and landslide activity exist at Leyden Gulch. Similar conditions within the nearby Ralston Reservoir have resulted in slope instability (URS 1999). Removal of the soils protective vegetative cover during construction would likely make them highly susceptible to erosion, unless otherwise stabilized.

Expansive Soils

Expansive soils alternately swell when wet and contract when dry potentially damaging structures. Thus, since moderate to highly expansive soils are widespread throughout the Leyden Gulch Reservoir site, construction of the dam should include appropriate design criteria for the expansive soils.

Reclamation Potential

Soil limitations at the Leyden Gulch Reservoir site that may influence reclamation potential are severe water erosion potential, moderate wind erosion potential, shrink-swell clays, shallow depth to bedrock, and occasional flooding (NRCS 1980, 2004). Leyden Gulch is currently dominated by grass and forbs (refer to Section 3.7), so erosion is minimal.

Contamination

Potential impacts from the Rocky Flats site north of the Leyden Gulch Reservoir site are addressed in Section 5.20.2.2. As described in Section 3.20.1.2, soil and groundwater at Rocky Flats have been extensively analyzed for radioactive isotopes and other contaminants. Extensive remediation has also been conducted at Rocky Flats with site closure completed in 2006. Section 5.20.2.2 also describes the potential impacts to soils resulting from polyaromatic hydrocarbon contamination from abandoned utility poles coated with creosote that exist within the Leyden Gulch Reservoir site. Both the Foothills Landfill and the Jefferson County Landfill are hydraulically downgradient from proposed reservoir site with little hydraulic connection; therefore, it is unlikely soils would be contaminated from the landfills.

5.6.3 Alternative 8a

5.6.3.1 Gross Reservoir

The potential permanent impacts to soils resulting from Alternative 8a (approximately 363 acres) are less than those described for the Proposed Action. Reservoir operations

would create water fluctuations between 7,298 feet in April and 7,354 feet in July and August. Shoreline impacts associated with fluctuating water levels at Gross Reservoir would be the same as described for the Proposed Action. Temporary impacts to soils resulting from Alternative 8a (approximately 98 acres) construction activities at Gross Reservoir are greater than the Proposed Action due to the larger amount of disturbed area that would remain exposed after inundation.

5.6.3.2 South Platte River Facilities

Soil limitations within the South Platte River Facilities study area are moderate erosion hazards and occasional flooding (refer to Table F-4 in Appendix F). Alternative 8a would result in permanent impacts (approximately 6 acres) and temporary impacts (approximately 11 acres) to soils associated with the construction of an Advanced Water Treatment Plant, dechlorination facility, diversion structure, and pump stations. Negligible impacts to soils would result from the gravel pipelines since they would primarily be constructed within existing roadways (curb-to-curb); however, approximately 1.5 acres of soils would be temporarily disturbed at the C-470/Northwest Parkway crossing.

Direct impacts to soils resulting from the gravel pit storage lakes were not quantified since ground-disturbing activities are assumed to be previously completed. It is assumed that when the Board of Water Commissioners (Denver Water) acquires the gravel pits, they would be completely mined, reclaimed for use as a water storage facility and empty. Once the gravel pits are filled and operating, soils would experience fluctuating water levels associated with seasonal changes and return flow obligations. There may be unknown impacts from buried materials or inert debris associated with construction dumpsites in this area (refer to Section 5.20.3.2).

5.6.3.3 Conduit O

Refer to Table F-3 in Appendix F for a description of soils that may be temporarily impacted by Conduit O. Negligible impacts to soils would result from Conduit O since construction of the pipeline would primarily occur within roadways (curb-to-curb). Approximately 7 acres of soils; however, would be temporarily disturbed at Conduit O crossings over U.S. Highway 36, Interstate 25, and the South Platte River. Additionally, 1.6 acres of soils would be permanently impacted from construction of the pump stations along Conduit O.

5.6.4 Alternative 10a

5.6.4.1 Gross Reservoir

The potential impacts associated with Alternative 10a are the same as those described for Alternative 8a, since the dam and reservoir enlargement areas are the same (52,000 AF).

5.6.4.2 Denver Basin Aquifer Facilities

The primary limitation of soils within the Denver Basin Aquifer Facilities study area is high shrink-swell potentials. Expansive soils would be addressed in the design stage of the facilities, where appropriate. Approximately 19 acres of soils would be permanently

impacted during construction of the Denver Basin Aquifer Facilities. Construction activities would result in approximately 25 acres of temporary disturbance to soils, which include nearly 3 acres of temporary impacts associated with the Denver Basin distribution pipeline stream crossings.

5.6.4.3 Conduit M

Refer to Table F-3 in Appendix F for a description of soils that may be temporarily impacted by Conduit M. Negligible impacts to soils would result from Conduit M since construction of the pipeline would primarily occur within roadways (curb-to-curb). Approximately 4 acres of soils, however, would be temporarily disturbed at Conduit M crossings over the South Platte River. Additionally, 1.6 acres of soils would be permanently impacted from construction of the pump stations along Conduit M.

5.6.5 Alternative 13a

5.6.5.1 Gross Reservoir

The potential permanent impacts to soils resulting from Alternative 13a (approximately 413 acres) are less than those described for the Proposed Action. Reservoir operations would create water fluctuations between 7,309 feet in April and 7,366 feet in July. Shoreline impacts associated with fluctuating water levels at Gross Reservoir would be the same as described for the Proposed Action. Temporary impacts to soils resulting from Alternative 13a (approximately 93 acres) construction activities at Gross Reservoir are slightly greater than the Proposed Action due to the larger amount of disturbed area that would remain exposed after inundation.

5.6.5.2 South Platte River Facilities

The permanent impacts associated with the South Platte River Facilities are the same as those described for Alternative 8a (approximately 6 acres). Temporary impacts (12 acres) to soils under Alternative 13a are approximately 1 acre greater than Alternative 8a due to a gravel pit pipeline crossing over the South Platte River.

An estimated 3,900 acres of agricultural lands (approximately 1% of all irrigated acres in Weld County) would be taken out of irrigation. Moderate indirect impacts to soils may result from the dry up. Hydric soils that may support wetland and riparian areas would no longer be hydric without supplemental irrigation water.

5.6.5.3 Conduit O

The impacts associated with Conduit O under Alternative 13a are the same as those described for Alternative 8a.

5.6.6 No Action Alternative

There are no ground-disturbing activities associated with the No Action Alternative; thus no direct impacts to soils would occur. Under the Depletion of Strategic Water Reserve Strategy, water levels in Gross Reservoir would fluctuate between 7,215 feet in April and

7,261 feet in July. Shoreline impacts associated with fluctuating water levels at Gross Reservoir would be the same as described for the Proposed Action.

Under the Combination Strategy, reservoir levels would fluctuate less particularly in dry years, but would also create similar impacts as described from the Proposed Action.

5.6.7 Mitigation and Monitoring

With any dam raise alternative, Denver Water will implement environmental protection, mitigation, and enhancement measures at Gross Reservoir, including an erosion and sediment control plan for social trails and roads.

Plans to prevent water and wind erosion during construction are required by the State of Colorado. Colorado Department of Public Health and Environment Water Quality Control Division would require a stormwater discharge permit, and the Air Pollution Control Division would require a fugitive dust control plan. These plans would incorporate BMPs to prevent soil losses during construction. Methods may include controlling surface water flows and installation of sediment barriers such as silt fences of straw bales or erosion control fabric. Erosion controls would be inspected regularly during construction, especially where construction is active and after precipitation. These controls would be installed prior to soil disturbance.

As discussed in Section 5.6.2.2, the Leyden Gulch Reservoir site contains some abandoned utility poles that may be coated with creosote. Poles located in the proposed reservoir inundation area would be removed along with any stained soil prior to construction activities. Similarly, the South Platte River Facilities study area may contain localized areas of soil contamination associated with construction dumpsites. If either Alternative 8a or 13a is implemented, soils suspected of contamination would be sampled and tested prior to construction activities.

5.6.8 Unavoidable Adverse Impacts

Construction and operation of Gross Reservoir and/or the proposed Leyden Gulch Reservoir and related facilities would unavoidably result in excavation, covering, or inundation of hundreds of acres of previously undisturbed soils. Some soil losses would occur during Project construction even with use of appropriate erosion control measures, because some soils have high erosion or poor reclamation potential. Operation of the reservoirs would result in shoreline erosion associated with fluctuating water levels.

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5.7 VEGETATION

This section describes the direct and indirect impacts to vegetation expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. The primary issues identified during scoping include:

- Impacts of water depletions on riparian vegetation, as well as any permanent changes to vegetation structure and composition.
- Impact of reservoir inundation on rare plants or communities.
- Impact of post-construction revegetation and/or restoration efforts.
- Impact of proposed method for timber removal in the proposed inundation area of Gross Reservoir.

Other issues addressed in this section include the impacts of Project implementation on noxious weed and exotic species introduction. This section primarily discusses impacts to upland vegetation types; impacts to riparian and wetland vegetation are discussed in more detail in the Section 5.8, along with impacts from water depletions. Impacts to sensitive plant communities are discussed in this section and impacts to rare plants are evaluated in Section 5.10.

Vegetation would be directly and indirectly impacted by the Moffat Project. Direct impact mechanisms would include inundation, grubbing, clearing, soil compaction, soil removal, rock quarrying, fuel or other hazardous material spills, paving, or other construction-related activities that would result in the removal or modification of vegetation. Indirect impacts to vegetation may include the introduction or establishment of noxious weeds, erosion, and hydrological modifications.

Both permanent and temporary impacts would occur. Permanent impacts include loss or permanent modification of vegetation communities due to replacement by Project facilities and unvegetated areas. Temporary impacts are associated with construction, but would not have long-term impacts on the viability or composition of a community, or would be revegetated. Temporary impacts can be restored to approximately preconstruction conditions.

5.7.1 Proposed Action (Alternative 1a)

5.7.1.1 Gross Reservoir

The Proposed Action would directly impact approximately 508 acres of vegetation, including approximately 456 acres of permanent vegetation loss and approximately 52 acres of temporary impact. An additional 98 acres of unvegetated areas would be affected (mostly standing water). Most of the impacts would be permanent, and most would occur in the ponderosa and ponderosa pine/Douglas fir communities (Table 5.7-1). All of the direct impacts of this alternative would occur at Gross Reservoir. Because the affected vegetation types are common in the region, losses of vegetation are considered a moderate impact.

Most of the impacts would occur in the new inundation area (between 7,282 and 7,406 feet) and would occur from site preparation. All trees and wood would be removed from the inundation area and from the shoreline up to elevation 7,410 feet. Various methods may be used to remove the trees, as described in Section 2.3.2.1. Trees and associated slash and debris would be removed for sale or disposal, and the area would be cleared prior to inundation. A portion of the cleared area would also be used for borrow material. Post-construction restoration of the cleared area above the inundation line would include re-vegetating with a mix of native grass, forb, and shrub species. The Board of Water Commissioners (Denver Water) would work closely with the U.S. Forest Service (USFS) to ensure that forest clearing and revegetation would be consistent with National Forest standards.

Table 5.7-1
Proposed Action (Alternative 1a) Vegetation Impacts at Gross Reservoir[1]

Vegetation Area	Permanent Impacts (acres)	Temporary Impacts (acres)	Total Direct Impacts (acres)
Vegetated Areas[1]			
Disturbed rangeland	21.4	0.0	21.4
Grassland/forb mix	11.5	2.1	13.6
Ponderosa pine	169.9	7.4	177.3
Ponderosa pine/Douglas fir	253.0	42.5	295.5
Subtotal	**455.8**	**52.0**	**507.8**
Unvegetated Areas			
Disturbed soil	8.9	3.6	12.5
Standing water	0.0	33.7	33.7
Talus slope/rock outcrop	0.4	0.0	0.4
Subtotal	**9.3**	**37.3**	**46.6**
Total	**465.1**	**89.3**	**554.4**

Note:
[1]Vegetation impacts were calculated based on an elevation of 7,410 feet.

Tree clearing would affect about 400 acres and approximately 200,000 trees over 4 inches in diameter (Land Stewardship Associates LLC 2008). For comparison, forests and woodlands cover approximately 24 million acres in Colorado (Colorado State Forest Service 2010). Tree removal would generate an estimated 50,000 tons of forest residues, which would contain approximately 18,000 tons of carbon. This is equivalent to about 66,000 tons of sequestered carbon dioxide, assuming all of it was burned, which is about 0.07 percent (%) of annual carbon dioxide emissions estimated for Colorado for the late 1990's (CDPHE 2002). Denver Water will work with the USFS to determine the best disposal option, which may involve the use of an air curtain incinerator onsite, grinding the trees and removing the chips, and/or sale of merchantable timber. About half of the forest residue would be merchantable timber that may be able to be utilized commercially. Removal of trees is not likely to lead to additional spread of mountain pine beetle which is currently the most damaging forest insect in Colorado (Colorado State Forest Service 2011a). Ponderosa pine is the most common tree at Gross Reservoir and is susceptible to mountain pine beetle. The mountain pine beetle outbreak that began in 1996 in northern

Colorado has mostly affected lodgepole pine but has recently expanded into ponderosa pine forests east of the Continental Divide. In 2010, there were approximately 229,000 acres of ponderosa pine infestation compared to 22,000 in 2009 (Colorado State Forest Service 2011a). Affected ponderosa pine stands typically have a scattering of smaller infested areas with 10-15 dying trees in each stand. Mountain pine beetle activity in ponderosa pine is expected to continue over the next several years, with areas of older and dense trees the most affected. There appears to have been little or no activity in the Gross Reservoir area through 2010, but aerial mapping shows nearby activity in 2010 including north and west of the reservoir in lodgepole pine and limber pine, and southeast of the reservoir in ponderosa pine (Colorado State Forest Service 2011b). Because of wind dispersal, mountain pine beetle may be identified in any ponderosa pine stand along the northern Front Range.

Mountain pine beetles disperse July through September and cutting of trees during this period could attract mountain pine beetles. Most of the areas of tree removal are on USFS land and Denver Water would consult with the USFS regarding appropriate removal methods and timing. Methods to avoid and minimize impacts may include surveys to identify beetle activity prior to timber clearing, scheduling of tree cutting to avoid beetle dispersal, and storage and process of forest residue in a manner that would limit dispersal of mountain pine beetles. Logs can be treated to prevent beetles developing in them by peeling away the bark, by chipping, burning, or solar treatment. The proposed disposal methods, including use of an air curtain burner, chipping, and commercial use of merchantable logs, are all appropriate means of disposal for beetle infested trees.

Construction activities at the site and vehicle movement along the access routes may cause a temporary increase in the potential for initiation of wild fires. With standard safety precautions and training of the construction workers, fires are likely to be quickly contained or extinguished, and are not expected to adversely affect forest and other vegetation.

During operation, the formerly vegetated areas within the reservoir would be open water or barren areas along the shorelines where the water level fluctuates. The degree, duration, and time of year at which a reservoir is drawn down and refilled are the main factors determining the type and extent of vegetation along the shoreline. Other factors that would influence shoreline vegetation establishment include topography, soil substrate, aspect, and shading. Under the Proposed Action, the average water elevation would fluctuate about 57 feet per year, from 7,326 feet in April to 7,383 feet in July, based on reservoir modeling. Reservoir elevations would change over time as seasonal demand changes or as precipitation fluctuates. Based on the large annual fluctuation in water level, the drawdown zone would likely be relatively barren, but may contain some pioneering annual species, similar to the existing reservoir. Upland perennial species may become established if the water level remains below the maximum capacity for any prolonged period of time.

Small scattered patches of riparian or wetland vegetation may also become established in areas where appropriate hydrology remains consistent for a period of time, particularly at the mouths of perennial or intermittent drainages where there is supplemental water. Along the shore of the reservoir, the water levels would remain relatively constant from June to July but would drop about 8 feet by September. These communities are unlikely to become dominant because of the large water elevation fluctuations and relatively short period of stable water elevations. Once the water is drawn down, local hydrology is expected to be

short-lived because most of the terrain is relatively steep and/or has coarse-textured soils. These dry conditions tend to favor upland plant species, but the short growing season after drawdown would prevent much growth of vegetation. The existing Gross Reservoir has about 0.5 acre of wetland and 2 acres of riparian vegetation along its shoreline (excluding stream inlets), and a roughly similar area of wetland and riparian vegetation can be expected to naturally become established along the new shoreline.

Permanent impact to vegetation would also occur from dam enlargement, construction of new roads, quarrying, and construction of the auxiliary spillway and channel. Temporary impacts would occur where existing vegetation would be mostly or entirely removed during construction, but the areas would be revegetated after construction. Temporary impacts would occur from the dam enlargement, construction of the auxiliary spillway and channel, operation of the quarry, and use of spoil and stockpile areas.

Specific restoration and revegetation plans have not been identified, but would likely consist of seeding of native grass, forb, and shrub species that are appropriate for the post-construction conditions. Revegetation of the cleared area above the inundation area would be done in the first appropriate season following timber removal, while revegetation of other construction areas would mostly occur at the end of construction. Within the inundation area there could be a gap of several years between timber removal and inundation. Control of wind and water erosion would be addressed by the construction contractor in the stormwater management plan and fugitive dust control plan. Plant communities resulting from revegetation efforts would be relatively sparse initially, primarily consisting of grasses, forbs, and shrubs, similar to what is found in an early successional plant community. As the revegetated sites mature they would begin to look more similar to adjacent plant communities. The quarry site would be difficult to revegetate because of exposed rock and lack of suitable soil for restoration efforts. Denver Water would coordinate with the USFS to ensure appropriate reclamation of this and any alternative quarry sites. The reservoir drawdown area and the temporarily disturbed areas would provide good habitat for noxious weeds and exotic species. County-listed species that would be most likely to invade the upper part of the drawdown area include Canada thistle and yellow toadflax. These species along with cheatgrass, common mullein, houndstongue, diffuse knapweed, and musk thistle are already present at Gross Reservoir, and could be spread by construction activities. Additional noxious weed species may be introduced to the area with the importation of fill and other construction material as well as by the use of equipment and new roads. Noxious weed seeds may also be spread by moving water. There are scattered individuals of oxeye daisy along the banks of South Boulder Creek above the reservoir and along the reservoir shoreline that may have established from waterborne seed from the diversion points in Grand County or from higher elevation areas of the South Boulder Creek watershed in Boulder County. The Project would not change the potential for waterborne distribution of weed seeds from Grand County, because there would not be any construction activities at the diversion points. Currently, Denver Water has a weed control program under its current Federal Energy Regulatory Commission (FERC) license and will continue to implement it to prevent the establishment and spread of noxious weeds. With application of the weed control program, impacts from weeds are expected to be minor.

The increased inundation area would affect two globally rare plant communities that are tracked by the Colorado Natural Heritage Program (CNHP): river birch/mesic forb foothills riparian shrub and thinleaf alder/mesic forb riparian shrubland. Impacts to these communities were estimated based on the results of riparian and wetland surveys (Tables 5.8-1 and 5.8-3) and are summarized in Table 5.7-2. Although wetland and riparian surveys used vegetation structure (e.g., tree, shrub, herbaceous) rather than composition, it is likely that all or most of the wetlands identified as palustrine scrub-shrub (PSS) and palustrine emergent wetland (PEM)/PSS and riparian areas identified as riparian shrubland and riparian wood/shrubland are likely to be these communities. Based on these results, a total of about 4.9 acres of these communities would be affected, in Winiger Gulch, Forsythe Gulch, and South Boulder Creek west of the reservoir, and in the three tributaries on the south side of the reservoir. Only the occurrences along Winiger Gulch and South Boulder Creek have been identified by CNHP. Direct effects from Gross Reservoir would reduce but would not eliminate these plant communities from these six drainages.

Table 5.7-2
Impacts to Sensitive Plant Communities at Gross Reservoir[1]

River Birch/Mesic Forb and Thinleaf Alder/Mesic Forb	Proposed Action	Alternative 1c	Alternative 8a	Alternative 10a	Alternative 13a
Wetland Type					
PSS	1.0	0.7	0.9	0.9	0.9
PEM/PSS	0.5	0.4	0.5	0.5	0.5
Riparian					
Wood/shrubland	1.1	0.9	0.9	0.9	1.0
Shrubland	2.3	1.8	2.0	2.0	2.2
Total Birch & Alder	4.9	3.8	4.3	4.3	4.6
Existing Old Growth	1.2	0.2	0.5	0.5	0.8

Note:
[1]Impacts were calculated based on an elevation of 7,410 feet.

The river birch/mesic forb community has a CNHP conservation rating of G4/S2; the S2 rating means that this community is known typically from 6 to 20 locations in Colorado and/or has few remaining acres. River birch/mesic forb occurs in the Boulder Foothills and Fairview Peak Potential Conservation Areas (PCAs) in Boulder County, in addition to Gross Reservoir, and has been reported in Nevada and Utah in addition to Colorado (CNHP 2009). The thinleaf alder/mesic forb (*Alnus incana*/mesic forb) community has a rating of G3/S3, where the S3 rating means that it is known typically from 21 to 100 locations in Colorado. The thinleaf alder/mesic forb community is not listed for other CNHP PCAs in Boulder County (CNHP 2009) but is known from Idaho, Nevada, Utah, and Wyoming in addition to Colorado.

Impacts to these two communities are considered moderate because they would cause a local loss of biodiversity but would not substantially affect their overall distribution or abundance.

The Proposed Action (Alternative 1a) would also affect about 1 acre of old growth ponderosa pine. According to the USFS, there are approximately 1,300 acres of old growth ponderosa pine in the Arapaho & Roosevelt National Forests (ARNF) (USFS 1997b).

Impacts of Gross Reservoir expansion would cause a loss of about 0.1% of old growth ponderosa pine on the ARNF, a negligible impact.

5.7.2 Alternative 1c

Alternative 1c would directly impact 914.6 acres of vegetation, including 675.7 acres of permanent impacts and 238.9 acres of temporary impacts at Gross Reservoir and the new Leyden Gulch Reservoir. The majority of impacts would occur at the Leyden Gulch Reservoir site. Impacts associated with each site are discussed below.

5.7.2.1 Gross Reservoir

Alternative 1c would result in 359.6 acres of direct impacts to vegetation at Gross Reservoir: 292.5 acres of permanent impacts and 67.1 acres of temporary impacts. The types and sources of impacts would be similar to the Proposed Action and would affect the same plant communities. Although the area of permanent vegetation loss would be less than the Proposed Action, the area of temporary impacts would be larger. Impacts to plant communities are summarized in Table 5.7-3. An additional 46.6 acres of unvegetated areas would be affected (mostly standing water). Tree clearing would affect 337 acres. Like the Proposed Action, Alternative 1c is not likely to increase the potential for spread of mountain pine beetle. Although construction activities are likely to increase the potential for wildfires, they are likely to be quickly contained or extinguished.

Table 5.7-3
Alternative 1c Vegetation Impacts at Gross Reservoir[1]

Vegetation Area	Permanent Impacts (acres)	Temporary Impacts (acres)	Total Direct Impacts (acres)
Vegetated Areas			
Disturbed Rangeland	13.1	0.0	13.1
Grassland/Forb Mix	7.0	2.1	9.1
Ponderosa Pine	109.7	10.8	120.5
Ponderosa Pine/Douglas Fir	162.7	54.2	216.9
Subtotal	**292.5**	**67.1**	**359.6**
Unvegetated Areas			
Disturbed Soil	8.6	3.9	12.5
Standing Water	0.0	33.7	33.7
Talus Slope/Rock Outcrop	0.4	0.0	0.4
Subtotal	**9.0**	**37.6**	**46.6**
Total	**301.5**	**104.7**	**406.2**

Note:
[1]Vegetation impacts were calculated based on an elevation of 7,367 feet.

Similar to the Proposed Action, most of the impacts of Alternative 1c at Gross Reservoir would occur in the expanded inundation area and along the shoreline during site preparation. There would be limited establishment of wetland, riparian or perennial vegetation along the shoreline because of large annual fluctuations in average water level. The average water level would fluctuate annually between 7,275 feet in April and 7,335 feet in July. This is a 60-foot elevation difference on average throughout the year.

The large water level fluctuation would result in a wide drawdown zone and bare shoreline. Impacts from noxious weeds would be similar to the Proposed Action. The area of temporary impacts would be larger than the Proposed Action, because less of the areas affected by construction would be covered by the expanded reservoir.

Inundation of CNHP listed communities, water birch/mesic forb foothills riparian shrub and thinleaf alder/mesic forb riparian shrubland, would be about 25% less than described for the Proposed Action, and would total about 3.8 acres (Table 5.7-2).

5.7.2.2 Leyden Gulch Reservoir Site

Construction of a new reservoir at Leyden Gulch would result in direct impacts of 555.0 acres of vegetation, including 383.2 acres of permanent impacts and 171.8 acres of temporary impacts. The vegetation types that would be affected are predominantly grass/forb rangeland with small inclusions of cottonwoods, herbaceous riparian, snowberry/shrub mix, disturbed rangeland, and disturbed soil areas. Table 5.7-4 summarizes the impacts to vegetation at Leyden Gulch Reservoir. Permanent impacts would mostly result from the construction of the dam and clearing of the reservoir area, and temporary impacts would mostly be caused by construction of the dam and inlet/outlet works and use of staging and spoil areas. An additional 10.4 acres of unvegetated areas would be affected (mostly disturbed soil). Because the affected vegetation types are common in the region, losses of vegetation are considered a moderate impact.

Table 5.7-4
Alternative 1c Vegetation Impacts at the Leyden Gulch Reservoir Site[1]

Vegetation Area	Permanent Impacts (acres)	Temporary Impacts (acres)	Total Direct Impacts (acres)
Vegetated Areas			
Cottonwood	0.0	8.7	8.7
Disturbed Rangeland	11.8	0.0	11.8
Grassland/Forb Mix	363.0	143.5	506.5
Residential Development[1]	0.1	0.3	0.4
Sedge	6.2	14.7	20.9
Snowberry/Shrub Mix	2.1	4.6	6.7
Subtotal	**383.2**	**171.8**	**555.0**
Unvegetated Areas			
Disturbed Soil	5.7	3.3	9.0
Running Water	0.1	0.9	1.0
Standing Water	0.0	0.4	0.4
Subtotal	**5.8**	**4.6**	**10.4**
Total	**389.0**	**176.4**	**565.4**

Note:
[1]Vegetation impacts were calculated based on an elevation of 7,367 feet.

The relocation of 4,000 linear feet of State Highway 93 would result in the loss of 7.1 acres consisting predominantly of grass/forb mix and smaller quantities of sedge and snowberry/shrub mix. The Leyden Gulch Reservoir site would also include the

construction of an 8-foot diameter outlet tunnel connecting with Conduits 16 and 22, access roads, and the relocation of a 1 mile segment of South Boulder Diversion Canal. These auxiliary features would predominantly impact grass/forb mix.

On average, reservoir operations at Leyden Gulch would cause the water level to fluctuate between elevation 6,113 feet in April and elevation 6,121 feet in August. However, the water level would be maintained between elevations 6,121 and 6,120 feet for 7 months of the year, from June to December. The relatively consistent reservoir water elevation, gentle topography, and loamy and clayey soils at Leyden Gulch would create hydrological conditions along the shoreline that would be conducive to growing wetland and riparian vegetation. Wetland and riparian vegetation that is likely to become established would include cattails, bulrush, peachleaf willow, cottonwood, and coyote willow.

No sensitive plant communities would be affected at the Leyden Gulch Reservoir site.

Noxious weed species are prevalent throughout the Leyden Gulch Reservoir site. Grading and other construction related activities have the potential to spread noxious weed seeds to uninfested areas within the Project site as well as into surrounding areas. Noxious weed species present include diffuse knapweed, field bindweed, cheatgrass, dalmation toadflax, and musk thistle. Although no importation of fill would be required, additional species of noxious weeds could be introduced by vehicular traffic and construction equipment. Grading and other soil disturbing activities would likely create new opportunities for noxious weeds to become established or spread.

5.7.3 Alternative 8a

Alternative 8a would result in direct impacts to 441.6 acres of vegetated areas. Impacts include 361.2 acres of permanent impacts and 80.4 acres of temporary impacts at Gross Reservoir, South Platte River Facilities, and Conduit O. Most of the impacts would occur at Gross Reservoir. The impacts to vegetation for each site resulting from Alternative 8a are discussed below.

5.7.3.1 Gross Reservoir

The types of impacts to vegetation at Gross Reservoir as a result of Alternative 8a would be similar to those listed for the Proposed Action. Vegetation impacts at Gross Reservoir would be 414.3 acres, including 353.8 acres of permanent loss, and 60.5 acres of temporary disturbance (Table 5.7-5). An additional 46.6 acres of unvegetated areas would be affected (mostly standing water). Tree clearing would affect 388 acres. Like the Proposed Action, Alternative 8a is not likely to increase the potential for spread of mountain pine beetle. Although construction activities are likely to increase the potential for wildfires, they are likely to be quickly contained or extinguished.

Table 5.7-5
Alternatives 8a and 10a Vegetation Impacts at Gross Reservoir[1]

Vegetation Area	Permanent Impacts (acres)	Temporary Impacts (acres)	Total Direct Impacts (acres)
Vegetated Areas			
Disturbed Rangeland	16.0	0.0	16.0
Grassland/Forb Mix	8.6	2.1	10.7
Ponderosa Pine	133.8	8.6	142.4
Ponderosa Pine/Douglas Fir	195.4	49.8	245.2
Subtotal	**353.8**	**60.5**	**414.3**
Unvegetated Areas			
Disturbed Soil	8.8	3.7	12.5
Standing Water	0.0	33.7	33.7
Talus Slope/Rock Outcrop	0.4	0.0	0.4
Subtotal	**9.2**	**37.4**	**46.6**
Total	**363.0**	**97.9**	**460.9**

Note:
[1]Vegetation impacts were calculated based on an elevation of 7,384 feet.

Similar to the Proposed Action, most of the impacts of Alternative 8a at Gross Reservoir would occur in the new inundation area and along the shoreline during site preparation. There would be limited establishment of wetland, riparian, or perennial vegetation along the shoreline because of large annual fluctuations in average water level. The average water level would fluctuate annually between 7,298 feet (April) and 7,354 feet (June and July), resulting in a 56 feet elevation difference based on reservoir modeling. The large water level fluctuation would result in a wide drawdown zone and bare shoreline. Impacts from noxious weeds would be similar to the Proposed Action. The area of temporary impacts would be larger than the Proposed Action, because less of the areas affected by construction would be covered by the expanded reservoir.

Inundation of CNHP listed communities, water birch/mesic forb foothills riparian shrub and thinleaf alder/mesic forb riparian shrubland, would be about 4.3 acres (Table 5.7-2), less than described for the Proposed Action.

5.7.3.2 South Platte River Facilities

The Worthing, Challenger, North Tower and South Tower pits were studied as representative sites to illustrate the type of impacts that might occur with implementation of this alternative. Based on these reference sites, Alternative 8a would directly affect approximately 17.1 acres of vegetation at the South Platte River Facilities (Table 5.7-6). Impacts to vegetation would be minor because of the existing level of disturbance.

Table 5.7-6
Alternative 8a Vegetation Impacts at South Platte River Facilities[1]

Impact Type	Advanced Water Treatment Plant (acres)	Dechlorination Facility (acres)	Diversion Structure (acres)	Gravel Pit Pump Stations (acres)	Gravel Pit Pipeline Crossings (acres)	Total Disturbance Area (acres)
Permanent	4.0	0.1	0.1	1.6	0.0	5.8
Temporary	7.0	0.0	1.6	1.2	1.5	11.3
Total	**11.0**	**0.1**	**1.7**	**2.8**	**1.5**	**17.1**

Note:
[1]Gravel pit storage sites would be completely mined and devoid of vegetation prior to Moffat Project water storage.

Vegetation communities at the Worthing and Challenger sites are mostly in a disturbed condition and colonized by weedy species such as cheatgrass, field bindweed, prickly lettuce, Canadian horseweed, redstem stork's bill, and common mullein. Other vegetation communities include small areas of disturbed rangeland, forest riparian, shrub riparian, herbaceous riparian, and areas of disturbed soils. Since it is assumed that the Moffat Project would utilize an existing pit that has already been mined, no additional disturbance for excavation of a gravel pit site is shown in Table 5.7-5. The gravel pit storage sites are anticipated to be kept full with little seasonal fluctuation in water level, which would favor the establishment of riparian and wetland vegetation similar to what is described at the North Tower and South Tower pits in Chapter 3. Vegetation/habitat types present at the North Tower and South Tower pits include open water surrounded by a narrow ring of riparian and wetland vegetation along the reservoir banks including cottonwood, peachleaf willow, sandbar willow, and cattail.

Permanent impacts would occur primarily from the Advanced Water Treatment Plant (AWTP) and gravel pit pipeline pump stations, and most of the impacts of the South Platte River Facilities would be temporary. The diversion structure in the South Platte River and associated conveyance would impact wetland and riparian herbaceous vegetation along the banks of the South Platte River and disturbed rangeland along the pipeline. Areas of temporary impact would be revegetated with native species appropriate for site-specific post-construction conditions. No specific revegetation plans have been prepared by Denver Water at this time. Construction activities could provide opportunities for the expansion of noxious weeds into the newly disturbed areas. However, due to the existing disturbed conditions, the impacts would be relatively minor. Due to the disturbed nature of the existing sites, overall direct and indirect impacts on vegetation would likely be negligible.

5.7.3.3 Conduit O

Conduit O and associated pump stations would directly impact a total of 10.2 acres, including 1.6 acres of permanent impacts for the pump stations, and 1.2 acres of temporary impacts for the pump stations, and 7.4 acres of temporary impacts for pipeline crossings. Most of the 25.2 mile pipeline would be constructed within existing roads, but surface disturbance in vegetated areas would occur at crossings of two highways and the South Platte River. Most of the crossing areas would consist of disturbed rangeland and grassland/forb mixture. Although ground disturbance at crossings would be revegetated

with appropriate species, the pipeline corridor would be maintained to prevent the establishment of large trees that could damage the pipeline.

Noxious weeds along Conduit O are typical for urban riparian areas and include Canada thistle, cheatgrass, common teasel, hoary cress, and salt cedar. Construction could potentially spread these species into less infested areas.

5.7.4 Alternative 10a

Alternative 10a would result in direct impacts to 423.7 acres of vegetation, including 336.6 acres of permanent impacts and 87.1 acres of temporary impacts at Gross Reservoir and Denver Basin Aquifer Facilities sites. Most of the impacts would occur at Gross Reservoir.

5.7.4.1 Gross Reservoir

Impacts to Gross Reservoir would be the identical to Alternative 8a (Table 5.7-5).

5.7.4.2 Denver Basin Aquifer Facilities

The Denver Basin Aquifer Facilities and AWTP would be located within Denver Parks' properties that primarily consist of lawns, trees, and ornamental vegetation typical of parks and golf courses. A total of 38.0 acres would be impacted, consisting of 17.5 acres of permanent impacts and 20.5 acres of temporary impacts. Other vegetation types include disturbed rangeland and riparian shrub at representative sites such as the Airport Nursery and Lakewood Gulch sites. Permanent impacts at the AWTP would consist of 4.0 acres and 13.5 acres at the well facilities. Temporary impacts would consist of 7.0 acres at the AWTP and 10.8 acres at the well facilities. Impacts to vegetation from these facilities would be minor to moderate.

The 36-mile long Denver Basin distribution pipelines would follow streets and urban utility corridors, but would cross riparian woodland and other vegetation types at several stream crossings including the South Platte River, Cherry Creek, and Sand Creek. Stream crossings would utilize an open cut method and would temporarily impact 2.7 acres of vegetation, including riparian and wetland vegetation. Temporary impacts would be revegetated with either ornamental landscaping or native vegetation as appropriate. The pipeline corridor would be maintained to prevent the establishment of large trees that could damage the pipeline.

Because the finished wells and facilities would be developed features in managed landscapes, noxious weeds are not likely to be an issue during operation. Regular operations and maintenance would treat any noxious weeds that become established. The disturbances at the riparian and creek crossings would be susceptible to invasion by noxious weeds and construction of stream crossing could potentially spread these species into less infested areas.

5.7.4.3 Conduit M

Impacts associated with Conduit M would be similar to Conduit O described above. The 18.5-mile pipeline would be constructed in existing roads with some roadside/median

staging required. Three small pump stations would result in 1.6 acres of permanent impact and 1.2 acres of temporary impacts to existing vegetation, and pipeline crossings would affect 3.6 acres, for a total of 6.4 acres of impact to vegetation. Conduit M would impact riparian and other vegetation at crossings of Clear Creek and the South Platte River. Riparian vegetation impacted at these locations would likely include species such as cottonwood, peachleaf willow, sandbar willow, and other herbaceous riparian vegetation, similar to Conduit O. At these locations the vegetation would be temporarily removed during construction and revegetated with appropriate species following construction. However, trees would not be allowed to grow on top of the pipeline.

Noxious weed species that would likely be encountered and susceptible to spreading include Canada thistle, cheatgrass, common teasel, hoary cress, leafy spurge, perennial pepperweed, poison hemlock, quackgrass, Russian olive, salt cedar, and Scotch thistle.

5.7.5 Alternative 13a

Alternative 13a consists of expansion at Gross Reservoir, construction of the South Platte River Facilities, and Conduit O. This alternative would affect 487.9 acres of vegetation, including 410.9 acres of permanent impacts and 77.0 acres of temporary impacts. Most of the impacts would occur at Gross Reservoir.

5.7.5.1 Gross Reservoir

Impacts at Gross Reservoir associated with Alternative 13a would be similar in type, but slightly less than impacts for the Proposed Action. Total vegetation impacts for Gross Reservoir would be 459.5 acres, with 403.5 acres being permanent and 56.0 acres being temporary. Impacts to vegetation at Gross Reservoir associated with Alternative 13a are summarized in Table 5.7-7. An additional 46.6 acres of unvegetated areas would be affected (mostly standing water). Tree clearing would affect 428 acres. Like the Proposed Action, Alternative 13a is not likely to increase the potential for spread of mountain pine beetle. Although construction activities are likely to increase the potential for wildfires, they are likely to be quickly contained or extinguished.

Similar to the Proposed Action, most of the impacts of Alternative 13a at Gross Reservoir would occur in the new inundation area and along the shoreline during site preparation. There would be limited establishment of wetland, riparian, or perennial vegetation along the shoreline because of large annual fluctuations in average water level. The average water level would fluctuate annually between 7,309 feet in April and 7,366 feet in July, resulting in a 57 feet elevation difference based on reservoir modeling. Impacts from noxious weeds would be similar to the Proposed Action.

Inundation of CNHP listed communities, water birch/mesic forb foothills riparian shrub along South Boulder Creek and thinleaf alder/mesic forb riparian shrubland along Winiger Gulch, would be 4.6 acres (Table 5.7-2), less than described for the Proposed Action, but more than the other alternatives.

Table 5.7-7
Alternative 13a Vegetation Impacts at Gross Reservoir[1]

Vegetation Area	Permanent Impacts (acres)	Temporary Impacts (acres)	Total Impacts (acres)
Vegetated Areas			
Disturbed Rangeland	19.5	0.0	19.5
Grassland/Forb Mix	10.0	2.1	12.1
Ponderosa Pine	150.8	7.9	158.7
Ponderosa Pine/Douglas Fir	223.2	46.0	269.2
Subtotal	**403.5**	**56.0**	**459.5**
Unvegetated Areas			
Disturbed Soil	8.8	3.7	12.5
Standing Water	0.0	33.7	33.7
Talus Slope/Rock Outcrop	0.4	0.0	0.4
Subtotal	**9.2**	**37.4**	**46.6**
Total	**412.7**	**93.4**	**506.1**

Note:
[1]Vegetation impacts were calculated based on an elevation of 7,395 feet.

5.7.5.2 South Platte River Facilities

Impacts of Alternative 13 from the South Platte River Facilities would be similar to those described for Alternative 8a at the Worthing and Challenger pits. Under Alternative 13a, the gravel pit pipeline would be 5.5 miles long and would have more temporary impacts (2.6 acres) at crossings of the South Platte River and C-470. Table 5.7-8 shows a summary of the impacts associated to Alternative 13a at the South Platte River Facilities.

Table 5.7-8
Alternative 13a Vegetation Impacts at South Platte River Facilities

Impact Type	Advanced Water Treatment Plant (acres)	Dechlorination Facility (acres)	Diversion Structure (acres)	Gravel Pit Pump Stations (acres)	Gravel Pit Pipeline Crossings (acres)	Total Disturbance Area (acres)
Permanent	4.0	0.1	0.1	1.6	0.0	5.8
Temporary	7.0	0.0	1.6	1.2	2.6	12.4
Total	**11.0**	**0.1**	**1.7**	**2.8**	**2.6**	**18.2**

Transfer of agricultural water rights on about 3,900 acres would primarily affect irrigated croplands used for growing alfalfa, corn, hay, pasture, sugar beets, and other crops. In addition, about 2% (77 acres) of the affected area is likely to be wetlands and about 0.2% (7 acres) ponds and irrigation ditches, based on a study of a similar area in Weld County for the Northern Integrated Supply Project Environmental Impact Statement (Corps 2007b). Most of the affected area would be converted to dryland cropland and pasture grasslands. Emergent wetlands would also likely convert to grassland when water sources are removed.

Some areas may be abandoned or fallowed for an extended period of time, and changes in agricultural land use have the potential to substantially increase the distribution and cover of noxious weeds depending on how the lands are managed and weeds controlled following the removal of irrigation.

5.7.5.3 Conduit O

Impacts would be the same as described for Alternative 8a.

5.7.6 No Action Alternative

There would be no direct vegetation impacts as a result of the No Action Alternative. However, indirect impacts to vegetation resources would occur at Gross Reservoir as a result of more frequent and prolonged drawdowns. The area between the normal water elevation and the minimum drawdown level would remain barren of vegetation but would be increasingly susceptible to noxious weed infestations.

With the exception of mandatory restrictions imposed during Stages 3 and 4 drought periods, vegetation resources in the vicinity of Project components and throughout the greater Project service area would remain largely unchanged under the No Action Alternative. In both Stages 3 and 4 droughts, lawn watering would be prohibited (Section 2.10.2.2). Non-native lawn species and ornamental landscaping would be impacted by the mandatory restrictions. Trees, shrubs, and high-use public turf areas would be limited to watering once per week. This would result in temporary stresses to irrigation dependent vegetation, however, these areas should recover once restrictions are removed. Under Stage 4 drought restrictions, all outdoor watering is prohibited, including trees, shrubs, and high-use public turf areas. Mortality, although impossible to quantify, is likely in some irrigation dependent areas.

5.7.7 Mitigation and Monitoring

Possible measures to minimize adverse impacts to vegetation, erosion, and the colonization of noxious weeds in disturbed areas may include those described below.

1. A revegetation plan would be developed prior to construction for all areas that would be temporarily disturbed during construction of the Moffat Project. The plan would be in compliance with the ARNF revegetation policy for lands administered by the USFS. In order to increase the likelihood of successful revegetation, the plan should address the selection of site-appropriate species, including native herbaceous and/or woody species, soil preparation, seeding rates and methods, planting of shrubs, mulching and soil amendments, watering frequency and duration (if needed), and monitoring of reestablishment. With the potential for noxious weeds, seed rates should be high to load the seed bank in the soil. Forb species would be included in the seed mixes to provide more food sources for wildlife and to improve the natural environment. Seed mixes would be developed in coordination with the USFS. In addition, Colorado Parks and Wildlife (CPW) (previously called Colorado Division of Wildlife), should be consulted during the preparation of seed mixes to ensure that desirable native species are used. Plantings of cottonwood, willows, currant, and snowberry would also be considered.

2. All temporary impact areas would be reseeded and/or planted promptly after construction completion. If these areas have been compacted by equipment and construction activities, the soil would be ripped and tilled prior to seeding to improve water infiltration. Erosion matting, straw, soil amendments or other measures may need to be maximized revegetation success, especially in highly disturbed areas exposed to wind. If matting is used, it should be a product made of biodegradable material, with a single layer to avoid trapping wildlife, such as coconut-straw erosion blankets. Use of soil amendments and fertilizers would be reviewed with the USFS to ensure that they would not favor noxious weeds at the expense of desired vegetation, and that they would not adversely affect riparian areas or water quality.
3. The removal of trees in temporary disturbance areas would be avoided whenever possible to maintain structural diversity and to provide necessary shade for preventing the invasion of noxious weeds. Woody debris resulting from vegetation clearing would be utilized on site to the extent practical.
4. Construction areas would be fenced or marked to confine construction activities to prevent unnecessary disturbance to soil and native plant communities.
5. A weed management plan would be prepared to control noxious weeds and to prevent degradation of habitats. The weed plan should identify the primary species of concern, potential method of spread, proposed methods of control, and monitoring of weed conditions. It would be developed in coordination with the existing FERC-required weed management plan, the USFS, and various county weed coordinators and implemented as part of construction and regular reservoir operations.
6. All equipment used in the Project area must be weed-free. All equipment would be cleaned prior to entering the site in order to remove soil and plant parts that may contain weed seeds. Only certified weed-free mulch and bales would be used. All forage products used on USFS lands would comply with USFS Rocky Mountain Region Order No. 02-2005-01 requiring use of certified weed-free hay, straw, or mulch in all activities on National Forest lands.
7. All seed used would be free of noxious weeds. Any seed used on USFS land would be required to be tested for smooth brome and "all states noxious weed exam" according to Official Seed Analysts standards and will be certified by a Registered Seed Technologist or Seed Analysts as meeting the requirements of the Federal Seed Act and the Rules and Regulations for the Colorado Seed Act. The USFS has requested the following language, or equivalent language as approved by the USFS, to be included in contract specifications for revegetation: "Seed mixes will be approved by FERC and the USFS. If a species in the seed mix is not available, the Contractor shall provide written evidence from three seed vendors that the species is not available. With written approval, the mix may be adjusted and the new species may be substituted after consultation with the FERC and the USFS. Seed lot tags shall be available to FERC and the USFS at least one month prior to seeding, for testing that may be performed by USFS. If noxious weeds or smooth brome seeds are found, seed may be rejected and the Contractor shall be responsible for the replacement cost of seed."

8. Native topsoil would be salvaged and replaced as part of construction techniques to the extent feasible. Topsoil would be salvaged from areas of temporary disturbance and permanent impacts at the construction sites and would be reused in order to enhance revegetation efforts. Topsoil would not be salvaged from areas infested with noxious weeds. During pipeline construction, where not in existing roadways, topsoil would be salvaged from the trench area and from the subsoil spoil area, stockpiled along the ROW, and respread over the disturbed area. Special topsoil handling protocols would be developed and used to minimize loss, degradation, and mixing with subsoil. Fertilizer would not be used in seeded areas if it would enhance the growth of noxious weeds at the expense of desired vegetation.
9. Denver Water would coordinate with the USFS to ensure appropriate reclamation of the Gross Reservoir quarry site and any alternative quarry sites.
10. Clearing of trees at Gross Reservoir would need to be conducted in a manner that does not lead to additional spread of mountain pine beetle. Methods to avoid and minimize impacts may include surveys to identify beetle activity prior to timber clearing, and storage and processing of forest residue in a manner that would limit dispersal of beetles. Most of the areas of tree removal are on USFS land and Denver Water would consult with the USFS regarding appropriate removal methods and timing.
11. For Alternative 13a, lands affected by agricultural water rights transfer should be seeded with grasses to limit expansion of noxious weeds, where the transfer would result in cessation of agricultural activity or prolonged fallow periods.

Additionally, Denver Water would continue to be involved in various cooperative and collaborative efforts like the Upper South Platte Project, the Front Range Roundtable, Watershed Wildfire Protection Work Group, Forest-to-Faucet Partnership, Forsythe Fuel Reduction Project, and the Winiger Ridge Ecosystem Management Project (all described in Appendix G-4) for forest health treatments to help protect water resources for Denver Water's customers as well as millions of other downstream beneficiaries, including homes, businesses, and agriculture.

5.7.8 Unavoidable Adverse Impacts

The construction and operation of the reservoir sites and related facilities would unavoidably cause the loss of hundreds of acres of natural vegetation due to reservoir inundation. Additionally, the Proposed Action would temporarily disturb vegetation resulting from temporary construction impacts until fully restored. Despite revegetation efforts, the post-revegetation communities would remain different for years following construction completion. The Project would unavoidably create favorable conditions for the establishment of noxious weeds, as a result of construction and operation.

5.8 RIPARIAN AND WETLAND AREAS

This section describes the direct and indirect riparian and wetland impacts expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Five potential riparian and wetland issues were identified during scoping:

- Impact of depletions to the Fraser River on the water quality functions of wetlands of the Fraser and Blue rivers and the Colorado River downstream.
- Impact of constructing the proposed reservoir at Leyden Gulch on existing wetlands; replacing impacted wetlands with a comparable wetland area immediately downstream of the disturbance should be considered for mitigation.
- Impact of proposed water level changes in Gross Reservoir on existing wetlands.
- Impact of Fraser River and South Boulder Creek depletions on riparian and aquatic habitat.
- Impact of changes in stream flows causing a trend from aquatic vegetation species to upland species.

The scoping issues along with potential construction and inundation impacts to riparian and wetland areas are evaluated in Sections 5.8.1 through 5.8.6. This section evaluates changes that would result from the Proposed Action and other alternatives compared to Full Use of the Existing System.

Construction and Inundation

Impacts to waters of the United States (U.S.), including wetlands are subject to review by the U.S. Army Corps of Engineers (Corps) under Section 404 of the Clean Water Act. Any Project that includes the placement of dredged or fill material into waters deemed jurisdictional by the Corps must obtain a Section 404 Permit prior to the activity. Depending on the specific Section 404 authorization, the Corps may also be required to determine that potential impacts have been avoided or minimized to the maximum extent practicable and remaining unavoidable impacts have been mitigated to maintain no overall net loss of wetlands. This Environmental Impact Statement (EIS) provides the basis for regulatory review of the Section 404 Permit application for the Moffat Project. Appendix K contains a detailed Section 404(b)(1) analysis conducted by the Corps.

As discussed in the introduction to Section 4.6.8, construction and inundation effects include direct permanent impacts, indirect permanent impacts, and temporary impacts.

Direct permanent impacts can result from clearing, excavating, inundation, filling, and/or other grading that would modify the existing functions of these areas. The inundation impact area includes the area 10 feet above the expanded pool for Alternatives 1c, 8a, 10a, and 13a. The Proposed Action (Alternative 1a) with the Environmental Pool inundation impact area includes vegetation up to elevation 7,410 feet. Project impacts were assessed by overlaying the footprint of the facilities and construction areas on maps of wetlands and other water features. Table 5.8-1 compares the direct permanent impacts to wetlands by alternative. Table 5.8-2 compares direct impacts to other waters of the U.S.

Table 5.8-1
Summary of Direct Impacts to Wetlands

Study Area		Wetland Impact by Alternative (acres)									
		Proposed Action		Alternative 1c		Alternative 8a		Alternative 10a		Alternative 13a	
		Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Gross Reservoir											
Wetland Type	PEM	0.43	--	0.43	--	0.43	--	0.43	--	0.43	--
	PSS	1.03	--	0.74	--	0.86	--	0.86	--	0.93	--
	PEM/PSS	0.49	0.12	0.43	0.12	0.46	0.12	0.45	0.12	0.47	0.12
	Total	**1.95**	**0.12**	**1.60**	**0.12**	**1.75**	**0.12**	**1.75**	**0.12**	**1.83**	**0.12**
Leyden Gulch Reservoir											
Wetland Type	PEM	--	--	4.49	12.50	--	--	--	--	--	--
	PSS	--	--	0.06	--	--	--	--	--	--	--
	PEM/PSS	--	--	--	0.68	--	--	--	--	--	--
	Total	**--**	**--**	**4.55**	**13.18**	**--**	**--**	**--**	**--**	**--**	**--**
South Platte River Facilities											
Wetland Type	PEM	--	--	--	--	--	--	--	--	--	--
	PSS	--	--	--	--	--	--	--	--	--	0.02
	PEM/PSS	--	--	--	--	0.02	0.22	--	--	0.04	0.22
	Total	**--**	**--**	**--**	**--**	**0.02**	**0.22**	**--**	**--**	**0.04**	**0.24**
Denver Basin Aquifer Facilities											
Wetland Type	PEM	--	--	--	--	--	--	--	<.01	--	--
	PSS	--	--	--	--	--	--	--	0.03	--	--
	PEM/PSS	--	--	--	--	--	--	--	0.02	--	--
	Total	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**0.05**	**--**	**--**

Table 5.8-1 (continued)
Summary of Direct Impacts to Wetlands

Study Area		Wetland Impact by Alternative (acres)									
		Proposed Action		Alternative 1c		Alternative 8a		Alternative 10a		Alternative 13a	
		Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Transfer of Agricultural Water Rights											
Wetland Type	PEM/PSS	--	--	--	--	--	--	--	--	82.0	--
Conduit O											
Wetland Type	PEM	--	--	--	--	--	<0.01	--	--	--	<0.01
	PSS	--	--	--	--	--	--	--	--	--	--
	PEM/PSS	--	--	--	--	--	0.06	--	--	--	0.06
	Total	**--**	**--**	**--**	**--**	**--**	**0.06**	**--**	**--**	**--**	**0.06**
Conduit M											
Wetland Type	PEM	--	--	--	--	--	--	--	0.02	--	--
	PSS	--	--	--	--	--	--	--	--	--	--
	PEM/PSS	--	--	--	--	--	--	--	--	--	--
	Total	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**0.02**	**--**	**--**
Totals for Alternatives		**1.95**	**0.12**	**6.15**	**13.43**	**1.77**	**0.4**	**1.75**	**0.19**	**83.87**	**0.42**

Notes:
The calculation of the noted acres for the Proposed Action assumes disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).
PEM = palustrine emergent
PSS = palustrine scrub/shrub

Table 5.8-2
Summary of Impacts to Other Waters of the U.S.

Facility	Other Water Features (acres)									
	Proposed Action		Alternative 1c		Alternative 8a		Alternative 10a		Alternative 13a	
	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Gross Reservoir										
South Boulder Creek	2.78	0.48	2.36	0.48	2.59	0.48	2.59	0.48	2.70	0.48
Forsythe Canyon	0.36	--	0.20	--	0.26	--	0.26	--	0.31	--
Winiger Gulch Tributary	0.05	--	0.02	--	0.03	--	0.03	--	0.04	--
Winiger Gulch	0.22	--	0.16	--	0.18	--	0.18	--	0.20	--
Unnamed Southern Tributary	0.12	--	0.07	--	0.09	--	0.09	--	0.10	--
Chamberlain Gulch	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total	**3.53**	**0.49**	**2.82**	**0.49**	**3.16**	**0.49**	**3.16**	**0.49**	**3.36**	**0.49**
Leyden Gulch Reservoir										
Ralston Creek (Perennial)	--	--	--	0.42	--	--	--	--	--	--
Leyden Gulch	--	--	0.17	--	--	--	--	--	--	--
South Boulder Diversion Canal	--	--	0.06	0.77	--	--	--	--	--	--
Stock Pond	--	--	0.04	0.21	--	--	--	--	--	--
Stormwater Ditch	--	--	0.04	0.04	--	--	--	--	--	--
Irrigation Ditch	--	--	--	0.11	--	--	--	--	--	--
Total	**--**	**--**	**0.31**	**1.55**	**--**	**--**	**--**	**--**	**--**	**--**
South Platte River Facilities[1]										
South Platte River	--	--	--	--	0.04	0.36	--	--	0.04	0.90
Total	**--**	**--**	**--**	**--**	**0.04**	**0.36**	**--**	**--**	**0.04**	**0.90**

Table 5.8-2 (continued)
Summary of Impacts to Other Waters of the U.S.

Facility	Other Water Features (acres)									
	Proposed Action		Alternative 1c		Alternative 8a		Alternative 10a		Alternative 13a	
	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Transfer of Agricultural Water Rights										
Irrigation Ditches and Ponds	--	--	--	--	--	--	--	--	8.0	--
Denver Basin Aquifer Facilities										
Cherry Creek	--	--	--	--	--	--	--	0.27	--	--
South Platte River	--	--	--	--	--	--	--	0.74	--	--
Sand Creek	--	--	--	--	--	--	--	0.17	--	--
Total	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**1.18**	**--**	**--**
Conduit O										
South Platte River	--	--	--	--	--	0.32	--	--	--	0.32
Little Dry Creek	--	--	--	--	--	<.01	--	--	--	<.01
Stormwater ditch at 1-25	--	--	--	--	--	<.01	--	--	--	<.01
Total	**--**	**--**	**--**	**--**	**--**	**0.33**	**--**	**--**	**--**	**0.33**
Conduit M										
South Platte River	--	--	--	--	--	--	--	0.34	--	--
Burlington Ditch	--	--	--	--	--	--	--	0.18	--	--
Little Dry Creek	--	--	--	--	--	--	--	<.01	--	--
Total	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**0.52**	**--**	**--**
Total for Alternative	**3.53**	**0.49**	**3.12**	**2.04**	**3.20**	**1.18**	**3.16**	**2.19**	**11.40**	**1.72**

Notes:
[1]The gravel pit storage facilities are considered representative of typical facilities found along the South Platte River; therefore, these impact acreages are estimates. The actual location and configuration of the gravel pits and associated facilities would be determined during the design phase for the alternative to be permitted by the Corps.
The calculation of the noted acres for the Proposed Action assumes disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).

Table 5.8-3 summarizes direct impacts to riparian habitats. The jurisdictional status (for Section 404 permitting) of the wetlands and other waters has not been included in this section. Rather the Corps will conduct a formal jurisdictional determination of wetlands and waters of the U.S. for the selected alternative that is permitted.

Table 5.8-3
Summary of Impacts to Riparian Habitats

Alternative	Habitat Type (acres)							
	Woodland		Wood/Shrubland		Shrubland		Total	
	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Gross Reservoir								
Proposed Action	0.69	0.04	1.09	--	2.30	--	**4.08**	**0.04**
1c	0.62	0.04	0.86	--	1.76	--	**3.24**	**0.04**
8a	0.65	0.04	0.95	--	2.02	--	**3.62**	**0.04**
10a	0.65	0.04	0.95	--	2.02	--	**3.62**	**0.04**
13a	0.68	0.04	1.03	--	2.17	--	**3.88**	**0.04**
Leyden Gulch Reservoir								
Proposed Action	--	--	--	--	--	--	**--**	**--**
1c	--	0.07	0.13	0.63	0.08	0.62	**0.21**	**1.32**
8a	--	--	--	--	--	--	**--**	**--**
10a	--	--	--	--	--	--	**--**	**--**
13a	--	--	--	--	--	--	**--**	**--**
South Platte River Facilities								
Proposed Action	--	--	--	--	--	--	**--**	**--**
1c	--	--	--	--	--	--	**--**	**--**
8a	<0.01	0.03	--	--	--	--	**<0.01**	**0.03**
10a	--	--	--	--	--	--	**--**	**--**
13a	--	0.03	<0.01	0.06	--	--	**<0.01**	**0.09**
Denver Basin Aquifer Facilities								
Proposed Action	--	--	--	--	--	--	**--**	**--**
1c	--	--	--	--	--	--	**--**	**--**
8a	--	--	--	--	--	--	**--**	**--**
10a	--	--	--	0.30	--	--	**--**	**0.30**
13a	--	--	--	--	--	--	**--**	**--**
Conduit O								
Proposed Action	--	--	--	--	--	--	**--**	**--**
1c	--	--	--	--	--	--	**--**	**--**
8a	--	0.01	--	<0.01	--	--	**--**	**0.01**
10a	--	--	--	--	--	--	**--**	**--**
13a	--	0.01	--	<0.01	--	--	**--**	**0.01**

Table 5.8-3 (continued)
Summary of Impacts to Riparian Habitats

Alternative	Habitat Type (acres)							
	Woodland		Wood/Shrubland		Shrubland		Total	
	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Conduit M								
Proposed Action	--	--	--	--	--	--	--	--
1c	--	--	--	--	--	--	--	--
8a	--	--	--	--	--	--	--	--
10a	--	0.10	--	0.15	--	--	--	**0.25**
13a	--	--	--	--	--	--	--	--
Totals by Alternatives								
Proposed Action	**0.69**	**0.04**	**1.09**	**0.00**	**2.30**	**0.00**	**4.08**	**0.04**
1c	**0.62**	**0.11**	**0.99**	**0.63**	**1.84**	**0.63**	**3.45**	**1.36**
8a	**0.65**	**0.08**	**0.95**	**<0.01**	**2.02**	**--**	**3.62**	**0.08**
10a	**0.65**	**0.14**	**0.95**	**0.45**	**2.02**	**--**	**3.62**	**0.59**
13a	**0.68**	**0.08**	**1.03**	**0.06**	**2.17**	**--**	**3.88**	**0.14**

Indirect permanent impacts to wetlands and riparian zones include constriction of stream flow from open-cut trenching, erosion resulting from sedimentation, hydrologic modifications as a result of earthwork in adjacent areas, off-highway vehicle use, or noxious weed invasion. Indirect impacts were assessed qualitatively.

Temporary impacts are primarily associated with construction access and staging areas, and generally do not have long-term impacts on wetland hydrology and/or function. Construction impacts would occur in temporary use areas and construction access roads and would be relatively minor and localized. Construction impacts may include cutting vegetation and covering to facilitate construction adjacent to wetlands, or temporarily placing fill into a wetland area. The topography and hydrology of temporarily affected area would be re-established after construction, which would promote wetland and riparian vegetation. Herbaceous wetlands would re-establish relatively quickly, while impacts to riparian woodland would take much longer to restore.

Stream Flow Changes

All of the action alternatives and the No Action Alternative, would involve changes in Board of Water Commissioners' (Denver Water's) management of its existing system that would result in flow changes in the Fraser River and some of its tributaries, Williams Fork River and some of its tributaries, Colorado River, Blue River South Boulder Creek, North Fork South Platte River, and the South Platte River. An introduction to the analysis of stream flow changes is provided in Section 4.6.8.

Maintenance of the hydrology to support riparian vegetation is the result of complex interactions between surface flows, groundwater, precipitation, and the physical

characteristics of a stream channel and the floodplain it occupies. It is difficult to establish simple cause and impact relationships between stream flow and riparian vegetation. The analysis looked at two primary mechanisms that may affect riparian vegetation, changes in the width of bank area regularly inundated by stream flows, and lowering of groundwater tables to a degree that would cause plant mortality. More information on this topic is provided in the introduction to Section 4.6.8.

The groundwater analysis described in Section 5.4 indicates that regional groundwater sources would not be affected by the Project. Localized impacts would be restricted to the immediate vicinity of the streams and would not be any larger than stream elevation changes. These changes would be related only to groundwater storage from high flows; groundwater levels and discharge from regional and local aquifers would remain the same except for a slight increase in discharge to the stream in gaining reaches. Therefore, most of the analysis for riparian and wetland areas focused on how the inundation area along river segments would be modified by reduced flows. Modeling of impacts was conducted using the Hydrologic Engineering Centers-River Analysis System (HEC-RAS) model and involved detailed hydraulic and vegetation data collected at the 12 sampling sites. The evaluation focused on 2-year runoff events, which generally correlate with bankfull conditions. Results for the 5- and 10-year return flows are also presented as an estimator of impacts from changes in out of bank floods.

5.8.1 Proposed Action (Alternative 1a)

5.8.1.1 Gross Reservoir

Wetlands

As shown in Table 5.8-1, the Proposed Action would result in direct and permanent impact to 1.95 acres of wetlands in the Gross Reservoir study area. All permanent impacts would be to wetlands associated with natural hydrology. The majority of the impacts would be associated with the 77,000 acre-feet (AF) reservoir enlargement, including tree removal (elevation 7,410 feet), from inundation at creek and gulch inlets (0.13 acre of impact to South Boulder Creek upstream of the reservoir, 0.49 acre to the tributary to Winiger Gulch, 0.40 acre to Winiger Gulch, 0.32 acre to the unnamed southern tributary, and 0.02 acre to Forsythe Canyon), and 0.47 acre of shoreline wetlands for a total impact to wetlands from reservoir enlargement of 1.83 acres. An equivalent area of shoreline wetlands (approximately 0.5 acre) are likely to reestablish along the new shoreline. Larger acreages of shoreline wetlands are unlikely to stay established due to extreme seasonal fluctuations in water levels.

Smaller areas of wetlands would be permanently affected by the auxiliary spillway and dam. The auxiliary spillway channel would impact 0.03 acre of wetlands along Chamberlain Gulch. The dam footprint would impact 0.08 acre of wetlands along South Boulder Creek downstream from the reservoir.

Temporary impacts to wetlands in the Gross Reservoir study area from construction disturbance consists of 0.12 acre of impact to palustrine emergent/palustrine scrub-shrub (PEM/PSS). This includes 0.08 acre to wetlands along South Boulder Creek downstream

of the reservoir from dam construction and 0.04 acre to wetlands along Chamberlain Gulch from spillway construction.

Other Waters of the U.S.

A shown in Table 5.8-2, permanent impacts to other waters of the U.S. includes 3.53 acres (8,180 feet) of perennial waters of the U.S., a major impact, and 0.01 acre (127 feet) of intermittent waters (Chamberlain Gulch), a minor impact. Less than 0.01 acre of this impact would be to South Boulder Creek from construction of the dam and 0.01 acre would occur to Chamberlain Gulch from auxiliary spillway construction. The majority of impacts to other waters of the U.S. would result from reservoir filling and include:

- 2.78 acres (2,575 feet) to South Boulder Creek upstream of the reservoir
- 0.36 acre (1,420 feet) to Forsythe Canyon
- 0.05 acre (674 feet) to Winiger Gulch tributary
- 0.22 acre (2,350 feet) to Winiger Gulch
- 0.12 acre (1,161) to the unnamed southern tributary

Temporary impacts would primarily occur at South Boulder Creek downstream of the reservoir (0.48 acre; 326 feet) with an additional 0.01 acre (127 feet) of temporary impact at Chamberlain Gulch for a total of 0.49 acre (453 feet) of temporary impacts to other waters of the U.S. The temporary impacts to South Boulder Creek downstream of the reservoir would result from construction of the dam. Impact to Chamberlain Gulch would result from disturbance associated with construction of the auxiliary spillway.

Riparian Habitat

As summarized in Table 5.8-3, the Proposed Action would result in 4.08 acres of permanent impact to riparian habitats and 0.04 acre of temporary impact. Permanent loss of riparian habitat would be a major impact. The proposed dam would permanently impact 0.04 acre of riparian woodland along South Boulder Creek and the auxiliary spillway would impact 0.03 acre of riparian woodland associated with Chamberlain Gulch. Most of the permanent impacts would result from inundation by the expanded reservoir. Of the shrubland impacted by reservoir enlargement, the majority would occur around the shoreline (0.74 acre) and along Forsythe Canyon (0.68 acre). Shrubland/woodland would primarily be permanently impacted along the reservoir shoreline (0.63 acre), with additional habitat impacted along the unnamed southern tributaries (0.38 acre) and South Boulder Creek upstream of the reservoir (0.09 acre). Permanent woodland impacts from reservoir filling would be greatest along the shoreline (0.48 acre), with additional impacts along Forsythe Canyon (0.03 acre), Winiger Gulch (0.06 acre), and South Boulder Creek upstream of the reservoir (0.04 acre).

As shown in Table 5.8-3, the Proposed Action would result in 0.04 acre of temporary impact to riparian woodland habitat. These impacts would occur along Chamberlain Gulch from spillway construction.

Similar areas of woodland and shrubland vegetation would likely naturally establish themselves along the new reservoir shoreline. The total area of riparian habitat along the

existing shoreline is 1.85 acres, including 0.74 acre of shrubland, 0.63 acre of shrubland/ woodland, and 0.48 acre of woodland.

5.8.1.2 River Segments

The analysis in this section focuses on the interaction between flow changes and inundated areas on each drainage potentially affected by the Moffat Project. Modeled changes in flood elevations and widths that would result from the Proposed Action and other alternatives, compared to Full Use of the Existing System, are shown in Tables 5.8-4, 5.8-5, and 5.8-6. The results for each river segment are discussed below. The elevation and width changes in this and the other tables in this section represent an average of the results from about 14 transects within each representative reach. The sampling sites represent a small portion of each affected river segment and results will vary by channel geometry and distance from the diversion, but are considered to be generally representative of the river segment in which they are located.

Table 5.8-4
Two-Year Flow Changes for Sampling Sites, Proposed Action Compared to Full Use of the Existing System

Sampling Site	Study Segment Length (feet)	Average Channel Width of 2-Year Flow at Full Use (feet)	Environmental Effects of Proposed Action Compared to Full Use of the Existing System, for the 2-Year Flow Event			
			2-Year Flow Elevation Change (inches)	2-Year Flow Width Change (feet)*	2-Year Flow Area of Change within Study Segment (acres)	2-Year Flow Area of Change (acres/miles)
FR1	539	28.38	-8.09	-3.22	-0.040	-0.39
FR2	872	83.88	-3.49	-5.16	-0.103	-0.62
FR3	335	51.12	-1.94	-2.47	-0.019	-0.30
FR4	571	20.10	-1.00	-0.27	-0.004	-0.03
WF1	590	66.27	0.00	0.00	0.000	0.00
WF2	590	29.97	-0.21	-0.16	-0.002	-0.02
CR1	953	139.11	-0.15	-0.08	-0.002	-0.01
BR1	1,000	100.88	-2.41	-2.10	-0.048	-0.25
SBC1	599	46.10	+1.59	+0.62	+0.008	+0.08
SBC3	446	70.26	-1.99	-4.70	-0.048	-0.57
NF1	300	53.38	+0.18	+0.14	+0.001	+0.02
NF2	778	64.43	+0.70	+0.16	+0.003	+0.02

Note:
*Change of width includes both sides of river.

Table 5.8-5
Five-Year Flow Changes for Sampling Sites, Proposed Action Compared to Full Use of the Existing System

Sampling Site	Study Segment Length (feet)	Average Channel Width of 5-Year Flow at Full Use (feet)	Environmental Effects of Proposed Action Compared to Full Use of the Existing System, for the 5-Year Flow Event			
			5-Year Flow Elevation Change (inches)	5-Year Width Change (feet)*	5-Year Area of Change within Study Segment (acres)	5-Year Area of Change per Mile (acres per mile)
FR1	539	36.68	-2.1	-2.75	-0.03	-0.33
FR2	872	105.52	-0.85	-2.40	-0.05	-0.29
FR3	335	58.49	-0.88	-1.20	-0.01	-0.11
FR4	571	20.89	-0.00	0.00	0.00	0.00
WF1	590	69.97	-0.00	0.00	0.00	0.00
WF2	590	33.80	-0.00	0.00	0.00	0.00
CR1	953	177.89	-1.56	-1.96	-0.04	-0.24
BR1	1,000	108.11	-0.00	0.00	0.00	0.00
SBC1	599	47.09	+0.21	+0.06	+0.001	+0.01
SBC3	446	73.38	-2.04	-2.01	0.02	-0.24
NF1	300	53.86	+0.00	+0.02	0.000	+0.001
NF2	778	65.08	+0.05	+0.01	0.000	+0.001

Note:
*Change of width includes both sides of river.

Table 5.8-6
Ten-Year Flow Changes for Sampling Sites, Proposed Action Compared to Full Use of the Existing System

Sampling Site	Study Segment Length (feet)	Average Channel Width of 10-Year Flow at Full Use (feet)	Environmental Effects of Proposed Action Compared to Full Use of the Existing System for the 10-Year Flow Event			
			10-Year Flow Elevation Change (inches)	10-Year Flow Width Change (feet)*	10-Year Flow Area of Change within Study Segment (acres)	10-Year Flow Area of Change (acres/mile)
FR1	539	42.13	-4.6	-4.13	-0.05	-0.50
FR2	872	139.22	-2.92	-16.66	-0.33	-2.02
FR3	335	60.60	0.00	0.00	0.00	0.00
FR4	571	22.13	0.00	0.00	0.00	0.00
WF1	590	72.48	0.00	0.00	0.00	0.00
WF2	590	34.56	0.00	0.00	0.00	0.00
CR1	953	186.54	-1.68	-1.22	-0.03	-0.15
BR1	1,000	108.89	0.00	0.00	0.00	0.00
SBC1	599	47.23	+0.27	+0.09	+0.001	+0.01
SBC3	446	74.07	-2.39	-2.36	-0.02	-0.29
NF1	300	54.06	+0.02	+0.01	0.00	0.00
NF2	778	65.44	0.00	0.00	0.00	0.00

Note:
*Change of width includes both sides of river.

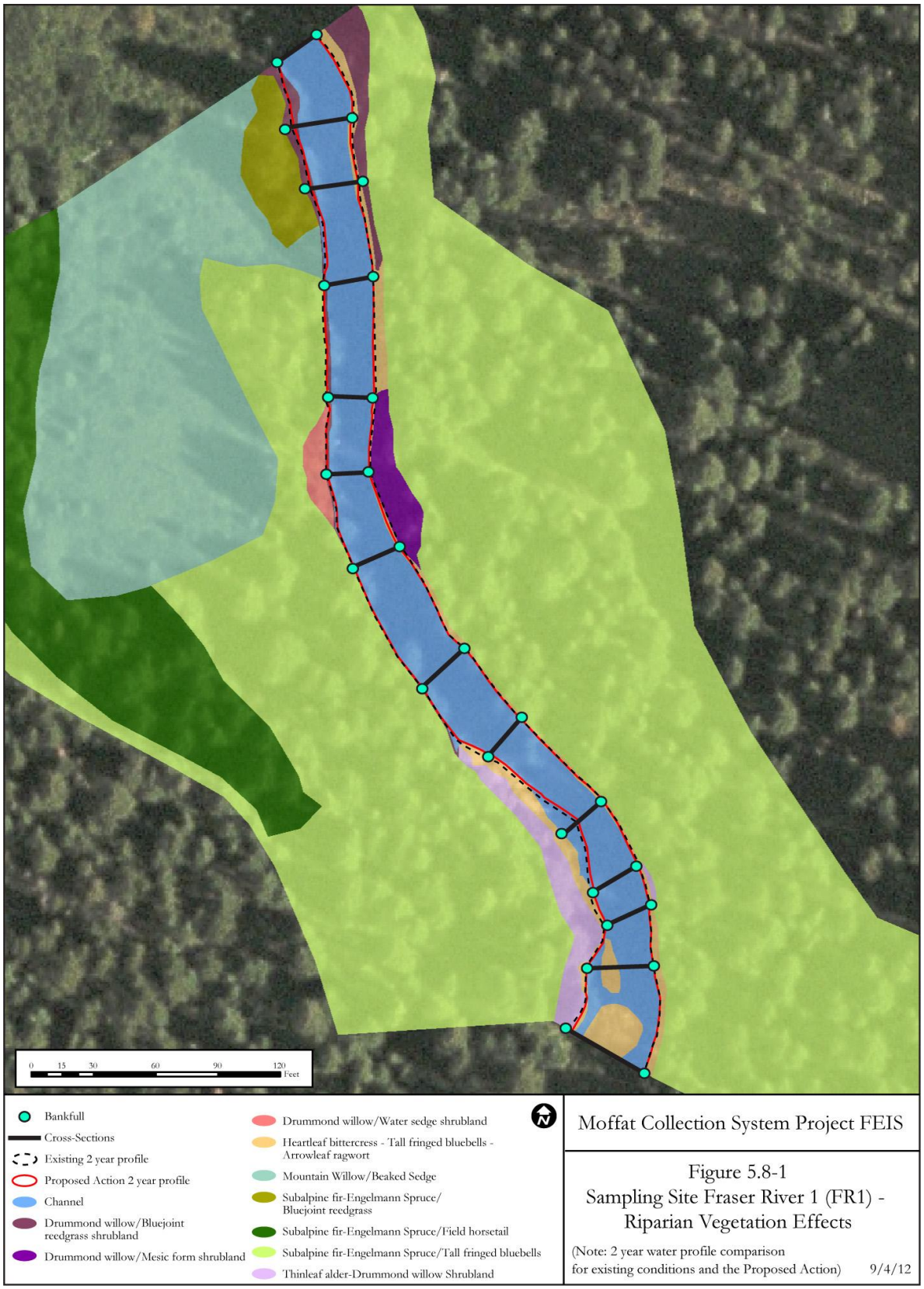
Fraser River

Sampling Site FR1. Four sampling sites were established in the Fraser drainage (FR1, FR2, FR3, and FR4), which includes streams with some of the highest levels of proposed flow modification. At these locations, the FR1 site near Winter Park would have the highest depletion level. Based on the Platte and Colorado Simulation Model (PACSM) output for the Fraser River near Winter Park gage (Table H-3.6), there would be an average flow reduction in May and June of approximately 40 percent (%) compared to Full Use of the Existing System. In terms of actual flow numbers, the average flow in June would drop from 53 cubic feet per second (cfs) to 30 cfs at the gage. The impact of additional diversions would result in a reduction in stage (stream elevation) for a 2-year flow event at FR1 (136 cfs under Full Use versus 54 cfs under the Proposed Action, Table 4.6.8-1), of approximately 8 inches (Table 5.8-4). Durations of flows of 50 cfs or less would remain very similar to Full Use of the Existing System at FR1 (Appendix H-9).

Figure 5.8-1 shows the change in inundated area along a 539-foot segment of the Fraser River at sampling site FR1. Refer to Figure 3.0-2 for the location of FR1 in the study area. The stream elevation of the 2-year flow would drop by about 8 inches, compared to Full Use of the Existing System. The width of the 2-year flow would be reduced by about 3 feet, about 11% of the channel width at Full Use. The total area within the zone between the existing and simulated stream profile in the sample site would be approximately 0.04 acre. The amount of area affected would remain very small even when extrapolated over a longer distance (e.g., a 1-mile segment would experience a reduction in inundated area of approximately 0.39 acre). The width of the area of reduced inundation, as measured at the sampling site, would be approximately 1.6 feet on each side of the channel.

Within the narrow zone of reduced inundation, vegetation would respond in a variety of ways. Shallow rooted herbaceous vegetation that requires hydric conditions is the plant group most vulnerable to changes in inundated area (Stromberg et al. 2005). The heartleaf bittercress-tall fringed bluebells-arrowleaf ragwort herbaceous community typically occurs in narrow bands along flowing streams (Carsey et al. 2003) and is an early seral community that is maintained by frequent disturbance from the 2-year flows. Over time, it is likely that herbaceous vegetation within the area affected by the change in 2-year flows would respond to somewhat drier conditions and show a transition to more tolerant species such as bluejoint. Some individual trees and shrub species may be adversely affected over time, but the overall impact on these species would be minor. The reduction in wetted area would be small, ranging from approximately several inches to just over 1.5 feet, a distance that is sufficiently narrow to allow trees and shrubs with large root masses to adapt. Further, these species are less dependent on periodic inundation and at many locations are supported by contact with groundwater, normal precipitation and hillside runoff.

Changes in the 5- and 10-year flow width and elevation are presented in Tables 5.8-5 and 5.8-6. The 5-year flow would be reduced from 249 cfs under Full Use of the Existing System to 212 cfs, and the 10-year flow would be reduced from 362 cfs to 274 cfs. Changes in the 5-year flow would result in reductions in the flow elevation of about 2 inches in height and less than 3 feet in width, which is about 7% of the channel width, compared to Full Use of the Existing System. Changes in the 10-year flow compared to Full Use would result in reductions in the flow elevation of about 3 inches in height and


0 15 30 60 90 120
Feet
Bankfull
Cross-Sections
Existing 2 year profile
Proposed Action 2 year profile
Channel
Drummond willow/Bluejoint reedgrass shrubland
Drummond willow/Mesic form shrubland
Drummond willow/Water sedge shrubland
Heartleaf bittercress - Tall fringed bluebells - Arrowleaf ragwort
Mountain Willow/Beaked Sedge
Subalpine fir-Engelmann Spruce/ Bluejoint reedgrass
Subalpine fir-Engelmann Spruce/Field horsetail
Subalpine fir-Engelmann Spruce/Tall fringed bluebells
Thinleaf alder-Drummond willow Shrubland
N
Moffat Collection System Project FEIS
Figure 5.8-1
Sampling Site Fraser River 1 (FR1) - Riparian Vegetation Effects
(Note: 2 year water profile comparison for existing conditions and the Proposed Action)
9/4/12

about 4 feet in width, which is about 10% of the channel width. The 5-year flow elevation would be about 13.5 inches higher than the 2-year flow, and the 10-year flow elevation would be about 17 inches higher. Reductions in the 5- and 10-year flows would primarily affect the Drummond's willow/bluejoint reedgrass shrubland, thinleaf alder–Drummond's willow shrubland, and Drummond's willow/mesic forb shrubland communities adjacent to the river.

While the 2-year flow represents bankfull flow, the 5- and 10-year flows involve overbank flooding. Overbank flooding occurs when flows are large enough to cover portions of the floodplain outside of the river banks. The width affected by overbank flooding under the Proposed Action would be relatively narrow, about 8.8 feet for the 5-year flow and 13.8 feet for the 10-year flow, which is similar to Full Use of the Existing System (8.9 and 13.5 feet, respectively). The average width of the riparian area, excluding the area within the banks, is about 260 feet under Current Conditions (Table 5.8-7). The area of riparian vegetation therefore extends well beyond the area of flooding associated with the 10-year flow, and the area of overbank flooding would cover less than 5% of the riparian area for the 5- and 10-year flows. The primary source of hydrology for the riparian area is high groundwater. A fen occupies about one-quarter of the sampling site on the west side of the Fraser River. Saturated soils in the fen occur at elevations of several feet above the current river bank, and would not be affected by changes in stream flow. On the east side of the river, the subalpine fir-Engelmann spruce/tall fringed bluebells community extends 30 to 100 feet or more away from the stream, well beyond the area affected by the 10-year flow.

Table 5.8-7
Width of Overbank Flooding, Proposed Action
Compared to Full Use of the Existing System

Sampling Site	Average Width of Overbank Flooding – 5-Year Flow (feet)[1]		Average Width of Overbank Flooding – 10-Year Flow (feet)[1]		Average Width of Existing Riparian Area (feet)[2]
	Full Use	Proposed Action	Full Use	Proposed Action	
FR1	8.9	8.8	13.5	13.8	260
FR2	22.0	21.4	45.9	43.8	535
FR3	7.4	8.2	9.4	11.4	165
FR4	0.8	1.1	2.0	2.3	9
WF1	3.7	3.7	6.2	6.2	270*
WF2	3.8	4.0	4.6	4.8	75*
CR1	40.2	36.9	45.1	46.3	110
BR1	3.2	9.3	3.7	10.1	65
SBC1	1.2	0.4	1.3	0.6	15
SBC3	2.5	5.8	4.4	7.1	24
NF1	1.6	0.4	1.9	0.6	100
NF2	0.8	0.5	1.1	0.9	75

Notes:
[1]Based on Hydrologic Engineering Centers-River Analysis System (HEC-RAS) modeling. Overbank flooding is area between 2-year and 5- or 10-year width. Width includes both sides of stream (approximately half on each side).
[2]Based on mapping of riparian vegetation at sampling sites. Existing riparian does not include stream or gravel bars.
*Additional areas of riparian vegetation supported by groundwater discharge are located adjacent to but outside of the mapped riparian vegetation in the sampling area.

Considering the small amount of area involved and the likely responses of vegetation to the changes in stream stage, the impact on riparian vegetation on the Fraser River are expected to be minor, implementation of the Proposed Action would therefore have minor impacts to wetland or riparian habitats at this site. The riparian area appears to be primarily supported by high groundwater, and the influence of stream flows appears to be limited to a very small portion of the sampling site. A small narrowing of the zone of inundation from high flows and localized decreases in the water table along the banks would not cause dramatic changes in riparian structure, but could result in long-term changes in composition in some areas and shifts in position of some communities.

At this sampling site, implementation of the Proposed Action would have minor effects to several other wetland and riparian functions, including maintenance of fish/aquatic habitat, flood attenuation, short- and long-term water storage, and production export/food chain support. Impacts to other functions would be negligible. The amount of shading of the stream is not likely to change. Here and at the other sample sites, changes in functions would be localized along the edge of the river and would not affect wetlands or riparian areas that are more than a short distance away from the river, or that are primarily supported by groundwater or flow from undiverted tributaries.

Sampling Site FR2. The Fraser Canyon Reach (FR2) is located approximately 1 mile downstream of Tabernash and consists of a study reach length of 872 feet. Based on PACSM output for the Fraser River below Crooked Creek (Table H-3.22), average flows would be reduced during the spring runoff season (May-July), with average flow in June diminished by 19% from 476 cfs to 388 cfs. The 2-year flow would be reduced from 824 cfs under the Proposed Action to 659 cfs under Full Use of the Existing System (Table 4.6.8-1). Durations of flows of 500 cfs or less would remain similar to Full Use of the Existing System at FR2 (Appendix H-9).

The stream elevation of the 2-year flow would drop by approximately 3.5 inches (Table 5.8-4). The width of the 2-year flow would be reduced by about 5 feet, about 6% of the channel width at Full Use. Expressed in terms of area, the reduction in inundated area at the sampling site would amount to approximately 0.1 acre, or when extended over a 1-mile distance, the area becomes 0.6 acre. The width of the area of reduced inundation, as measured at the sampling site, would be approximately 2.6 feet on each side of the channel.

The plant community that primarily occurs along the side of the channel is narrow strips of bluejoint reedgrass herbaceous community adjacent to the stream, and the edge of the Geyer willow-mountain willow-bluejoint reedgrass that occupies much of the sampling site. There are several small side channels or overflow channels dominated by beaked sedge herbaceous vegetation. The narrow strips of bluejoint reedgrass herbaceous vegetation along the edge of the channel are likely maintained by disturbance associated with the 2-year flow and are likely to continue to exist along the edge of the narrower channel. The areas currently occupied by these communities are likely to be occupied by other riparian species, especially Geyer's willow and mountain willow. Reduced inundation or localized deepening of the water table may cause the beaked sedge herbaceous vegetation to be replaced by bluejoint reedgrass or other species that can tolerate somewhat drier conditions. The riparian shrub communities that occupy most of the sampling site are generally above the zone that would be affected by the 2-year flow. Where they are within the two-year

flow there may be a shift in the herbaceous vegetation toward more mesic species. The existing shrubs are likely to adapt to somewhat drier conditions, but may gradually change in composition to include more mesic species such as shrubby cinquefoil and conifers. Similar changes could occur from reductions in the height of the water table along the stream banks.

Changes in the 5- and 10-year flow width and elevation are presented in Tables 5.8-5 and 5.8-6. The 5-year flow would be reduced from 1,211 cfs at Full Use to 1,167 cfs under the Proposed Action, and the 10-year flow would be reduced from 1,652 cfs under Full Use to 1,454 cfs under the Proposed Action. Changes in the 5-year flow compared to Full Use would result in less than one inch reduction in stream elevation and less than 2.5 feet in channel width, about 2% of the channel width under Full Use. Changes in the 10-year flow compared to Full Use would result in a reduction in stream elevation of about 3 inches in height but about 17 feet in width, about 12% of the channel width under Full Use. The 5-year flow elevation would be about 10 inches higher than the 2-year flow, and the 10-year flow elevation would be about 15 inches higher. Reductions in the 5- and 10-year flows would occur primarily in the Geyer willow-mountain willow/bluejoint reedgrass community, which extends well beyond the area that would be directly affected by these flows. Smaller areas of mountain rush herbaceous vegetation, and wolf willow-mesic forb shrubland would also be affected.

The average width of the riparian area affected by overbank flooding would be about 21 feet for the 5-year flow and 44 feet for the 10-year flow under the Proposed Action, generally similar to Full Use (22 and 46 feet, respectively). The width of current riparian vegetation is about 535 feet (Table 5.8-7). The area of current riparian and wetland vegetation therefore extends well beyond the flooding associated with the 10-year flow, and overbank flooding would cover less than 5% of the riparian zone for the 5-year flow and less than 10% for the 10-year flow. The primary source of hydrology for the riparian vegetation appears to be groundwater, which is supported by the presence of wetlands along the base of the slopes about 200-300 feet north of the river.

Changes in flow at this sampling site would result in minor changes to wetland and riparian habitat including changes in composition to more mesic species in areas adjacent to the stream. Implementation of the Proposed Action could have minor effects to several wetland and riparian functions, including support of fish and aquatic habitat and populations, flood attenuation, short- and long-term water storage, and production export and food chain support. Impacts to other functions would be negligible. The existing riparian vegetation provides minimal shading of the stream and this would not change.

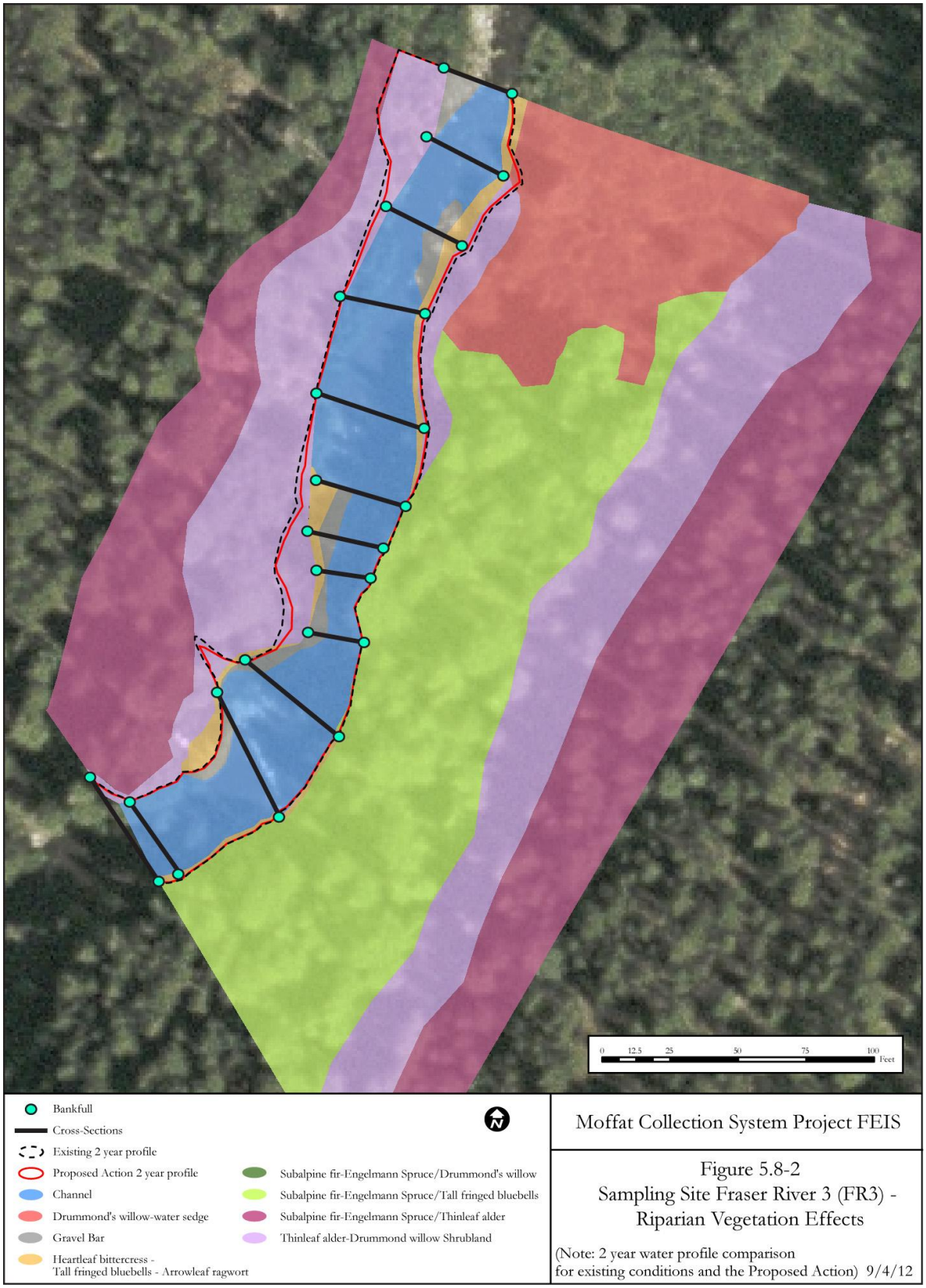
Sampling Site FR3. This site is located on St. Louis Creek above the Town of Fraser (Figure 3.0-2). This site is also situated at an elevation of approximately 9,000 feet. Based on PACSM output for St. Louis Creek below Denver Water's diversion (Table H-3.13), average monthly flow reductions at this location would be less than at the mainstem Fraser site, reaching a maximum of 26% in June. Average monthly flows in June would drop from 39 cfs under Full Use to 29 cfs under the Proposed Action. The 2-year flow would be reduced from 188 cfs under Full Use to 154 cfs under the Proposed Action at FR3 (Table 4.6.8-1). Durations of flows of 100 cfs or less would be very similar to Full Use of the Existing System at FR3 (Appendix H-9).

Figure 5.8-2 depicts the result of this flow modification by showing the difference between the area inundated by the 2-year flow under pre- and post-Project conditions. The stream elevation of the 2-year flow would drop by about 2 inches compared to Full Use (Table 5.8-4). The width of the channel would be reduced by about 2.5 feet, about 5% of the bankfull stream width at Full Use. The reduction in inundated area over the length of the 335-foot segment that was evaluated would be approximately 0.02 acre. If extrapolated over a distance of 1 mile, the Area of Potential Effects increases to approximately 0.3 acre. The width of the area of reduced inundation, as measured at the sampling site, is approximately 1.3 feet on each side of the channel.

The plant communities that mostly occur along the edge of the channel are heartleaf bittercress-tall fringed bluebells-arrowleaf ragwort herbaceous community and thinleaf alder-Drummond's willow shrubland. The herbaceous community is an early seral community that is maintained by frequent disturbance. It is likely to move or expand to stay within the area of the new 2-year flow, as the channel gradually narrows in response to reductions in the 2-year flow. The area currently occupied by this community is likely to be gradually occupied by other riparian species, including Drummond's willow and thinleaf alder. Thinleaf alder-Drummond's willow shrubland is a common community along relatively fast-moving streams with stable shaded streambanks. Reductions in the 2-year flow and narrowing of the stream may cause this community to gradually shift in position to the new stream edge. The upper edges of this community may gradually change to a subalpine fir-Engelmann spruce/thinleaf alder community as conifers become established.

Changes in the 5- and 10-year flow widths and elevations are presented in Tables 5.8-5 and 5.8-6. The 5-year flow would be reduced from 299 cfs at Full Use to 278 cfs under the Proposed Action, and the 10-year flow would remain the same at 335 cfs. Changes in the 5-year flow would result in a stream elevation reduction of about 1 inch in height and a reduction in channel width of about 1.20 feet in width, about 2% of the channel width under Full Use. There would be no changes to the 10-year flow, compared to Full Use. Reductions in the 5-year flows would occur immediately adjacent to the stream and would primarily affect the thinleaf alder-Drummond's willow shrubland community as well as a portion of an area occupied by Drummond's willow-water sedge.

The width of the riparian area affected by overbank flooding would be about 8.2 feet for the 5-year flow and 9.4 feet for the 10-year flow, the same as Full Use. The width of current riparian vegetation is about 165 feet. The area of current riparian and wetland vegetation therefore extends well beyond the flooding associated with the 10-year flow, and overbank flooding would cover only about 5% of the riparian zone for the 5-year flow and about 7% for the 10-year flow. The primary source of hydrology for the riparian vegetation appears to be groundwater. The Drummond's willow-water sedge and thinleaf alder-Drummond's willow shrubland had soils saturated to the surface in September 2010 at elevations above the stream bank.


0 12.5 25 50 75 100 Feet
Bankfull
Cross-Sections
Existing 2 year profile
Proposed Action 2 year profile
Channel
Drummond's willow-water sedge
Gravel Bar
Heartleaf bittercress - Tall fringed bluebells - Arrowleaf ragwort
Subalpine fir-Engelmann Spruce/Drummond's willow
Subalpine fir-Engelmann Spruce/Tall fringed bluebells
Subalpine fir-Engelmann Spruce/Thinleaf alder
Thinleaf alder-Drummond willow Shrubland
Moffat Collection System Project FEIS
Figure 5.8-2
Sampling Site Fraser River 3 (FR3) - Riparian Vegetation Effects
(Note: 2 year water profile comparison for existing conditions and the Proposed Action) 9/4/12

Changes in flow at this sampling site would result in minor changes to wetland and riparian habitat including changes in composition to more mesic species in relatively small areas adjacent to the stream. At this sampling site, implementation of the Proposed Action would have minor effects to several wetland and riparian functions, including support of fish and aquatic habitat and populations, flood attenuation, and short- and long-term water storage. Impacts to other functions would be negligible. The amount of shading of the stream is not likely to change.

Sampling Site FR4. One other site in the upper Fraser River Basin was evaluated (FR4), a site on Ranch Creek just below the confluence with the North Fork of Ranch Creek. This sample site has a limited amount of riparian vegetation because of its topographic setting; it is a Rosgen Type A stream with steep to vertical cuttbanks and riparian vegetation narrowly confined to the margins of the stream. Based on PACSM output for Main Ranch Creek below Denver Water's diversion (Table H-3.20), average monthly flows in June would drop from 20 cfs to 16 cfs, a 21% reduction. Reductions in flow would occur in May, June, and July and there would be little or no change during the remainder of the year below the diversion. The 2-year flow would be reduced from 77 cfs under Full Use to 68 cfs under the Proposed Action at FR4 (Table 4.6.8-1). Durations of flows of 25 cfs or less would remain very similar to Full Use of the Existing System at FR4 (Appendix H-9).

The stream elevation of the 2-year flow would drop by approximately 1 inch (Table 5.8-4), and the width of the channel would be reduced by about 0.27 feet, about 1% of stream width at Full Use. The reduction in inundated area over the length of the 571-foot segment that was evaluated would be less than one hundredth of an acre, or 0.03 acre when extrapolated over a 1-mile distance. Plant communities along the edge of Ranch Creek include heartleaf bittercress-tall fringed bluebells-arrowleaf ragwort herbaceous vegetation, subalpine fir-Engelmann spruce/tall fringed bluebells forest, and subalpine fir-Engelmann spruce/thinleaf alder forest. Because of the small change to the 2-year flow, changes to these plant communities are likely to be confined to the edge of the stream and consist of shifts in vegetation composition. These changes are expected to be negligible.

There would be no changes in the 5- and 10-year flows compared to Full Use of the Existing System (Tables 5.8-5 and 5.8-6). The 5- and 10-year flow would be 101 cfs and 126 cfs, respectively. The width of overbank flow would only be about 1 foot for the 5-year flow and 2 feet for the 10-year flow under both Full Use and the Proposed Action.

Implementation of the Proposed Action would have negligible effects to riparian/wetland functions along the Fraser River.

Fraser River Tributaries. In addition to St. Louis Creek and Ranch Creek where sampling was conducted, there are 31 other tributaries in the Fraser Valley from which water is diverted by Denver Water. Under the Proposed Action, the amount of water diverted would increase from all of these creeks (Table 5.8-8). A number of these streams have minimum bypass requirements (Table 3.1-8), while others that do not have minimum bypasses are already fully diverted at times during the year (Denver Water 2009b). The two tributaries that were evaluated at sampling sites FR3 and FR4 both have minimum bypass flows.

Table 5.8-8
Summary of Hydrological Changes for Fraser River Tributaries, Proposed Action with RFFAs Compared to Full Use of the Existing System

Stream Type and Name	Appendix Table with Flow Change Data	Average Flow Reduction in June / % Change	Dry Period (No Flow) will Occur Under Full Use (average days per year)	Increased Number of Days During Growing Season* with No Flow	Affected Length (miles)
Rosgen Type B/C Streams, with Bypass Requirements					
St. Louis Creek	H-3.13	-10.0 cfs / -26%	No	0	9.7
Vasquez Creek	H-3.8	-20.0 cfs / -37%	No	0	3.0
Main Ranch Creek	H-3.20	-4.3 cfs / -21%	No	0	10.6
Rosgen Type B/C Streams, No Bypass Requirements					
Jim Creek	H-3.3	-4.0 cfs / -46%	Yes (347)	4	0.9
Main Elk Creek	See Elk Creek and Tributaries				4.7
West St. Louis	See St. Louis Creek Tributaries				2.4
Rosgen Type A/Aa+ Streams, with Bypass Requirements					
Englewood Ranch Gravity System (Little Cabin, Cabin, Hamilton, Hurd, North and South Trail, Meadow)	H-3.18	-1.4 cfs / -2%	No	0	21.2
Rosgen Type A/Aa+ Streams, No Bypass Requirements					
St. Louis Creek Tributaries - West St. Louis, Short, Iron, Byers, East St. Louis, Fool	H-3.14	-11 cfs / -41%	Yes (339)	11	2.0 (does not include West St. Louis, shown above)
King Creek	H-3.16	-0.5 cfs / -41%	Yes (344)	11	1.4
Elk Creek and Tributaries - West Elk, East Fork Main Elk, West Fork Main Elk, Main Elk, East Elk Creeks	H-3.12	-2.5 cfs / -35%	Yes (240)	5	3.8 (does not include Main Elk, shown above)
Little Vasquez Creek	H-3.9	-3.8 cfs / -60%	Yes (348)	8	1.3
Cooper Creek	H-3.5	-0.3 cfs / -66%	Yes (297)	5	0.6

Table 5.8-8 (continued)
Summary of Hydrological Changes for Fraser River Tributaries, Proposed Action with RFFAs Compared to Full Use of the Existing System

Stream Type and Name	Appendix Table with Flow Change Data	Average Flow Reduction in June / % Change	Dry Period (No Flow) will Occur Under Full Use (average days per year)	Increased Number of Days During Growing Season* with No Flow	Affected Length (miles)
Cub and Buck Creeks	H-3.4	-1.0 cfs / -52%	Yes (178)	5	1.1
Middle and South Forks of Ranch Creek	H-3.21	-8.6 cfs / -35%	Yes (330)	11	4.7
North Fork Ranch and Dribble Creeks	H-3.19	-3.5 cfs / -23%	Yes (299)	7	1.3

Notes:
*The growing season is defined as April through September.
% = percent
cfs = cubic feet per second
RFFA = reasonably foreseeable future action

As described in Section 4.6.8, streams classified as Rosgen Type B/C have large wetland and riparian complexes on relatively wide valley floors downstream of the diversions, while streams classified as Rosgen A/Aa+ have little wetland and riparian areas except on the flatter downstream reaches of some streams. Field observations in September and October 2010 above and below 19 of the 27 Denver Water diversion sites on Rosgen A/A+ streams found that riparian vegetation was variable but generally limited in area.

The Proposed Action would include two types of changes to hydrology that could affect wetland and riparian habitats: (1) it would reduce the amount of flow during spring runoff at all diversions, and (2) it would extend the season with no surface flow at some of the diversions. Flows and diversions occur primarily during snowmelt in May, June, and July. Flows in tributaries would be reduced by 20 to 60% in June. Changes in the larger streams and those with bypass flows would be generally similar to those described for sampling sites FR3 and FR4. The pattern of seasonally high stream flow during snowmelt would continue, but the amounts would be reduced. The large valley wetlands along the Rosgen B/C streams are probably maintained by a mix of surface and groundwater, and groundwater discharge was evident at some sites that were assessed in 2010 including lower St. Louis Creek, Jim Creek, and Vasquez Creek. Reductions of flows could have localized effects on groundwater, but discharge of groundwater from adjacent uplands would remain unchanged. Impacts to riparian areas along the Rosgen A/Aa streams would be minor because of the limited occurrence of riparian habitats. Although the high flows associated with snowmelt would be reduced, there would continue to be seasonally high flows during snowmelt. Reductions of the high flows during snowmelt would reduce

hydrology during the growing season, and may result in a gradual reduction in the amount of species such as alder and Drummond's willow.

There are 21 streams in the Fraser Valley without bypass requirements where current diversions already capture most of the natural flow for large portions of the year. Increased diversions would mostly occur during the runoff season and would not increase the length of the dry period in most years. Increased diversions would only occur in the winter during two wet years during the study period, at a time when the tributaries are normally dry. The other 43 years would remain unchanged. At streams that do have bypass requirements, the reductions in June would be less, and there would be no months without flow in the streams.

Fraser Valley Fens. The primary source of hydrology for fens is regional groundwater, and the Proposed Action would have no or negligible effects to fens. Additional information on fens is provided in Section 4.6.8.

Williams Fork River

Sampling Site WF2. Two sampling sites were established on the upper portion of the Williams Fork River. At the upper site (WF2), impacts would be very similar to those described for Total Environmental Effects in Section 4.6.8. Based on PACSM output for the Williams Fork below Steelman Creek gage (Table H-3.29), flows would be diminished by 21% in June, from 88 cfs to 69 cfs. Decreased flow would occur in almost every month at the gage. The 2-year flow would decrease from 205 cfs under Full Use to 202 cfs under the Proposed Action at WF2 (Table 4.6.8-1). Durations of flows of about 40 cfs or less would remain very similar to Full Use of the Existing System at WF2 (Appendix H-9).

Compared to Full Use, the stream elevation of the 2-year flow would drop by approximately 0.2 inch (Table 5.8-4) and the channel width would be reduced by 0.16 feet, about 0.5% of the channel width for the 2-year flow at Full Use. Expressed as an area, the reduction over the 590-foot study segment would be approximately 0.002 acre, or 0.02 acre when extrapolated over a 1-mile distance, a negligible effect. The reduction in channel width for the 2-year flow would primarily occur in the narrow areas along the stream edge, in heartleaf bittercress-tall fringed bluebells-arrowleaf ragwort herbaceous vegetation and subalpine fir-Engelmann spruce/Drummond's willow forest. It would not affect the bog birch/mesic forb-mesic graminoid community, which is located above the 2-year flow.

There would be no changes in the 5- and 10-year flow elevation and channel width compared to Full Use (Tables 5.8-5 and 5.8-6). The 5- and 10-year flows would be 276 cfs and 292 cfs under Full Use and the Proposed Action, respectively.

Implementation of the Proposed Action would have no effect on the fen that extends to the edge of the Williams Fork in the southwest portion of the sampling site, because the fen is topographically higher than the river at bankfull. The small reduction in 2-year flow would not change the sources of hydrology for the fen.

Implementation of the Proposed Action would have minor effects to several wetland and riparian functions, including support of fish/aquatic habitat, flood attenuation and short- and long-term water storage. Impacts to other functions would be negligible.

Sampling Site WF1. At the Williams Fork River near Sugarloaf Campground site, the flow reduction would be approximately 10% in May and June. The stream elevation of the 2-year flow would not change from Full Use (Table 5.8-4), and there would be no effects to riparian or wetland areas. There would also be no changes in the 5- and 10-year flows compared to Full Use (Tables 5.8-5 and 5.8-6). Implementation of the Proposed Action would therefore have no effects to wetland and riparian functions.

Williams Fork Tributaries. The Proposed Action would include increased diversions from four tributaries of the Williams Fork (Table 5.8-9). As with the Fraser River tributaries, diversions from tributaries of the Williams Fork include two types of changes to hydrology that could affect wetland and riparian habitats – they would reduce the amount of flow during spring runoff at all diversions and would extend the season with no surface flow at some of the diversions. Flows and diversions occur primarily during snowmelt in June and July. Flows in tributaries would be reduced 20-30% in June, the month of highest runoff. The pattern of seasonally high stream flow during snowmelt would continue, but the amounts would be reduced. The Proposed Action would also extend the period without flow, primarily in the fall. Steelman and Bobtail are Rosgen Type A streams, and Jones and McQueary are Rosgen Type Aa+ streams. National Wetland Inventory (NWI) maps show that the Steelman Creek Diversion is located within a valley wetland/riparian complex (PSS/PEM) while the others do not have mapped wetlands or riparian areas below the diversion, except a very small area on Bobtail Creek. Wetland/riparian areas are present upstream in flat valley bottoms on Steelman, Bobtail, and McQueary creeks.

Table 5.8-9
Summary of Hydrological Changes for Williams Fork Tributaries, Proposed Action with RFFAs Compared to Full Use of the Existing System

Stream Name	Appendix Table with Flow Change Data	Flow Reduction in June / % Change	Dry Period (No Flow) will Occur Under Full Use (average days per year)	Increased Number of Days During Growing Season* with No Flow	Affected Length (miles)
Steelman Creek	H-3.25	-4.1 cfs / -21%	Yes (328)	8	1.9
Bobtail Creek	H-3.26	-8.3 cfs / -24%	Yes (330)	10	1.6
Jones Creek	H-3.27	-2.0 cfs / -18%	Yes (327)	8	0.2
McQueary Creek	H-3.28	-3.5 cfs / -28%	Yes (331)	10	0.4

Notes:
*The growing season is defined as April through September.
% = percent
cfs = cubic feet per second
RFFA = reasonably foreseeable future action

The increased diversions on the Williams Fork tributaries would cause flow reductions in June similar to those at sampling sites FR3, FR4, and WF2. Similar to those sites, impacts to riparian areas from reductions in high flows are expected to be negligible to minor.

Colorado River

One sampling site (CR1) was established to represent conditions on the Colorado River segment which is located between the towns of Parshall and Hot Sulphur Springs. Based

on PACSM output for the Colorado River below Windy Gap Diversion (Table H-3.31), reductions in flow would mostly occur from May through July and would be about 13% in June, from 637 cfs under Full Use to 555 cfs under the Proposed Action. The 2-year flow at CR1 would be reduced from 618 cfs under Full Use to 610 cfs under the Proposed Action at CR1 (Table 4.6.8-1). Durations of flows of 1,000 cfs or less would remain similar to Full Use of the Existing System at CR1 (Appendix H-9).

The change in stream elevation associated with a 2-year event at this segment would be very small (0.15 inch drop in stream elevation), and the change in river width would be about 1 inch, less than 0.1% of the channel width at Full Use (139 feet). The reduction in inundated area would be 0.002 acre within the 953-foot study segment and 0.01 acre when extrapolated over a 1-mile distance. These impacts along the Colorado River would be negligible. The change in wetted channel width would primarily affect reed canarygrass herbaceous vegetation, which occurs at and below the bankfull elevation. This is an aggressive non-native species which can grow under both hydric and mesic conditions and is not likely to be adversely affected by small changes in stream flow. The beaked sedge herbaceous vegetation occurs lower on the banks and would not be affected by changes in the 2-year flow.

Changes in the 5- and 10-year flow width and elevation are presented in Tables 5.8-5 and 5.8-6. The 5-year flow would be reduced from 2,362 cfs at Full Use of the Existing System to 2,235 cfs under the Proposed Action, and the 10-year flow would be reduced from 3,496 cfs to 3,294 cfs under Full Use and the Proposed Action, respectively. Changes in the 5-year flow would result in a reduction of about 1.5 inches in flow elevation and about 2 feet in channel width, about 1% of channel width at Full Use. Changes in the 10-year flow would result in a reduction of about 1.7 inches in flow elevation and about 1.25 feet in channel width, less than 1% of the channel width at Full Use. The small amount of reductions due to changes in the 5- and 10-year flows would primarily affect thinleaf alder-mixed willow shrubland. The average width of overbank flooding would be about 37 feet for the 5-year flow and 46 feet for the 10-year flow under the Proposed Action, which is similar to the area of overbank flooding under Full Use (40 and 45 feet, respectively). Overbank flooding would affect about 37% of the riparian area for the 5-year flow and 46% for the 10-year flow. Changes to riparian vegetation resulting from changes to the 5- and 10-year flows would be negligible.

At this sampling site, implementation of the Proposed Action would have negligible effects to wetland and riparian functions. The amount of shading of the stream is not likely to change.

Blue River

The 1,000-foot long representative sampling site (BR1) is located along the Blue River midway between Dillon Reservoir and Green Mountain Reservoir. Based on PACSM output for Dillon Reservoir outflow (Table H-3.36), stream flows would be reduced 8% in June, from 561 cfs under Full Use to 516 cfs under the Proposed Action. The 2-year flow would be reduced from 1,511 cfs under Full Use to 1,358 cfs under the Proposed Action (Table 4.6.8-1). Durations of flows of about 1,000 cfs or less would remain similar to Full Use of the Existing System at BR1 (Appendix H-9).

The reduction in stream elevation associated with changes in the 2-year flow event at this location would be about 2.4 inches (Table 5.8-4). The width of the stream would be reduced by 2.1 feet, about 2% of the channel width at Full Use. Over a distance of 1,000 feet, this translates to a reduction in inundated area of approximately 0.04 acre, or 0.25 acre when projected over a 1-mile distance. The width of the area of reduced inundation would be approximately 1 foot on each side of the channel. The plant community that is located within the zone of reduced inundation is thinleaf alder-mixed willow shrubland, which occurs as a narrow strip on each side of the river, restricted by topography. On the right (north) side of the river the shrubs are bounded by a steep slope that rises about 25 feet to the valley bottom. On the left bank the strip of dense shrub is bordered by a steep slope and a terrace with groundwater wetlands. There is likely to be little observable impact to the alders and willows because of the small amount of change relative to the size of the plants. The narrow strip of land that results from narrowing of the channel may be gradually occupied by alder, willow or herbaceous wetland vegetation. The width of the streamside shrub community is likely to remain the same or may increase slightly as the channel narrows because hydrology for the streamside shrubs appears to be provided both from the river and from groundwater wetlands on a terrace above the channel on the south side. The impact on riparian vegetation would be minor.

There would be no changes in the 5- and 10-year flow width and elevation when compared to Full Use (Tables 5.8-5 and 5.8-6). The 5- and 10-year flows would be slightly higher under the Proposed Action. The 5-year flow would be increased from 2,272 cfs at Full use of the Existing System to 2,282 cfs under the Proposed Action, and the 10-year flow would be increased from 2,380 cfs to 2,402 cfs under Full Use and the Proposed Action, respectively. The wetlands that occur on the terrace south of the stream are above the elevations affected by 5- and 10-year flows. They are supported by groundwater and would not be affected by changes in stream flow. These include the blue spruce–thinleaf alder woodland and beaked sedge communities that comprise most of the wetland and riparian vegetation at this sampling site.

At this sampling site, implementation of the Proposed Action would have negligible effects to wetland and riparian functions. The amount of shading of the stream is not likely to change.

South Boulder Creek

Sampling Site SBC1. South Boulder Creek above Gross Reservoir would be affected by flow increases as well as flow decreases. In the segment above Gross Reservoir (sampling site SBC1), flows would increase by 17% in June, from 620 cfs under Full Use to 726 cfs under the Proposed Action, with smaller increases in several other months, based on PACSM output for South Boulder Creek at Pinecliffe gage (Table H-3.38). These flows are within the normal range of variability at that location. For example, the average monthly flow in June is forecasted to be 726 cfs with implementation of the Project, but flows in excess of 1,100 cfs already occur during wet years at the gage. The 2-year flow at SBC1 would increase from 882 cfs under Full Use to 944 cfs under the Proposed Action (Table 4.6.8-1). There would be changes in durations of flows above about 150 cfs at SBC1, compare to Full Use of the Existing System (Appendix H-9).

In terms of stage, the elevation of a 2-year event under the Proposed Action would increase by approximately 1.6 inches (Table 5.8-4). The width of the channel would be increased by about 0.6 feet, about 1% of the channel width at Full Use. The area affected over the 559-foot reach would be 0.008 acre, or 0.08 acre when extrapolated over a 1-mile distance. Within the narrow zone influenced by this increase in stage, there may be a gradual increase in species better adapted to wetter conditions, such as beaked sedge, but the overall impact on riparian vegetation would be negligible. It is also possible that there would be a small increase in the area occupied by riparian vegetation or in the density of riparian vegetation due to the increase in inundated area associated with a 2-year event. The increased 2-year flow would primarily affect the Drummond's willow/mesic forb shrubland.

Changes in the 5- and 10-year flow width and elevation are presented in Tables 5.8-5 and 5.8-6. The 5-year flow at site SBC1 would be increased from 985 cfs under Full Use to 993 cfs under the Proposed Action, and the 10-year flow would be slightly increased from 1,003 cfs under Full Use to 1,015 cfs and the Proposed Action. Increases in the 5-year flow would result in an increase of about 0.2 inch in flow elevation and about 0.06 feet in width, about 0.1% of the channel width under Full Use. Changes in the 10-year flow would result in an increase of about 0.5 inch in flow elevation and about 0.09 feet in channel width, about 0.1% of channel width under Full Use. The area of overbank flooding from the 5- and 10-year flow would be very small (<1 foot) under Current Conditions and would be similar under Full Use and the Proposed Action. The increased amount of overbank flow would primarily occur in the Drummond's willow/mesic forb shrubland. These increases would have a negligible effect on riparian vegetation.

Implementation of the Proposed Action would have negligible effects to wetland and riparian functions.

Sampling Site SBC3. In the segment below Gross Reservoir and above the South Boulder Diversion Canal, flows would decrease primarily during the months of May, June, and July and would greatly increase from November to February, based on PACSM output for Gross Reservoir outflow (Table H-3.39). The reduction in outflow in June would be 13%, from 459 cfs under Full Use to 398 cfs under the Proposed Action. The 2-year flow at SBC3 would be reduced from 645 cfs under Full Use to 574 cfs under the Proposed Action (Table 4.6.8-1). There would be changes in durations of most flows at SBC3 compared to Full Use of the Existing System (Appendix H-9).

The flow elevation would decrease by about 2 inches as a result of the change in the 2-year flow event flow elevation (Table 5.8-4). The width of the channel would be reduced by about 4.7 feet, about 7% of the channel width at Full Use. The area affected over the 446-foot reach would be 0.05 acre, or 0.57 acre when extrapolated over a 1-mile distance.

The width of the area of reduced inundation would be approximately 2.35 feet on each side of the channel. The streambanks in this sampling area are dominated by river birch/mesic forb, which are not likely to be affected by a small change in stage. The herbaceous understory generally consists of species, such as bluejoint reedgrass, that are capable of adapting to somewhat drier conditions. This community is likely to gradually colonize the gravel bars on the edge of the reduced channel. Most of the redtop herbaceous vegetation would not be affected. The beaked sedge and bluejoint reedgrass herbaceous vegetation

communities along the banks would likely move to maintain their position along the narrower streambank. The impact on riparian vegetation would be minor.

Changes in the 5- and 10-year flow width and elevation are presented in Tables 5.8-5 and 5.8-6. The 5-year flow would be reduced from 766 cfs under Full Use to 687 cfs under the Proposed Action, and the 10-year flow would be reduced from about 834 cfs under Full Use to 737 cfs under the Proposed Action. Reductions in the 5-year flow would result in a decrease of about 2 inches in flow elevation and a decrease of about 2 feet in channel width, about 3% of the channel width under Full Use. Reductions in the 10-year flow would result in a decrease of about 2.4 inches in flow elevation and a decrease of about 2.4 feet in channel width, also about 3% of the channel width at Full Use. The 5-year flow would be about 3 inches higher than the 2-year flow, and the 10-year would be about 4 inches higher than the 2-year flow. The width of overbank flooding under the Proposed Action would be fairly small, a total of about 6 feet in width for the 5-year flow and 7 feet for the 10-year flow. Reductions in the 5- and 10-year flows would likely affect vegetation mapped as blue spruce/field horsetail woodland, river birch/mesic graminoid, and redtop herbaceous vegetation. These three communities extend above the area affected by 10-year flows and are probably supported by groundwater discharge.

At this sampling site, implementation of the Proposed Action would have negligible effects to wetland and riparian functions. The amount of shading of the stream is not likely to change.

North Fork South Platte River

Sampling Site NF1. Two sampling sites were established along the North Fork South Platte River (NF1 and NF2), both of which would experience a decrease in flows during the winter months and an increase in flows during the summer months.

Average monthly flows at the North Fork South Platte River above Geneva Creek gage would increase by approximately 10 to 20% during the period May through August based on PACSM output for the North Fork South Platte River below Geneva Creek gage (Table H-3.41). The average monthly flow in June would increase from 356 cfs under Full Use to 404 cfs under the Proposed Action. The 2-year flow at NF1 would increase from 628 cfs under Full Use to 636 cfs under the Proposed Action (Table 4.6.8-1). There would be changes in durations of most flows, compared to Full Use of the Existing System (Appendix H-9). The increased summer flows would fall within the normal range of variability from year to year that already occurs. The average monthly flow decrease at this location during the period November-March would range from 25 to 30% (Table H-3.41). In the absence of an impact on groundwater levels, which is not expected due to an overall increase in flows, decreased flows in winter should not have any impact on riparian vegetation during its dormant period.

The increase in flow elevation from changes in the 2-year event would be less than an inch (Table 5.8-4). The width of the channel would be increased by about 0.14 feet (about 2 inches), about 0.2 to 0.3% of the channel width at Full Use. The area affected over the study reach would be 0.001 acre, and only 0.02 acre when extrapolated over a 1-mile distance. Impacts would occur in the blue spruce/river birch community at NF1. These impacts on riparian vegetation would be negligible.

Changes in the 5- and 10-year flow width and elevation are presented in Tables 5.8-5 and 5.8-6. The 5-year flow would be slightly increased from 654 cfs under Full Use to 656 cfs under the Proposed Action, and the 10-year flow would be increased from 667 cfs under Full Use to 668 cfs under the Proposed Action. These small increases would result in increases of only 0.01 to 0.02 feet in the channel width for the 5- and 10-year flows. These changes would have no effects on riparian vegetation.

Flow changes along the North Fork South Platte River at NF1 would have negligible effects on wetland and riparian functions under the Proposed Action.

Sampling Site NF2. Like NF1, NF2 (North Fork South Platte River near Pine), would experience a decrease in flows during the winter months and an increase in flows during the summer months (Table H-3.41). The 2-year flow at NF2 would increase from 652 cfs under Full Use to 683 cfs under the Proposed Action (Table 4.6.8-1). There would be changes in the durations of most flows (Appendix H-9).

The increased flow elevation as a result of changes in the 2-year event would be 0.7 inch at sampling site NF2 (Table 5.8-4). The channel width associated with the 2-year flow would be increased by about 0.16 feet, about 2 inches. The area affected would be less than 0.001 acre within the sampling site, and about 0.02 acre extrapolated over a 1-mile distance. The changes would have negligible impacts to the strapleaf and sandbar willow communities at NF2.

Changes in the 5- and 10-year flow width and elevation are presented in Tables 5.8-5 and 5.8-6. The 5-year flow would be increased from 763 cfs under Full Use to 772 cfs under the Proposed Action at NF2, and there would be no change in the 10-year flow. Increases in the 5-year flow would results in an increase of only 0.05 inch in flow elevation and an increase of about 0.01 inch in channel width. These changes would have no effects on riparian vegetation.

Flow changes along the North Fork South Platte River at NF2 would have negligible effects on wetland and riparian functions.

South Platte River

No sampling sites were located along 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. Changes in flow during the growing season would be minimal in the upper South Platte River (Antero Reservoir to Cheesman Reservoir outflow, Tables H-3.42, H-3.43, and H-3.44) and at the Denver and Henderson gages (Tables H-3.47 and H-3.48). Changes at the Waterton gage would be minor – average monthly reductions of 2 to 5% in an average year. In dry years, there would be an increase in flow at the beginning of the growing season (April through May) and almost no changes from June to September. These flow changes are likely to have a minimal impact on stream elevation and inundated area during a 2-year event, and impacts on wetland and riparian habitats or functions would be negligible.

Summary of Impacts of Sampling Sites under the Proposed Action

The area covered by 2-year flows would decrease in the Fraser River and its tributaries, Colorado River, Blue River, and South Boulder Creek below Gross Reservoir; and would

increase in South Boulder Creek above Gross Reservoir and North Fork South Platte River, compared to Full Use of the Existing System. Changes would be largest along the Fraser River near Winter Park, where the 2-year flow would be reduced by about 8 inches in depth and 3.25 feet in width. Changes are considered minor at the two mainstem Fraser River sampling sites (FR1 and FR2), St. Louis Creek (FR3), Blue River (BR1) and South Boulder Creek below Gross Reservoir (SBC3), and negligible at the other sites except WF1 which would have no changes in the 2-year flow.

Decreases in the 2-year flow could result in a gradual narrowing of the stream banks, which would decrease flows that would support wetlands within the banks. However, sediment deposition may be temporary and may be removed by longer-term floods. Impacts would be confined to a wetland fringe where it currently exists along the edge of the channel. In the long run, the wetland may relocate to the new edge of channel. Herbaceous wetland vegetation affected by less frequent or prolonged flooding would likely change in composition and become more mesic. The affected area would be relatively narrow and is not likely to lead to the death of shrubs or trees. Where narrowing would occur, vegetation would respond by gradually adjusting its location, moving downgradient to remain in the same hydrological zone. Changes are likely to be very slow in most areas because the reductions in the 2-year flow would be relatively small compared to the rooting zone of most of the affected vegetation (willow and alder shrubs). Thus an individual shrub might have reduced water in a portion of its rooting zone but may not show a visible response because most of its rooting zone is not affected. Herbaceous vegetation is likely to respond faster. The zone affected by reduced flows is likely to show a change in composition to riparian species with somewhat lower water requirements, or upland species such as conifers. Vegetation would respond similarly to increases in flow at SBC1, NF1, and NF2, with small gradual upward shifts in wetland vegetation.

The area of overbank flooding resulting from the 5- and 10-year flows would decrease in the Fraser River, Colorado River, Blue River, and South Boulder Creek below Gross Reservoir and would have little change at the other sites. For affected sites, changes in the 5- and 10-year flows would generally reduce the flow elevation by 1 to 7 inches in height, and the inundated channel width by 2 to 6 feet, and by 0.1- to 0.8 acre/mile. Reduction in overbank flow would reduce flows that supports bank and overbank vegetation, and groundwater recharge. These changes could reduce riparian vegetation density or productivity and cause change in composition including increases in upland species. Changes in 5- and 10-year flows would result in minor effects to riparian habitat on the Fraser River (FR1 and FR2), and South Boulder Creek below Gross Reservoir (SBC3), and negligible or no effects at other sites.

Changes in the channel width associated with changes in the 5- and 10-year flows would be relatively small at all locations and would affect relatively narrow areas along the banks. Although shown as an average width in the tables, the actual channel width would be variable based on the local microtopography and flooding patterns. The total channel width associated with the 5- and 10-year flows shown in Tables 5.8-5 and 5.8-6 are not substantially larger the channel width for the 2-year flows at all locations. In the larger valleys such as the lower Fraser River, Colorado River, Blue River, and North Fork South Platte River, the width of the valley floor is typically much larger than the channel width associated with the 5- and 10-year flows as a result in part from historic movements of the

channel during floods. Historic reductions in peak flows reduce channel movement and may affect recruitment of cottonwoods, which germinate after floods on wet bare mineral soil.

In addition to stream flow, wetlands and riparian areas along the stream segments are supported by groundwater. Reductions in stream flows have very limited effects on groundwater, and would be restricted to localized areas immediately below the diversion and adjacent to the creeks. Discharge of groundwater that originates as snowmelt or hillslope runoff would continue. All of the streams flow through mountainous terrain and are expected to be gaining streams along much of their length. Several of the sampling sites have evidence of groundwater discharge and groundwater-supported wetlands, including FR1, FR2, FR3, WF1, WF2, and BR1. Information on the relative contributions of groundwater and surface water is not available. However, the width of riparian vegetation is often much wider than the area affected by 5- and 10-year flows, suggesting a large contribution from groundwater. In addition, wetlands are often located near the edge of the valley or on terraces above the rivers.

5.8.2 Alternative 1c

5.8.2.1 Gross Reservoir

Wetlands

As shown in Table 5.8-1, Alternative 1c would result in direct and permanent impact to 1.60 acres of wetlands in the Gross Reservoir study area. Impacts to wetlands would be similar to the Proposed Action, but slightly less as Alternative 1c would consist of a smaller Gross Reservoir (40,700 AF).

The majority of the impacts under Alternative 1c would be associated with the reservoir enlargement from inundation at creek and gulch inlets (0.13 acre of impact to South Boulder Creek upstream of the reservoir, 0.29 acre to the tributary to Winiger Gulch, 0.34 acre to Winiger Gulch, 0.22 acre to the unnamed southern tributary, and 0.02 acre to Forsythe Canyon), and the remaining 0.47 acre from inundation of shoreline wetlands. Additional impacts would occur from the dam enlargement and auxiliary spillway, the same as with the Proposed Action (0.11 acre).

Temporary impacts to wetlands in the Gross Reservoir study area would be the same as the Proposed Action (0.12 acre).

Other Waters of the U.S.

A shown in Table 5.8-2, impacts to other waters of the U.S. includes 2.81 acres (5,118 feet) of perennial waters of the U.S., and 0.01 acre (172 feet) of intermittent waters of the U.S. (Chamberlain Gulch). Less than 0.01 acre of this impact would be to South Boulder Creek from construction of the dam and 0.01 acre would occur to Chamberlain Gulch from auxiliary spillway construction. The majority of impacts to other waters of the U.S. would result from reservoir filling and include:

- 2.36 acres (2,178 feet) to South Boulder Creek upstream of the reservoir

- 0.20 acre (646 feet) to Forsythe Canyon
- 0.02 acre (125 feet) to Winiger Gulch tributary
- 0.16 acre (1,477 feet) to Winiger Gulch
- 0.07 acre (692 feet) to the unnamed southern tributary

Temporary impacts to other waters of the U.S. in the Gross Reservoir study area would be the same as the Proposed Action (0.49 acre).

Riparian Habitat

As summarized in Table 5.8-3, Alternative 1c would result in 3.24 acres of permanent impact to riparian habitats at Gross Reservoir. The proposed dam and spillway impacts would be the same as the Proposed Action. Most of the permanent impacts would result from inundation by the expanded reservoir. Of the shrubland impacted by reservoir enlargement, the majority lost would occur around the shoreline (0.76 acre) and along Forsythe Canyon (0.43 acre). Shrubland/woodland would primarily be permanently impacted along the reservoir shoreline (0.55 acre), with additional habitat impacted along the unnamed southern tributaries (0.24 acre) and South Boulder Creek downstream of the reservoir (0.09 acre). Permanent woodland impacts from reservoir filling would be greatest along the shoreline (0.52 acre), Winiger Gulch (0.02 acre), and South Boulder Creek upstream of the reservoir (0.04 acre).

Temporary impacts to riparian habitats in the Gross Reservoir study area would be the same as the Proposed Action.

5.8.2.2 Leyden Gulch Reservoir Site

Wetlands

As shown in Table 5.8-1, Alternative 1c would result in direct and permanent impact to 4.55 acres of wetlands in the Leyden Gulch Reservoir site study area, a major impact. The majority of permanent wetland impacts would be associated with construction of the dam and inundation of wetlands from the 31,300-AF reservoir.

Reservoir filling would result in wetland impacts of 0.98 acre along Leyden Gulch, 0.94 acre of wetlands associated with hillside seeps, and wetlands associated with tributaries of Leyden Gulch of less than 0.01 acre. The dam would impact 0.89 acre of wetlands along Leyden Gulch, 0.86 acre of wetlands associated with the hillside seep, and 0.07 acre of wetlands along tributaries of Leyden Gulch near the hillside seep. The potential realignment of State Highway 93 would impact 0.18 acre of wetlands along Leyden Gulch. Wetlands are likely to establish along the shoreline of the new reservoir where the topography slopes gently and along Leyden Gulch.

Temporary impacts to wetlands in the Leyden Gulch study area would consist of 13.18 acres. Temporary disturbance from reservoir construction would impact 1.06 acres of wetlands, including 0.62 acre of wetlands along Leyden Gulch. Construction disturbance would impact 10.61 acres to a tributary to Leyden Gulch below the dam footprint for an access road, emergency outlet, and the pipeline tunnel. The impact acreage

for this wetland is estimated based on aerial photos as access to the site was not allowed at the time of field visits. Disturbance from construction of the reservoir outlet pipeline would impact 1.05 acres of wetlands, including 0.65 acre of wetlands associated with Ralston Creek. The cut and cover portion of the pipeline would temporarily impact 0.41 acre of wetlands associated with Ralston Creek.

Other Waters of the U.S.

A shown in Table 5.8-2, impacts to other waters of the U.S. includes 0.31 acre of intermittent waters. Leyden Gulch would incur the majority of impact. The proposed reservoir would impact 0.17 acre (1,275 feet) of Leyden Gulch and 0.04 acre of a stock pond for a total impact from reservoir filling of 0.21 acre. Construction of the dam would impact 0.01 acre of the South Boulder Diversion Canal and 0.05 acre of the canal from the discharge structure. These impacts would be minor.

Temporary impacts to other waters of the U.S. in the Leyden Gulch Reservoir site study area would total 1.55 acres (2,945 feet). Temporary disturbance from reservoir construction would impact 1.03 acres (1,754 feet), including 0.77 acre (1,569 feet) to the South Boulder Diversion Canal. Ralston Creek, a perennial water source in the study area, would not be permanently impacted but would incur 0.42 acre (720 feet) of temporary impact from pipeline construction.

Riparian Habitat

As summarized in Table 5.8-3, Alternative 1c at Leyden Gulch Reservoir site would result in 0.21 acre of permanent impact and 1.32 acres of temporary impact to riparian habitats. The majority of permanent impacts would be to woodland/shrubland habitat around a stock pond from the dam footprint. The South Boulder Diversion Canal discharge would permanently impact 0.05 acre of shrubland, and the Dam Crest Access Road 0.04 acre of shrubland. These impacts to riparian habitat would be minor.

Temporary impacts to riparian habitat would total 1.32 acres. Impacts from disturbance associated with reservoir construction would total 0.62 acre to shrubland. Disturbance from construction of the reservoir outlet pipeline would impact 0.70 acre of riparian habitat along Ralston Creek, including 0.38 acre of woodland/shrub and 0.32 acre of woodland. Denver Water may choose to maintain a cleared right-of-way (ROW) through wooded habitat, which would result in a permanent loss of 0.70 acre of riparian habitat at Ralston Creek.

5.8.2.3 River Segments

Flow changes and effects to riparian habits associated with this alternative would be nearly the same as those described for the Proposed Action (Table 5.8-10). All 2-year flow changes would be the same except at sampling sites FR3, BR1, and SBC3. Impacts would be slightly less at FR3 and SBC3 than for the Proposed Action, and slightly larger at BR1. The largest difference would be at SBC3, where the changes in the area wetted by the 2-year flow would be reduced from 0.57 acre/mile for the Proposed Action to 0.48 acre/mile under Alternative 1c. Impacts to wetland and riparian habitats would be minor along the Fraser River, St. Louis Creek, and Blue River and negligible along the other river segments.

Five- and 10-year flow changes would also mostly be the same as the Proposed Action. The impacts associated with changes in both the 5- and 10-year flows would be greatly reduced at SBC3 under this alternative, and other differences would be small (Table 5.8-10). Impacts would be minor along the Fraser River (FR1 and FR2), St. Louis Creek (FR3), and South Boulder Creek below Gross Reservoir, and negligible or none at the other sites.

Table 5.8-10
Two-, Five-, and 10-Year Flow Changes for Sampling Sites, Alternative 1c Compared to Full Use of the Existing System

Sampling Site	Average Channel Width Flow at Full Use (feet)	Impacts of Alternative 1c Compared to Full Use of the Existing System			Proposed Action Area of Flow Change (acres/mile)
		Flow Elevation Change (inches)	Flow Width Change (feet)	Area of Flow Change (acres/mile)	
2-Year Flows					
FR3	51.12	-1.91	-2.40	-0.29	-0.30
BR1	100.88	-2.54	-2.20	-0.27	-0.25
SBC3	70.26	-1.12	-3.97	-0.48	-0.57
5-Year Flows					
FR1	36.68	-1.85	-2.39	-0.29	-0.33
FR2	102.52	-0.78	-2.23	-0.27	-0.29
CR1	177.89	-1.34	-1.67	-0.20	-0.24
SBC3	73.38	-0.42	-0.42	0.05	-0.24
10-Year Flows					
FR1	42.13	-3.92	-3.58	-0.43	-0.50
SBC3	74.97	-0.29	-0.25	-0.03	-0.29

Note:
Only changes different than the Proposed Action are shown.

For the Fraser River and Williams Fork tributaries, the percent change in flows from Full Use of the Existing System would be the same or slightly less than the Proposed Action. The effects on wetlands and riparian resources associated with the tributaries would be similar and would be minor.

5.8.3 Alternative 8a

5.8.3.1 Gross Reservoir

Wetlands

Impacts to wetlands under Alternative 8a are summarized in Table 5.8-1. Alternative 8a would result in direct and permanent impact to 1.75 acres of wetlands in the Gross Reservoir study area. Impacts to wetlands would be similar as described for the Proposed Action, but less as Alternative 8a would consist of a smaller Gross Reservoir (52,000 AF). The majority of wetland impacts (1.64 acres) would be associated with the reservoir enlargement from inundation at creek and gulch inlets (0.13 acre of impact to South

Boulder Creek upstream of the reservoir, 0.37 acre to the tributary to Winiger Gulch, 0.37 acre to Winiger Gulch, 0.27 acre to the unnamed southern tributary, and 0.02 acre to Forsythe Canyon), and the remaining 0.47 acre to inundation of shoreline wetlands. Permanent impacts associated with the auxiliary spillway channel and dam footprint would be the same as the Proposed Action (0.11 acre).

Temporary impacts to wetlands in the Gross Reservoir study area would be the same as the Proposed Action (0.12 acre).

Other Waters of the U.S.

A shown in Table 5.8-2, impacts to other waters of the U.S. includes 3.15 acres (6,194 feet) of perennial waters of the U.S., and 0.01 acre (172 feet) of intermittent waters (Chamberlain Gulch). Less than 0.01 acre of this impact would be to South Boulder Creek from construction of the dam and 0.01 acre of impact to Chamberlain Gulch from spillway construction. The majority of impacts to other waters of the U.S. would result from reservoir filling and include:

- 2.59 acres (2,224 feet) to South Boulder Creek
- 0.26 acre (940 feet) to Forsythe Canyon
- 0.03 acre (283 feet) to Winiger Gulch tributary
- 0.18 acre (1,892 feet) to Winiger Gulch
- 0.09 acre (855 feet) to the unnamed southern tributary

Temporary impacts to wetlands in the Gross Reservoir study area would be the same as the Proposed Action.

Riparian Habitat

As summarized in Table 5.8-3, Alternative 8a would result in 3.62 acres of permanent impact to riparian habitats in the Gross Reservoir study area. The proposed dam and spillway impacts would be the same as the Proposed Action. Most of the permanent impacts would result from inundation by the expanded reservoir. Of the shrubland impacted by reservoir enlargement, the majority lost would occur around the shoreline (0.76 acre) and along Forsythe Canyon (0.52 acre). Shrubland/woodland would primarily be permanently impacted along the reservoir shoreline (0.61 acre), with additional habitat impacted along the unnamed southern tributaries (0.26 acre) and South Boulder Creek downstream of the reservoir (0.09 acre). Permanent woodland impacts from reservoir filling would be greatest along the shoreline (0.48 acre), but would also occur along South Boulder Creek upstream of the reservoir (0.04 acre), and Winiger Gulch (0.02 acre).

Temporary impacts of 0.04 acre to riparian woodland habitat would occur at Chamberlain Gulch from construction disturbance associated with the spillway.

5.8.3.2 South Platte River Facilities

The gravel pit storage facilities (gravel pits, diversion structure, pipelines, and Advanced Water Treatment Plant [AWTP]) are considered representative of typical facilities that would be constructed. The actual location and configuration of the gravel pits and

associated facilities would be determined during the design phase should this alternative be permitted by the Corps.

Wetlands

As summarized in Table 5.8-1, permanent wetland impacts under Alternative 8a for the South Platte River Facilities would total 0.02 acre of PEM/PSS wetlands from construction of the diversion dam and outlet structure, a minor impact. It is assumed that all gravel pits would be excavated and empty and all associated ponds would be graded when Denver Water takes possession and therefore no impacts are associated with these facilities.

Temporary wetland impacts at the South Platte River Facilities total 0.22 acre of PEM/PSS wetlands, including 0.22 acre to wetlands at the South Platte River from construction of the diversion structure and less than 0.01 acre from construction of the outlet structure.

Other Waters of the U.S.

Impacts under Alternative 8a to other waters of the U.S. by construction of the South Platte River Facilities are summarized in Table 5.8-2 and total 0.04 acre of permanent impact to the South Platte River from the diversion dam and 0.36 acre of temporary impacts from construction disturbance associated with the diversion structure.

Riparian Habitat

As summarized in Table 5.8-3, impacts to riparian habitat from construction of the South Platte River Facilities under Alternative 8a would result in 0.03 acre of temporary impact to woodland habitat from the diversion pipeline corridor. Permanent impacts associated with Alternative 8a from construction of the South Platte River Facilities would be less than 0.01 acre.

5.8.3.3 Conduit O

Wetlands

No wetlands would be permanently impacted as a result of Conduit O. Temporary impacts total 0.06 acre, including less than 0.01 acre of PEM wetlands from construction of the pump station and 0.06 acre of PEM/PSS wetlands from conduit construction. Temporary impacts include less than 0.01 of wetlands associated with a stormwater ditch under Interstate (I-) 25, 0.06 acre of wetlands associated with the South Platte River where it is crossed by Conduit O, and less than 0.01 acre to Little Dry Creek wetlands from construction of the pump station.

Other Waters of the U.S.

Conduit O would have no permanent impacts to other waters of the U.S. As shown in Table 5.8-2, Conduit O would have temporary impacts of 0.33 acre (125 feet), including 0.32 acre (101 feet) to the South Platte River, and less than 0.01 acre to Little Dry Creek and a stormwater ditch.

Riparian Habitat

As shown in Table 5.8-3, Conduit O would temporarily impact 0.01 acre of woodland habitat at a stormwater ditch at I-25 and less than 0.01 acre at of woodland/shrubland at Little Dry Creek from construction of the pump station. No riparian habitat would be permanently impacted by construction of Conduit O.

5.8.3.4 River Segments

Flow changes associated with this alternative are nearly the same as those described for the Proposed Action (Table 5.8-11). All changes would be the same or near the same except at sampling sites FR1, FR2, FR3, and NF1. Impacts would be slightly less at these four sites than for the Proposed Action. The largest difference would be at FR1, where the area wetted by the 2-year flow would be reduced from 0.39 acre/mile for the Proposed Action to 0.32 acre/mile for Alternative 8a. As with the Proposed Action, changes in wetland and riparian habitats would be minor along the Fraser River, St. Louis Creek, Blue River, and South Boulder Creek below Gross Reservoir, and negligible or none along the other river segments.

Five- and 10-year flow changes would also mostly be the same as the Proposed Action (Table 5.8-11). The only differences between Alternative 8a and the Proposed Action would be at FR1 and CR1, where impacts would be less under Alternative 8a. Impacts would be minor along the Fraser River (FR1 and FR2), St. Louis Creek (FR3), and South Boulder Creek below Gross Reservoir, and negligible or none at the other sites.

Table 5.8-11
Two-, Five-, and 10-Year Flow Changes for Sampling Sites, Alternative 8a Compared to Full Use of the Existing System

Sampling Site	Average Channel Width Flow at Full Use (feet)	Impacts of Alternative 8a Compared to Full Use of the Existing System			Proposed Action Area of Flow Change (acres/mile)
		Flow Elevation Change (inches)	Flow Width Change (feet)	Area of Flow Change (acres/mile)	
2-Year Flows					
FR1	28.38	-6.20	-2.68	-0.32	-0.39
FR3	51.12	-1.70	-2.16	-0.26	-0.30
FR4	20.10	-0.80	-0.20	-0.02	-0.03
NF1	53.38	+0.17	+0.12	+0.01	+0.02
5-Year Flows					
FR1	36.68	-1.92	-2.48	-0.30	-0.33
10-Year Flows					
FR1	42.13	-4.53	-4.08	-0.49	-0.50
CR1	186.54	-1.17	-0.84	-0.10	-0.15

Note:
Only changes different than Proposed Action are shown.

For the Fraser River and Williams Fork tributaries, the percent change in flows from Full Use of the Existing System would be similar but less than the Proposed Action and would

be the least of the action alternatives. The effects on wetlands and riparian resources associated with the tributaries would be similar and would be minor.

5.8.4 Alternative 10a

5.8.4.1 Gross Reservoir

Impacts to wetlands, other waters of the U.S., and riparian habitats are the same as those described for Alternative 8a.

5.8.4.2 Denver Basin Aquifer Facilities

Wetlands

No wetlands would be permanently impacted in the Denver Basin study area. As shown in Table 4.8-1, temporary wetland impacts would total 0.05 acre from the aquifer pipeline. Temporary impacts of 0.02 acre would occur at Cherry Creek, including less than 0.01 acre to PEM wetlands and 0.01 acre to PEM/PSS wetlands. Temporary wetlands impacts would also occur at Sand Creek to 0.03 acre of PSS wetlands and to 0.01 acre of PEM/PSS wetlands at the South Platte River.

Other Waters of the U.S.

As shown in Table 5.8-2, other waters of the U.S. would incur 1.18 acres (766 feet) of temporary impacts from placement of the aquifer pipeline, including impact to the South Platte River, Cherry Creek, and Sand Creek. No other waters of the U.S. would be permanently impacted by construction of the Denver Basin Aquifer Facilities under Alternative 10a.

Riparian Habitat

No riparian habitats would be permanently impacted by construction of the Denver Basin Aquifer Facilities. Temporary impacts would occur to 0.30 acre of woodland/shrubland habitat, including 0.12 acre at Cherry Creek, less than 0.01 acre at Sand Creek, and 0.18 acre at the South Platte River from placement of the aquifer distribution pipeline. If Denver Water chooses to maintain a cleared ROW, losses of woodland and shrub habitat would be permanent.

5.8.4.3 Conduit M

Wetlands

Conduit M would not permanently impact wetlands under Alternative 10a; temporary impacts would total 0.02 acre. Temporary impacts to PEM wetlands at the South Platte River where it is crossed by Conduit M would total 0.02 acre. Temporary impacts from pump station construction would total less than 0.01 acre to PEM wetlands at Little Dry Creek.

Other Waters of the U.S.

No other waters of the U.S. would be permanently impacted by Conduit M under Alternative 10a; however, temporary impacts would total 0.52 acre (244 feet). Temporary impacts from construction of the pump station would total less than 0.01 acre (5 feet) to Little Dry Creek. Placement of Conduit M at the South Platte River would impact 0.34 acre (121 feet) and 0.18 acre (117 feet) at the Burlington Ditch.

Riparian Habitat

Conduit M would not permanently impact riparian habitat under Alternative 10a. Temporary impacts would total 0.25 acre, including 0.15 acre of woodland/shrubland at Burlington Ditch, 0.10 acre of woodland at the South Platte River, and less than 0.01 acre to woodland/shrubland at Little Dry Creek. If Denver Water chooses to maintain a cleared ROW, losses of woodland and shrub habitat would be permanent.

5.8.4.4 River Segments

Impacts to riparian vegetation would be the same as those described for Alternative 8a.

5.8.5 Alternative 13a

5.8.5.1 Gross Reservoir

Wetlands

As shown in Table 5.8-1, Alternative 13a would result in direct and permanent impact to 1.83 acres of wetlands in the Gross Reservoir study area. Impacts to wetlands would be similar to those described for the Proposed Action, but less as Alternative 13a would consist of a smaller Gross Reservoir (60,000 AF). The majority of wetland impacts would be associated with the reservoir enlargement (1.72 acres), from inundation at creek and gulch inlets (0.13 acre of impact to South Boulder Creek upstream of the reservoir, 0.41 acre to the tributary to Winiger Gulch, 0.39 acre to Winiger Gulch, 0.28 acre to the unnamed southern tributary, and 0.02 acre to Forsythe Canyon), and 0.47 acre of shoreline wetlands. Permanent impacts associated with the auxiliary spillway channel and dam footprint would be the same as the Proposed Action.

Temporary impacts to wetlands in the Gross Reservoir study area would be the same as the Proposed Action.

Other Waters of the U.S.

As shown in Table 5.8-2, impacts to other waters of the U.S. includes 3.35 acres (6,939 feet) of perennial waters of the U.S., and 0.01 acre (172 feet) of intermittent waters (Chamberlain Gulch).

Less than 0.01 acre of this impact would be to South Boulder Creek from construction of the dam and 0.01 acre of impact to Chamberlain Gulch from spillway construction. The majority of impacts to other waters of the U.S. would result from reservoir filling and include:

- 2.70 acres (2,395 feet) to South Boulder Creek
- 0.31 acre (1,123 feet) to Forsythe Canyon
- 0.04 acre (399 feet) to Winiger Gulch tributary
- 0.20 acre (2,077 feet) to Winiger Gulch
- 0.10 acre (945 feet) to the unnamed southern tributary

Temporary impacts to other waters of the U.S. in the Gross Reservoir study area would be the same as the Proposed Action.

Riparian Habitat

As summarized in Table 5.8-3, Alternative 13a would result in 3.88 acres of permanent impact to riparian habitats.

The proposed dam and spillway impacts would be the same as the Proposed Action. Most of the permanent impacts would result from inundation by the expanded reservoir. Of the shrubland impacted by reservoir enlargement, the majority lost would occur around the shoreline (0.74 acre) and along Forsythe Canyon (0.59 acre). Shrubland/woodland would primarily be permanently impacted along the reservoir shoreline (0.66 acre), with additional habitat impacted along the unnamed southern tributaries (0.31 acre) and South Boulder Creek downstream of the reservoir (0.05 acre). Permanent woodland impacts from reservoir filling would be greatest along the shoreline (0.48 acre), but would also occur along Forsythe Canyon (0.07 acre), Winiger Gulch (0.03 acre), and South Boulder Creek upstream of the reservoir (0.07 acre).

Temporary impacts to riparian habitats in the Gross Reservoir study area would be the same as the Proposed Action.

5.8.5.2 South Platte River Facilities

The gravel pit storage facilities (gravel pits, diversion structure, pipelines, and AWTP) are considered representative of typical facilities that would be constructed. The actual location and configuration of the gravel pits and associated facilities would be determined during the design phase should this alternative be permitted by the Corps.

Wetlands

As summarized in Table 5.8-1, permanent wetland impacts under Alternative 13a for the South Platte River Facilities would total 0.04 acre of PEM/PSS wetlands. Of this total, 0.02 acre of impact would occur from construction of the AWTP, 0.02 acre from diversion dam construction, and less than 0.01 acre from the outlet structure. These wetlands are present along the South Platte River. It is assumed that all gravel pits would be excavated and empty and all associated ponds would be graded when Denver Water takes possession and therefore no impacts are associated with these facilities.

Temporary impacts to wetlands would total 0.24 acre of impact to wetlands along the South Platte River. These impacts include 0.02 acre to PSS wetlands for construction of the gravel pit pipeline over the river, as well as less than 0.01 acre of impact to PEM/PSS

wetlands from the outlet structure, and 0.22 acre of impact from construction disturbance associated with the diversion structure.

Transfer of agricultural water rights on about 3,900 acres of land would adversely affect wetlands and other water features in ditches and ponds and in wetlands sustained by leakage, overflows, and/or return water flows. Based on a study conducted by ERO Resources Corporation (ERO) (2008) for the Northern Integrated Supply Project EIS (Corps 2008), for a similar area in southern Weld County, about 2.1% (82 acres) of the irrigated land is expected to be wetlands, and about 0.2% (8 acres) would be other water features including ditches and stock and irrigation ponds. Most of the affected wetlands would be PEM wetlands. Cessation of irrigation would dry up wetlands, ditches, and ponds that are supported by irrigation. Riparian areas along streams are not likely to be affected. The ERO study used a combination of aerial photography, Colorado Parks and Wildlife (CPW) (previously called Colorado Division of Wildlife) riparian mapping, and NWI maps to map wetlands and other water features in their 17,137-acre study area.

Other Waters of the U.S.

Impacts under Alternative 13a to other waters of the U.S. by construction of the South Platte River Facilities are summarized in Table 5.8-2 and total 0.04 acre (22 feet) of permanent impacts and 0.90 acre (273 feet) of temporary impacts. Permanent impacts would occur at the South Platte River from the diversion dam (0.04 acre) and the outlet structure (less than 0.01 acre). The majority of temporary impacts (0.90 acre) would occur at the South Platte River from the gravel pit pipeline across the South Platte River (0.54 acre), construction associated with the diversion structure (0.34 acre), and the outlet structure (0.02 acre).

Riparian Habitat

Under Alternative 13a, less than 0.01 acre of riparian habitat at the South Platte River would be permanently impacted from construction of the outlet structure. Temporary impacts would total 0.09 acre, including 0.06 acre from construction of the outlet structure and 0.03 acre from the diversion pipeline.

5.8.5.3 Conduit O

Wetlands

No wetlands would be permanently impacted as a result of Conduit O. Temporary impacts total 0.06 acre of PEM/PSS wetlands and less than 0.01 acre of PEM wetlands and would be the same as described under Alternative 8a.

Other Waters of the U.S.

Impacts to other waters of the U.S. from construction of Conduit O would be the same as Alternative 8a.

Riparian Habitat

Impacts to riparian habitat from construction of Conduit O would be the same as Alternative 8a.

5.8.5.4 River Segments

Flow changes associated with this alternative are essentially the same as those described for the Proposed Action (Table 5.8-12). All changes would be the same or near the same except at sampling sites FR1, FR3, FR4, and BR1. Impacts would be slightly less at these four sites than for the Proposed Action. The largest difference would be at FR1, where the area wetted by the 2-year flow would be reduced from 0.39 acre/mile for the Proposed Action to 0.32 acre/mile for Alternative 13a. As with the Proposed Action and the other action alternatives, changes in wetland and riparian habitats would be minor along the Fraser River, St. Louis Creek, Blue River, and South Boulder Creek below Gross Reservoir, and negligible or none along the other river segments.

Five- and 10-year flow changes would also mostly be the same as the Proposed Action (Table 5.8-12). The only differences between Alternative 13a and the Proposed Action would be at FR1, CR1, and SBC3 where impacts would be less under Alternative 13a. Impacts would be minor along the Fraser River (FR1 and FR2), St. Louis Creek (FR3), and South Boulder Creek below Gross Reservoir, and negligible or none at the other sites.

Table 5.8-12
Two-, Five-, and 10-Year Flow Changes for Sampling Sites, Alternative 13a Compared to Full Use of the Existing System

Sampling Site	Average Channel Width Flow at Full Use (feet)	Impacts of Alternative 13a Compared to Full Use of the Existing System			Proposed Action Area of Flow Change (acres/mile)
		Flow Elevation Change (inches)	Flow Width Change (feet)	Area of Flow Change (acres/mile)	
2-Year Flows					
FR1	28.38	-6.20	-2.68	-0.32	-0.39
FR3	51.12	-1.82	-2.31	-0.28	-0.30
FR4	20.10	-0.80	-0.20	-0.02	-0.03
BR1	100.88	-2.54	-2.21	-0.27	-0.25
5-Year Flows					
FR1	36.68	-1.92	-2.48	-0.30	-0.33
10-Year Flows					
FR1	42.13	-4.53	-4.08	-0.49	-0.50
CR1	186.54	-1.45	-1.05	-0.13	-0.15
SBC3	74.97	-2.19	-2.16	-0.26	-0.29

Note:
Only changes different than Proposed Action are shown.

For the Fraser River and Williams Fork tributaries, the percent change in flows from Full Use of the Existing System would be similar but slightly less than the Proposed Action, and the effects on wetlands and riparian resources associated with the tributaries would be similar and would be minor.

5.8.6 No Action Alternative

5.8.6.1 Depletion of Strategic Water Reserve Strategy

With this alternative, Denver Water would continue to operate their existing system at Full Use of the Existing System but under a higher demand. In addition, the No Action Alternative would use a combination of depleting the 30,000 AF Strategic Water Reserve and more frequent mandatory restrictions on use during droughts. Stream flows would change compared to Full Use of the Existing System because of operational changes including increased use of Blue River and South Platte River supplies and the Strategic Water Reserve, especially during droughts. Hydrologic impacts would be less than the action alternatives in the Fraser and Williams Fork river basins and greater in the Blue River Basin. Flows in South Boulder Creek above and below Gross Reservoir would be less on average than the action alternatives while flows in the North Fork South Platte River would increase on average due to additional Roberts Tunnel imports from the Blue River Basin.

Modeled changes in the wetland area affected by changes in 2-year flows associated with this alternative are presented in Table 5.8-13. Changes from Full Use of the Existing System would be higher than the Proposed Action at the sampling site on the Blue River (BR1), but the same or less at all other sampling sites. The largest changes would occur at sampling site BR1, where changes in the area affected under the No Action Alternative would be twice as much as changes in the affected area under the Proposed Action. The 2-year flow elevation would decrease by 5.6 inches under the No Action Alternative compared to Full Use of the Existing System, and the width of the inundated area would be reduced by 4.6 feet, a reduction of less than 5% of the channel width at Full Use. Changes at other sampling sites would be less than 2 inches in flow elevation and 1 foot in channel width. Changes would be minor along the Blue River (site BR1), and would be negligible or none at the other sites. Changes in flow are unlikely to adversely affect riparian and wetland habitats along the South Platte River, because flow changes would generally be small on both an annual average and monthly basis.

Table 5.8-13
Two-Year Flow Changes for Sampling Sites, No Action Alternative Compared to Full Use of the Existing System

Sampling Site	Average Channel Width of 2-Year Flow at Full Use (feet)	Impacts of No Action Alternative Compared to Full Use of the Existing System			Proposed Action 2-Year Area of Flow Change (acres/mile)
		2-Year Flow Elevation Change (inches)	2-Year Flow Width Change (feet)	2-Year Area of Flow Change (acres/mile)	
FR1	28.38	-1.91	-0.95	-0.12	-0.39
FR2	83.88	-0.04	-0.11	-0.01	-0.62
FR3	51.12	+0.10	+0.14	-0.02	-0.30
FR4	20.10	0.00	0.00	0.00	-0.03
WF1	69.97	0.00	0.00	0.00	0.00
WF2	29.97	0.00	-0.00	0.00	-0.02
CR1	139.11	-0.15	-0.08	-0.01	-0.01

Table 5.8-13 (continued)
Two-Year Flow Changes for Sampling Sites, No Action Alternative Compared to Full Use of the Existing System

Sampling Site	Average Channel Width of 2-Year Flow at Full Use (feet)	Impacts of No Action Alternative Compared to Full Use of the Existing System			Proposed Action 2-Year Area of Flow Change (acres/mile)
		2-Year Flow Elevation Change (inches)	2-Year Flow Width Change (feet)	2-Year Area of Flow Change (acres/mile)	
BR1	100.88	-5.57	-4.64	-0.56	-0.25
SBC1	46.10	+0.18	+0.07	+0.01	+0.08
SBC3	70.26	+0.77	+0.75	+0.09	-0.57
NF1	53.86	0.00	+0.14	+0.02	+0.02
NF2	64.43	+0.36	+0.09	+0.01	+0.02

Changes in flow elevations and channel widths due to changes in the 5- and 10-year flows under the No Action Alternative are presented in Table 5.8-14, for locations where changes are different than for the Proposed Action. About half of the sampling sites would have changes that are the same as the Proposed Action and are therefore not shown in Table 5.8-14. Changes in 5-and 10-year flows under the No Action Alternative would be less than under the Proposed Action and other action alternatives, and would result in changes in flow elevations of less than 2 inches and changes in channel width of less than 2 feet at all sites. Effects on riparian and wetland vegetation would be negligible.

Table 5.8-14
Five- and 10-Year Flow Changes for Sampling Sites, No Action Alternative Compared to Full Use of the Existing System*

Sampling Site	Average Channel Width Flow at Full Use (feet)	Impacts of No Action Alternative Compared to Full Use of the Existing System			Proposed Action Area of Flow Change (acres/mile)
		Flow Elevation Change (inches)	Flow Width Change (feet)	Area of Flow Change (acres/mile)	
5-Year Flows					
FR1	36.68	-0.56	-0.52	-0.06	-0.33
FR2	102.52	-0.66	-1.92	-0.23	-0.29
FR3	58.49	-0.08	-0.11	-0.01	-0.15
CR1	177.89	-1.34	-1.67	-0.20	-0.24
BR1	108.11	-0.43	-0.23	-0.03	0.00
SBC1	47.08	+0.06	+0.02	+0.001	+0.01
SBC3	73.38	-0.44	-0.44	-0.05	-0.24

Table 5.8-14 (continued)
Five- and 10-Year Flow Changes for Sampling Sites,
No Action Alternative Compared to Full Use of the Existing System

Sampling Site	Average Channel Width Flow at Full Use (feet)	Impacts of No Action Alternative Compared to Full Use of the Existing System			Proposed Action Area of Flow Change (acres/mile)
		Flow Elevation Change (inches)	Flow Width Change (feet)	Area of Flow Change (acres/mile)	
10-Year Flows					
FR1	42.13	-1.59	-1.54	-0.19	-0.50
FR2	139.22	-0.03	-0.17	-0.02	-2.02
CR1	186.54	-0.34	-0.24	-0.03	-0.15
BR1	108.89	-1.22	-0.62	-0.08	0.00
SBC1	47.22	0.00	0.00	0.00	+0.01
SBC3	74.97	--0.47	-0.45	-0.05	-0.29

Note:
*Only changes different than Proposed Action are shown.

For the Fraser River and Williams Fork tributaries, the percent change in flows from Full Use of the Existing System under No Action would be the same or slightly less than the Proposed Action.

5.8.6.2 Combination Strategy

No additional impacts on riparian vegetation would result from implementing the Combination Strategy. During a drought, stream flows could decrease in some streams because less water would be released from storage.

5.8.7 Mitigation and Monitoring

5.8.7.1 Compensatory Mitigation

Section 404 of the Clean Water Act requires that impacts to wetlands and other waters of the U.S. must be avoided, minimized, or mitigated (in order of sequence). Impacts to wetlands were minimized where possible during alternatives development. For example, Alternative 1c was re-configured with different reservoir sizes based on feasibility level engineering analysis and an assessment of environmental constraints, primarily wetland habitat. Alternative 1c was finalized with an enlarged Gross Reservoir (additional 40,700 AF) and new Leyden Gulch Reservoir (31,300 AF). Conduits M and O would be placed within existing roadways (curb-to-curb), eliminating impacts to wetlands for these pipelines. All impacted wetlands and other water features would be mitigated in accordance with current Corps mitigation policies, and the conditions of the Section 404 Permit. All mitigation plans would be developed in coordination with the Corps and other appropriate agencies during the Section 404 permitting process. The Corps would determine the appropriate level of mitigation based upon the wetland functions lost or adversely affected as a result of impacts to aquatic resources. In general, a 1:1 replacement of functions is required, using on- or off-site mitigation.

In its Moffat Collection System Project Fish and Wildlife Mitigation Plan (Appendix M), Denver Water notes that wetland mitigation will be determined by the Corps and proposes to meet mitigation requirements by either purchasing credits from an approved wetland mitigation bank, or by creating permittee-responsible mitigation wetlands within the South Boulder Creek watershed.

Denver Water also proposes to mitigate for impacts to other waters of the U.S. streams (that would be inundated by the expanded reservoir or impacted by the expanded dam), by creation of an Environmental Pool for Gross Reservoir. The Environmental Pool would be used to enhance low flows in the 17 miles of South Boulder Creek downstream of Gross Reservoir, and would be managed under an Intergovernmental Agreement.

Denver Water also proposes to mitigate direct impacts to riparian habitat at Gross Reservoir by planting native woody riparian vegetation in suitable areas around the reservoir. Denver Water will prepare a riparian vegetation establishment plan for review by the CPW, Corps, the Federal Energy Regulatory Commission (FERC), and the U.S. Forest Service, that would establish a schedule, identify planting areas, type and quantity of plant materials, success criteria and monitoring methods. FERC may need to approve the riparian vegetation establishment plan.

5.8.7.2 Mitigation During Construction

In addition to a mitigation plan, the mitigation measures listed below would further minimize adverse impacts to wetlands and other water features from sedimentation and erosion of wetlands and other water features during construction:

- Vehicle operation would be limited to designated construction areas, and the limits of the construction area would be fenced where they are adjacent to sensitive habitats including riparian areas and wetlands.
- Best Management Practices would be implemented during all phases of construction to reduce impacts from sedimentation and erosion, including the use of berms, brush barriers, check dams, erosion control blankets, filter strips, sandbag barriers, sediment basins, silt fences, straw-bale barriers, surface roughening, and/or diversion channels.
- When practicable, construction in waterways would be performed during low flow or dry periods.
- Flowing water would be diverted around active construction areas.
- No fill material would be stored in wetlands or other water features.
- No unpermitted discharges would be allowed.
- To minimize or eliminate unnecessary and unplanned wetland impacts, the following mitigation measures are proposed:
  - Prior to construction, orange temporary fence and sediment control measures would be placed to delineate and protect existing wetlands that are located outside the planned area of disturbance.

- Wetland areas designated as temporary disturbance that would be used for construction access would be covered with geotextile, straw, and soil prior to use.
- The location and design of stormwater ponds would be coordinated with the Project biologist.

5.8.7.3 Alternative 1c – Leyden Gulch Reservoir Site

If Alternative 1c were permitted, impacted wetlands at Leyden Gulch Reservoir from construction disturbance associated with the access road, emergency outlet, and the pipeline tunnel would be identified for further minimization and avoidance during final design.

5.8.8 Unavoidable Adverse Impacts

Direct impacts to wetlands and to perennial and intermittent stream channels resulting in both permanent and temporary losses would occur as a result of the Project and cannot be totally avoided. However, no additional mitigation measures beyond those identified in Section 5.8.7 are expected to be necessary for Project impacts.

Although minor changes in vegetation composition may occur from changes in stream flows, no unavoidable adverse impacts to riparian vegetation would be expected as a result of the Moffat Project.

5.9 WILDLIFE

This section describes the direct and indirect impacts to wildlife expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Four potential wildlife issues were identified during scoping:

- Impact of depletions to the Fraser River on fisheries and other wildlife.
- Impact of the water reuse component on wildlife living in the affected areas.
- Impact on prairie dog habitat and migrating elk at the Leyden Gulch Reservoir site.
- Impact of a dam raise and expanded inundation area on elk and other wildlife on the western shores of Gross Reservoir.

Impacts to fisheries are evaluated in Section 5.11, and impacts to threatened, endangered, and other special status species are addressed in Section 5.10. A discussion of elk habitat and migration corridors at the reservoir sites are described in Sections 5.9.1.1 and 5.9.2.2. Prairie dog colonies at the Leyden Gulch Reservoir site are evaluated in Section 5.9.2.2.

5.9.1 Proposed Action (Alternative 1a)

5.9.1.1 Gross Reservoir

Wildlife present in the Gross Reservoir area includes big game, other mammals, raptors, migratory birds, reptiles and amphibians, and fish (refer to Section 3.11, for description of aquatic resources). Habitat in the Gross Reservoir area that would be impacted by reservoir expansion includes ponderosa pine woodland, ponderosa pine/Douglas-fir woodland, mountain grassland, talus slopes/rock outcrops, open water, and disturbed or unvegetated areas (refer to Section 5.7). Disturbed/unvegetated areas, while not high-quality wildlife habitat, do provide movement corridors and relatively contiguous habitat and are therefore included in the impact analysis. Table 5.9-1 compares direct impacts to wildlife habitats by alternative at Gross Reservoir. Most of the impacts to wildlife habitat would occur in the new inundation area (between 7,282 and 7,406 feet) and would occur from site preparation. All trees and wood would be removed from the inundation area and from the shoreline up to elevation 7,410 feet. The acres of impact include the area above the expanded pool for each alternative. Small areas of wetland and riparian vegetation would also be affected (Section 5.8). Direct impacts to wildlife would result from loss or degradation of habitat, mortality from ground-disturbing activities, and from vegetation clearing and inundation of natural habitat. Indirect impacts consist of displacement of wildlife by noise and disturbance resulting from on-site construction, quarrying, and transport of materials and people.

Table 5.9-1
Direct Impacts to Wildlife Habitat in Gross Reservoir Study Area by Alternative

Wildlife Habitat	Acres of Impact to Wildlife Habitat									
	Proposed Action		Alternative 1c		Alternative 8a		Alternative 10a		Alternative 13a	
	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
Ponderosa Pine	169.9	7.4	109.7	10.8	133.8	8.6	133.8	8.6	150.8	7.9
Ponderosa Pine/ Douglas-fir Mix	253.0	42.5	162.7	54.2	195.4	49.8	195.4	49.8	223.2	46.0
Grassland/ Forb Mix	32.9	2.1	20.1	2.1	24.6	2.1	24.6	2.1	29.5	2.1
Disturbed/ Unvegetated	8.9	3.6	8.6	3.9	8.8	3.7	8.8	3.7	8.8	3.7
Open Water	0.0	33.7	0.0	33.7	0.0	33.7	0.0	33.7	0.0	33.7
Talus Slope/ Rock Outcrop	0.4	0.0	0.4	0.0	0.4	0.0	0.4	0.0	0.4	0.0
Total	**465.1**	**89.3**	**301.5**	**104.7**	**363.0**	**97.9**	**363.0**	**97.9**	**412.7**	**93.4**

Note:
The calculations of the noted acres assumes disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).

Big Game

Big game, including mule deer, elk, mountain lion, and black bear, would lose habitat because of permanent and temporary losses of habitat during construction and reservoir enlargement. The Proposed Action would have the greatest impacts on big game habitats of all of the action alternatives.

Mule deer, mountain lion, and black bear occur at the Gross Reservoir site year-round. Direct losses of habitat are summarized in Table 5.9-1, and would include 465.1 acres of permanent impacts and 89.3 acres of temporary impacts. Mule deer herds inhabiting the Gross Reservoir area are not likely to be adversely effected by the reservoir enlargement because no crucial seasonal habitats are present, and the affected area represents a very small part of the habitat available to the data analysis unit No. 27 herd. The Proposed Action would affect about 544 acres of summer range, which would have a minor effect on the mule deer herd. Impacts to mountain lion and black bear habitat would be minimal because the impacted area represents only a small portion of the typical home range occupied by individuals of these species. In addition, mountain lions prey mostly on mule deer and their prey base is not expected to be reduced.

Elk are present in the area during the winter, and three types of crucial seasonal habitats are present: elk migration corridor, severe winter range, and winter concentration areas. A summary of impacts to these habitats is presented in Table 5.9-2. Severe winter range and winter concentration areas are separate categories that overlap in some areas and cannot be added together to derive a total area of elk impact. Elk migration corridors and severe winter range are separate categories, but all of the construction and operation impacts would occur in both habitats.

Table 5.9-2
Direct Impacts to Elk Seasonal Habitats

Type of Habitat/Impact	Acres of Impact to Elk Seasonal Habitats			
	Proposed Action	Alternative 1c	Alternatives 8a/10a	Alternative 13a
Elk Severe Winter Range and Migration Corridor				
Permanent	465.1	301.5	363.0	412.7
Temporary	89.3	104.7	97.9	93.4
Total impacts	**544.4**	**406.2**	**460.9**	**506.1**
Elk Winter Concentration Area				
Permanent	269.0	167.5	203.2	235.5
Temporary	52.1	62.3	58.2	55.2
Total impacts	**321.1**	**229.8**	**261.4**	**290.7**

Note:
The calculation of the noted acres assumes disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).

The direct loss of elk winter concentration areas represents about 1.3 percent (%) of this habitat in the map unit, of which 0.2% would be temporary impacts. The loss of severe winter range represents 1.8% of this habitat in the affected map unit, of which 0.3% would be temporary impacts. Impacts would be less than 1% to these habitats across the entire herd unit, a minor impact. About 7.0% of the migration corridor would be lost due to the Proposed Action, of which about 1.1% would be temporary impact. Permanent loss of portions of the migration corridor would likely cause changes in elk migration patterns, as described below.

Year-round construction activities at the dam and nearby areas would displace big game from the eastern side of the reservoir. Operation of the quarry would contribute to displacement although the Board of Water Commissioners (Denver Water) would use confined charge blasting to reduce noise. The distance that animals move to avoid human disturbance is dependent on the species and/or individual, topography, vegetation cover, and intensity of the disturbance. The amount of displacement is difficult to estimate, but is likely to be one-quarter to one-half mile or more, involving hundreds of acres adjacent to the construction areas on the east side of the reservoir and areas along the western shore facing the dam and quarry. Displacement is not likely to affect use of most of the Winiger Ridge area. Construction would occur year-round, including the winter when the area would normally be used as elk winter range, concentration area and severe winter range. This displacement would occur each winter during the construction period for four years. During operation, big game are unlikely to exhibit any changes in behavior from Current Conditions (2006).

The only construction activities on the western, northern and southern sides of the reservoir would be clearing and disposal of woody vegetation from the new reservoir footprint. This activity would also displace big game, but would occur mostly during the summer and fall. Clearing and disposal of trees is expected to take 6 to 8 months and is unlikely to affect wintering elk. Activities in the dam area are unlikely to cause displacement of big game from the west side of the reservoir because of the distance from construction disturbance.

Gross Reservoir is near the eastern end of a migration corridor that extends from elk summer concentration areas west of Nederland to winter concentration areas around and north of the reservoir. About 7.0% of the migration corridor would be lost due to the Proposed Action, of which about 1.1% would be temporary impact. Permanent loss of portions of the migration corridor would likely cause changes in elk migration patterns, and would be a moderate impact. The migration corridor extends around the reservoir, including the north and south shores (Figure 3.9-2). Construction activities on the east side of the reservoir could affect movement of elk near the reservoir and displace them to adjacent areas, but movement on the west side of the reservoir and most of the corridor is unlikely to be affected. During operation, the expanded reservoir would back up water in South Boulder Creek and other tributaries and would create greater obstacles for movement. Under the Proposed Action, approximately 2,495 feet of South Boulder Creek and approximately 2,160 feet of Winiger Gulch would be inundated. Inundation of these streams is likely to result in changes in movement for elk and deer. Inundation of South Boulder Creek above the reservoir could affect movement of elk and deer near Pinecliffe, because the canyon between the enlarged reservoir and Pinecliffe is narrow and steep and may be difficult to cross. The new reservoir arms would be relatively narrow and big game may continue to cross them especially in the spring when the reservoir would be at a lower elevation. Loss of habitat and potential change of use patterns may force elk and deer to adjacent private lands, which could increase the Colorado Parks and Wildlife (CPW) (previously called Colorado Division of Wildlife) obligations for game damage compensation. Management of nuisance wildlife issues and public safety is a CPW priority. Hunting is a primary tool for managing herd size, but closure of areas in Boulder County near Gross Reservoir to hunting makes it more difficult to achieve adequate harvest of big game.

Other short-term direct impacts to big game would occur from potential collisions with haul trucks and other vehicles along access routes including County Road (CR) 77S, and State Highways (SHs) 72, 93, and 128 due to the increase in traffic from construction. Approximately 202 construction worker vehicle trips and 44 to 74 supply delivery trips would occur per day, as described in the Transportation Analysis (Section 5.12.1). The increase in traffic on CR 77S may result in an increase in collisions with big game and other wildlife, but are not likely to adversely affect local populations. As shown in Figure 3.9-1, portions of SHs 72 and 93 that are potential haul routes for construction of the Gross Reservoir expansion are frequently crossed by mule deer. These areas are used year-round by mule deer. Although they are a safety concern, collisions would have a negligible effect on big game populations.

Carnivores and Small- and Medium-sized Mammals

Direct impacts to small- and medium-sized mammals include habitat loss and mortality from ground-disturbing construction activity. Small-bodied animals in the immediate area of construction activity would likely be killed by crushing or burial during construction. More mobile species, including medium-sized animals, could avoid the construction zones but would be temporarily displaced by construction. Temporary displacement could result in increased mortality from vehicle collisions and increased resource competition.

As discussed under Big Game, the increased water level up the fingers at Winiger Gulch and South Boulder Creek would create a barrier to movement for these species, especially smaller sized mammals that would have to travel long distance to move around the water. The indirect impacts of the enlarged reservoir to small- and medium-sized mammals would be fragmentation of habitat.

Numerous bats inhabit the mixed conifer and ponderosa pine woodlands in the Gross Reservoir study area. The primary impacts to these species would be loss of roosting trees around the perimeter of the reservoir and disturbance to roosting bats during construction and vegetation clearing activity. The enlarged reservoir would create additional open water foraging habitat for some bat species.

Raptors

Although no raptor nests were observed during field surveys, several species listed in Table 3.9-1 may nest in the vicinity of the reservoir and could be affected by construction. Clearing of vegetation during reservoir site preparation has the potential to remove trees with stick nests used by hawks or cavity nests used by owls. The Project does not involve construction on cliffs and is very unlikely to affect cliff nesting species such as falcons and is not expected to affect the osprey nesting platforms at Gross Reservoir.

All raptors are protected under the Migratory Bird Treaty Act, and removal or destruction of an active nest would be a violation of the act. Impacts would be avoided or minimized by use of pre-construction surveys to identify active nests in the Project footprint, as described in Section 5.9.7. If nests are found in the construction area, they would be removed during the non-breeding season when they are not being actively used. Removal of inactive nests during vegetation clearing would have no direct impacts on raptors, but could affect use of breeding territories during the next breeding season. Some species, such as red-tailed hawk and golden eagle, typically have multiple nests within their territory, and breeding would likely occur at one of the alternate nests. Other species often build or use new nests each year, such as great-horned owl and sharp-shinned hawk, and loss of an old nest site would have no effect. Impacts would be greatest for species that have high nest fidelity and that use the same nest for many years, such as bald eagle and osprey, which are not known to nest at Gross Reservoir.

Direct impacts could occur during construction from disturbance from human activity around an active raptor nest. Depending on several factors such as species, the type of activity, topography, and individual sensitivity, disturbance could result in loss of eggs or young from nest abandonment. CPW has recommended buffer zones and seasonal restrictions that range from 0.25 to 0.5 mile for nests of various raptor species including golden eagle, red-tailed hawk, osprey, and northern goshawk (CDOW 2008b). In addition to buffers and seasonal restrictions for human encroachment, CPW recommendations generally include no surface occupancy (no new structures) within buffer zones. The CPW recommendations do not address some species that may occur, including owls, sharp-shinned hawk, and Cooper’s hawk. If raptor nests are discovered during raptor surveys, seasonal buffers would be established and coordinated with CPW to avoid or minimize impacts to nesting raptors.

Loss of habitat from inundation would be limited to a strip about 150-300 feet wide along most of the reservoir perimeter under the Proposed Action and would be less under other action alternatives (Figure 2-3). Most of the affected area is forest or woodland, and loss of habitat would reduce foraging habitat both for forest birds and for species that forage in ponderosa pine woodlands. There would be increases in open water and shoreline habitat. The Proposed Action is not expected to adversely affect populations of sensitive raptor species such as northern goshawk and flammulated owl, as discussed in Section 5.10.1.

Other Birds

Direct impacts to other birds would consist of loss of habitat from vegetation clearing and inundation, as well as disturbance during construction activities. Birds primarily affected by vegetation clearing include those in Table 3.9-2 that inhabit ponderosa pine and ponderosa pine/Douglas fir woodland habitats.

As described for raptors, disturbance to nesting birds and young, or removal or destruction of an active nest is a violation of the Migratory Bird Treaty Act. Vegetation clearing around the reservoir shoreline, and in other construction areas should be timed to avoid the nesting season of migratory birds and waterfowl (generally March 1 through July 31). As discussed in Section 2.8.1, the Gross Reservoir Dam and other facility construction would occur primarily between May and September, which would likely result in impacts to migratory birds. In Denver Water's Moffat Collection System Project Fish and Wildlife Mitigation Plan, which has been approved by the Colorado Wildlife Commission, Denver Water has committed to the use of pre-construction surveys to identify active nests in the Project footprint and timing of activities to avoid the breeding season.

Operation of the enlarged reservoir would benefit waterfowl due to the increased surface area of the water body. Under the Proposed Action, the reservoir expansion would provide an additional 400 acres of open water habitat, depending on water level. Shorebirds, such as spotted sandpiper, may utilize the shoreline for foraging. Nesting habitat along the shoreline for waterfowl and other birds would be limited due to the fluctuating water levels.

Reptiles and Amphibians

Since most of the reptile and amphibian species occur in riparian habitats, the primary impact to these species would be crushing or burial from earth-moving equipment during construction. At areas such as South Boulder Creek and Winiger Gulch, the inlets into the reservoir would be inundated, resulting in loss of habitat. Reptiles and amphibians would be able to move to avoid inundation during reservoir filling. After reservoir expansion, the fluctuating water levels would make creation of new riparian/wetland habitat unlikely except at creek inlets.

U.S. Forest Service (USFS) Wildlife Habitats

Impacts to USFS wildlife habitats are summarized in Table 5.9-3. In forested habitats (forested corridors, interior forest, inventoried and developing old growth), both permanent and temporary impacts (Table 5.9-1) would remove the habitat and would be considered a long-term impact. With the exception of developing old growth, Project impacts would affect the local availability of several types of habitat but would have a minor effect over a larger area.

Table 5.9-3
Impacts to USFS Wildlife Habitats

Type of Habitat/Impact	Acres of Impact to USFS Wildlife Habitats			
	Proposed Action	Alternative 1c	Alternatives 8a/10a	Alternative 13a
Inventoried ponderosa pine-Douglas fir old growth	1.2	0.2	0.5	0.8
Low elevation old growth development area	195.4	132.9	158.8	176.2
Forested corridors	223.5	134.0	166.7	191.6
Open corridors	4.4	1.2	1.9	2.9
Permanent disturbance	196.8	123.5	152.8	174.9
Temporary disturbance	2.0	2.0	2.0	2.0
Total	**198.8**	**125.5**	**154.8**	**176.9**
Interior forest	16.5	5.6	9.1	12.4

Note:
The calculations of the noted acres assumes disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).

The Proposed Action would affect 1.2 acres of inventoried old growth. This represents about 6% of the inventoried old growth in the Gross Reservoir study area, and less than 0.1% of the 1,600 acres of old growth ponderosa pine on the Arapaho & Roosevelt National Forests (ARNF) (USFS 1997b). The Proposed Action would also affect 195.4 acres of old growth development areas, which is about 43% of these areas in the Gross Reservoir study area and 0.3% of the 72,700 acres of ponderosa pine and Douglas-fir old growth development areas on the ARNF. Losses of inventoried old growth and developing old growth would occur from inundation and tree clearing along the edge of the reservoir. The amount of loss of old growth development areas may be in conflict with the ARNF management goal for the Thorodin Geographic Area: "emphasize old-growth recruitment and retention" (USFS 1997b). In addition, effects on existing old growth conflicts with Forest-wide direction in the ARNF Resource Management Plan, specifically operational goal 118 "Retain all existing Douglas-fir and ponderosa pine old growth and increase amounts in the future" (USFS 1997b).

Two types of travel corridors were analyzed by the USFS, forested corridors and open corridors. The Proposed Action would affect 223.5 acres of forested corridors, which is 32% of the forested corridor on USFS lands in the Gross Reservoir study area. Forested corridors occupy about 60% of the entire ARNF, more than 750,000 acres (USFS 1997b), along with most of the USFS lands in the Gross Reservoir study area. Losses of forested corridor at Gross would occur adjacent to the existing reservoir, and would not result in an overall loss of connectedness except along the newly inundated portion of South Boulder Creek.

The Proposed Action would also affect 4.4 acres of open corridors, about 14% of the area of open corridor in the Gross Reservoir study area and about 21% of the ARNF. The small area of open corridor that would be affected is adjacent to the reservoir. Open corridors in the Gross Reservoir study area are restricted to a portion of Winiger Ridge, which is poorly

connected to other areas of open corridor. Impacts of the Proposed Action to open corridors would not reduce the level of connectedness.

The Proposed Action would affect 198.8 acres of effective habitat on USFS lands, about 37% of the effective habitat on USFS lands in the Gross Reservoir study area, about 6% of the effective habitat on USFS land in the Thorodin Geographic Area, and a very small part of the approximately 860,000 acres of effective habitat on the ARNF (about 67% of the ARNF). The Proposed Action would reduce the habitat effectiveness on USFS land in the Thorodin Geographic Area from about 59% to about 55.5%. Losses of effective habitat would occur primarily from inundation, and there would not be any new roads or trails that would alter the locations of effective habitat or increase road and trail density. Recreational facilities that would be inundated would be relocated above the new high water line. Although recreational use would increase, the overall distribution of recreation would be similar to Current Conditions. Most of the USFS lands in the Gross Reservoir study area would continue to be effective habitat. However, the Proposed Action may conflict with Forest-wide direction in the ARNF Resource Management Plan, specifically operational goal 95: "retain the integrity of effective habitat areas."

The Proposed Action would affect 16.5 acres of interior forests, about 12% of the interior forest on USFS land in the Gross Reservoir study area. All impacts would occur on the periphery of mapped areas of old growth, near the existing reservoir. The approximate area of interior forest on the ARNF is about 190,000 acres (USFS 1997b).

USFS Management Indicator Species

Construction and operation of Gross Reservoir would have negligible to moderate impacts to the various Management Indicator Species (MIS). Elk and mule deer are discussed above under Big Game. Impacts to elk would be moderate and to deer would be minor. Impacts for each of the remaining MIS species are described below.

Pygmy nuthatch is an indicator for existing and potential old growth and is most often associated with mature ponderosa pine stands (USFS 1997b). The Proposed Action would affect 1.2 acres of inventoried old growth and 195.4 acres of developing old growth, all of which is ponderosa pine or ponderosa pine-Douglas-fir forest, and potential habitat for pygmy nuthatch. The removal of 196.6 acres of suitable habitat would reduce the local population of this species but would have a minor effect to the regional population. Pygmy nuthatch pairs or families occupy year-round territories that vary from 1.3 to 20.1 acres in size (Ghalambor and Dobbs 2006) and averages about 3 acres per breeding pair (USFS 1997b). Based on the territory size, the Proposed Action could affect about 65 pairs or families, assuming all of the existing and developing old growth was occupied. The estimated number of breeding pairs in Colorado is 51,000 to 399,000 pairs (Kingery 1998). The Proposed Action would affect about one-third of this habitat available within the Gross Reservoir study area.

Golden-crowned kinglet may occur in the Gross Reservoir study area during migration and winter (Andrews and Righter 1992) but is not likely to breed. Nesting occurs primarily in mature, dense spruce-fir forest at elevations above 7,600 feet, while wintering occurs primarily in Douglas-fir and ponderosa pine. This species is considered to be uncommon on the ARNF (USFS 1997b). This species is an indicator for interior forest. The Proposed

Action would affect only 16.5 acres of interior forest that could be suitable breeding habitat, which occurs at the lower end of the elevation range where breeding may occur. Because there is a low potential for breeding habitat to be affected, the Proposed Action is expected to have a negligible effect on this species.

Hairy woodpecker is an indicator for young to mature forest, and is known to occur in the Gross Reservoir study area. Home range is about 6 to 9 acres per pair (USFS 1997b). The Proposed Action would remove about 268 acres of forest on USFS lands. This represents habitat for about 30-43 pairs. This would reduce the local population of this species but would have a minor effect to the regional population. The estimated population of hairy woodpecker in Colorado is 28,000 to 160,000 pairs (Kingery 1998).

Mountain bluebird is an indicator for forest openings. The Proposed Action would permanently affect about 42 acres of open grasslands and disturbed areas that are potential habitat for mountain bluebirds. Clearing of trees in areas of temporary disturbance may create about 50 acres of new habitat after construction is completed and the areas are revegetated. Mountain bluebirds usually nest in old woodpecker holes or natural cavities in dead trees, and bluebirds would be unlikely to occur unless snags are present either in the cleared area or in the adjacent forest, or nest boxes are provided. The Proposed Action would reduce the local population of this species but would have a minor effect to the regional population.

Warbling vireo is an indicator for aspen forests and also nests in cottonwoods and in riparian shrub (Kingery 1998). The Proposed Action would not affect any aspen forest or cottonwoods, but would affect about 5.6 acres of riparian shrub. The area of riparian shrub is equivalent to the breeding territories of 1 to 2 pairs of warbling vireos, according to nesting densities referenced in Kingery (1998). Therefore, the Proposed Action is expected to have a negligible effect on warbling vireo populations.

Wilson's warbler is an indicator for montane riparian and wetland habitat. Nesting occurs from about 8,000 to 12,000 feet elevation, with Wilson's warblers overlapping with yellow warblers from 8,000 to 10,000 feet (Andrews and Righter 1992). The Gross Reservoir study area is below 8,000 feet, and the primary occurrence of Wilson's warblers is likely to be during migration. About 5.6 acres of riparian shrubland would be affected. Based on the limited habitat and the likely absence of breeding, the Proposed Action is likely to have negligible effects to Wilson's warbler.

There would be no impacts to Rocky Mountain bighorn sheep or boreal toad in the Gross Reservoir area.

Sensitive Areas

Potential Conservation Areas (PCAs) identified by Colorado Natural Heritage Program (CNHP) and Environmental Conservation Areas (ECAs) identified by Boulder County are shown in Figure 3.9-3 and would be directly impacted by vegetation removal and inundation around the perimeter of the reservoir. These sites are those considered important for protection by CNHP and Boulder County. Table 5.9-4 lists impacted acreage to sensitive areas by alternative.

Table 5.9-4
Direct Impacts to Sensitive Areas by Alternative

		Impact by Alternative (acres)									
		Proposed Action		Alternative 1c		Alternative 8a		Alternative 10a		Alternative 13a	
Type	Sensitive Area	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary	Permanent	Temporary
PCA	Winiger Gulch	71.8	--	42.0	--	53.1	--	53.1	--	61.6	--
	Rocky Flats	--	--	--	2.6	--	--	--	--	--	--
	South Platte River	--	--	--	--	5.6	9.6	6.1	9.4	5.1	9.4
ECA	Winiger Ridge	243.4	--	144.2	--	180.6	--	180.6	--	211.8	--
Other	South Platte River Greenway	--	--	--	--	<0.1	1.4	0.3	2.4	0.1	2.4
	Total	**315.2**	**--**	**186.2**	**2.6**	**239.3**	**9.2**	**240.1**	**11.7**	**278.9**	**8.9**

Notes:
The calculation of the noted acres assumes disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).
ECA = Environmental Conservation Area
PCA = Potential Conservation Area

Under the Proposed Action, direct impact to the Winiger Gulch PCA includes inundation of 71.8 acres (3.8% of total PCA area) and the Winiger Ridge ECA would lose 243.4 acres (7%) to inundation. Two rare plant communities occur in the PCA and would be affected (Section 5.7.1). The Hawkin Gulch/Walker Ranch/Upper Eldorado Canyon ECA, located below the dam, would not incur impact under the Proposed Action or any other action alternatives.

5.9.1.2 River Segments

The Moffat Project does not include any construction activities along the river segments, and the analysis of impacts is therefore focused on effects to habitat that may result from changes in stream flows. The conclusions in this section are based on more detailed analysis in Sections 5.4 and 5.8. Hydrologic impacts are based on a comparison of Full Use of the Existing System and Full Use with a Project Alternative (2032).

Wetland and riparian habitats occur in areas of greater moisture provided by complex interactions between stream flows, groundwater, precipitation, and the physical characteristics of the stream channel and its floodplain. The riparian/wetland analysis focused on two primary mechanisms that may affect riparian vegetation, lowering of groundwater tables to a degree that causes plant mortality, and changes in the width regularly inundated by stream flows. The Proposed Action is designed to capture surface water flows only during periods of higher runoff in wet or average years, and increased diversions would generally not occur in dry years or during periods of low flows. Flow

modifications resulting from the Proposed Action are within the range of normal variability, and flows already vary substantially from dry year to wet year and over the course of a season.

The groundwater analysis in Section 5.4 indicates that flow changes along the river segments would cause localized, minimal effects to the water table that would not be any larger than stream elevation changes and would be well within the range of normal seasonal fluctuations. The small changes in the water table may cause a slight trend toward reduction in wetland species and increase in upland or facultative species on the banks, but effects are expected to be minimal. Given the small amount of change and complexity of riparian areas, changes are likely to be small in magnitude and patchy in distribution.

Modeling of impacts from stream flow changes is summarized in Section 5.8. The analysis is based on detailed hydraulic and vegetation data collected at 12 sampling sites. The largest changes in the 2-year flows would be 8 inches or less in height, and up to 5 feet in width (Table 5.8-4). The area covered by 2-year flows would decrease in the Fraser River and its tributaries, Colorado River, Blue River, and South Boulder Creek below Gross Reservoir; and would increase in South Boulder Creek above Gross Reservoir and North Fork South Platte River, compared to Full Use of the Existing System. Decreases in the 2-year flow could result in a gradual narrowing of the stream banks, which would decrease hydrology for wetlands within the banks. However, longer-term floods may remove accumulated sediment and reverse the narrowing. Where narrowing occurred, vegetation would respond by gradually adjusting its location, moving downgradient to remain in the same hydrological zone. Changes are likely to be very slow in most areas. The zone of reduced hydrology may show a change in composition to riparian species with somewhat lower water requirements, or upland species such as conifers. Wetlands and riparian areas that are maintained primarily by groundwater discharge would not be affected.

The analysis in Section 5.8 also addresses overbank flooding associated with 5- and 10-year flows. The area of overbank flooding would decrease in the Fraser River, Colorado River, Blue River, and South Boulder Creek below Gross Reservoir but changes would be relatively small, 1-8 inches in height and 2-6 feet in width. These changes could reduce riparian vegetation density or productivity and cause change in composition including increases in upland species.

The analysis of changes to wetlands and riparian habitats in Section 5.8 characterizes changes to riparian and wetland habitats as minor or negligible in the various streams, with changes more likely to involve a shift in composition rather than a loss of habitat. These small changes could potentially affect food availability or cover for riparian wildlife species. Changes in habitat quality are likely to be small and patchy and relatively subtle in most places. These changes are not likely to affect overall distribution or populations of bird, mammal, reptile, and amphibian species.

Changes in stream flows in the Fraser River, Williams Fork, and their tributaries would have negligible effects on moose and elk distribution and population. Moose concentration areas include stream valleys below a number of the diversions, but also include upland areas between the drainages. Elk summer range occurs throughout the Fraser and Williams Fork valleys. Although some changes to riparian and wetland habitats could occur along

the streams, the large wetlands and riparian complexes appear to be primarily supported by groundwater and are unlikely to be affected.

Two USFS MIS species occur along the Fraser and Williams Fork rivers and their tributaries, Wilson's warbler and boreal toad. Boreal toad is a special status species that would have negligible effects from the Proposed Action. It is discussed in more detail in Section 5.10. Wilson's warbler is an indicator for montane riparian and wetland habitat, is known to occur and is likely to be common in suitable habitat along all of the streams in the Fraser and Williams Fork valleys. Wilson's warblers nest and forage in and near montane and subalpine riparian shrub and wet meadows (Kingery 1998; Johnson and Henderson 2003). The availability of suitable habitat appears to be a limiting factor for Wilson's warbler populations, and dewatering of riparian habitats is one of the primary threats to this species (Johnson and Henderson 2003). As discussed in Section 5.8, the Proposed Action would have negligible to minor impacts to riparian vegetation along the Fraser River, Williams Fork, and their tributaries. These changes may affect Wilson's warbler locally, but are not likely to result in adverse effects to overall distribution or population.

The Proposed Action would have no or negligible effects to PCAs and State Wildlife Area (SWAs) that occur downstream of the diversions. In the Fraser Valley, the riparian habitats in the PCAs are partly supported by the diverted streams but also receive water from other streams and/or groundwater discharge. The South Fork Williams Fork includes part of the mainstem of the Williams Fork, where diversions are expected to have no or negligible effects to riparian habitats. The Upper Williams Fork PCA was designated because of occurrences of Colorado River cutthroat trout and boreal toad. As described in Section 5.10, the Proposed Action would have no or negligible effect on boreal toad and to conservation populations of Colorado River cutthroat trout above the diversions. Changes in Colorado River and Blue River riparian habitats are expected to be negligible. South Boulder Creek east of Gross Reservoir flows through the Hawkin Gulch/Walker Ranch/ Upper Eldorado Canyon ECA and the Boulder Foothills PCA, but flow changes would not affect the resources for which these areas were identified.

5.9.2 Alternative 1c

5.9.2.1 Gross Reservoir

Impacts to wildlife under Alternative 1c would be similar to those described under the Proposed Action, but would affect less area. Alternative 1c would involve a smaller reservoir enlargement (40,700 acre-feet [AF]), compared to 77,000 AF for the Proposed Action. Impacts to wildlife would be similar to the Proposed Action, although less habitat would be removed under Alternative 1c, as shown in Tables 5.9-1 and 5.9-2, and Figure 2-3. The enlarged reservoir would still result in loss and fragmentation of habitat, as described under the Proposed Action. In riparian areas such as Winiger Gulch and South Boulder Creek, Alternative 1c would result in slightly less fragmentation as the water level would be lower. Approximately 2,100 feet of South Boulder Creek and approximately 1,370 linear feet of Winiger Gulch would become inundated and a barrier for terrestrial wildlife.

The loss of elk winter concentration areas (229.8 acres, Table 5.9-2) represents approximately 0.9% of this habitat in the map unit; about 0.25% of this loss would be temporary. Approximately 1.3% of elk severe winter range in the map unit would be lost due to reservoir expansion; of which about 0.3% would be temporary impact to severe winter range. Direct losses of habitat would be less than the Proposed Action, and would be less than 1% of the habitat available to the Clear Creek elk herd, a minor impact. About 5.2% of the migration corridor would be lost due to the Proposed Action, of which about 1.2% would be temporary impact. Permanent loss of portions of the migration corridor would likely cause changes in elk migration patterns, as described for the Proposed Action. Alternative 1c would affect about 406 acres of mule deer summer range, which would have a minor effect on the mule deer herd.

Alternative 1c would affect smaller amounts of USFS wildlife habitats at Gross Reservoir than the Proposed Action (Table 5.9-3), including existing old growth, developing old growth, forested corridors, open corridors, effective habitat, and interior forests. As with the Proposed Action, losses of inventoried and developing old growth and reductions in effective habitat may be in conflict with ARNF management goals. Losses of forested and open corridor would occur adjacent to the existing reservoir and would not cause a reduction in connectedness.

Alternative 1c impacts to MIS species at Gross Reservoir would be similar to the Proposed Action; Alternative 1c would have a smaller footprint and would affect a smaller amount of habitat for each of the species. In addition to elk and mule deer, described above, Alternative 1c would affect about 133 acres of pygmy nuthatch habitat (existing and potential old growth), about 165 acres of hairy woodpecker habitat (forests), and about 35 acres of mountain bluebird habitat (openings). Impacts to these species would reduce local populations but would be minor on a regional basis. Alternative 1c would also remove about 4.4 acres of warbling vireo habitat, a negligible impact. Golden-crowned kinglet and Wilson's warbler are unlikely to breed in the Gross Reservoir study area, and loss of habitat is expected to have a negligible effect on migrating birds. There would be no impacts to Rocky Mountain bighorn sheep or boreal toad in the Gross Reservoir area.

Impacts to sensitive areas would be reduced compared to the Proposed Action. As shown in Table 5.9-3, the Winiger Gulch PCA at Gross Reservoir would be permanently impacted by reservoir filling resulting in 42.0 acres of impact at Gross Reservoir. Under Alternative 1c, 2.2% of the PCA area Winiger Gulch PCA would be lost to the expanded reservoir. The Winiger Ridge ECA would lose 144.2 acres (4.1%) to inundation.

5.9.2.2 Leyden Gulch Reservoir Site

Habitats affected by construction and operation of the proposed Leyden Gulch Reservoir include grassland/forb mix, foothills deciduous shrub, wetlands, rural residential (deciduous trees, ornamental plantings), open water (South Boulder Diversion Canal), and disturbed/unvegetated. Table 5.9-5 shows the acres of direct impact to these habitats in the Leyden Gulch study area under Alternative 1c. Vegetation temporarily disturbed or removed would be revegetated following construction.

Table 5.9-5
Direct Impacts to Wildlife Habitat at the
Leyden Gulch Reservoir Site Under Alternative 1c

Wildlife Community	Acres of Direct Impact	
	Permanent	Temporary
Cottonwood	0.0	8.7
Foothills deciduous shrub	2.1	4.6
Wetland	6.2	14.7
Open Water	0.1	1.3
Rural Residential	0.1	0.3
Grass/Forb mix	374.8	143.5
Disturbed/Unvegetated	5.7	3.3
Total	**389.0**	**176.4**

The proposed Leyden Gulch Reservoir would be maintained more or less at capacity except in an extended drought, although the water levels would fluctuate during operation. At the normal water level of 6,124 feet the reservoir would have a capacity of approximately 31,300 AF and the surface area would be 332 acres. Monthly average, dry, and wet end-of-month contents would be approximately 28,000 AF to 31,000 AF or up to 3,000 AF below capacity (Table H-2.22). These averages reflect drawdowns that would occur in drought years. Annually, water levels would be highest from June to December, which would allow herbaceous wetland vegetation to establish around the shoreline. These wetlands would provide cover and habitat for wildlife, including nesting and foraging waterfowl. Over the long term, deciduous riparian woodland, such as cottonwoods and willows may establish in areas around the shoreline, which would support migratory birds, raptors, and small mammals. However, if noxious weeds become established in these areas, they could invade and degrade adjacent habitats, reducing the quality of habitat surrounding the reservoir for wildlife use.

Big Game

The primary impacts to big game are loss and fragmentation of habitat from reservoir construction. Construction of the reservoir would permanently remove approximately 383 acres of habitat for the dam and reservoir, and would temporarily affect 172 acres of big game habitat. Mule deer occur in the Leyden Gulch study area during both summer and winter, while elk are present during winter. Wintering elk and deer would experience more stress from habitat loss, because resources are more limited. However, creation of Leyden Gulch Reservoir would not measurably affect big game populations as no critical habitats would be affected.

After reservoir construction and filling, the 31,300 AF-reservoir would prevent these animals from directly moving east-west, although this area is not considered an important migratory corridor. Animals would be required to travel around the reservoir. In addition, the reservoir may be hazardous to big game that try to cross thin ice or try to cross over the ice when predators such as coyotes or mountain lions are present.

As described for Gross Reservoir under the Proposed Action, mule deer and other big game would likely be displaced from the area while construction is occurring.

Black bear primarily use the Ralston Creek corridor. Black bear would be temporarily displaced from this area during construction activity. Bears would likely return to the area following construction. Mountain lions would likely avoid the area during construction. Conflicts between humans and these animals would likely increase during operations due to the increased human presence in the area for reservoir operation and maintenance.

Carnivores, Medium- and Small-sized Mammals

Direct impacts to medium- and small-sized mammals would include loss and fragmentation of habitat, displacement, and mortality. The reservoir creates a barrier to movement and smaller bodied mammals would have to travel longer distances to find suitable habitat. Like big game, more mobile mammals would be displaced from the area during construction. Small mammals would likely be crushed or buried during earth-moving activities as these animals are less able to travel to avoid noise and ground-disturbance.

Prairie dog colonies in the reservoir footprint are small and isolated and are at the western boundary of the species range. Denver Water controls the prairie dogs within the reservoir Project area. Construction of the reservoir would remove 7.2 acres of black-tailed prairie dog colonies and eliminate approximately 380 acres of potential prairie dog habitat during reservoir construction and inundation. Besides the mortality of prairie dogs, the proposed reservoir would eliminate habitat for numerous other species that are associated with prairie dog colonies.

Raptors

During field surveys, a red-tailed hawk nest was observed along Ralston Creek (refer to Figure 3.9-4). Construction of the South Boulder Diversion Canal pipeline and associated staging would occur within 0.25 mile of the nest. Disturbance to active nests along the riparian corridor could result in nest abandonment and loss of eggs or young, a violation of the Migratory Bird Treaty Act. A nest survey should be conducted prior to construction to determine numbers and locations of active raptor nests in the Project area and construction avoided in the vicinity of action nests until chicks have fledged.

As mentioned above, the prairie dog colonies in the study area provide foraging habitat for raptors. The reservoir would permanently eliminate this habitat.

Other Birds

The primary impact to migratory birds would be loss of habitat from the reservoir and displacement during construction. After reservoir construction, the reservoir footprint and associated facilities would be unsuitable for most migratory land bird use during breeding, foraging, or migration. Some bird species that forage over open water, such as swallows, would benefit from the reservoir. Very few trees are present in the reservoir footprint, but nests may occur in these trees or on the ground. If vegetation clearing or construction occurs during the general nesting season (May through July), active nests may be destroyed, resulting in a violation of the Migratory Bird Treaty Act.

Operation of the reservoir would be beneficial to waterfowl, shorebirds, and other water birds. The reservoir would provide an average of 332 acres of open water habitat, depending on water level. For waterfowl, the reservoir would provide resting and loafing areas and potential foraging habitat. Although the reservoir would not be stocked with fish, some rainbow trout, brown trout, and other species may enter the reservoir through the South Boulder Diversion Canal. These fish would provide a food source for piscivorous birds such as cormorants and herons.

Herbaceous vegetation is likely to become established along the shoreline since water elevations would generally remain stable during summer months. Over the long term, cottonwood and willow and herbaceous wetland vegetation may become established in some areas around the reservoir. Therefore, nesting habitat for waterfowl would develop along the shoreline in wetland vegetation. The shoreline would also be used by shorebirds, primarily those in migration.

Reptiles and Amphibians

Similar to impacts described for small mammals, less mobile reptiles and amphibians such as toads and frogs would be crushed or buried by construction equipment during vegetation clearing and ground disturbance. More mobile species such as snakes may be able to avoid construction activities, though unlikely due to the large area that would be disturbed. The new reservoir and shoreline would provide new habitat for some species of reptiles or amphibians, because the stable water elevations during the summer would promote establishment of wetland herbaceous vegetation and riparian shrubs and trees around the perimeter.

Sensitive Areas

The CNHP-designated Rocky Flats PCA overlaps the northern portion of the Leyden Gulch study area (refer to Figure 3.9-3). A 2.5-acre (less than 1%) portion of the PCA would be temporarily impacted for a 41-acre construction staging and spoil area located north of the reservoir. This area would store the excavated material from the reservoir pool area prior to the dam construction and earth-moving equipment would be entering and exiting the area. As stated in Section 2.4.2.2, the staging area would be restored to its approximate existing condition following the completion of the reservoir. This would primarily impact habitat for migratory birds until revegetation is completed.

5.9.2.3 River Segments

Impacts would be similar to those described under the Proposed Action. Changes in flow and resulting changes in wildlife habitats would be the same or nearly the same, and would be negligible to minor along the various stream segments.

5.9.3 Alternative 8a

5.9.3.1 Gross Reservoir

Impacts to wildlife and wildlife habitat under Alternative 8a would be similar to those described under the Proposed Action, but less as Alternative 8a would result in only a

52,000 AF enlargement. Impacts to wildlife would be similar to the Proposed Action, though less habitat would be removed under Alternative 8a, as shown in Table 5.9-1. The enlarged reservoir would still result in loss and fragmentation of habitat, as described under the Proposed Action. In riparian areas such as Winiger Gulch and Forsythe Canyon, Alternative 8a would result in slightly less fragmentation as the water level would be lower. Approximately 2,140 feet of South Boulder Creek and 1,780 feet of Winiger Gulch would become inundated and a barrier for terrestrial wildlife.

The loss of elk winter concentration represents approximately 1.1% of the habitat in the map unit; 0.25% of this loss would be temporary. Approximately 1.5% of elk severe winter range in the map unit would be lost due to reservoir expansion; 0.3% would be temporary impact to severe winter range. Direct losses of habitat would be less than the Proposed Action, and would be less than 1% of the habitat available to the Clear Creek elk herd, a minor impact. About 5.9% of the migration corridor would be lost due to the Proposed Action, of which about 1.3% would be temporary impact. Permanent loss of portions of the migration corridor would likely cause changes in elk migration patterns, as described for the Proposed Action. Alternative 8a would affect about 461 acres of mule deer summer range, which would have a minor effect on the mule deer herd.

Alternative 8a would affect smaller amounts of USFS wildlife habitats at Gross Reservoir than the Proposed Action but more than Alternative 1c (Table 5.9-3). These habitats include existing old growth, developing old growth, forested corridors, open corridors, effective habitat, and interior forests. As with the Proposed Action, losses of inventoried and developing old growth and reductions in effective habitat may be in conflict with ARNF management goals. Losses of forested and open corridor would occur adjacent to the existing reservoir and would not cause a reduction in connectedness.

Alternative 8a impacts to MIS species at Gross Reservoir would be similar to the Proposed Action, although Alternative 8a would have a smaller footprint and would affect a smaller amount of habitat for each of the species. In addition to elk and mule deer, described above, Alternative 8a would affect about 159 acres of pygmy nuthatch habitat (existing and potential old growth), about 203 acres of hairy woodpecker habitat (forests), and about 39 acres of mountain bluebird habitat (openings). Impacts to these species would reduce local populations but would be minor on a regional basis. Alternative 8a would also remove about 4.9 acres of warbling vireo habitat, a negligible impact. Golden-crowned kinglet and Wilson's warbler are unlikely to breed in the Gross Reservoir study area, and loss of habitat is expected to have a negligible effect on migrating birds. There would be no impacts to Rocky Mountain bighorn sheep or boreal toad in the Gross Reservoir area.

Under Alternative 8a, direct impact to the Winiger Gulch PCA includes inundation of 53.1 acres (2.8% of total PCA area). The Winiger Ridge ECA would lose 180.6 acres (5.1%) to inundation.

5.9.3.2 South Platte River Facilities

Gravel Pits

The gravel pits will already be excavated so no additional ground disturbance would occur and no adverse impacts from gravel pit construction is expected. Filling and operation of

the gravel pit reservoirs would provide a beneficial impact to wildlife because approximately 5,000 AF (approximately 200 acres) of open water habitat would be created for waterfowl, shorebirds, migratory birds, as well as for amphibians and reptiles. Areas that become vegetated along the shoreline may provide nesting habitat for mallards, geese, and red-winged blackbirds. Use of the gravel pits would not cause habitat fragmentation because they already exist and their location does not block movement along the South Platte River corridor.

Gravel Pit Pipelines

Impacts would primarily be limited to disturbance during construction as the pipeline would mostly be placed within existing road right-of-ways (ROWs). Construction of pipelines would temporarily affect aquatic and upland habitat along the South Platte River.

Diversion Structure

The diversion structure includes a 750-foot buried 54-inch pipe connected to southern gravel pit (Worthing Pit). The diversion structure would be constructed in the South Platte River near the Worthing Pit. Impacts to wildlife from construction would include temporary disturbance for the duration of construction. The pipeline would follow an existing gravel road and construction staging would be temporary. A raptor nest was identified in the vicinity of the diversion structure in 2005. Surveys for raptor nests would be needed prior to construction to determine locations of active nests.

Advanced Water Treatment Plant (AWTP)

Construction of the AWTP adjacent to the Worthing Pit would result in a permanent impact to 4 acres of habitat and temporary disturbance to 7 acres. However, as described in Section 3.9.3.4, the site of the AWTP is not good quality wildlife habitat due to the lack of vegetation.

Sensitive Areas

Most of the South Platte River Facilities would be located in the South Platte River PCA and the diversion dam and outlet structure would also be located in the South Platte River Greenway. Alternative 8a would involve both temporary and permanent impacts within these areas. Because much of the habitat is already disturbed and the South Platte River Facilities would occupy only a small part of the PCA and Greenway, construction of these facilities would not adversely affect the viability of the PCA or Greenway.

5.9.3.3 Conduit O

Conduit O is a new 36-inch diameter pipeline that would extend between the Moffat Collection System delivery point at SH 72 (South Boulder Diversion Canal) and the proposed advanced water treatment along Brighton Boulevard (Figure 2-9). It is assumed that the conduit would be constructed within existing roadways (curb-to-curb). Crossing of the South Platte River and Farmer's Highline and Croke canals would be open cut per Denver Water's standard method (see Section 2.8.3 for a detailed description of this method). Each crossing would be completed in 20 working days, depending on weather and other conditions.

Construction of Conduit O would occur within the existing road ROWs. Habitats adjacent to or crossed by Conduit O include grassland, urban/developed, riparian and wetland, and open water. Riparian habitats crossed include Farmers Highline and Croke canals, and the South Platte River. Permanent impacts to 0.08 acre of grassland wildlife habitat would occur from construction of the dechlorination facility at the western end of Conduit O.

Big Game

The only big game animals likely to occur along Conduit O are elk, mule deer, and white-tailed deer. Elk may occur in the western portion of the conduit (near the Rocky Flats National Wildlife Refuge) between May and June, during calving season. Elk may cross SH 93 in the vicinity of SH 72, but calving would be unlikely to occur near or at the conduit. Mule deer and white-tailed deer would occur along the major riparian corridors, primarily the South Platte River, crossed by Conduit O. Deer would likely avoid areas during construction.

Small- and Medium-sized Mammals

Small, less mobile mammal species would incur direct impacts from mortality. These species would likely be crushed or buried during earth-moving activities. Medium-sized mammals such as coyotes, foxes, and raccoons, would temporarily avoid construction areas for the duration of construction. No prairie dog colonies would be impacted by construction of Conduit O.

Raptors

During 2005 surveys, raptor nests were identified at the eastern terminus of Conduit O as shown in Figure 3.9-4. If construction begins after the start of the nesting season (generally March 15 to July 31), construction activity may remove trees with active nests or cause abandonment of active nests in the vicinity of construction, resulting in loss of eggs or young. Destruction of an active nest or activities that result in nest failure would be a violation of the Migratory Bird Treaty Act. A nest survey should be conducted prior to construction to determine whether active nests are present, and construction avoided in the vicinity of active nests until chicks have fledged.

Other Birds

Construction of Conduit O at riparian crossings, including Croke and Farmers Highline canals and South Platte River would potentially disrupt nesting activity of waterfowl and other birds. If construction begins after the start of the nesting season (generally April 1 to July 31), construction activity may remove trees with active nests or cause nest abandonment, resulting in loss of eggs or young. Destruction of an active nest or activities that result in nest failure would be a violation of the Migratory Bird Treaty Act.

Reptiles and Amphibians

Impacts to reptiles and amphibians would be limited since construction of Conduit O would occur in the existing roads. Conduit construction at riparian crossings has the potential to kill or crush reptiles and amphibians during trenching. More mobile species may avoid

earth-moving activities, though smaller less mobile species would be crushed or buried by construction.

Sensitive Areas

As shown in Table 5.9-3, sensitive areas along the South Platte River would be impacted under Alternative 8a from construction of the South Platte River Facilities and Conduit O where it crosses the South Platte River. The crossing of Conduit O over the South Platte River would be located in both the South Platte River PCA and South Platte River Greenway. A small area of habitat would be temporarily affected during construction. Because of the small area and temporary impacts, construction of the crossing would not adversely affect these areas.

5.9.3.4 River Segments

Impacts would be similar to those described under the Proposed Action. Changes in flow and resulting changes in wildlife habitats would be the same or nearly the same, and would be negligible to minor along the various stream segments.

5.9.4 Alternative 10a

5.9.4.1 Gross Reservoir

Impacts to wildlife and wildlife habitat under Alternative 10a would be the same as described under Alternative 8a.

5.9.4.2 Denver Basin Aquifer Facilities

Construction of the AWTP, which would occupy approximately 4.0 acres, would be unlikely to disturb wildlife due to the urban/industrial land use in the vicinity of the AWTP site. Well sites would be within recreational parks and not likely to disturb wildlife due to high levels of current human activity.

The aquifer distribution pipelines would consist of approximately 36 miles of 12- to 48-inch pipeline, buried curb-to-curb and within urban utility corridors. This pipeline would cross Clear Creek, the South Platte River, Cherry Creek in three locations, and Sand Creek. Two of the Cherry Creek crossings are in highly urban areas, and wildlife impacts are not expected. Cottonwood/peachleaf willow woodland is present at the southern South Platte River crossing, the Sand Creek crossing, and the most eastern crossing of Cherry Creek. Impacts to wildlife at these crossings would be temporary and consist of disturbance during construction activities, as well as mortality to smaller animals from crushing or burial from earth-moving. Construction of these facilities would not adversely affect the viability of the South Platte River PCA or Greenway.

5.9.4.3 Conduit M

The alignment for Conduit M is the same for Conduit O between the Moffat Collection System delivery point and the intersection of 80th Avenue and Pierce Street. Habitats adjacent to and crossed by Conduit M include grassland, urban/developed, riparian and wetland, and open water. Riparian habitats crossed include Farmers Highline and Croke

canals, Little Dry Creek, Clear Creek, and the South Platte River. Less than 0.01 acre of cottonwood/willow riparian woodland habitat would be impacted at Little Dry Creek, while no habitat would be permanently or temporarily impacted by construction of Conduit M.

The impacts to wildlife from the western terminus to 80th Avenue and Pierce Street would be the same as described under Conduit O for Alternative 8a. Impacts to wildlife from construction of Conduit M east of this point are discussed below.

Big Game

Mule deer and white-tailed deer inhabiting the Clear Creek and South Platte River corridors would be disturbed during construction activities. Disturbance to individual deer would result in avoidance of construction zones for the duration of activity. However, movement patterns would be expected to return to normal following construction.

Small- and Medium-sized Mammals

Impacts to other mammals from construction of Conduit M would be similar to those described for Conduit O.

Birds

Impacts to birds from construction of Conduit M would be similar to those described for Conduit O.

Reptiles and Amphibians

Impacts to reptiles and amphibians from construction of Conduit M would be similar to those described for Conduit O.

Sensitive Areas

Impacts to sensitive areas would be similar to those as described for Alternative 8a for Conduit O. The crossing of Conduit M over the South Platte River would be located in both the South Platte River PCA and South Platte River Greenway and one of the pump stations would be located in the PCA. A small area of habitat would be temporarily affected during construction. Because much of the habitat is already disturbed and these facilities would occupy only a small part of the PCA and Greenway, construction of these facilities would not adversely affect the viability of the PCA or Greenway.

5.9.4.4 River Segments

Impacts would be the same as described for Alternative 8a.

5.9.5 Alternative 13a

5.9.5.1 Gross Reservoir

Impacts to wildlife and wildlife habitat under Alternative 13a would be similar to those described under the Proposed Action, but less as Alternative 13a would result in only a 60,000 AF enlargement compared to a 77,000 AF enlargement. Impacts to wildlife would

be similar to the Proposed Action, though less habitat would be removed under Alternative 13a, as shown in Table 5.9-1 and Figure 2-3. The enlarged reservoir would still result in loss and fragmentation of habitat, as described under the Proposed Action. In riparian areas such as Winiger Gulch and Forsythe Canyon, Alternative 13a would result in slightly less fragmentation because the water level would be lower. Approximately 2,320 feet of South Boulder Creek and 2,045 linear feet of Winiger Gulch would become inundated and a barrier for terrestrial wildlife.

The loss of elk winter habitat represents approximately 1.2% of the habitat in the map unit; 0.25% of this loss would be temporary. Approximately 1.6% of elk severe winter range in the map unit would be lost due to reservoir expansion; including about 0.3% of temporary impacts to severe winter range. Direct losses of habitat would be less than the Proposed Action, and would be less than 1% of the habitat available to the Clear Creek elk herd, a minor impact. About 6.5% of the migration corridor would be lost due to the Proposed Action, of which about 1.3% would be temporary impact. Permanent loss of portions of the migration corridor would likely cause changes in elk migration patterns, as described for the Proposed Action. Alternative 13a would affect about 515 acres of mule deer summer range, which would have a minor effect on the mule deer herd.

Alternative 13a would affect smaller amounts of USFS wildlife habitats at Gross Reservoir than the Proposed Action but more than Alternatives 1c, 8a, or 10a (Table 5.9-3). The affected habitats include existing old growth, developing old growth, forested corridors, open corridors, effective habitat and interior forests. As with the Proposed Action, losses of inventoried and developing old growth and reductions in effective habitat may be in conflict with ARNF management goals. Losses of forested and open corridor would occur adjacent to the existing reservoir and would not cause a reduction in connectedness.

Alternative 13a impacts to MIS species at Gross Reservoir would be similar to the Proposed Action. Alternative 13a would have a smaller footprint and would affect a smaller amount of habitat for each of the species than the Proposed Action, but more than Alternatives 1c, 8a, or 10a. In addition to elk and mule deer, described above, Alternative 13a would affect about 177 acres of pygmy nuthatch habitat (existing and potential old growth), about 231 acres of hairy woodpecker habitat (forests), and about 44 acres of mountain bluebird habitat (openings). Impacts to these species would reduce local populations but would be minor on a regional basis. Alternative 13a would also remove about 5.3 acres of warbling vireo habitat, a negligible impact. Golden-crowned kinglet and Wilson's warbler are unlikely to breed in the Gross Reservoir study area, and loss of habitat is expected to have a negligible effect on migrating birds. There would be no impacts to Rocky Mountain bighorn sheep or boreal toad in the Gross Reservoir area.

As shown in Table 5.9-3, under Alternative 13a, direct impact to the Winiger Gulch PCA includes inundation of 61.6 acres (3.2% of total PCA area). The Winiger Ridge ECA would lose 211.8 acres (6.1%) to inundation.

5.9.5.2 South Platte River Facilities

Impacts from gravel pits would be similar to those described under Alternative 8A, except under Alternative 13a only 3,625 AF of open water habitat would be created. Additionally, the gravel pit pipeline would extend 5 miles to the northern Challenger Pit and would cross

the South Platte River at Bridge Street. Impacts at this crossing would be similar to those described under Alternative 8a for Conduit O crossing of the South Platte River.

Transfer of agricultural water rights would result in conversion of about 3,900 acres of irrigated land to dryland agriculture, as well as loss of about 82 acres of wetlands and 8 acres of surface water in ditches and ponds. Most of the affected area is likely to have low to moderate value for wildlife. Although these land use changes would affect the numbers and types of animals in the affected area, the wildlife of the affected area would continue to be dominated by species adapted to rural habitats, and most of the species currently present would continue to be present. Species adapted to aquatic habitat and to more mesic environments are likely to decrease, such as red-winged blackbird, raccoon, ring-necked pheasant, waterfowl, garter snakes, turtles, and frogs. Migratory birds that feed on waste corn would have reduced foraging habitat. The area of upland grasslands is likely to increase and species adapted to this habitat may increase. Prairie dog towns are likely to expand. Trees and shrubs growing along irrigation ditches may have reduced growth or be killed by drought, resulting in a minor loss of habitat for breeding birds. The lower vegetation productivity of non-irrigated land may result in a reduction of prey base for raptors and other carnivores, but increases in prairie dogs would be beneficial.

5.9.5.3 Conduit O

Impacts from construction of Conduit O would be similar to those described for Alternative 8a.

5.9.5.4 River Segments

Impacts would be similar to those described under the Proposed Action. Changes in flow and resulting changes in wildlife habitats would be the same or nearly the same and would be negligible to minor along the various stream segments.

5.9.6 No Action Alternative

The No Action Alternative (i.e., both the Depletion of the Strategic Water Reserve Strategy and Combination Strategy) would not result in any direct effects to habitat because no ground-disturbing Project components would be implemented. Changes in operation of the existing system would result in changes in stream flows, which would result in only minor changes in the extent and type of riparian habitat (Section 5.8.6). Therefore, similar to the Proposed Action, implementation of the No Action Alternative would not have a noticeable effect on wildlife habitat or species.

5.9.7 Mitigation and Monitoring

Denver Water prepared the Moffat Collection System Project Fish and Wildlife Mitigation Plan, which has been approved by the Colorado Wildlife Commission and is provided in Appendix M. Mitigation relevant to wildlife includes compliance with the Migratory Bird Treaty Act, use of CPW's Best Management Practices (BMPs) for wildlife, implementation of revegetation, forest management and weed control, and development of woody riparian plant communities around Gross Reservoir.

Mitigation measures listed in the Final EIS Section 5.7.7 for vegetation and Section 5.8.7 for riparian and wetlands areas would minimize adverse effects to wildlife habitat. These include revegetation, weed management, compensatory mitigation for wetland impacts, and construction practices that minimize impacts from sedimentation and erosion. Additional mitigations for wildlife and wildlife habitat may include the following:

Wildlife Habitat

- During construction, vehicle operation would be limited to designated construction areas, and the limits of the construction area would be fenced where they are adjacent to sensitive habitats including prairie dog towns, riparian areas, wetlands, and upland trees and shrubs.
- Silt fencing, erosion logs, temporary berms, and other BMPs would be used to prevent degradation of habitats adjacent to the construction area by transport of eroded sediment.
- Temporarily disturbed areas would be seeded with an appropriate mixture of native grasses and forbs; shrubs would be planted where appropriate.
- Open cut streams would be restored equal to or better than pre-construction conditions. To control erosion, bioengineering or the use of plants to control erosion would be preferred instead of riprap or other unnatural bank stabilization techniques. Banks would be planted with native plant species.

Raptors

- If practicable, trees in the construction footprint would be cleared prior to March 1 or after July 31 to prevent raptors (and other birds) from nesting on site and avoid take of or disturbance to active nests during the breeding season. If construction begins after March 1 or prior to July 31, nest surveys would be conducted prior to construction to ensure that no active nests are present in or near the construction footprint.
- Surveys would be conducted during an appropriate season (generally April 1 through June 1) to determine presence of active raptor nests. Surveys may need to be conducted at multiple times to address all species, including owls.
- If an active nest is located, protective buffer zones would be established around active nests during construction to avoid disturbance while nesting. Buffer zones and seasonal restrictions would be based on CPW recommendations (CDOW 2008b) and on consultation with CPW.
- Within deciduous riparian woodland, individual trees removed would be replaced as specified by State and Federal wildlife agencies to ensure raptor perch trees are replaced for future use. New trees would be planted near areas that naturally receive adequate water, such as near drainage areas or wetlands. Sapling trees in riparian mitigation areas may require initial watering for establishment.

Migratory Birds

Destruction or disturbance of nests that results in loss of eggs or young is a violation of the Migratory Bird Treaty Act. To comply with the Act, land-clearing activities would be timed to avoid the breeding season to avoid impacts to active bird nests. If clearing during the breeding season cannot be avoided, compliance would occur by surveys and avoidance of active nests until young are fledged. In Denver Water's Moffat Collection System Project Fish and Wildlife Mitigation Plan, which has been approved by the Colorado Wildlife Commission, Denver Water has committed to use of pre-construction surveys to identify active nests in the Project footprint and timing of activities to avoid the breeding season.

5.9.7.1 Gravel Pit Habitat Management

Under Alternatives 8a, 10a, and 13a, the gravel pit storage reservoirs are within the 17-mile reach covered by the South Platte River Heritage Corridor Plan (Adams County 1997). The goal of this plan is to protect and restore the special qualities of the South Platte River corridor between Denver and Brighton. A portion of the proposed South Platte Heritage Project Trail Corridor would traverse the study area north of Worthing Pit, and connect to trails along the river. The Platte River trail is planned to extend along the northern edge of the study area to the Adams County line. The goal is development of habitat features that address the needs of multiple species, in order to enhance ecological diversity and productivity in the South Platte riparian corridor.

The gravel pit reservoirs are located in a riparian corridor and are therefore likely to be used by waterfowl, bald eagles, and other wildlife. The following are guidelines and considerations for enhancement of wildlife habitat in the gravel pit reservoirs and adjoining riparian and upland habitats.

- Provide for interconnection with open spaces and natural areas along the South Platte River consistent with the goals and guidelines of the South Platte River Heritage Corridor Plan (Adams County 1997).
- Enable completion of South Platte River trail and other trail links, so that the study area is integrated with local and regional trail system.
- Maintain the ecological value of riparian habitat
- Habitat improvements along the shore and within the gravel pit reservoirs should be located mostly in the western portions adjacent to the South Platte River.
- Develop multi-species wildlife habitat in the gravel pit storage reservoirs and adjoining lands.
- Stocking of non-game fish in Leyden Gulch Reservoir or the gravel pit reservoirs would improve habitat for piscivorous wildlife foraging in the reservoirs.

- Creation of habitat diversity within the reservoirs would enhance food sources of piscivorous wildlife by increasing warmwater fish populations. These may include shallow shelves that promote spawning; artificial reefs along the shore of scrap concrete, boulder-sized riprap, old irrigation or sewer pipe, anchored tree trunks, Christmas trees, or brush bundles; willows or large riprap along the shore; and shallows with aquatic plants. Structures should be placed so that they extend at least 3 feet above the bottom of the gravel pit after settling.
- Use fencing that provides adequate security for the reservoir complex but does not interfere with floods, aesthetic values, or wildlife habitat use.
- Use shoreline vegetation to accomplish multiple purposes, including wildlife habitat, restriction of public access, and shoreline stabilization.
- Exposed structures like boulders should be used to provide basking areas for turtles and snakes, and loafing platforms for birds.
- Snags (dead trees) can be set along the shoreline or on islands to provide perching habitat for bald eagles and other species.
- Piles of rocks within wetlands or along the shore may be used as snake hibernacula.
- Nest boxes, nest platforms, and nest structures can be used to enhance reproduction for specific bird species.
- Small earthen or rock mounds with a 6-foot diameter flat top can also be developed to provide nesting habitat for some species in areas that would have water throughout the breeding season.
- Placement of 2-inch gravel on gradually sloping areas would promote use by shorebirds.
- If present, areas of high ground water can be used to support riparian shrub and tree species such as cottonwood, willows, wild rose, golden current, hawthorn, skunkbush sumac, and chokecherry. Cottonwoods should not be planted immediately adjacent to the reservoir to reduce the potential for disruption of the liner. These shrubs and trees would provide habitat, visual interest to people using trails, and screening of the fences and reservoirs. Existing riparian areas near the gravel pit lakes should get an adequate water supply to maintain habitat quality.
- All disturbed areas not needed for reservoir operations should be revegetated, for habitat, visual appeal, and to reduce the potential for noxious weeds. A noxious weed plan should be developed to help control noxious weeds that already occur or are likely to occur, such as leafy spurge, Canada thistle, whitetop, and Scotch thistle.

5.9.8 Unavoidable Adverse Impacts

The Moffat Project would unavoidably result in the loss of habitat for big game, other mammals, migratory birds and raptors, and reptiles and amphibians throughout the Project area. In addition, the Moffat Project would displace wildlife from construction zones and create barriers to wildlife movement and temporarily fragment habitat, especially construction of the proposed Leyden Gulch Reservoir and expansion of Gross Reservoir.

The Moffat Project would unavoidably cause disturbance to existing vegetation in temporarily affected areas, but habitat values can be restored through successful revegetation. It would also result in unavoidable increase in the potential for noxious weed invasions, but degradation of habitat can be avoided by weed control. The Moffat Project would create new lake habitat and would create opportunities for habitat preservation and enhancement at the reservoirs, gravel storage pits, and diversion sites.

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5.10 SPECIAL STATUS SPECIES

This section describes the direct and indirect impacts to special status species expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Several potential special status species issues related to stream flow changes and Project construction were identified during scoping:

- Impact on threatened and endangered species in the Colorado River Basin.
- Impacts to the four endangered fish species in the 15-mile reach of the Colorado River near Grand Junction and the relationship between Moffat Project depletions and the Colorado River Endangered Species Recovery Program.
- Impact of diverting more water from the West Slope to the East Slope and the impact on the baseline and on threatened and endangered species. Refer to the Platte River Environmental Impact Statement (EIS) in considering this impact.
- Impact of additional diversions and return flows to the South Platte River Basin on endangered species in the South Platte River.
- Impact on Preble's meadow jumping mouse (Preble's) habitat.
- Coordinate with the U.S. Fish and Wildlife Service (USFWS) regarding the following issues:
  - River restoration, flow and channel modifications, wetlands, and habitat fragmentation regarding species' habitat requirements
  - Impact on boreal toad habitat and populations

5.10.1 Proposed Action (Alternative 1a)

Consultation with the USFWS is required under Section 7 of the Endangered Species Act (ESA) prior to authorization of any Federal action that may affect endangered or threatened species or critical habitat. The U.S. Army Corps of Engineers (Corps) met with the USFWS in January 2008 to initiate Section 7 consultation on the Proposed Action. A request for formal consultation and a Biological Assessment (BA) were provided to the USFWS on February 20, 2009. The USFWS issued a Biological Opinion (BO) on July 31, 2009 which evaluated and managed any potential impacts to Federal threatened or endangered species under the ESA specifically for the Board of Water Commissioners' (Denver Water's) Proposed Action (refer to Appendix G-2).

The Corps submitted a request for reinitiation of consultation on August 14, 2012, in response to a February 16, 2010 letter from USFWS commenting on the Draft EIS. After some discussion, USFWS indicated that it would provide two BOs for the Project, one addressing depletions to the Platte River and Colorado River and additional information on Preble's meadow jumping mouse, and the second addressing impacts to greenback cutthroat trout in the Fraser and Williams Fork river systems. The Corps submitted a Revised BA for depletions and Preble's on August 14, 2013 and a Final BO from the USFWS was provided

on December 6, 2013 that replaced the BO dated July 31, 2009. The conclusions in that BO are summarized by species in Sections 5.10.1.1 and 5.10.1.2.

The Corps is preparing and will submit a Supplemental BA for greenback cutthroat trout. Section 7 consultation will be completed prior to issuance of the Record of Decision (ROD). In addition, a technical report was prepared to assist the U.S. Forest Service (USFS) in meeting its guidelines and policies for management of sensitive species (refer to Appendix G-3). More specifically, the report addresses USFS Region 2 sensitive animal and plant species and communities of local concern in the Arapaho & Roosevelt National Forests (ARNF).

5.10.1.1 Gross Reservoir

The calculation of acres of impact in this section assumes disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).

Federal and State Listed Species

As discussed in Section 3.10.1.1 and shown in Appendix Table G-1, one Federally listed species, greenback cutthroat trout, has the potential to occur at Gross Reservoir. As described in Section 3.10, Preble's is not known or expected to be present at Gross Reservoir, and would not be affected by construction and expansion of the reservoir.

Greenback Cutthroat Trout

The USFWS concurred that construction and operation of the expanded reservoir are "not likely to adversely affect" this species. Although greenback cutthroat trout were stocked in Gross Reservoir in 2002 and 2004, they were not found in 2007. Hatchery raised fish are unlikely to live more than 5 years, and it is unlikely that any would be present at the time of construction. In addition, the greenback cutthroat trout stocked at Gross Reservoir appear to be of hybrid origin, and they were stocked to support a recreational fishery and not as part of a recovery effort. There is no evidence that greenback cutthroat trout have reproduced in the reservoir.

Other Special Status Species

Impacts to other special status species listed in Appendix G-3 from enlargement of Gross Reservoir would include direct and indirect, permanent and temporary impacts as described below. The primary direct impact would be loss of habitat from reservoir enlargement and the associated facilities.

Other Special Status Animal Species

Seven of the 11 special status wildlife species are migratory birds, including northern goshawk, flammulated owl, bald eagle, American tree-toed woodpecker, olive-sided flycatcher, American peregrine falcon, and black swift. Disturbance to nesting migratory birds would be avoided or minimized by procedures described in Section 5.10.7. If practicable, trees in the construction footprint would be cleared prior to March 1 or after July 31 to avoid take of or disturbance to active nests. If construction begins after March 1 or prior to July 31, nest surveys would be conducted prior to construction to minimize the

potential for impacts to active nests in or near the area of clearing. If surveys are needed, appropriate survey protocol would be used for each of the species of concern addressed by the survey.

Northern goshawk was observed on the west side of the reservoir in 2010. No nests were found, and the study area likely provides suitable foraging and/or post-fledging habitat, at least on Winiger Ridge. Disturbance to nesting goshawks would be avoided or minimized by avoidance of construction activity during the nesting season, or surveys to identify active nests and use of buffer zones and seasonal restrictions on activity in the vicinity of a goshawk nest. Colorado Parks and Wildlife (CPW) (formerly referred to as Colorado Division of Wildlife), recommends a seasonal restriction on human activity within ½ mile of active nests from March 1 through September 15 (CDOW 2008b).

In addition, construction activities could temporarily displace individuals during operation of heavy equipment and removal of timber, and inundation of the reservoir would result in a loss of foraging habitat. The Proposed Action would result in the loss of about 473 acres of forested habitat, which may affect the availability of prey. This habitat is distributed around the existing reservoir, and an unknown proportion may be used by northern goshawk. Goshawk home range size reported in North American is about 1,235 to 9,885 acres (about 1.93 to 15.4 square miles) (Kennedy et al. 2003), and therefore the loss of habitat may represent a large or small portion of a foraging territory. Displacement during construction and loss of habitat from inundation may have minor to moderate effects to one pair of northern goshawk, but it not likely to affect regional populations. The estimated northern goshawk population in Colorado is 1,250 breeding pairs (Kingery 1998).

Flammulated owl. This species is likely to occur in the Gross Reservoir study area because the study area is within the known range and includes typical habitat. Tree clearing and other construction activities have the potential to disturb and displace flammulated owls, although they are reported to be tolerant of human activity (McCallum 1994). Tree clearing would be avoided between March 1 and July 31, which generally covers the nesting period, although some young may fledge in early August. Surveys for flammulated owls would be conducted prior to tree clearing if clearing is scheduled to occur between May 10 and August 10, and seasonal buffer zones would be established around nests. Flammulated owls are neotropical migrants that are on their breeding range in Colorado from about late April/early May through October, and are actively nesting in May, June, and July.

Clearing and inundation would result in the loss of 473 acres of forest, about half of which consists of suitable mature ponderosa pine and Douglas-fir forest. The Project would affect only 1 acre of old growth forest preferred by this species. Densities of flammulated owls are typically less than one territory per 100 acres and are often 0.5 territory or less per 100 acre (McCallum 1994), and therefore the impacted area is equivalent in size to 1 to 2 territories, although it could contain portions of several territories. Territories often appear to be clumped with suitable but unoccupied habitat in between. Home ranges of flammulated owls have been reported as 27-45 acres in one study in central Colorado (Linkhart 1998), but territories were not contiguous and the study area included a large component of old ponderosa pine and Douglas-fir. Removal of trees followed by inundation would have negligible to moderate effects to flammulated owls in and near the

construction area, but would not be likely to affect regional populations. The estimated population in Colorado is 1,800 to 5,000 pairs (Kingery 1998).

American three-toed woodpecker and **olive-sided flycatcher** may occur in forested and riparian areas around the reservoir. Construction could temporarily displace individuals during operation of heavy equipment, and inundation of the reservoir would result in a loss of potential habitat. As with other migratory bird species, impacts to nesting birds would be minimized by avoidance of tree clearing between March 1 and July 31, which encompasses the breeding season. Pre-construction surveys for nests of these and other migratory bird species would be conducted if tree clearing were scheduled between March 1 and July 31. Disturbance and removal of habitat would affect individual woodpeckers and flycatchers, but would have negligible effects on regional populations.

Bald eagles may occur around Gross Reservoir during foraging or migrating. Bald eagles do not nest at Gross Reservoir and there would be no effects to nesting bald eagles. During construction, disturbance from equipment operation and earth-moving activities may temporarily disturb foraging bald eagles. Additionally, construction disturbance may affect availability of prey species. Construction of the enlarged reservoir and associated increased surface water is unlikely to adversely impact bald eagles.

American peregrine falcon and **black swift** have the potential to occur at Gross Reservoir during and after construction but are unlikely to occur regularly. Construction may have temporary, minor indirect impacts on these birds due to noise and disturbance associated with earth-moving and construction activity. Construction would not impact peregrine falcon nesting because known nesting locations are approximately 3 miles away from the reservoir. Black swift may be present on the reservoir during foraging. Impacts to **dwarf shrew** would primarily be loss of habitat and possible crushing of individuals during construction, if it is present. Impacts to **fringed myotis** and **Townsend's big-eared bat** would be limited since these species forage at night. However, individuals at day roosts located near construction activity may be displaced to other areas. Known Townsend's big-eared bat roosts are located approximately 2 miles from the reservoir site and therefore construction and operation would not impact roosting individuals.

Northern leopard frog is unlikely to occur in drainages and inlets along the reservoir, and was not found in surveys in 2010. Vegetation clearing and inundation of the expanded reservoir would remove marginally suitable habitat in these areas.

Other Special Status Plant Species

Impacts to special status plants are summarized in Table 5.10-1. The Proposed Action would not affect any USFS Region 2 sensitive species, but would affect several species of local concern in the ARNF. For several species, inundation would destroy a large portion of the known populations in the Gross Reservoir area. USFS policy, stated in Forest Service Manual 2600, is to maintain viable populations of all native and desired nonnative wildlife, fish, and plant species in habitats distributed throughout their geographic range on USFS land. Because of the size of the populations and the relatively high proportion of plants affected, Project impacts may affect the long-term viability of populations of several species within the ARNF. Mitigations recommended by the USFS (Popovich 2011) are provided in Section 5.10.7. Impacts to each species are discussed below.

Table 5.10-1 provides the estimated number of plants of each species that are present within the area of inundation and tree-clearing. Plants within the inundation area would be destroyed by flooding. Plants within area of tree-clearing around the reservoir perimeter could be destroyed or injured by movement of equipment and construction activity, but impacts are avoidable. Most of these species occur in open areas where tree clearing would not be necessary or would be limited. Impacts to plants in the tree-clearing area are avoidable if populations are located and marked in advance of clearing, and vehicles and mechanical equipment are not allowed to operate within the sensitive area.

Table 5.10-1
Impacts to Special Status Plant Species at Gross Reservoir

	Total Observed Population in 2010	Type of Impact	Estimated Number of Plants Affected			
			Proposed Action	Alternative 1c	Alternatives 8a and 10a	Alternative 13a
Normal water elevation (feet)	Not applicable	Inundation	7,406[1]	7,357	7,374	7,385
Maximum elevation of construction disturbance (tree-clearing along shoreline, feet)	Not applicable	Tree-clearing[2]	7,410	7,367	7,384	7,395
Wild sarsaparilla *Aralia nudicaulis*	5,082	Inundation	4,122	3,937	3,992	4,022
		Tree-clearing	20	55	0	100
Dewey sedge *Carex deweyana*	342	Inundation	156	46	59	81
		Tree-clearing	30	0	7	46
Sprengel's sedge *Carex sprengelii*	653	Inundation	593	37	457	542
		Tree-clearing	31	21	81	66
Enchantress's nightshade *Circaea alpina*	907	Inundation	706	700	700	700
		Tree-clearing	0	0	0	0
Tall blue lettuce *Lactuca biennis*	149	Inundation	115	115	115	115
		Tree-clearing	0	0	0	0
Dwarf raspberry *Rubus arcticus* ssp. *acaulis* (*Cylactis arcticus* ssp. *acaulis*)	8	Inundation and Tree-clearing	0	0	0	0
Maryland sanicle *Sanicula marilandica*	32	Inundation	17	0	7	7
		Tree-clearing	0	0	0	0
False melic *Schizachne purpurascens*	N/A (4 sites)	Inundation and Tree-clearing	3 sites	2 sites	3 sites	3 sites

Table 5.10-1 (continued)
Impacts to Special Status Plant Species at Gross Reservoir

	Total Observed Population in 2010	Type of Impact	Estimated Number of Plants Affected			
			Proposed Action	Alternative 1c	Alternatives 8a and 10a	Alternative 13a
Ferns: • Brackenfern *Pteridium aquilinum*, • Forked spleenwort *Asplenium septentrionale*, • Male fern *Dryopteris filix-mas*, • Rocky Mountain polypody *Polypodium saximontanum*, • Oregon cliff fern *Woodsia oregana* spp. *cathcartiana*	N/A	Inundation and Tree clearing	N/A	N/A	N/A	N/A

Notes:
[1]The elevation of 7,406 feet includes the Environmental Pool storage.
[2]The calculation of the noted acres assumes disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).
N/A = not available

Wild sarsaparilla. All of the action alternatives would inundate about 80 percent (%) of the wild sarsaparilla plants that were found in and near the study area, with the Proposed Action having the greatest effect. The action alternatives would affect all or nearly all of the wild sarsaparilla plants found along South Boulder Creek above the reservoir and along the two tributaries on the south side of the reservoir. About 440 plants in Forsythe Canyon and 500 in Winiger Gulch would not be affected by any of the alternatives. There are five to ten other locations of this species in the ARNF with less than a thousand individuals (Popovich 2011). The proportion of loss of this species from construction and inundation may affect viability of the local populations, but is not likely to result in a loss of viability Forest-wide. This species is not tracked by Colorado Natural Heritage Program (CNHP) and impacts at Gross Reservoir are not likely to affect overall occurrence in Colorado.

Dewey sedge. Proposed Action inundation would affect nearly half of the Dewey sedge observed, and the other alternatives would affect between about 13 and 24%. Additional plants could be damaged by tree clearing. About 140 Dewey sedge plants were observed that would not be affected by any of the alternatives, in Forsythe Canyon, Winiger Gulch, and one of the southern tributaries. Most of the observed population was in Winiger Gulch and Forsythe Canyon, where about 65 and 76 plants, respectively, would not be affected by

any alternative. The populations in the Gross Reservoir area are the only confirmed location in the ARNF (Popovich 2011), although herbarium species have been collected at several additional sites. The Proposed Action may affect viability of this species Forest-wide, but Alternatives 1c, 8a, 10a, and 13a are not likely to result in loss of Forest-wide viability. This species is not tracked by CNHP and impacts at Gross Reservoir are not likely to affect overall occurrence in Colorado.

Sprengel's sedge. Proposed Action inundation would destroy about 90% of the observed population. Impacts would be reduced under the other alternatives. Additional plants could be damaged by tree clearing. All of the 37 plants observed along Forsythe Canyon would be affected under all alternatives, and 70 to 92% of the plants in Winiger Gulch would be affected under the Proposed Action and Alternatives 8a, 10a, and 13a. None of the plants in Winiger Gulch would be affected under Alternative 1c. Under the Proposed Action, the only unaffected subpopulation would be about 50 plants in Winiger Gulch and 10 plants on the South Fork Winiger Gulch. According to Popovich (2011), the populations in the Gross Reservoir area are the only confirmed location in the ARNF although herbarium specimens have been collected from several additional locations. All of the alternatives except 1c may affect viability of this species Forest-wide. This species is tracked by CNHP and the State rating of S2S3 means it is intermediate between S2 (typically 6 to 20 known occurrences) and S3 (typically 21 to 100 known occurrences).

Enchantress's nightshade. Inundation associated with all of the alternatives would destroy about 77% of the plants of this species. All of the alternatives would affect one large group of about 500 plants in lower Winiger Gulch and about 200 plants in one of the tributaries on the south side of Gross Reservoir. About 201 plants in the South Fork of Winiger Gulch would not be affected by any of the alternatives. There are other known populations in the ARNF, and all alternatives are not likely to affect Forest-wide viability, but may affect viability of the local population. This species is not tracked by CNHP and impacts at Gross Reservoir are not likely to affect overall occurrence in Colorado.

Tall blue lettuce. One large group of 115 plants would be affected by all alternatives, and represents about 77% of the individuals that were found. Plants in Forsythe Canyon and further upstream along Winiger Gulch and the south fork of Winiger Gulch would not be affected by any of the alternatives. According to Popovich (2011), this is the only known confirmed locations in the ARNF, although herbarium specimens have been collected from several other locations. The proportionate loss of plants may affect viability of this population Forest-wide, as well as locally. This species is not tracked by CNHP and impacts at Gross Reservoir are not likely to affect overall occurrence in Colorado.

Dwarf raspberry. None of the alternatives would affect the reported location of this species, which is about 600 feet upstream of the area of impact for the Proposed Action, the alternative with the largest footprint.

Maryland sanicle. About half of the observed population of Maryland sanicle would be affected under the Proposed Action, and about a quarter for Alternatives 8a, 10a, and 13a. Alternative 1c would not affect Maryland sanicle. None of the Maryland sanicle plants at Gross Reservoir are on USFS land. The alternatives may affect the viability of the local population, especially under the Proposed Action. This species is not tracked by the CNHP, and effects to the local population are not likely to affect overall occurrence in

Colorado. The population of Maryland sanicle along the drainage south of the reservoir extends outside of the study area onto private land, and there is a good possibility that additional plants occur upstream.

False melic. Two of the locations where this species was recorded would be affected by all action alternatives. The third location in Forsythe Gulch would be affected by all action alternatives except 1c. The location reported by Shapins Associates (2002) would not be affected by any of the alternatives. The occurrences in the Gross Reservoir area are the only confirmed locations in the ARNF (Popovich 2011), although herbarium specimens have been collected at several other locations. All of the alternatives may affect the viability of this species Forest-wide as well as locally. This species is not tracked by CNHP and impacts at Gross Reservoir are not likely to affect overall occurrence in Colorado.

Ferns. The Proposed Action will affect populations of five fern species considered to be of local concern in the ARNF. These species range from uncommon to common in Colorado. One of them, Rocky Mountain polypody, is tracked by CNHP with a rating of G3/S3 and another, forked spleenwort, is watch-listed. Although populations within the inundation area would be destroyed, the Proposed Action is not likely to affect the viability of these species in the ARNF or overall occurrence in Colorado.

5.10.1.2 River Segments

Project impacts to listed species and groups of species are described below for the various rivers in the Project area.

Colorado River Endangered Fish Species

Four Federally listed endangered fish species, Colorado pikeminnow, razorback sucker, bonytail and humpback chub, occur downstream of the Project area in the Colorado River. Critical habitat for endangered Colorado River fish extends from Rifle downstream to Lake Powell. Depletions adversely affect the listed species by reducing peak spring and base flows that limit access to and the extent of off-channel waters such as backwaters, eddies, and oxbows, which are necessary as rearing areas for young fish.

Under the Proposed Action, changes in flow in the Fraser, Williams Fork, Colorado, and Blue rivers would adversely affect Colorado River fish by causing water depletions in the upper Colorado River system. Depletions of any amount are considered by the USFWS to be an adverse impact. Under the Proposed Action, average annual diversions from the upper Colorado River would increase by 10,285 acre-feet per year (AF/yr) through the Moffat Tunnel, which includes water diverted from the Fraser River and from the Williams Fork River through the Gumlick Tunnel, and 4,836 AF/yr through the Roberts Tunnel, which diverts from the Blue River. These additional diversions translate into a decrease in flow of 14,373 AF/yr (20.2 cubic feet per second [cfs]) on average in the Colorado River near Kremmling gage or 2%. Refer to Section 5.1 and Appendix Table H-3.33 for more details on diversions and flow changes. Decreases in flow in the Colorado River would be a result of Denver Water's increased diversions through the Moffat Tunnel and Roberts Tunnel.

Consultation with USFWS is required under Section 7 of the ESA prior to authorization of any Federal action that may adversely modify critical habitat, which includes alteration of

flow volume or timing (i.e., depletion). In its Final BO for the Proposed Action, the USFWS concurred that the new depletions associated with the Proposed Action would be "likely to adversely affect" the endangered fish species. In 1999, the USFWS issued a Programmatic BO with specific elements to implement the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin (Recovery Program). In 2000, Denver Water signed a Recovery Agreement with the USFWS, which governs consultations under Section 7 of the ESA regarding depletions associated with Denver Water's Facilities. In the BO, the USFWS determined that proposed depletions to the Colorado River from implementing the Proposed Action would be covered under Denver Water's Recovery Agreement. Mitigation would be done through payment of a one-time fee to cover the costs of acquisition of water rights and other recovery actions to offset the depletion effect, and would be included as a stipulation in the Section 404 Permit. Refer to Section 5.10.7.

Platte River Endangered and Threatened Species in Nebraska

Several endangered or threatened species occur downstream in the Platte River in Nebraska, including whooping crane, least tern, piping plover, pallid sturgeon, Eskimo curlew, and western prairie fringed orchid. Similar to the Colorado River, depletions to the Platte River system are considered by the USFWS to have an adverse impact on endangered species, and specifically on the four target species: whooping crane, least tern, piping plover, and pallid sturgeon. Under the Proposed Action, average annual flows at the South Platte River at the Henderson gage would increase by 2%, as shown in Appendix Table H-3.48. The increase in flows would be due primarily to Denver Water's and the City of Arvada's additional effluent returns at the Metro Wastewater Reclamation District Plant and additional return flows accruing to the river due to outdoor water usage. Increases in flow would be greatest during the winter months from October through April. During those months, Denver Water's additional direct diversions from the South Platte River are considered minimal and there would be less demand for reusable effluent.

During the summer months, flow would decrease on average by up to 1%. Denver Water's additional direct diversions and exchanges upstream would exceed the additional return flows to the South Platte River during these months. The monthly average changes in flow range from a 9% increase in December to a 1% decrease in May and June. The average annual depletion from the South Platte River Basin would be 1,607 AF. Thus, under the Proposed Action, the USFWS determined that the depletions in the South Platte River would be "likely to adversely affect" the whooping crane, least tern, pallid sturgeon, piping plover, and western prairie fringed orchid in the central and lower Platte River in Nebraska.

In 2007, the USFWS issued a Programmatic BO and began implementing the Platte River Recovery Implementation Program (PRRIP) to address water-related activities affecting flow volume and timing in the central Platte River in Nebraska. Denver Water is a member of the South Platte Water Related Activities Program, Inc. (SPWRAP), which provides continued Programmatic coverage under the PRRIP for Denver Water's existing and future South Platte River Basin water depletions. In the BO, the USFWS determined that the proposed depletions to the South Platte River from implementing the Proposed Action would be covered by Denver Water's continued participation and membership in

SPWRAP. Denver Water's annual assessments to SPWRAP help to support the water user and State of Colorado obligations under the PRRIP.

Preble's Meadow Jumping Mouse

South Boulder Creek

A population of Preble's is present downstream from Gross Reservoir along South Boulder Creek (USFWS 2006). Water released from Gross Reservoir via South Boulder Creek is diverted at the existing South Boulder Diversion Canal diversion structure. Under the Proposed Action, 985 AF of water would be diverted from South Boulder Creek. Denver Water would not divert South Boulder Creek native water between November and March if diversion caused water flow to drop below 7 cfs downstream of the South Boulder Diversion Canal diversion point.

Downstream of the South Boulder Diversion Canal, flows in South Boulder Creek would generally decrease on average because Denver Water would divert more native South Boulder Creek water, either to storage at Gross Reservoir or under their direct diversion right at the South Boulder Diversion Canal. These additional diversions would occur in wet years during peak runoff in May and June, and would reduce flows below the canal by 1,000 AF (2%, Appendix H, Table H-3.40). Wet year average annual flows would decrease by 3,000 AF (5%), and dry year flows would increase by 150 AF (<1%). Riparian habitats occupied by Preble's near South Boulder Creek would still be maintained by water supplied from irrigation canals. Therefore, the decrease in flow to South Boulder Creek in wet years is unlikely to affect Preble's habitat in occupied areas downstream of the diversion canal. The USFWS concurred in the December 6, 2013 Final BO with the determination of "not likely to adversely affect."

South Platte River

Changes in flow in the South Platte River may affect, but are unlikely to adversely affect Preble's occupied habitat in the area between Waterton Canyon and Chatfield Reservoir, and occupied habitat upstream along the South Platte River between Cheesman Reservoir and Chatfield Reservoir. Average annual flow in the stretch of the South Platte River below Cheesman Reservoir would not change, as shown in Appendix Table H-3.44. However, average monthly flows would decrease during the winter months by up to 6% in March and increase during the summer months by up to 4% in May. In general, flows below Cheesman Reservoir would be lower on average during winter months because the Moffat Water Treatment Plant (WTP) would operate in those months under the Proposed Action; therefore, releases of stored water to Strontia Springs Reservoir would decrease.

Average annual flows would decrease on average at the South Platte River at Waterton gage by 3%, as shown in Appendix Table H-3.45. Average monthly flows would increase by up to 6% in November and decrease by up to 5% in June. Denver Water's direct diversions and exchanges to Strontia Springs Reservoir and Conduit 20 would change primarily in response to changes in Moffat WTP operations and the shift in seasonal operations between Denver Water's northern and southern WTPs, as well as the overall higher level of demand that would be met under the Proposed Action. As a result, South Platte River flows at the Waterton gage would decrease on average in the summer months. There would be little change in flows at Waterton gage in most winter months from

October through March; however, flow increases would occasionally occur. Increases in flows would be primarily in response to increased direct diversions and exchanges and the impact of load shifting between Denver Water's WTPs. Because flows would not be reduced in dry years, and would have relatively small changes in average and wet years, Project-related changes are unlikely to adversely affect Preble's or its habitat along the South Platte River. The USFWS concurred in the December 6, 2013 Final BO with the determination of "not likely to adversely affect."

North Fork South Platte River

Changes in flow under the Proposed Action in the North Fork South Platte River may affect, but are unlikely to adversely affect Preble's occupied habitat. Changes in flow would occur because of the shift in seasonal operations between Denver Water's northern and southern WTPs. Deliveries through the Roberts Tunnel would be lower in winter and higher in summer. Average annual flow would increase by 3%, as shown in Appendix Table H-3.41. Average monthly flows would decrease during the winter months of November to March by 25 to 30% and would increase by 13 to 29% during the months of May through September. Dry year annual flows would increase by about 1%, and wet year annual flows would decrease by about 2%. Changes in winter flows would be generally similar (as a percentage) in average, dry and wet years. Increases in summer flows would be less and for shorter periods during dry and wet years than during average years. Because flows would increase during the growing season, changes in flows are unlikely to adversely affect Preble's habitat. Reductions in flow during the winter months are unlikely to affect the availability or use of hibernacula.

Greenback Cutthroat Trout and Colorado River Cutthroat Trout

All of the core conservation populations of Colorado River lineage and greenback lineage cutthroat trout populations in the Fraser and Williams Fork tributaries from which water is diverted, occur above the diversions. The diversions are mostly considered to be complete or partial barriers, and all of the populations are described by Hirsch et al. (2006) as isolated with the exception of North, Middle, and South Fork Ranch Creek, which are considered weakly connected. Fish that move downstream of the diversions are therefore generally lost to the populations above the diversions. The source populations would not be affected by the flow changes below the diversions. Changes in flows below the diversions have the potential to affect individual fish, but would not affect the conservation populations.

The diversions do not include screens to prevent entrainment, and entrainment is likely to occur. The Project alternatives do not include any physical modifications to the diversion structures or operations with the exception of increased water diversions. The diversion structures are therefore not analyzed in the EIS. The risk of entrainment from operation of the Moffat Collection System is expected to increase because of the increased water diversions. Current rates of entrainment are unknown. Given the small size of the stream segments above them, the existing Moffat Collection System diversions may represent a substantial entrainment risk for native cutthroat trout. It is also possible that the isolated cutthroat trout populations upstream of these diversions have already lost their mobile component because downstream migrants cannot return to isolated headwater populations.

The cutthroat trout populations upstream of the diversions have sustained themselves for decades with the diversions functioning and entraining fish.

The Proposed Action is likely to adversely affect greenback cutthroat trout, a listed endangered species, because of increased entrainment into the Moffat Collection System during periods of increased stream diversions. A Supplemental BA is being prepared to address this species.

Canada Lynx

Canada lynx may regularly use riparian areas along some of the tributaries of the Fraser River including Vasquez and St. Louis creeks, and may occasionally use riparian areas along some of the other river segments including Fraser River, Williams Fork and its tributaries, Blue River, and the western portion of South Boulder Creek. The Proposed Action would have negligible to minor effects on riparian habitats in these areas, primarily involving changes in vegetation composition (see Section 5.8). These changes are unlikely to change habitat suitability or habitat use by Canada lynx. Lynx primarily use forested areas and have large home ranges, and small and localized changes in riparian habitat would be unlikely to affect habitat or overall habitat use. In addition, the Proposed Action would not involve any construction, clearing of vegetation, or change of human use activity in Canada lynx habitat. In its December 2013 BO, the USFWS concurred with the determination of "No effect" for this species.

Ute Ladies'-tresses Orchid

Ute ladies'-tresses orchid occur downstream from Gross Reservoir along South Boulder Creek. As discussed for Preble's, flow diversions at the South Boulder Diversion Canal would generally decrease flow to South Boulder Creek, which would be "not likely" to adversely affect populations of Ute ladies'-tresses orchid occurring downstream. The USFWS concurred with this determination in their December 2013 BO. Average year flow would be decreased by 1,000 AF (2%) and wet years by 3,000 AF (5%), while dry years would increase by 150 AF (<1%).

Changes in flow in the South Platte River would have no impact on Ute ladies'-tresses orchid, because there are no known occurrences.

River Otter

River otters occur along the Fraser, Colorado, and Blue rivers, but the tributaries of the Fraser River and the upper Williams Fork River are not part of their overall range (NDIS 2011). Flow changes would have minor or negligible impacts on riparian habitats along these rivers (Section 5.8), negligible to beneficial impacts to fish in the Fraser River, and no effect to the fish community in the Colorado and Blue rivers (Section 5.11). Changes in water levels would not affect access to dens in winter because flow changes during winter months would be relatively small, 0 to -6% from November to March in the upper and Middle Fraser rivers, (Appendix Tables H-3.2, 3.6, 3.11, and 3.17) and -3 to +3% in these months in the lower Fraser, Colorado, and Blue rivers (Appendix Tables H-3.22, 3.23, 3.31, 3.32, 3.33, and 3.36). In addition, river otters choose dens opportunistically and often use beaver bank dens, dams and lodges, and are highly mobile (S. Boyle 2006).

Based on these considerations, impacts would be negligible and would not affect distribution or abundance of river otter.

Boreal Toad

Boreal toads are known to occur along the upper Williams Fork and may occur along the Fraser River and its main tributaries, including Vasquez Creek. They are unlikely to occur along the Blue River and South Boulder Creek upstream of Gross Reservoir, where habitat is marginally suitable and there are no known breeding sites.

Boreal toads have three distinct habitat needs – breeding ponds, summer habitat, and hibernacula. Breeding occurs in a wide variety of water bodies such as beaver ponds, kettle ponds, streams, large reservoirs, and man-made ponds, in areas with shallow pooled or slow-moving water. Egg and tadpole development are temperature dependent, and eggs are deposited in shallow warm water that optimizes warmth of the sun. During the summer, boreal toads use a wide variety of wet and dry, forested and non-forested habitats. Adult boreal toads have been observed spending up to 90% of their life in upland terrestrial habitats (Jones et al. 2001). Hibernation occurs in terrestrial habitats, mostly in underground rodent burrows. Boreal toads may migrate up to about 1.5 miles between breeding ponds and hibernacula. Longer movements of up to 5 to 6 miles between small populations have been recorded.

The Project would not directly or indirectly affect known breeding sites. Boreal toads breed in ponds, most commonly in beaver ponds. The upper Williams Fork boreal toad breeding site is located very near the Williams Fork, but is supported by groundwater and surface flow from aside drainage and is located several feet higher in elevation than the Williams Fork. The Jim Creek and Vasquez Creek breeding sites in the Fraser Valley also appear to be supported by groundwater and have no recent breeding records. The McQueary Lake breeding site in the William Fork Valley and the Pole Creek breeding site in the Fraser Valley are located far upstream on tributaries.

The Project is unlikely to adversely affect availability of summer habitat and hibernacula. Flow changes are expected to have minor or negligible impacts on riparian habitats (refer to Section 5.8). Boreal toads use a wide variety of habitats during the summer and are not restricted to streamside areas. Large areas of both upland and riparian habitats in the Fraser and Williams Fork valleys are potential summer habitat, and small changes in streamside riparian habitats are unlikely to adversely affect their population or distribution. The Project would not involve any construction activity in their habitat and would not cause direct effects or transmission of disease.

Interior Least Tern and Piping Plover

These species are very rare migrants at the South Platte River and adjacent reservoirs, and are unlikely to incur impacts from flow changes under the Proposed Action.

Common Shiner

There are no recent records of this species in the portion of the South Platte River in the Project area, and it is unlikely to be affected by flow changes.

Other Special Status Species

Other species status species that may occur along the river segments include American peregrine falcon, bald eagle, various aquatic birds, northern leopard frog, and several plant species (Appendix Table G-5). Flow changes in other Project river segments are unlikely to affect these species because the flow changes would not noticeably affect availability of suitable habitat for aquatic or riparian species.

American peregrine falcon. This species nests along or near several of the river segments and is likely to forage along the rivers. Flow changes are unlikely to change the availability of prey or foraging conditions.

American bittern. This species may occur in marshes along the lower Fraser, Colorado, and South Platte rivers. Operation of the Project is unlikely to affect marsh habitat, which typically is associated with impoundments or areas of high groundwater.

American white pelican may occur in the lower South Platte River although it is more likely to occur in lakes and ponds than in the river itself. The Proposed Action would have a minor beneficial impact to fish populations that may benefit this species.

Bald eagle nests, roost sites, and/or foraging areas are located along the Fraser, Colorado, Blue, North Fork South Platte, and South Platte rivers. Flow changes are expected to have minor or negligible impacts on riparian habitats and fish populations, and are unlikely to change the availability of prey or foraging conditions.

Barrow's goldeneye winters on reservoirs and rivers, including the Colorado River and South Platte River. The Proposed Action does not involve increased diversions in winter and would have no effect on habitat for this species.

Greater sandhill crane may occur on migration along the North Fork South Platte and the South Platte rivers. Migrants occur on mudflats around reservoirs, in moist meadows and agricultural lands (Andrews and Righter 1992). The Proposed Action would have no effect on these habitats.

Ovenbird is a rare migrant that may occur in riparian areas along the lower South Platte River. The Proposed Action would have negligible effects on the availability of migration habitat because flows in the South Platte River would not be reduced in dry years and would have relatively small changes in average and wet years.

Snowy egret occurs along the South Platte River and may occur along the North Fork South Platte River, but appears to nest primarily on islands in lakes. Flow changes are unlikely to change the availability of prey or foraging conditions along rivers.

White-faced ibis may occur during migration along the South Platte River. Flow changes under the Proposed Action are unlikely to change the availability of prey or foraging conditions for this species.

Northern leopard frog has the potential to occur along all of the river segments but is more likely to occur in ponds and wetlands than in the rivers themselves. Predatory fish in the rivers are likely to strongly limit use of this habitat. Flow changes in the rivers under the Proposed Action would affect relatively narrow areas along the river banks and are not expected to affect availability of pond habitat.

Common garter snake occur along the lower South Platte River. Flow changes under the Proposed Action are expected to have a negligible effect on riparian habitat and unlikely to change the availability of prey or foraging conditions.

Iowa darter occurs in Eleven Mile Canyon Reservoir, which is located along the South Platte River. Iowa darters were also collected in 2003 and 2005 in the South Platte River between Chatfield Reservoir and the confluence with Bear Creek reservoirs and occur in downstream sections of the river. Chatfield Reservoir is drawn upon in multi-year droughts, and reservoir operation and contents under the Proposed Action would be similar to Current Conditions. The Proposed Action is unlikely to affect this species.

Park milkvetch may occur in sedge meadows and grassy stream banks along montane portions of the North Fork South Platte and South Platte rivers. Operation of the Proposed Action is expected to have negligible effects on riparian habitats along these rivers, and impacts to this species would also be negligible, if it is present.

Least moonwort, lesser panicled sedge, mud sedge, dwarf raspberry, and autumn willow are species that primarily occur in fens and peatlands in montane and subalpine areas, and may occur along the river segments in the Fraser and Williams Fork valleys. Changes in stream flows resulting from the Proposed Action would have no or negligible impacts to habitats of these plants, which are primarily supported by groundwater.

Buckbean and lesser bladderwort occur in montane and subalpine ponds. Changes in stream flows under the Proposed Action are expected to have no impacts to ponds.

American current occurs in lowland riparian areas along the South Platte River. Operation of the Proposed Action is expected to have negligible effects on riparian habitats along the South Platte River, and impacts to this species would also be negligible, if it is present.

Rocky Mountain bulrush may occur in ponds along the South Platte River. Changes in stream flows under the Proposed Action are expected to have no impacts to ponds.

5.10.2 Alternative 1c

5.10.2.1 Gross Reservoir

Federal and State Listed Species

Under Alternative 1c, there would be no impacts to Federal and State listed species at Gross Reservoir.

Other Special Status Species

Impacts to other special status species from Alternative 1c would be similar to described under the Proposed Action, but less as the reservoir would only be enlarged by 40,700 AF. Impacts to special status wildlife habitat would be reduced. Forest birds and terrestrial and burrowing species such as dwarf shrew, would incur less habitat loss.

Alternative 1c would not affect Maryland sanicle, and the number of affected individual plants affected would be reduced substantially for Dewey sedge and Sprengle's sedge

compared to the Proposed Action (Table 5.10-1). In addition, only two of the four reported locations for false melic would be affected. Impacts to other plant species of local concern, including wild sarsaparilla, enchantress's nightshade, and tall blue lettuce, would be the same or similar to the Proposed Action. This alternative may affect viability of tall blue lettuce and false melic in the ARNF, and also affect the local viability of populations of wild sarsaparilla and enchantress's nightshade.

5.10.2.2 Leyden Gulch Reservoir Site

Federal and State Listed Species

Burrowing Owl

Suitable nesting habitat for burrowing owls in the black-tailed prairie dog colonies at Leyden Gulch would be eliminated by reservoir construction. The presence of burrowing owls at the site is not known as no presence/absence surveys have been conducted for the Project. Denver Water is trying to eradicate the existing prairie dogs at Leyden Gulch, leaving a large number of prairie dog burrows unoccupied, which makes them more suitable for nesting burrowing owls. Surveys would be required to determine if burrowing owls occur at Leyden Gulch during the nesting season (April 1 to September 30). Earth-moving and vegetation-clearing activities occurring during the burrowing owl nesting season would cause owls to flush the nest or equipment could crush eggs, young, and adult burrowing owls. Rising water levels may flood nests during reservoir filling.

Preble's Meadow Jumping Mouse

As described in Section 3.10, the proposed Leyden Gulch Reservoir site study area has potential habitat for Preble's at Ralston Creek, however, due to fragmentation from known occupied habitat above Ralston Dam; the study area is unlikely to support a population of Preble's. Therefore, implementation of Alternative 1c is unlikely to adversely affect Preble's or Preble's habitat. However, Ralston Creek should be surveyed prior to construction to ensure Preble's have not colonized the site.

Ute Ladies'-tresses Orchid

No Ute ladies'-tresses orchid were observed in the site during 1997 and 2005 surveys, and construction and operation of Leyden Gulch Reservoir is unlikely to adversely effect this species. However, 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 are recommended prior to construction to determine if Ute ladies'-tresses orchid occupy the Leyden Gulch Reservoir site.

Construction of the reservoir would temporarily impact suitable Ute ladies'-tresses orchid habitat at Ralston Creek for the outlet pipeline, as well as 4.5 acres in the reservoir footprint.

Colorado Butterfly Plant

Construction of Leyden Gulch Reservoir would have no impact on Colorado butterfly plant as the species is not know from or expected to occur in the study area. The proposed Leyden Gulch Reservoir site does contain some areas of suitable habitat for Colorado butterfly plant at some riparian and wetlands areas such as Leyden Gulch and Ralston

Creek. No Colorado butterfly plants were found during 2005 surveys. Additional presence/absence surveys, in conjunction with Ute ladies'-tresses orchid surveys, are recommended prior to construction to determine if Colorado butterfly plant occupy the Leyden Gulch Reservoir site study area.

Other Special Status Species

Bald eagles are present in the vicinity of Leyden Gulch in winter. Disturbance from construction may result in avoidance of the area by bald eagles. Following inundation of the reservoir, bald eagles would lose a small prey base of prairie dogs at Leyden Gulch, but it would be replaced following construction of the reservoir by waterfowl and fish, if conditions were suitable. As discussed in Section 3.9, fish may become established in Leyden Gulch Reservoir from South Boulder Diversion Canal. Construction of Leyden Gulch Reservoir under Alternative 1c would not adversely impact bald eagles.

Approximately 7.2 acres of existing prairie dog colonies would be removed for construction of Leyden Gulch Reservoir. Besides the mortality of prairie dogs, the proposed reservoir would eliminate habitat for numerous other species that are associated with prairie dog colonies, including ferruginous hawk. The primary impact of Leyden Gulch Reservoir to peregrine falcon and ferruginous hawk under Alternative 1c would be loss of foraging habitat.

Northern leopard frog was observed in the proposed Leyden Gulch Reservoir site during 2005 field surveys. Impacts to northern leopard frog include direct loss of habitat as well as mortality to individual frogs by crushing or burial during earth moving activities for construction of the dam, pipeline, or access roads.

Several species of butterfly may occur at Leyden Gulch, as shown in Appendix Table G-3 and would lose habitat from construction of the reservoir. Suitable habitat for these species occurs in areas adjacent to the reservoir site so the Project is not expected to impact the viability of populations of these species.

Plant species, such as dwarf wild indigo, that may be present in the proposed reservoir footprint would be removed by construction or inundation.

5.10.2.3 River Segments

Operation of Alternative 1c would have the same effects on aquatic and riparian species as the Proposed Action. Operation would result in depletions to the Colorado and South Platte rivers, but adverse effects to listed species that occur in and along downstream rivers would be mitigated in accordance with the recovery programs. Operation would not adversely affect downstream habitat for Preble's, Canada lynx, and Ute ladies'-tresses orchid. Populations of greenback cutthroat trout and Colorado River cutthroat trout in the Fraser and Williams Fork river systems would be adversely affected by increased entrainment during periods of increased diversion. Operation is likely to have no effects on State listed species including river otter and boreal toad. Stream flow changes resulting from operation of the Project are expected to have no or negligible adverse effect to other special status species.

5.10.3 Alternative 8a

5.10.3.1 Gross Reservoir

Federal and State Listed Species

Under Alternative 8a, there would be no impacts to Federal and State listed species.

Other Special Status Species

Impacts to other special status species from Alternative 8a would be similar to the Proposed Action, but less as Gross Reservoir would only be enlarged by 52,000 AF, compared to 77,000 AF for the Proposed Action. Forest birds and terrestrial and burrowing species would incur less habitat loss.

Alternative 8a would affect fewer individuals of Dewey sedge, Sprengle's sedge, and Maryland sanicle, compared to the Proposed Action (Table 5.10-1). Impacts to other special status plant species, including wild sarsaparilla, enchantress's nightshade, tall blue lettuce and false melic, would be the same or similar to the Proposed Action. This alternative may affect viability of Sprengle's sedge, tall blue lettuce and false melic in the ARNF, and local viability of populations of wild sarsaparilla, Dewey sedge, and enchantress's nightshade.

5.10.3.2 South Platte River Facilities

Federal and State Listed Species

Burrowing Owl

If burrowing owls occur where prairie dogs are present along the gravel pit pipeline corridor, impacts would consist of temporary disturbance to nesting individuals during pipeline construction. If construction occurs during the burrowing owl breeding season (March 15 through July 31), heavy equipment operation and earth moving may cause nest abandonment or mortality from crushing or burial if a nest is located near the construction right-of-way (ROW).

Interior Least Tern and Piping Plover

This alternative includes 5,000 AF of gravel pit storage along the South Platte River (about 200 acres). Filling of the gravel pits under Alterative 8a would create habitat for migrating interior least terns and piping plovers. Construction of the associated facilities may temporarily disturb these birds during migration; however, considering the rarity of the species in the area, least terns are unlikely to incur impacts from construction.

Ute ladies'-Tresses Orchid and Colorado Butterfly Plant

There are no known occurrences of these species and construction of the South Platte River Facilities would not adversely affect them. The South Platte River at the diversion is within the Block Clearance Zone where these species are considered to not be present and presence/absence surveys would not be needed.

Other Special Status Species

Other special status species that may occur at the South Platte River Facilities include bald eagle, peregrine falcon, white pelican, Barrow's goldeneye, snowy egret, white-faced ibis, black-tailed prairie dog, northern leopard frog, and common garter snake.

Construction of the diversion pipeline, dam, and Advanced Water Treatment Plant (AWTP) pump station would potentially disturb or displace foraging bald eagles, especially if construction occurs during winter months. The South Platte River corridor adjacent to the proposed gravel pits is used by bald eagles for foraging year-round and is a winter concentration area (NDIS 2011). Operation of the Worthing, South Tower, and North Tower gravel pits would benefit bald eagles by creating approximately 5,000 AF (approximately 200 acres) of open water habitat that would provide an increased prey base of waterfowl and potentially fish. Fish may establish in the gravel pit reservoir from diversion canals. The Project would have no impact on nesting bald eagles since the nearest active bald eagle nests are located more than 3 miles from the South Platte River Facilities (NDIS 2011). A bald eagle communal roost is located near the crossing of the South Platte River at 112th Avenue. Construction and operation would not affect this roost as no facilities are planned within 1 mile of the roost.

Construction and operation of the facilities would have no impacts on peregrine falcons as the species occurs in the area during foraging and other habitats are available. Operation of the gravel pit storage ponds would be beneficial to white pelicans and Barrow's goldeneye through creation of open water habitat. Snowy egrets and white-faced ibis would also benefit from creation of shoreline habitat at the gravel pits, though both species would also incur direct and temporary impacts from temporary loss of habitat from construction of the diversion pipeline south of Worthing Pit.

Northern leopard frog and common garter snake would primarily incur impacts where the gravel pit pipeline crosses riparian and wetland habitats as shown in Figure 3.8-4. Small terrestrial species including northern leopard frog, common garter snake, and black-tailed prairie dogs would be directly impacted by ground disturbance for construction of pipelines and pump stations. Heavy equipment and earth moving may kill individual animals by crushing or burial. At the time of this analysis, no black-tailed prairie dog colonies would be impacted for the pipelines.

5.10.3.3 Conduit O

Federal and State Listed Species

Construction of the pipeline for Conduit O would be within existing roadways and would only disturb areas within the existing ROW. Conduit O would cross the South Platte River, Clear Creek, and other drainages as an open cut.

Burrowing Owl

Impacts to burrowing owl would consist of temporary disturbance during construction activity. Areas of potential habitat for burrowing owls occur near Conduit O occur in prairie dog colonies, including the western terminus of the pipeline in the vicinity of State Highways (SHs) 72 and 93, the vicinity of the South Platte River crossing, and south of the

gravel pits. If construction occurs during the burrowing owl breeding season (March 15 through July 31), heavy equipment operation and earth moving may cause nest abandonment or mortality from crushing or burial if a nest is located near the construction ROW.

Interior Least Tern and Piping Plover

These species are very rare migrants at the South Platte River and reservoirs, and are unlikely to incur impacts from construction.

Ute ladies'-tresses Orchid and Colorado Butterfly Plant

There are no known occurrences of these species and construction of Conduit O and would not adversely affect these species. Potential habitat for Ute-ladies'-tresses orchid and Colorado butterfly plant is present where Conduit O crosses the South Platte River but this area is within the Block Clearance Zone where they are not expected to occur and pre-construction surveys would not be needed.

Other Special Status Species

Other special status with habitat crossed by Conduit O include bald eagle, Barrow's goldeneye, ferruginous hawk, snowy egret, black-tailed prairie dog, swift fox, and common garter snake.

Impacts to bald eagles may include temporary disturbance during construction activities. Important bald eagle habitat occurs at Standley Lake, north of Conduit O, and therefore, bald eagles may occasionally fly over the conduit during foraging or migrating, but construction would not affect bald eagles occurring near Standley Lake. As shown in Figure 3.10-1, bald eagle habitat also occurs at the South Platte River. Heavy equipment use and earth moving for construction of Conduit O at the South Platte River would cause temporary and direct impacts to bald eagles from disturbance. Impacts to bald eagles from construction of Conduit O would be limited to avoidance of the area during construction activity.

Disturbance to Barrow's goldeneye, ferruginous hawk, snowy egret, and white-faced ibis from construction activity would cause temporary displacement for the duration of the disturbance. Since construction would occur within the existing roadway, no black-tailed prairie dog colonies would be removed; impacts would be limited to temporary disturbance to individuals located adjacent to the construction activity. Swift fox may occur in habitats crossed by Conduit O east of the South Platte River; construction of the conduit may cause individuals to avoid the area for the duration of construction. Impacts to common garter snake include crushing from heavy equipment and earthmoving where the snake may be present along roadsides at riparian crossings and wetlands.

5.10.3.4 River Segments

Impacts to special status species occurring in the river segments would be the same as described under the Proposed Action, except that the amount of depletion in the Colorado River system would be less and depletions to the South Platte River would change.

5.10.4 Alternative 10a

5.10.4.1 Gross Reservoir

Federal and State Listed Species

There would be no impacts to Federal and State listed species under Alternative 10a.

Other Special Status Species

Impacts to other special status species under Alternative 10a would be the same as Alternative 8a.

5.10.4.2 Denver Basin Aquifer Facilities

Federal and State Listed Species

Construction or operation of the Denver Basin Aquifer Facilities, including the AWTP would not affect interior least tern because they would be constructed adjacent to the South Platte River in a highly industrialized area.

Other Special Status Species

Habitat for American white pelican, northern leopard frog, and common garter snake is present in the Denver Basin aquifer storage site area. American white pelicans may occasionally be present in the vicinity of the aquifer wells, where wells would be placed in parks with open water habitat including City Park, Sloan's Lake, and Washington Park. Construction of wells is unlikely to impact pelicans as drilling would be temporary and the species occurs on open water habitats away from well drilling. Construction of the AWTP and aquifer distribution pipelines where they cross Sand Creek, Clear Creek, South Platte River, and Cherry Creek may eliminate habitat and crush or bury individual northern leopard frog or common garter snake, if present, in the construction footprint. Construction or operation of the AWTP would not affect bald eagle because the AWTP would be constructed adjacent to the South Platte River in a highly industrialized area.

5.10.4.3 Conduit M

The alignment for Conduit M is the same for Conduit O between the Moffat Delivery Point and the intersection of 80th Avenue and Pierce Street. Impacts to special status species from Conduit M are described below.

Federal and State Listed Species

Ute Ladies'-tresses Orchid and Colorado Butterfly Plant

A new population of Colorado butterfly plant was discovered along Clear Creek in 2011, within ½ mile of the Conduit M crossing. Presence/absence surveys have not been conducted at the Conduit M crossing of Clear Creek and this species could occur at the crossing. There are no known occurrences of Ute ladies'-tresses orchid in the vicinity of Conduit M. The South Platte River crossing is within the Block Clearance Zone for both species, where they are not expected to occur and surveys would not be necessary. Surveys

would be conducted at Clear Creek and other areas of suitable habitat outside the Block Clearance Zone prior to construction to determine the presence or absence of these plants, and to avoid impacts if present.

Burrowing Owl

Areas of potential habitat for burrowing owls occur in prairie dog colonies near western terminus of the pipeline in the vicinity of SHs 72 and 93. If construction occurs during the burrowing owl breeding season (March 15 through July 31), heavy equipment operation and earth moving may cause nest abandonment or mortality from crushing or burial if a nest is located near the construction ROW. In Denver Water's Moffat Collection System Project Fish and Wildlife Mitigation Plan (refer to Appendix M), which has been approved by the Colorado Wildlife Commission, Denver Water has committed to conducting pre-construction surveys to identify active nests in the Project footprint and timing of activities to avoid the breeding season.

Other Special Status Species

Other special status habitats crossed by Conduit M include bald eagle, peregrine falcon, ferruginous hawk, Barrow's goldeneye, snowy egret, black-tailed prairie dog, and arogos skipper butterfly. Construction occurring during winter may temporarily disturb foraging or day roosting bald eagles near Standley Lake or along the South Platte River. However, due to the industrial land uses in the vicinity, impacts to bald eagles would be minimal. Disturbance to peregrine falcon, ferruginous hawk, Barrow's goldeneye, and snowy egret from construction activity would cause temporary displacement for the duration of the disturbance. Construction would occur within the existing roadway and no black-tailed prairie dog towns would be removed. Arogos skipper would not incur any impacts as construction would occur in the existing ROW.

5.10.4.4 River Segments

Impacts to special status species would be the same as described under the Proposed Action, except that the amount of depletion in the Colorado River system would be less and depletions to the South Platte River would change.

5.10.5 Alternative 13a

5.10.5.1 Gross Reservoir

Federal and State Listed Species

Alternative 13a would have no impacts to Federal and State listed species at Gross Reservoir.

Other Special Status Species

Impacts to other special status species under Alternative 13a would be similar but less than those described under the Proposed Action as the reservoir would only be enlarged by 60,000 AF. Terrestrial and burrowing species and forest birds would incur less habitat loss.

Alternative 13a would affect fewer individuals of Dewey sedge and Maryland sanicle, compared to the Proposed Action (Table 5.10-1). Impacts to other special status plant species, including wild sarsaparilla, Sprengle's sedge, enchantress's nightshade, tall blue lettuce and false melic, would be the same or similar to the Proposed Action. This alternative may affect viability of Sprengle's sedge, tall blue lettuce and false melic in the ARNF, and local viability of populations of wild sarsaparilla, Dewey sedge, and enchantress's nightshade.

5.10.5.2 South Platte River Facilities

Impacts from gravel pits would be similar to Alternative 8A, although under Alternative 13a, only 3,625 AF (approximately 200 acres) of open water habitat would be created.

Transfer of agricultural water rights on 3,900 acres of land would not affect any Federally listed threatened or endangered species. Some other special status species, such as common gartersnake and northern leopard frog, would lose potential habitat in ditches, ponds and wetlands. Black-tailed prairie dogs are likely to increase, providing more habitat for burrowing owls and foraging ferruginous hawks.

5.10.5.3 Conduit O

Impacts to special status species from construction of Conduit O would be the same as those described for Alternative 8a.

5.10.5.4 River Segments

Impacts to special status species would be the same as described under the Proposed Action, except that the amount of depletion in the Colorado River system would be less and depletions to the South Platte River would change.

5.10.6 No Action Alternative

Under the No Action Alternative (i.e., both the Depletion of the Strategic Water Reserve Strategy and Combination Strategy), there would be no direct or indirect impacts to special status species from construction of new facilities, but changes in operation of the existing system would result in changes in stream flow in areas occupied by special status species. The impacts associated with these flow changes are discussed below. Because there would be no Federal action, the No Action Alternative would not require nor involve consultation with USFWS regarding these impacts.

As previously described, four Federally listed endangered fish species occur downstream in the Colorado River. Flow reductions in the Colorado River resulting from the No Action Alternative would be very similar to those described for the Proposed Action. In average and wet years there would be a reduction of 2% in annual flows at the Kremmling gage on the Colorado River (Appendix Table H-3.33), mostly occurring in June and July in average years and in June in wet years. There would be no changes in dry years. Flow reductions would fall under the existing Recovery Agreement that Denver Water signed with USFWS in 2000.

Several Federally listed species occur downstream in the Platte River in Nebraska. The No Action Alternative would result in an average annual increase of 1% in flows at the Henderson gage (Appendix Table H-3.48). Flows would remain the same or increase slightly in every month except June, when they would decrease by about 1%. The largest increases would be 3 to 5% in January, February, and March.

Preble's and Ute ladies'-tresses orchid occur along South Boulder Creek downstream of the South Boulder Diversion Canal. Under the No Action Alternative, average annual flows would decrease by 1% compared to Full Use of the Existing System (Appendix Table H-3.40). The flow reduction would occur primarily in May and June, when flows are highest. In wet years, flows would decrease by 2-3% in May and June (Appendix Table H-3.40). There would be no reductions in flows in dry years. Similar to the Proposed Action, the smaller changes in flows under the No Action Alternative are unlikely to adversely affect habitats used by these species along South Boulder Creek.

Preble's occur along the South Platte River from below Cheesman Reservoir to Chatfield Reservoir. Changes in the outflow of Cheesman Reservoir (Appendix Table H-3.44) would be minor, including small increases in winter (October to February, 1 to 3%) and decreases in summer (-1% in June, July, and August) (Appendix Table H-3.44). Dry years would have flow increases in the summer months (May to September, 8 to 14% increases). Wet years would show no change on an annual basis but slightly decreased flows from October through December and slightly increased flows from January through March. These changes are unlikely to adversely effect riparian habitats used by Preble's, and may have minor beneficial impacts because of increases in dry years during the warmer months. Changes at the Waterton gage (Appendix Table H-3.45) would be similar to but slightly larger than the Proposed Action, a decrease of 4% in annual flows in average years, 2% in wet years, and 1% in dry years. Decreases would occur most of the year. Similar to the Proposed Action, these small changes are unlikely to result in adverse changes to riparian habitat occupied by Preble's in the area between Waterton Canyon and Chatfield Reservoir.

Preble's also occurs along portions of the North Fork South Platte River. There would be an average increase of 7% in annual flows during average and wet years, and a 3% increase in dry years. Increases in flows would occur throughout the year, and would range from 2 to 11% per month in average years. Because flows would increase during the growing season, changes in flows are unlikely to adversely affect Preble's habitat.

5.10.7 Mitigation and Monitoring

The Corps prepared a BA for the USFWS to comply with the requirements of Section 7 of the ESA. The BA evaluated impacts to Federally listed, proposed and candidate species that would result from construction and operation of the Proposed Action. The BA provided information on affected species, type of impacts, conservation and mitigation measures, and determination of impact for each species. In response to the BA, the USFWS issued a BO on July 31, 2009 that determined the Project's potential to jeopardize the continued existing of listed species or adversely modify critical habitat (see Appendix G-2). It also identified any additional conservation and mitigation measures, and tiered to previously issued Programmatic BOs that address Colorado River fish and Platte River Valley species.

A Revised BA was submitted to the USFWS on August 14, 2013 for Denver Water's Platte River and Colorado River depletions and Preble's habitat located along the North Fork South Platte River. The USFWS issued a Final BO on December 6, 2013 that replaced the BO dated July 31, 2009 (see Appendix G-2). A Supplemental BA is being prepared to address new information about the presence of greenback cutthroat trout in the Fraser and Williams Fork drainages. If the Corps' ROD identifies an alternative different from the Proposed Action to be permitted, the Corps would re-initiate Section 7 consultation with the USFWS to re-evaluate impacts and mitigation measures.

Denver Water prepared the Moffat Collection System Project Fish and Wildlife Mitigation Plan, which has been approved by the Colorado Wildlife Commission and is provided in Appendix M. Mitigation relevant to special status species includes compliance with the Migratory Bird Treaty Act, use of CPW's Best Management Practices (BMPs) for special status species, continued participation in the Upper Colorado Endangered Fish Recovery Program, continued participation in the Platte River Recovery Implementation Program, and compliance with the Final BO issued by USFWS.

Sensitive Raptors and Migratory Bird Species

Northern goshawk and flammulated owl could nest in or near the Gross Reservoir area, although no nest sites have been identified. In addition, two other sensitive migratory birds, American three-toed woodpecker, and olive-sided flycatcher have the potential to nest at Gross Reservoir. Possible mitigations measures to avoid or minimize impacts, which are the same as raptor mitigations previously described in Section 5.9.7, may include:

- If practicable, trees in the construction footprint would be cleared prior to March 1 or after July 31 to prevent raptors (and other birds) from nesting on site and avoid take of or disturbance to active nests during the breeding season. If construction begins after March 1 or prior to July 31, nest surveys would be conducted prior to construction to ensure that no active nests are present in or near the construction footprint. Surveys would be conducted during an appropriate season (generally April 1 through June 1) to determine presence of active raptor nests. Surveys may need to be conducted at multiple times and using different techniques to address all species, including owls.
- If an active nest is located, protective buffer zones would be established around active nests during construction to avoid disturbance while nesting. Buffer zones and seasonal restrictions would be based on CPW recommendations (CDOW 2008b) and on consultation with CPW. CPW recommends a buffer zone of ½ mile radius around active northern goshawk nests from March 1 through September 15 (CDOW 2008b). In Denver Water's Moffat Collection System Project Fish and Wildlife Mitigation Plan, which has been approved by the Colorado Wildlife Commission, Denver Water has committed to use of pre-construction surveys to identify active nests in the Project footprint and timing of activities to avoid the breeding season.

Bald Eagle

Mitigation for bald eagle would be the same as described for raptors in Section 5.9. In addition, it is recommended that construction activity be restricted within 0.25 mile of active nocturnal roost sites between November 15 and March 15. No Project facilities are

currently planned to be located within 0.25 mile of known roost sites; the nearest is about 1 mile away, on the South Platte River at 112th Avenue.

Black-tailed Prairie Dogs

Possible mitigation measures to minimize impacts to prairie dogs are as follows:

- If possible, avoid direct impact to prairie dog colonies. Erect temporary fencing, such as silt fencing around active prairie dog colonies to prevent construction equipment from disturbing burrows.
- If avoidance of impact to prairie dogs is not feasible, consider relocation of prairie dogs to adjacent areas of suitable habitat.
- If relocation is not feasible, impacted black-tailed prairie dogs should be humanely removed from burrows that would be directly affected by the Project, and donated for feeding of captive black-footed ferrets or raptors.
- Locations and sizes of prairie dog towns would be updated by surveys prior to construction.

Burrowing Owl

Impacts would be avoided by implementing the procedures included in Recommended Survey Protocol and Actions to Protect Nesting Burrowing Owls (CDOW 2007c). These include the following:

- Pre-construction surveys would be conducted to identify actively used burrows that may be nest locations. Surveys would be conducted for any activities occurring between March 15 and October 31.
- Surveys would be conducted in the early morning and evening, when activity peaks, using broadcast calls.
- If burrowing owls are found, construction would be delayed until November 1 or until owls have left the town, for all areas within 150 feet of actively used burrows.

Common Garter Snake

To mitigate for impacts to common garter snakes in areas where BMPs would control erosion near streams and in riparian habitat, coconut-straw erosion blankets with a biodegradable thread would be used rather than turf reinforcement mats, which can harm snakes. The framework would be manufactured with openings of sufficient size and “give” to allow for safe passage of snakes through the blanket. Use of a netless excelsior blanket (Curlex® NetFree™) combined with a heavy woven coir mat has been found successful (install the coir mat on top of the netless excelsior and anchor down).

Special Status Plants at Gross Reservoir

During tree clearing operations, locations of USFS special status plants should be marked in the field prior to clearing operations, with a buffer zone of at least 10 feet. No ground disturbing activities should occur within the marked populations or buffer zones. Hand cutting of trees may be preferential in some locations.

The USFS (Popovich 2011) recommends the following additional mitigations for impacts to rare plants at Gross Reservoir:

- **Wild sarsaparilla.** Transplant 200 individuals from affected sites to suitable nearby sites that would not be affected by inundation, or collect and distribute seed from affected sites.
- **Dewey sedge.** Transplant all affected individuals to suitable nearby sites.
- **Sprengel's sedge.** Transplant all affected individuals to suitable nearby sites.
- **Enchantress's nightshade.** Collect and distribute seed to suitable nearby sites. Alternately, surveys may be used to document additional locations that would not be affected.
- **Tall blue lettuce.** Collect seed from affected plants for two years and spread seed in suitable nearby unaffected habitat.
- **Maryland sanicle.** Collect seed from affected plants and spread seed in suitable nearby unaffected habitat. Alternately, surveys may be used to document additional individuals that would not be affected upstream of the known location.
- **False melic.** Collect seed from affected plants and spread seed in suitable nearby unaffected habitat.
- **All sensitive and local concern plant species.** Collect herbarium voucher specimens from affected populations, and provide them to USFS for distribution to herbaria. Ten specimen sheets should be collected for each species, to document their occurrence.

5.10.8 Unavoidable Adverse Impacts

Construction of Gross Reservoir would unavoidably affect several USFS sensitive animal species and ARNF plant species of local concern. Construction and operation of Leyden Gulch Reservoir would unavoidably affect individuals and habitat of black-tailed prairie dogs, northern leopard frog, common garter snake, and burrowing owl.

Construction of the Conduits O and M, as well as other Project components in riparian areas would unavoidably affect northern leopard frog and common garter snake though there would be no net habitat loss. Other sensitive species would be unavoidably impacted, but only temporarily during construction with no net loss of habitat.

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5.11 AQUATIC BIOLOGICAL RESOURCES

The primary aquatic biological resources issue raised during scoping pertained to the potential relative impacts of the alternatives on the communities of fish and benthic macroinvertebrates and their habitat in the streams and reservoirs in the Moffat Collection System Project (Moffat Project or Project) area. The primary assumption in this section is that fish, benthic invertebrates, and their habitat represent the components of the aquatic environment of interest for the Project. Based on public comments received during scoping, comments on the Draft Environmental Impact Statement (EIS), and discussions with the State and Federal agencies, this assumption is appropriate.

Each of the alternatives involves changes in the hydrologic regime, including changes to the quantity and timing of flow and reservoir storage. This section evaluates changes in flow and storage that may affect the quality and amount of habitat available for fish and invertebrates in streams and reservoirs in the Project area. Most of the impacts to aquatic biological resources would be indirect and long term, through changes in stream flow (Appendix H-3) or reservoir operation (Appendix H-2), or the suitability of the stream to support aquatic life. Direct impacts would be very limited and temporary and would be limited to disturbances of reservoirs or short sections of streams during construction. Environmental effects are explained in greater detail in the Aquatic Biological Resources Technical Report.

The impact assessment in this section focused on changes in fish and invertebrate species composition and abundance parameters. This analysis of impacts also incorporates information from other resource areas. The suitability of a stream to support aquatic resources is also influenced by changes to channel morphology and water quality. Changes in hydrology can affect water quality, such as temperature and salinity, channel morphology, and sedimentation. Therefore, the evaluations of changes to water quality, channel morphology, and riparian vegetation were also considered as part of the cumulative impact analysis for aquatic biological resources and their habitat. Differences in these aspects of the aquatic environment were incorporated using professional judgment of the suitability of the stream to support aquatic life.

Habitat Simulation Methods

Physical Habitat Simulation (PHABSIM) was used for evaluating the impacts to fish populations, it simulates a relationship between fish habitat availability and flow in streams. Along with professional judgment, this method was used to evaluate the relative impacts of the Project on the relevant fish and benthic invertebrate parameters described above. PHABSIM information was available for every mainstem section of stream in the Project area with changes in average annual flow of greater than 10 percent (%) and several other sections of stream in the Project area.

PHABSIM data were available from previous work on the Fraser River, Williams Fork River, Blue River, South Boulder Creek, North Fork South Platte River, and the South Platte River (Chadwick and Associates 1986). Recent data at sites on St. Louis Creek, Vasquez Creek, Ranch Creek, the Fraser River, the Colorado River, and the Blue River were also available from the Grand County Stream Management Plan (Grand County 2008,

2010). The output from PHABSIM provides habitat versus flow relationships for different species of fish, based on each species' known habitat preferences. This relationship indicates potential habitat availability, expressed as square feet of weighted usable area (WUA) per 1,000 feet of stream (feet^2/1,000 feet) available over a range of flows. Combining this relationship with hydrologic data for a section of stream, fish habitat availability for Full Use of the Existing System and 2032 conditions, the alternatives were calculated and compared.

PHABSIM output data indicates habitat availability for distinct segments of stream (Table 5.11-1). The impacts analysis is organized with respect to the segments of stream established with the available PHABSIM data.

In the Fraser and Williams Fork river basins, there are tributaries with the Board of Water Commissioners (Denver Water) diversions that were included in the Project area. PHABSIM data were not available for most of these tributaries, but R-2-Cross data were available for a 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.

Table 5.11-1
Stream Segments Modeled with PHABSIM in the Moffat Project Area

Stream	Segment	Description
Fraser River	1	Headwaters to Vasquez Creek
	2	Vasquez Creek to St. Louis Creek
	3	St. Louis Creek to Ranch Creek
	4	Ranch Creek to Mouth of Canyon
	5	Mouth of Canyon to Colorado River
St. Louis Creek	1	Denver Water Diversion to Fraser River
Vasquez Creek	1	Denver Water Diversion to Fraser River
Little Vasquez Creek	1	Denver Water Diversion to Vasquez Creek
Ranch Creek	1	Denver Water Diversion to Fraser River
Williams Fork River	1	Confluence of Headwater Tributaries to South Fork
Colorado River	1	Windy Gap Reservoir to Williams Fork River
	2	Williams Fork River to Blue River
Blue River	1	Dillon Reservoir to Rock Creek
	2	Rock Creek to Green Mountain Reservoir
	3	Green Mountain Reservoir to Spring Creek
	4	Spring Creek to Colorado River
South Boulder Creek	1	Moffat Tunnel to Pinecliffe
	2	Pinecliffe to Gross Reservoir
	3	Gross Reservoir to South Boulder Diversion Canal
North Fork South Platte River	1	Roberts Tunnel to Buffalo Creek
	2	Buffalo Creek to South Platte River
South Platte River	5	Strontia Springs Reservoir to Chatfield Reservoir
	6	Chatfield Reservoir to Littleton

Life Stages of Fish and Periodicity

Fish pass through several life stages during their lives from egg to adult. Periodicity refers to the time of the year when a life stage is present and PHABSIMs are appropriate. In most of the streams and stream segments described in this report, brown trout are self-sustaining and are the dominant species of fish. All life stages of brown trout are present in these populations (Table 5.11-2). Brown trout spawn in the fall, and habitat simulations of the spawning life stage are only appropriate for October and November; simulating habitat for spawning brown trout in the spring would be inappropriate and irrelevant to the impacts analysis. Brown trout spawn when flows are low, but further flow reductions between the time of spawning and the time of egg incubation over the winter can be detrimental if the eggs do not remain submerged. Brown trout eggs hatch into fry in the spring, and fry are present through the summer; therefore, the periodicity for brown trout fry is March through September. Juvenile and adult brown trout are present throughout the year, and the periodicity for these two life stages is the entire year.

Table 5.11-2
Periodicity of Fish Species in Streams in the Moffat Project Area

Species/Life Stage	Adult	Spawning	Fry	Juvenile
Brook trout	All year	October – November	N/A	N/A
Brown trout	All year	October – November	March – September	All year
Rainbow trout	All year	April – May	June – September	All year

Note:
N/A = not applicable

For rainbow trout, populations are generally maintained through Colorado Parks and Wildlife (CPW) (previously called Colorado Division of Wildlife) stocking, although some natural reproduction may occur. They are stocked as fingerlings (juveniles) or catchable-sized fish (adults). The periodicity for these two life stages is the entire year. Because some natural reproduction likely occurs in some stream segments and may become more common in the future, habitat simulations for spawning and fry was appropriate. Periodicity for these two life stages is April through May for spawning and June through September for fry. For the spring spawning rainbow trout, eggs develop in a short period which coincides with rising spring runoff flows and dewatering of eggs is not a problem with the typical seasonal flow pattern.

Brook trout are present in some of the streams within the Project area. Habitat availability information was available for the adult and spawning life stages. Adults are present throughout the year, and the periodicity for spawning brook trout is October through November. Flow reductions between fall and winter would have similar detrimental effects on brook trout and brown trout. For the fry life stage of brown and rainbow trout, habitat was simulated for the spring and summer months, including the runoff period.

Lower runoff flows in many cases are beneficial in terms of short-term fish habitat availability, a slight reduction in stressful conditions, and a slight advantage in terms of recruitment can occur. However, these advantages still depend upon long-term

maintenance of channel processes such as sediment and nutrient transport and proper riparian function.

Seasonal Habitat Changes

For the adult and juvenile life stages of trout that are present throughout the year, habitat availability in most streams usually reaches a minimum during extreme flow conditions, either during the low flows in late winter or during the peak flows of runoff. During low flows, depths may be too shallow to support fish in much of the stream. Reduced habitat availability at high flows reflects the fact that when the stream approaches bankfull depth, velocities are high and low-velocity floodplain habitats and side channels may not be available. During high flows, velocity may become too fast for fish to maintain their preferred position or they may be washed downstream out of their preferred habitat. Reducing habitat availability during the times of the year that experience minimum habitat would reduce the suitability of the stream to support fish and would likely result in adverse impacts. Changes in habitat during other times of the year would have less influence on fish populations.

The fish habitat use criteria used in PHABSIM modeling represent habitat use for trout for the warmer seasons of the year and usually at low to moderate flows, as is common with many PHABSIM studies. Habitat use by fish in winter or at high flows in the study streams may be different. Qualitative studies suggest that trout use a subset of their summer habitat during the winter months. In winter, trout tend to use deeper habitat with slower velocity and slightly larger substrate and may be more oriented to cover. Therefore, using summer low flow habitat criteria for trout in this study may overestimate the habitat actually used in the winter.

Simulated Hydrology

The Platte and Colorado Simulation Model (PACSM) simulated hydrology data were used to evaluate indirect impacts at numerous hydrologic nodes, as described in the Section 3.1. Impacts were evaluated for two separate comparisons. The first was aquatic resources with existing conditions without the Project using Current Conditions (2006) hydrology compared to Full Use with a Project Alternative (2032) (refer to Section 4.6.11). The second comparison isolated the effects of the Moffat Project alternatives in the comparison to Full Use of the Existing System hydrology. Each of these comparisons is described in more detail in Sections 4.6.1 and 5.1.

Using the available hydrology data at PACSM nodes corresponding to the stream segments in the Project area, fish habitat availability was simulated with PHABSIM for average, wet, and dry years for each of the species and life stages (Table 5.11-3), given the periodicity described in Table 5.11-3. Mean daily flow was used as the time step for each of the three-year types. Briefly, average year hydrology included all 45 years in the hydrologic period from 1947 through 1991; wet year hydrology was based on the five wettest years within this period; and dry year hydrology was based on the five driest years within this period.

Table 5.11-3
PHABSIM Habitat Relationships Available for Stream Segments, Trout Species, and Life Stages in the Moffat Collection System Project Area

Stream	Segment	PACSM Node	Brook		Brown				Rainbow			
			A	S	A	S	F	J	A	S	F	J
Fraser River	1	2580	X	X	X	X		X	X	X		X
	2	2600	X	X								
	3	2720			X	X		X	X	X		X
	4	2810			X	X	X	X	X	X	X	X
	5	2900			X	X		X	X	X		X
St. Louis Creek	1	2200	X	X								
Vasquez Creek	1	2370	X	X								
Ranch Creek	1	2500	X	X								
Williams Fork River	1	3600	X	X								
Colorado River	1	1350			X	X		X	X	X		X
	2	1430			X	X		X	X	X		X
Blue River	1	4250			X	X	X	X				
	2	4500			X	X	X	X	X	X	X	X
	3	4650			X	X		X	X	X		X
	4	4800			X	X		X	X	X		X
South Boulder Creek	1	57100	X	X					X		X	X
	2	57120							X		X	X
	3	57140							X		X	X
North Fork South Platte River	1	50700			X	X	X	X				
	2	50750			X	X	X	X				
South Platte River	5	51200			X	X	X	X	X	X	X	X
	6	51290							X	X	X	X

Notes:
Refer to FEIS Figure 3.0-1 for the locations of the PACSM nodes.
A = Adult S = Spawning
F = Fry J = Juvenile

Output from the Indicators of Hydrologic Alteration (IHA) software (TNC 2006) was also used to evaluate impacts to aquatic resources. IHA estimates changes to many different types of flow components. IHA parameters evaluated in this report include the frequency, timing, and magnitude of high flows, small floods, and large floods which can affect aquatic biological resources (Mathews and Richter 2007). The IHA output is discussed in detail in the Surface Water sections of the EIS (Sections 3.1, 4.6.1, and 5.1), but changes to biologically relevant flow parameters are also discussed in this section.

Approach to Impacts Analysis

The types of impacts to aquatic biological resources could include beneficial impacts or adverse impacts depending on increases or decreases in the status of the aquatic resources for the Project alternatives in each stream segment and reservoir. Projected changes in flow

and modeled habitat (WUA) were a primary component of this impacts analysis using professional judgment about potential effects of each change on the suitability of the water body to maintain fish and invertebrate populations. Projected changes in water quality, water temperature, channel morphology, sediment characteristics, and riparian vegetation were also incorporated into this analysis using professional judgment. The Aquatic Biological Resources Technical Report reviews the approaches to impact analysis from past EISs and presents the rationale for the approach to impact analysis for aquatic biological resources used in this EIS.

There are no standard approaches for impact evaluation and past projects developed approaches appropriate for the specific conditions of the Project. The review of the literature also demonstrates that quantitative relationships between changes in flow or habitat (WUA) metrics and aquatic communities have not been developed and may not exist, especially for benthic invertebrates. Many EISs incorporated information from other resources, such as channel morphology and water quality into the impact analysis. When a threshold for impact intensity was identified, it was usually 10% or greater, with smaller changes assumed to have no impact. Few EISs identified or described impact intensity to qualify the level of impact.

In this EIS, the parameters that were the focus of the analysis of fish populations in streams were the number and density of self-sustaining species. These parameters are widely used in Colorado to describe fish communities. Self-sustaining species are fish species that maintain populations through natural reproduction and, as such, are directly affected by changes in habitat availability, water quality, hydrology, riparian vegetation, channel morphology, and other ecological factors. Stocked fish are also affected by these changes, but their population levels are controlled to a large extent by management decisions by agencies such as CPW.

In most of the coldwater streams in the Project area, the fish communities consist of one dominant trout species and several less common species of trout, as well as species of suckers, and sculpins. The species composition is generally stable, and there are limited opportunities for additional native or introduced species to become established. Therefore, impacts to Project area streams with the alternatives probably would not affect fish species composition very much except in situations of moderate to major changes in the suitability of the stream to support fish.

Parameters used in the analysis of fish in Gross Reservoir were the number and abundance of species. Gross Reservoir is stocked with fish to support recreational fishing and contains a mixture of a few abundant species and many less common species of both self-sustaining and stocked fish. This evaluation focused on the potential effects of the alternatives on the suitability of Gross Reservoir and the proposed Leyden Gulch Reservoir site to support self-sustaining and stocked species of fish. Since the fish community of Gross Reservoir is managed with stocked species, there are more opportunities for additional species to become established compared to the more stable species composition in coldwater streams. The impacts of the alternatives may affect fish species composition to a larger degree in reservoirs than in streams.

The parameters used in the effects analysis of benthic invertebrates were the number of species present, species composition, including analysis of both taxonomic and functional

diversity, and the abundance of invertebrates. These parameters are widely used in Colorado to describe invertebrate communities, and total number of taxa is included in the Colorado Multimetric Macroinvertebrate Index (MMI) as a component metric. Invertebrate communities in streams typically consist of a few abundant species and many less common species, such that as much as 33% of the taxa found in a stream can be found less than 5% of the time (Resh et al. 2005). These benthic invertebrate community parameters are sensitive to changes in habitat availability and water quality. There are many opportunities for invertebrate species introductions in streams primarily because many insects can fly between streams as a method of dispersal. Therefore, changes in the suitability of the habitat in a stream may affect invertebrate species composition to a greater degree than for fish.

Determination of Impacts Intensity

An approach to impacts analysis and descriptions of impact intensity were developed for the Moffat Project EIS based on concepts in past EISs and the conditions present for this EIS (Table 5.11-4). An incremental approach to impacts assessment, which assumes a greater intensity of impacts resulting from a greater change in conditions, was used. Impacts intensity in this analysis varied from no impact to negligible, minor, moderate, and major impacts. These descriptions of impact intensity primarily evaluated changes in flow and modeled habitat (WUA). Information from other resource areas in this EIS were also incorporated into the analysis including channel morphology, sediment characteristics, water quality, and riparian vegetation.

Table 5.11-4
Aquatic Biological Resources Impacts and Intensity Descriptions for the Moffat Project Area

Impact Intensity	Intensity Description
Negligible	The Project would likely result in a slight change to a fish or benthic invertebrate community, but the change would likely not be of measureable or perceptible consequence. Community metrics would fluctuate within the current range of natural variability.
Minor	The Project would likely result in a beneficial or adverse change to a fish or benthic invertebrate community. The change may be small, but measureable and similar to the current range of natural variability. There would likely be no change in species composition for fish and little change in species composition for benthic macroinvertebrates.
Moderate	Beneficial or adverse Impacts on the abundance of fish and benthic macroinvertebrates, their habitat, or the natural processes sustaining them would likely be detectible and readily apparent and outside the current range of natural variability. In coldwater streams and reservoirs there likely would be no change in fish species composition. In warmwater streams and reservoirs there likely would be changes in the number of the less common species. For benthic invertebrates there would be changes in species composition and other community metrics.
Major	The Project would likely result in a substantial and readily apparent beneficial or adverse change to abundance and species composition of the fish and benthic invertebrate communities outside the current range of natural variability.

The determination of no impact, beneficial impacts, adverse impacts, and the intensity of impacts were evaluated on a case-by-case basis for each stream segment and reservoir

included in the Project area. Differences of less than 10% are likely within the margin of error of the hydrologic and statistical data and would be unlikely to result in adverse or beneficial impacts on fish populations. If key WUA metrics decrease or increase by 10% or less and there are no substantial changes to channel morphology, water quality, etc., the effects of a Project alternative was considered to be no impact. This assumes there is likely to be no change in aquatic biological resources.

Negligible impacts resulted when differences in WUA metrics were less than 10% and there were slight changes in other components, such as flow or channel morphology, that would tend to be either favorable or unfavorable but were not substantial. Differences in WUA parameters of less than 10% would be unlikely to result in adverse or beneficial impacts on aquatic biota, because natural variability in hydrologic and biological data renders a change of less than 10% undetectable. Negligible impacts would indicate that fish and invertebrate populations would continue to fluctuate within normal historic ranges. Negligible impacts also resulted when one or more of the WUA metrics had differences of 10% or more but were judged to have no detectible effect on fish. This was the case when the differences resulted in a combination of a small number of favorable or unfavorable changes to WUA among the different fish species and life stages with no consistent trend.

If a difference in WUA metrics was more than 10%, the change was graded according to professional judgment. The impact intensity takes into account the magnitude of the change in a WUA metric, the risk of crossing an ecological threshold and causing a large change in fish or benthic macroinvertebrate species composition or abundance, and projected changes in water quality, temperature, channel morphology, sediment characteristics, and riparian vegetation. Minor impacts would result in small changes to aquatic resources. There would likely be no change in species composition for fish and little change in species composition for benthic macroinvertebrates. Moderate impacts would result in detectible and readily apparent changes outside the current range of natural variability. Major impacts would likely result in a substantial and readily apparent change in abundance and species composition of the fish and benthic invertebrate communities far outside the current range of natural variability.

Some of the aquatic 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.

Two flow-based thresholds were used. The first was based on a study by Carlisle et al. (2010), 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 was noted in Section 3.11 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 WUA 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 (Section 2.2.3). 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.

In this analysis, impacts on benthic invertebrate community parameters were evaluated based on professional judgment taking into account the available hydrology, water quality, sediment, and channel morphology information. There were no habitat simulations for benthic invertebrates. Reductions in high flows that result in increased sedimentation would be detrimental to macroinvertebrates. However, if reductions in seasonally high spring flows result in flow levels that are still adequate to maintain substrate composition, invertebrates would have more favorable habitat availability with reductions in peak runoff flow. During runoff, high water velocity can limit habitat availability and force refuging behaviors, and movements of the substrate can crush invertebrates. Increases in seasonably low winter flows can also benefit invertebrate populations by increasing the surface area available for supporting these organisms.

5.11.1 Proposed Action (Alternative 1a)

5.11.1.1 Gross Reservoir

The final surface area of the enlarged reservoir, including the Environmental Pool for mitigation, would be approximately 842 acres, over twice that of the existing reservoir with the Proposed Action. The water quality of the enlarged reservoir would be suitable for supporting fish with minimal changes from Current Conditions (refer to Section 5.2). One change to the limnology of Gross Reservoir would be the changes in water quality associated with decaying organic matter inundated with reservoir expansion (refer to Section 5.2). Although this effect will be minimized by removal of vegetation before inundation, phosphorus and chlorophyll *a* concentrations are expected to increase for a short time after inundation before returning to pre-Project levels. The increased productivity could cause a temporary increase in fish densities, as was observed in a Washington reservoir (Stables et al. 1990). When nutrient and dissolved oxygen levels stabilize after the inundation of new habitat, the increased volume of the reservoir may support larger fish populations. This would be a moderate beneficial impact to the reservoir fishery, since the enlarged reservoir would support more fish than the existing reservoir and may provide opportunities for additional species of fish to become established.

The enlarged reservoir is expected to have short-term increases in levels of methylmercury (refer to Section 5.2). This is partially due to the inundation of terrestrial vegetation with the new reservoir. Although this would be minimized with the removal of vegetation before inundation, there may be increases in fish tissue levels of mercury for an undetermined period following reservoir enlargement. Therefore, the enlarged Gross Reservoir likely would be on the Section 303(d) List for high levels of mercury in fish tissues like many other East Slope reservoirs in Colorado.

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. The effects of inundation are calculated from 7,410 feet and below. Approximately 1,350 feet of Forsythe Canyon and 2,160 feet of Winiger Gulch would be inundated. There would be a major adverse impact to the fish and/or macroinvertebrate communities in these streams. Approximately 5,000 feet of South Boulder Creek would also be inundated with the expanded reservoir and would transform this section of stream habitat into reservoir habitat. This would represent a major adverse impact to this section of stream, but a moderate beneficial impact to the reservoir.

Construction activities during enlargement would not substantially affect the normal operation of the reservoir. The fish and invertebrate communities in the reservoir would continue to function as normal.

The enlargement of Gross Reservoir could affect the Rocky Mountain capshell snail if it is present. However, because this species can tolerate a wide range of temperatures and can inhabit a wide range of substrates, it is likely that it would colonize new habitat as water levels rose.

5.11.1.2 River Segments

Riparian Vegetation and Water Quality

In most stream sections there would be no changes to most water quality parameters or riparian vegetation that would affect aquatic biological resources in the Project area due to the Project (refer to Sections 5.2 and 5.8). In river segments where there would be changes, they are discussed as appropriate.

Sediment and Channel Morphology

Reductions in flows with the Proposed Action are not expected to have long-term changes to channel morphology in most of the river segments in the Project area (refer to Section 5.3). The streams are expected to have similar riffle-pool complexes to Full Use of the Existing System conditions. There may be temporary increases in sediment accumulation in isolated locations and some impacts to bank erosion or vegetative encroachment and these are discussed as appropriate.

Fraser River Mainstem

Hydrology data in five segments of the Fraser River were available as input for Instream Flow Incremental Methodology (IFIM) habitat simulation: PACSM Node 2120 (Fraser River at Denver Water diversion) in IFIM Segment 1, Node 2600 (Fraser River below

Vasquez Creek) in IFIM Segment 2, Nodes 2700 (Fraser River below St. Louis [Hammond Ditch No. 1] and 2720 (Fraser River below Fraser Wastewater Treatment Plant [WWTP]), in Segment 3, Node 2810 (Fraser River below Crooked Creek) in IFIM Segment 4, and Node 2900 (Fraser River at Granby) in Segment 5.

Reductions in flow in late summer could affect water temperatures in the Fraser River from Fraser to Granby (PHABSIM Segments 2 through 5). Historically, there have been only two days of daily maximum (DM) temperature exceedances in these segments (refer to Section 3.2). The correlation with flow and water temperature is negative but weak, and variation in water temperature at low flows is extremely high; air temperature is much more likely to affect water temperatures in this stream. There are not expected to be more frequent temperature exceedances (refer to Section 5.2).

There would be no long-term increase in sediment deposition with the Proposed Action. Flow reductions would likely result in localized sediment deposition, however remaining flows are predicted to be high enough to mobilize sediment at a frequency that changes in channel morphology are not anticipated. Flushing of fine sediments and bed mobilization would continue with the Proposed Action throughout the length of the Fraser River. Therefore, there would be no increase in habitat for the *T. tubifex* that carry whirling disease. Water temperatures are expected to be similar to existing conditions on most days. Overall, the Proposed Action would not have an effect on whirling disease in the Fraser River. Adequate flows and the similarity in base flows in late summer and in the sediment transport capabilities of the Fraser River indicate that the Proposed Action would have no effect on Didymo as well. The Proposed Action would not change the current system of diversions and canals and would not introduce any new pathways for nuisance species distribution.

Segment 1, Headwaters to Vasquez Creek

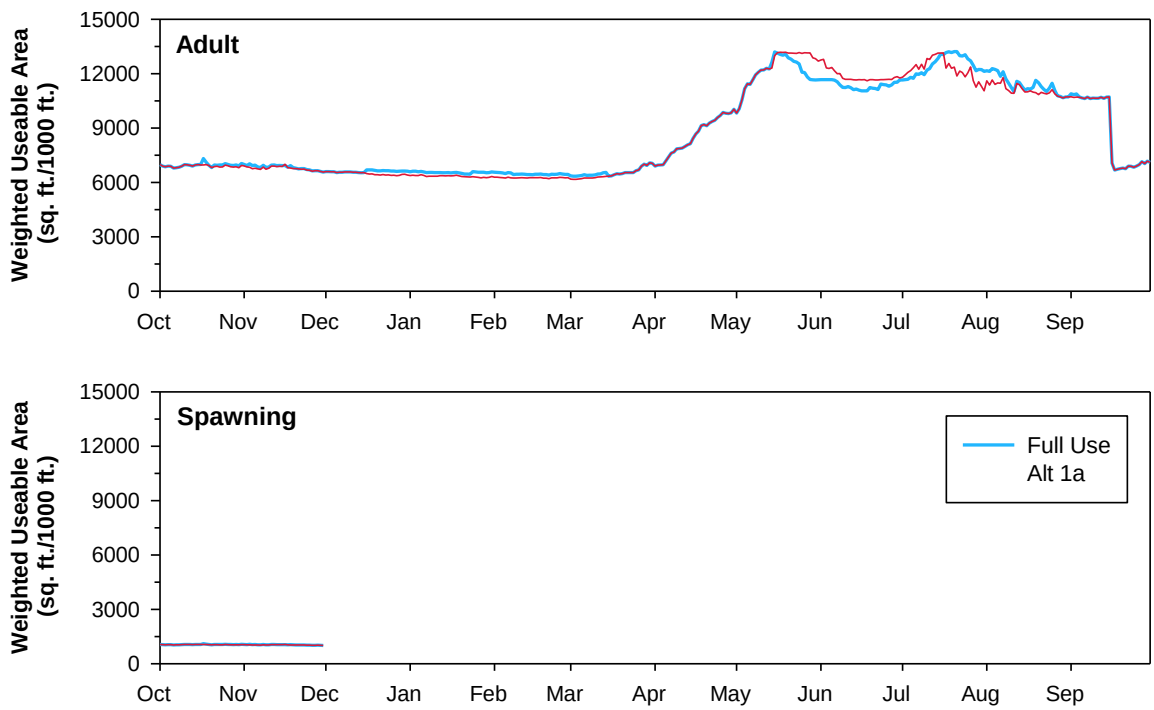
In average years, Segment 1 flow reductions between Full Use of the Existing System and Full Use with a Project Alternative (2032) would be 37% in May, 43% in June, and 15% in July (refer to Section 5.1 and Appendix H, Table H-3.6); flow reductions in the remaining months would not exceed 4%. The spring snowmelt runoff peak flow would be reduced by 6 cubic feet per second (cfs) (13%) on average and would be increased by 37 cfs (27%) in wet years (refer to Appendix H, Tables H-14.9 and H-14.10). In dry years, there would be no further reductions with the Proposed Action. In wet years, reductions would mainly occur from May through July and range from 3% in July to 46% in May. The Proposed Action would not increase the frequency and duration of dry years in the Fraser River compared to Full Use of the Existing System (refer to Section 5.1).

IHA analysis of the Fraser River just downstream of the diversion (PACSM Node 2120) shows that the Proposed Action would result in a minimal (less than 1%) reduction of the 90-day minimum flow. The IHA high flow parameters would be similar to Full Use of the Existing System conditions with respect to frequency, timing, and duration because natural high flows are already diverted with Current Conditions and with Full Use of the Existing System. However, the magnitude of the peak flow would be reduced by 19%. IHA small flood and large flood parameters look at floods that occur less frequently than once every two years. The characteristics of small and large floods in Segment 1 of the Fraser River would not change appreciably because they have already been altered by diversion and do

not occur every year under Current Conditions. However, large flood duration would be reduced by approximately 18% compared to Full Use of the Existing System conditions.

Brook trout are the dominant species in Segment 1 of the Fraser River. PHABSIM habitat relationships are available for brook, brown, and rainbow trout for this segment of the river. In Segment 1, brook trout adult habitat is most limited during peak runoff in median and wet years and during late summer, fall, and winter in dry years. Reductions in minimum and average annual habitat availability never exceed 3% in any year type. The largest change in habitat availability is a 21% increase during the spring runoff period in median and wet years (Figure 5.11-1), which may represent a reduction in stressful habitat conditions for brook trout. There would be minimal changes in spawning habitat availability.

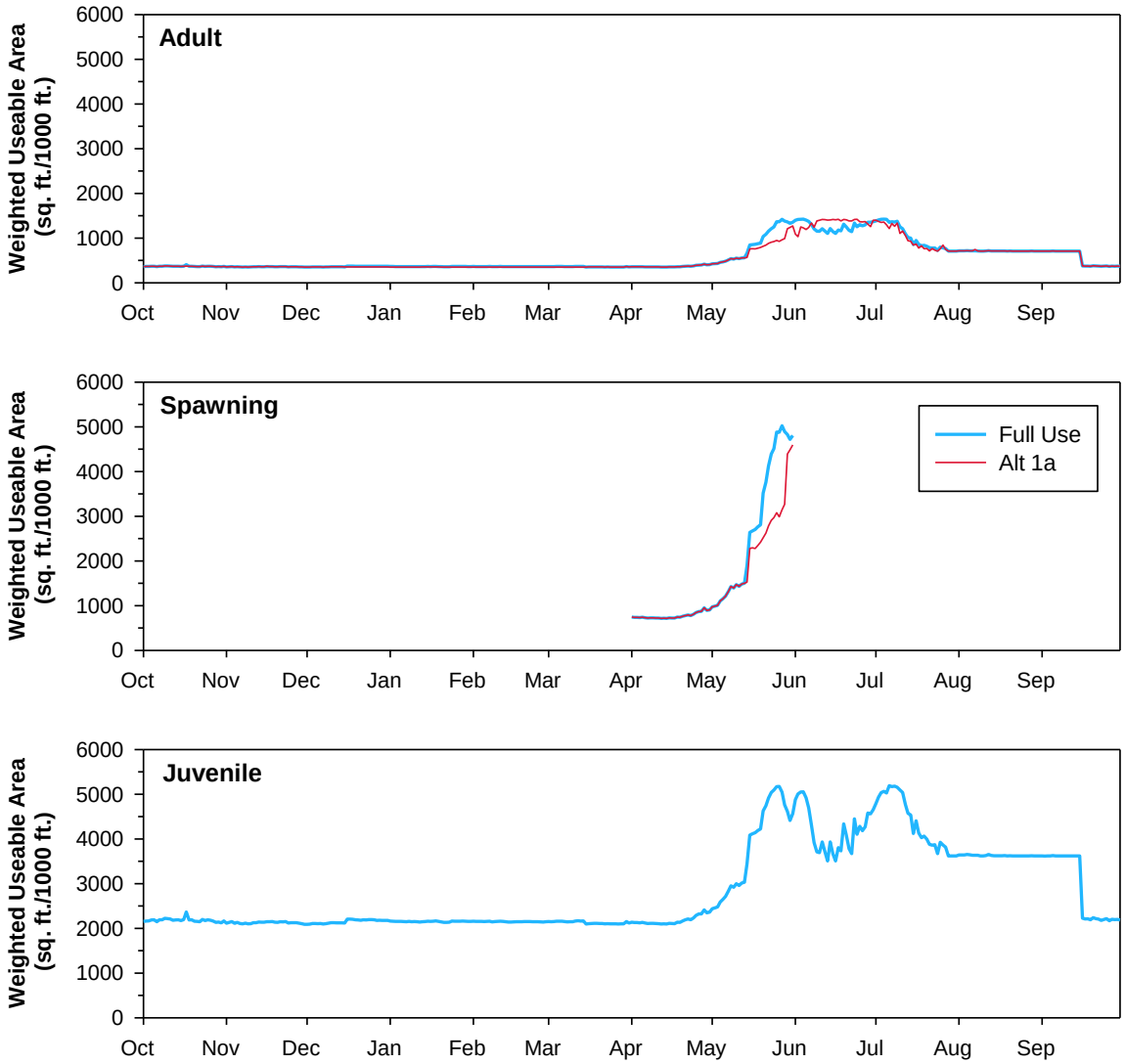
Figure 5.11-1
WUA for Adult and Spawning Brook Trout in Segment 1 of the Fraser River for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



Adult and juvenile brown trout habitat availability is highest during spring runoff and most limited in winter. Changes in minimum and average habitat availability for all life stages never exceed 2%.

Adult and juvenile rainbow trout habitat availability is lowest during winter and early spring and highest during peak runoff, similar to brown trout. In all three year types, reductions in minimum habitat availability for all life stages never exceed 1%, and reductions in average habitat availability for most life stages never exceed 4%. Average spawning habitat availability would be reduced by 15% in median years (Figure 5.11-2).

Figure 5.11-2
WUA for Three Life Stages of Rainbow Trout in Segment 1 of the Fraser River for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



The available literature suggests that benthic macroinvertebrates are less sensitive to flow reductions than fish. Because some macroinvertebrates can be dislodged during peak flows, some species can benefit from reduced runoff. As a result, macroinvertebrate communities that exist after the flow reductions with the Proposed Action may include more species and higher densities than Full Use of the Existing System conditions. However, macroinvertebrates with more generalized flow requirements may replace rheophilic species, leading to changes in the invertebrate community and similar or lower species richness. If rheophilic species persist or are replaced by generalist species that fill similar ecological roles, reductions in runoff flows with the Proposed Action could have a minor beneficial or negligible impact on the macroinvertebrate community of the Fraser River. The Fraser River in this segment is on the Section 303(d) List for aquatic life (provisionally listed) due to the samples with low MMI scores although some samples

scored above the threshold as well. The Proposed Action would not likely change MMI scores substantially.

Changes in sediment transport are expected to be insignificant. There may be changes in short-term sediment cycling that allow sediment to temporarily accumulate but sediment would be removed by periodic high flows, and no long-term change in channel morphology is expected (refer to Section 5.3). Very limited exceedances of water quality standards for copper and zinc already occur in the upper Fraser River and there are likely to be further occurrences in the future (refer to Section 5.2). Projected habitat availability and temperature changes in this segment of the Fraser River as a result of the Proposed Action would not be sufficient to affect trout populations in Segment 1. Also, long-term aggradation is not expected, so spawning habitat would not become permanently embedded. However, the short-term accumulations of sediment and the likely changes in benthic macroinvertebrate species composition indicate that the Proposed Action would have a minor adverse impact on aquatic resources in Segment 1 of the Fraser River. This segment of the Fraser River has not crossed ecological tipping points that would affect the suitability to maintain fish and invertebrate populations and likely will not cross a tipping point with the Proposed Action.

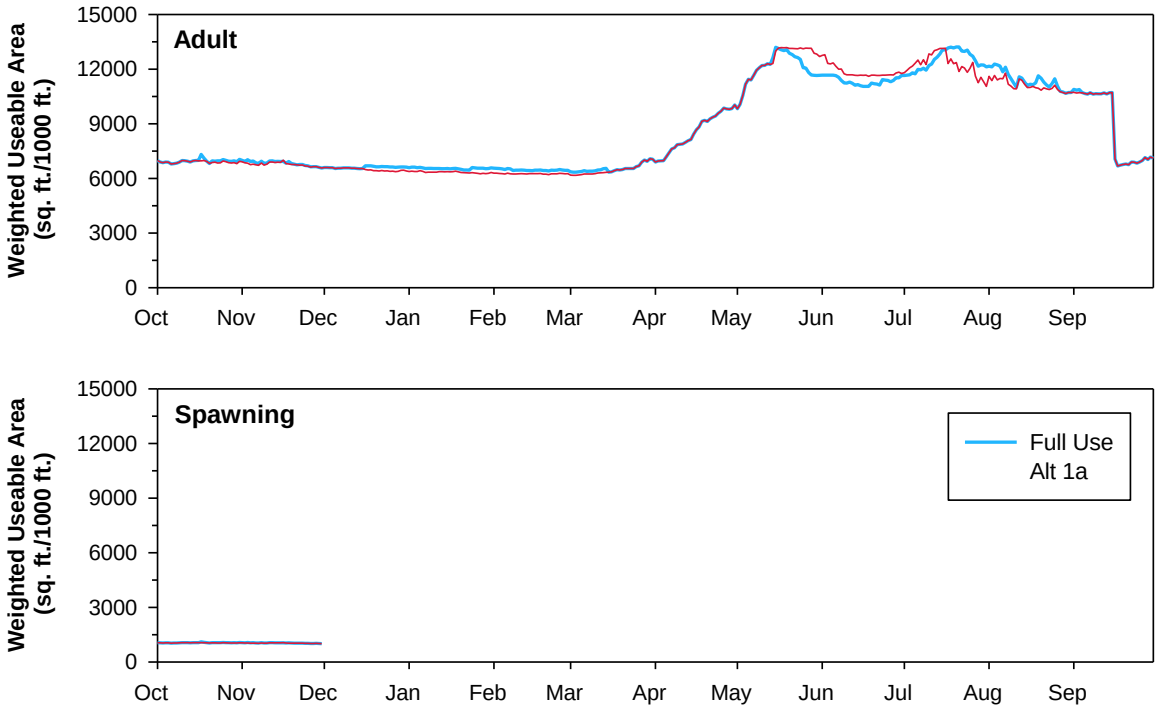
Segment 2, Vasquez Creek to St. Louis Creek

In Segment 2, substantial flow reductions would occur in May through July due to the Project. In average years, reductions in monthly flow in these months would range from 23% to 38%, reducing flows up to 46 cfs (refer to Appendix H, Table H-3.11). Wet year reductions would be 35% in May, 24% in June, and 6% or less in the remainder of the year. There would be no reductions in dry years.

The habitat relationship for adult brook trout for Segment 2 of the Fraser River indicates that the low flows of winter result in relatively low habitat availability. The reductions in flow with the Proposed Action would result in no reductions in minimum or average habitat availability in median, dry, and wet years greater than 3% (Figure 5.11-3) and no changes in dry years.

There would be temporary changes in short-term sediment cycling, but sediments will continue to be removed by periodic high flows, and no long-term aggradation is expected (refer to Section 5.3). Because sedimentation appears to be concentrated near diversions and is not pervasive throughout the segment, spawning habitat should not be affected. There would be no temperature changes in this segment of the Fraser River as a result of the Proposed Action sufficient to affect trout populations. There may be changes in macroinvertebrate species composition as rheophilic species are reduced and replaced by species that prefer lower current velocity. The minimal changes in brook trout habitat availability would result in no change in populations in Segment 2 of the Fraser River. A minor adverse impact to aquatic resources is expected as a result of changes to the macroinvertebrate community. However, the impact is not expected to preclude the maintenance of fish and invertebrate populations and this segment will not be degraded past a tipping point. The Fraser River in this segment is on the Section 303(d) List for aquatic life (provisionally listed) due to the samples with low MMI scores although some samples scored above the threshold as well. The Proposed Action would not likely change MMI scores substantially and they may continue to indicate impairment in the future.

Figure 5.11-3
WUA for Adult and Spawning Brook Trout in Segment 2 of the Fraser River for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



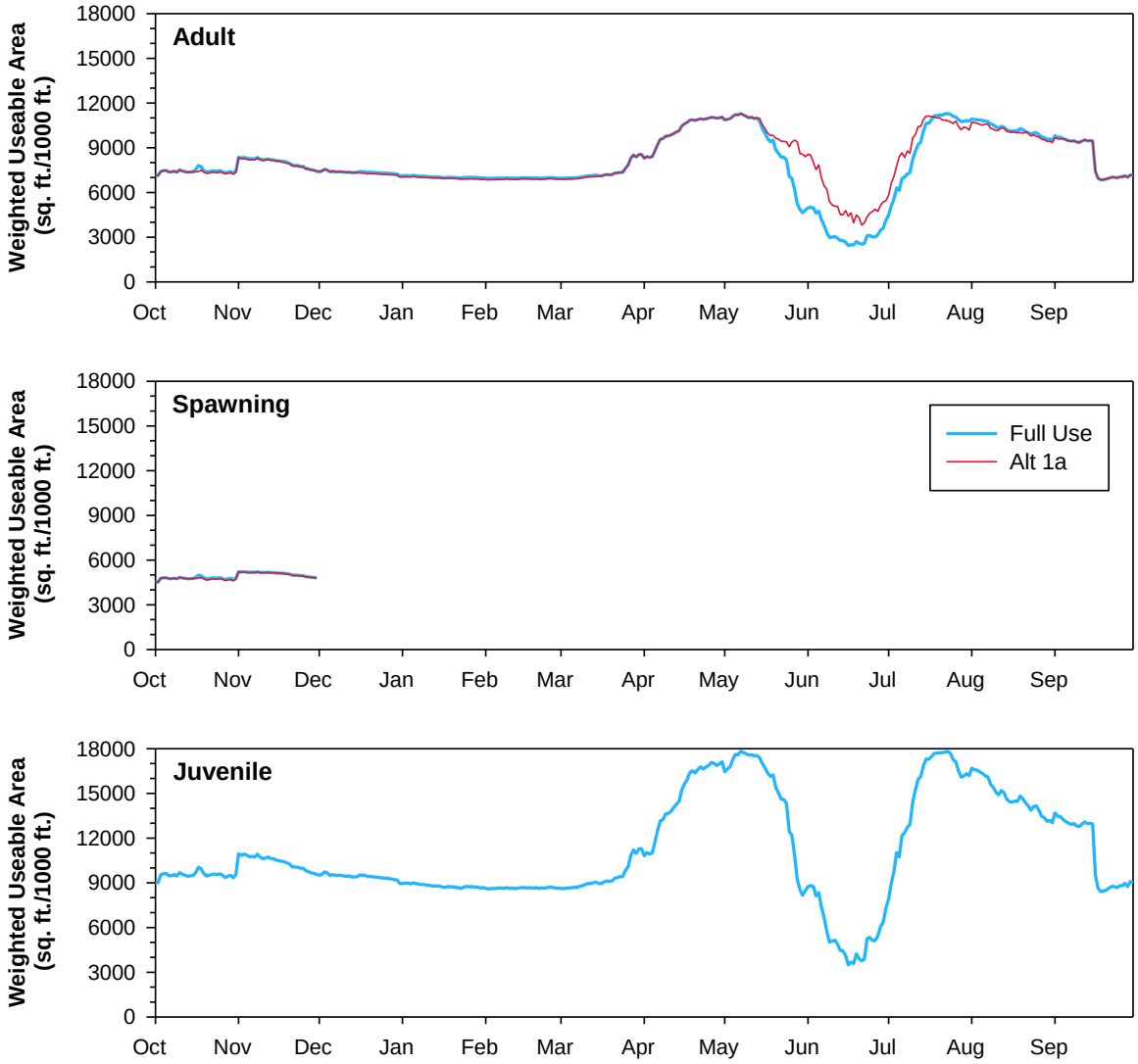
Segment 3, St. Louis Creek to Ranch Creek

In Segment 3 of the Fraser River, monthly flows reductions would be 9% to 31% lower than Full Use of the Existing System conditions in May through August of average years (refer to Appendix H, Table H-3.17). During the rest of the year, there would be no changes greater than 6%. Peak flows would be reduced by 79 cfs (28%) in average years (refer to Appendix H, Table H-14.9). In dry years, there would be no flow reductions and in wet years, reductions during the wet months would range from 2% to 22% of Full Use flows.

IHA analysis of flows in the Fraser River downstream of St. Louis Creek (PACSM Node 2700) shows that the Proposed Action would result in no change in the 90-day minimum flow and a few days of zero flow modeled in some years. Although the largest amount of water would be withdrawn during peak flows, the Fraser River would still experience runoff flows, albeit reduced, in June and July. The high flow parameters would be similar in magnitude, duration, frequency and timing. Small and large floods would remain unaffected with respect to timing and magnitude of peak flow, but the duration of large floods would decrease by 28%.

In Segment 3 of the Fraser River, habitat relationships were available for adult, juvenile, and spawning life stages of rainbow and brown trout. In this segment, minimum habitat availability for brown trout and rainbow trout occurs during peak runoff in median and wet years and during low flows in dry years (Figure 5.11-4). The juvenile life stage of both species has a similar pattern of habitat availability as adults.

Figure 5.11-4
WUA for Three Life Stages of Brown Trout in Segment 3 of the Fraser River for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



Under the Proposed Action, peak runoff flows would be reduced and minimum habitat availability would increase by 57% and 58% for adult brown and rainbow trout in median years. For juvenile brown and rainbow trout, minimum habitat availability would increase by 92% and 79%, respectively in median years. Average annual habitat availability would not change by more than 4% for any life stage of brown or rainbow trout. Habitat availability would remain largely unaffected during low flows (Figure 5.11-4). The large increases in juvenile and adult minimum habitat availability would occur in median years because lowest habitat availability occurred during peak runoff. This may represent a reduction in stressful conditions for these life stages. In dry and wet years, changes in habitat availability for all life stages of brown and rainbow trout would be 4% or less and there would be no changes in dry years.

Temperature exceedances in Segment 3 of the Fraser River occasionally occur and are not expected to increase as a result of the Proposed Action. Sediment and channel morphology are not expected to change. However, the reductions in peak flows would increase habitat availability for fish and invertebrates. The Proposed Action would have a moderate beneficial impact to aquatic resources in Segment 3 of the Fraser River.

Segment 4, Ranch Creek to Mouth of Canyon

In Segment 4, monthly flow reductions in average years would be 19% in June and 14% in July (refer to Appendix H, Table H-3.22). During the rest of the year, flow reduction would be less than 5% and usually less than 2%. Peak flows would be reduced by 21% (116 cfs) (refer to Appendix H, Table H-14.9). There would be no flow reductions in dry years. In wet years, flow reductions would be greatest in June (11%, up to 114 cfs), but they would be 4% or less during summer low flows.

IHA analysis of the Fraser River below Crooked Creek (PACSM Node 2810) shows that the Proposed Action would result in no reduction of 90-day minimum flows. Low and high pulse counts and durations would not change. The high-flow metrics would be similar to Full Use of the Existing System conditions with respect to timing and duration but 20% lower in frequency. The frequency, timing, and duration of small floods would not change substantially. Large flood peaks would be reduced in magnitude (18%) and duration (11%), but timing would not change significantly.

PHABSIM habitat relationships were available for adult, juvenile, fry, and spawning life stages of rainbow and brown trout. Minimum habitat availability for brown trout would not be changed by more than 1% for any life stage in median, dry, or wet years. Average annual habitat availability would not be changed by more than 3% for any life stage in median, wet, or dry years. Habitat availability during low flows would not be affected.

Minimum habitat availability for rainbow trout would not be changed by more than 5% under the Proposed Action for most life stages. However, an increase in minimum fry (54%) and juvenile (14%) rainbow trout habitat would occur under the Proposed Action in median years because the minimum habitat availability for both of these life stages currently occurs during peak runoff. This increase in minimum habitat availability may represent a decrease in stressful conditions for these stages of rainbow trout.

Changes in average annual habitat availability for all year types would be 5% or less for all rainbow trout life stages except spawning. Reductions in average annual spawning habitat would be 11% in median years. However, the prevalence of whirling disease has essentially prevented rainbow trout reproduction in the Fraser River. Efforts to establish whirling disease resistant Hofer-strain rainbow trout populations could be negatively affected by this reduction in spawning habitat.

For almost all life stages of brown and rainbow trout there would be minimal changes in habitat availability in this segment of the Fraser River. Exceedances of temperature standards have not occurred in this segment and changes are expected to be minimal. Changes to sedimentation and channel morphology are not expected. The result of the Proposed Action would be a negligible impact to aquatic resources compared to Full Use of the Existing System conditions, and density changes to fish populations are not expected.

Segment 5, Mouth of Canyon to Colorado River

In Segment 5, average year monthly flow reductions would be 17% and 14% in June and July; reductions would be 6% or less in remaining months (refer to Appendix H, Table H-3.23). In dry years, there would be no reductions and in wet years, depletions would 10% in June and would be no more than 7% in remaining months.

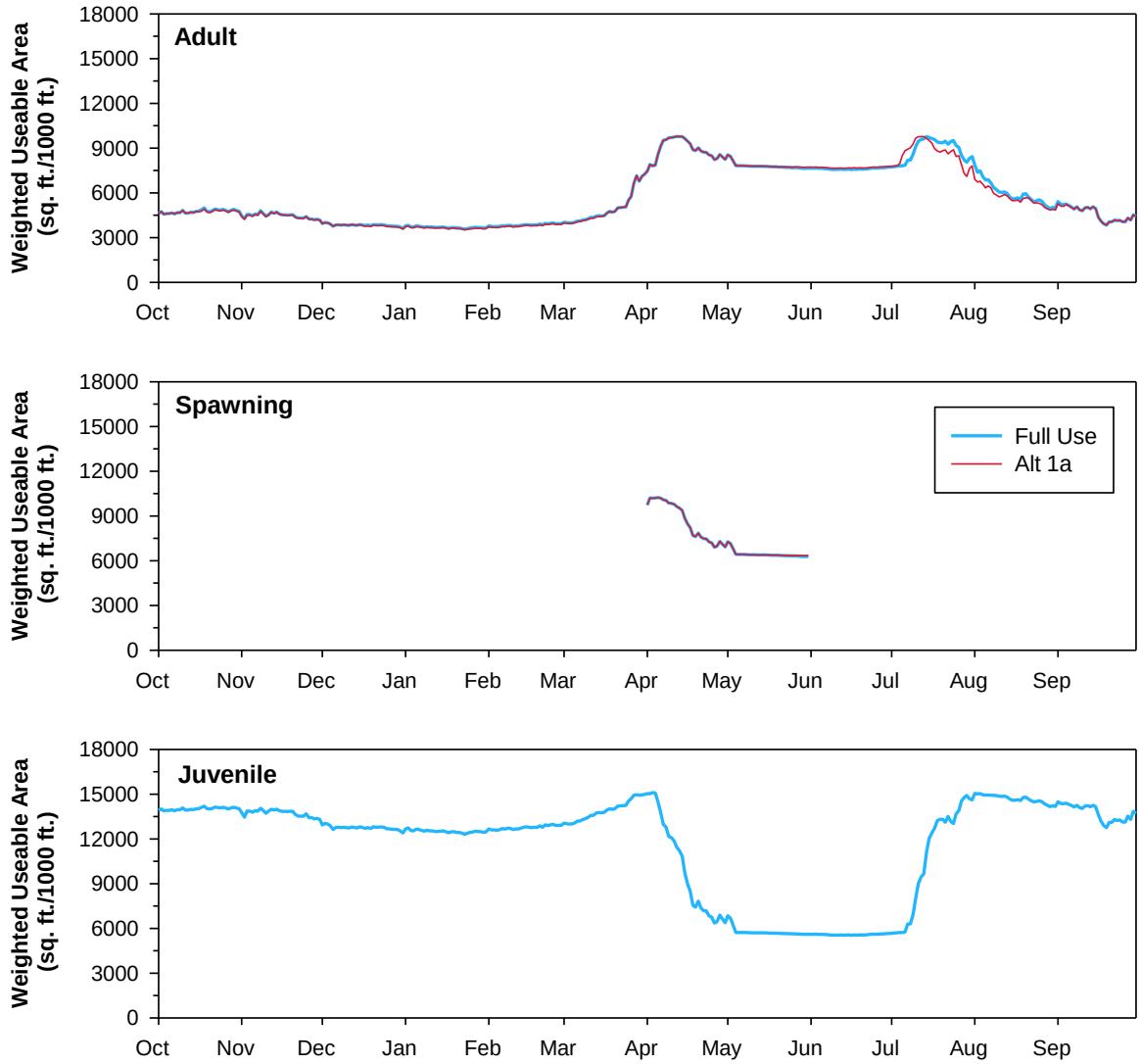
Seasonal changes in habitat availability for brown trout in Segment 5 of the Fraser River indicate that habitat is most limited at low flows in median and dry years and during spring runoff flows in wet years. Habitat simulations for brown trout indicate minimal changes in minimum and average annual habitat availability of 1% or less for all life stages in median, dry and wet years. Habitat availability during low flows would remain unaltered.

WUA output for rainbow trout also indicates that habitat availability changes seasonally: adult habitat was most limited at low flows in all year types, and juvenile habitat was most limited during spring runoff in all year types. The Proposed Action would not result in minimum habitat availability changes greater than 3% for any life stage in any year type. Average annual habitat would not change by more than 1% for any life stage or year type under the Proposed Action (Figure 5.11-5). Habitat during low flows would not be reduced.

Low winter flows usually occur in January and are generally above 30 cfs in median and wet years. In dry years low flows under Full Use and the Proposed Action would be approximately 23 cfs. These flows are similar to the recommended minimum flows based on R-2-Cross data (20 cfs and 30 cfs at two sites) and would not change substantially with the Proposed Action.

The small reductions in peak flows with the Proposed Action would have little effect on fish habitat availability in Segment 5 of the Fraser River. Temperature changes are expected to be minimal and would not affect trout populations in Segment 5. Also, long-term sedimentation is not expected, so spawning habitat would not become permanently embedded. Therefore, the Proposed Action is expected to have a negligible impact to aquatic resources in Segment 5 of the Fraser River.

Figure 5.11-5
WUA for Three Life Stages of Rainbow Trout in Segment 5 of the Fraser River for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



Fraser River Tributaries

There would be additional diversions on tributary streams in average and wet years with the Proposed Action compared to Full Use of the Existing System conditions. There would be no additional diversions in dry years in any of these streams. The timing of the seasonal pattern of spring runoff when flows bypass the diversions would not change substantially although the magnitude and duration would be reduced in some years. The Proposed Action would not substantially increase the frequency and duration of dry years in any of the Fraser River tributaries compared to Full Use of the Existing System (refer to Section 5.1). Many of the tributary streams are fully diverted at times with no flow past the

diversion. Days when the streams are fully diverted are zero flow days. The number of zero flow days changes with the Project in some streams and was evaluated.

Many of the tributary streams are fully diverted at times with Current Conditions and would be with Full Use of the Existing System. These have limited or no fish population, and have macroinvertebrate communities limited to species tolerant of low flows. Many of these streams also have groundwater and wetland inputs that allow more robust aquatic communities at increasing distances downstream of the diversions. Most of these streams are already past tipping points.

Based on information from Jim Creek, many of the tributaries that are fully diverted at times are currently undergoing channel narrowing and vegetative encroachment. With flow reductions as a result of the Proposed Action, this narrowing could continue (refer to Section 5.3). This could be the case with many of the Fraser River tributaries without bypass flows.

St. Louis Creek Tributaries

The PACSM Node (2180) for the St. Louis Creek tributaries (refer to Appendix H, Table H-3.14) includes the hydrology data for West St. Louis Creek, Short Creek, Iron Creek, Byers Creek, East St. Louis Creek, and Fool Creek. The Proposed Action would divert 42% more water from these streams in average years and 18% more water in wet years on an average annual basis; no additional diversions are proposed for dry years. The average year peak flow would be reduced by 39% (refer to Appendix H, Table H-14.9). The diversions would occur from May through September; because flows are already nearly 100% diverted in the remaining months. The additional diversions would extend the period of no flow by one to two weeks on average (refer to Section 5.1). The additional diversions would extend the period of no flow by one to two weeks on average (refer to Section 5.1) although there would be one year (in the 45-year modeling period) with up to 62 additional zero flow days. There is no bypass flow for these streams.

IHA analysis of PACSM Node 2180 shows that the Proposed Action would result in no reduction in minimum flows, because these tributaries are currently 100% diverted for most of the year. The remaining flows in the St. Louis Creek tributaries occur during spring runoff. These spring flows would be reduced under the Proposed Action so that flows that would be high enough to meet the IHA high flow parameter would decrease from 1 to 0 occurrence per year and the duration of high flows would decrease by 27%. Small and large floods would remain largely unaffected except for decreases in duration. High flow, small flood, and large flood durations would be reduced by 25% to 63%.

All of these tributary streams are currently severely diverted and are often dry below the diversions. The hydrology data for these streams indicate that water passes the diversions only during the high flow months in most years, May through July. During the rest of the year the streams are fully diverted and resume flowing at varying distances downstream as water enters the streams from tributaries, groundwater, and wetlands. The periods in severely diverted streams when water does not pass the diversions represent stressful conditions for aquatic organisms, especially in winter, the period of lowest flow and cold temperatures. The Proposed Action would not change flow conditions during the critical winter months in the St. Louis Creek tributaries, but would reduce the flows that pass the diversions in wet months and extend the period when water does not pass the diversion.

The St. Louis Creek tributaries have not been individually studied, but streams below diversions with no bypass flows likely already have some channel narrowing and vegetative encroachment (refer to Section 5.3) and this likely would continue to occur. The Proposed Action would have a minor adverse impact on the aquatic organisms in these streams. The impact would be minor because any organisms that persist downstream of these diversions are tolerant of very low flows and because proposed changes are small in relation to historic diversions.

Most of the flows have been previously diverted from these six St. Louis Creek tributaries and further threshold effects are unlikely as a result of the Proposed Action. These streams are already past the ecological tipping point. These streams currently have greater than 60% of their average annual flow removed, and although 60% of peak flows are not currently diverted in all year types, greater than 90% of flows are removed during the low-flow months. These streams do not currently support fish populations or many rheophilic macroinvertebrate species. As a result, no changes in fish populations are expected as a result of the Proposed Action. The relatively small increase in the number of zero flow days would further limit the amount of time when water flows past the diversion carrying with it drifting macroinvertebrates from upstream, and is available for colonization by macroinvertebrates downstream, or is available to augment flow increases from tributaries and groundwater further downstream. This could lead to a decrease in macroinvertebrate densities and may further restrict the presence of rheophilic species.

St. Louis Creek

In St. Louis Creek downstream of the Denver Water diversion (PACSM Node 2170), on an average annual basis there would be 16% less water in average years and 10% less in wet years with no additional diversions in dry years (refer to Appendix H, Table H-3.13). The additional diversions would occur during spring runoff. Peak flow would decrease by 11 cfs (21%) in average years (refer to Appendix H, Table H-14.9).

IHA analysis of upper St. Louis Creek shows that the Proposed Action would result in no reduction in minimum flows, likely because of the bypass flow in this stream. The frequency of high flows would not change, but the magnitude would increase slightly, and the duration would decrease by 20%. The small and large flood peaks would not experience appreciable decreases in magnitude, but their durations would decrease by 71% and 27%, respectively. The reductions in high flows would have a minor adverse impact on the section of St. Louis Creek just downstream of the diversion. Because of the lower spring flows, there may be changes to the macroinvertebrate community with fewer rheophilic species. Also, the lower flows would further limit the water past the diversion carrying with it drifting macroinvertebrates from upstream and available for colonization by downstream, slightly decreasing connectivity to upstream populations. Almost all of the MMI scores for samples from St. Louis Creek were well above the threshold for attainment. The minor changes in the benthic invertebrate community with the Proposed Action would not likely affect MMI scores substantially and St. Louis Creek would continue to attain the aquatic life use.

In the lower section of St. Louis Creek, the differences in hydrology near Fraser (PACSM Node 2200) with the Proposed Action indicate that runoff flows during May, June, and July

would be reduced to create additional average diversions of 13% in average years and 9% in wet years with no further reductions in dry years (refer to Appendix H, Table H-3.15).

PHABSIMs were available for one site on lower St. Louis Creek. Changes in minimum and average habitat availability for brook trout would not exceed 1% under the Proposed Action in any year. Minimum habitat availability for brook trout occurs during peak runoff at this node, but model outputs indicate few changes to habitat availability during peak flows.

Water quality and water temperatures are not expected to change under the Proposed Action (refer to Section 5.2). The current sediment regime is also expected to be maintained annually (refer to Section 5.3). St. Louis Creek has minimum bypass flows in summer and winter. The reductions in flow would result in a negligible impact for the Proposed Action in the lower section of St. Louis Creek.

Flow-related threshold effects are also not likely under the Proposed Action. Under Current Conditions, less than 60% of peak runoff and less than 60% of average annual flow are diverted in average and wet years and this stream has not crossed a tipping point. Additional diversions associated with the Proposed Action would not cross either threshold. In dry years, over 60% of peak flow is currently diverted, but 60% of the average annual flow is not. No changes in water diversion are proposed in dry years.

King Creek

In King Creek (PACSM Node 2220), average annual flows downstream of the diversion would be reduced by 43% in average years and 17% in wet years with the additional diversions occurring throughout the year (refer to Appendix H, Table H-3.16). Average year peak flow in King Creek is already very low at 1.8 cfs and the Proposed Action would result in a further reduction of 0.5 cfs (31%) (refer to Appendix H, Table H-14.9). This tributary currently has no bypass flow requirements, and greater than 90% of the stream's native flow is diverted for eight months of the year. This stream does not support fish either upstream or downstream of the diversion but does support macroinvertebrates. The reductions in flow with the Proposed Action would not change winter flows but would reduce the flows that pass the diversion during wet months and extend the period when water does not pass the diversion by approximately two weeks on average (refer to Section 5.1). In some years there would be no additional diversions, but there would be up to 69 additional days with no flow past the diversion in one year.

IHA analysis shows that the Proposed Action would result in no reduction in minimum flows, because of the extent of current diversions. The remaining spring runoff flows in King Creek would be reduced under the Proposed Action so that flows that would be high enough to meet the IHA high flow parameter would not occur annually. The occurrences and characteristics of high flows, and small and large floods would decrease in duration by 13%, 54%, and 44%, respectively, but not in magnitude.

The flow reductions would have a minor adverse impact compared to Full Use of the Existing System conditions. This would further limit the amount of time available with flowing water past the diversion and available for macroinvertebrate production and to augment groundwater inputs downstream. King Creek is already severely diverted and may be near an ecological tipping point. Apparently, inputs of groundwater downstream of the

diversion sustain a community of macroinvertebrates. No flow-based threshold effects are expected. However, a slightly longer no-flow period could lead to decreases in macroinvertebrate density, diversity, and number of Ephemeroptera, Plecoptera and Trichoptera (EPT) species and slight changes in species composition.

Elk Creek and Tributaries

PACSM Node 2300 includes West Elk Creek, West Fork Main Elk Creek, Main Elk Creek, and East Elk Creek (refer to Appendix H, Table H-3.12). The additional diversions with the Proposed Action would reduce flows by 28% in average years and 16% in wet years on an average annual basis with no additional diversions in dry years. Average year peak flows would decrease by 30% (refer to Appendix H, Table H-14.9). These four streams have no bypass flows and flows that pass the diversion would occur approximately one week less (refer to Section 5.1). In most years, there would be a few additional days with no flow past the diversion; however, additional days would range up to just less than 31 days in one year.

IHA analysis of Elk Creek and its tributaries shows that the Proposed Action would result in no reduction in minimum flows, because these tributaries are currently 100% diverted for much of the year. Flows that would be high enough to meet the IHA high flow parameter would occur 50% less under the Proposed Action and the magnitude would decrease by 20%. The frequency of small and large floods would not change. Small floods and large floods would decrease in duration by 62% and 87%, respectively.

Three of these tributaries are severely diverted and past tipping points: West Fork Main Elk, Main Elk, and East Elk creeks. As a result, no flow-based threshold effects are expected for these three tributaries. The reductions in flow with the Proposed Action would result in minor impacts that would reduce connectivity to upstream macroinvertebrate populations and further limit the water available to augment groundwater inputs downstream.

West Elk Creek contained populations of fish and invertebrates downstream of the diversion. This stream is mildly diverted and likely not past an ecological tipping point. Although an average of 60% of peak flows is not currently removed from these streams, they are nearly 100% diverted for seven months of the year. The reductions in flow with the Proposed Action would result in a minor adverse impact compared to Full Use of the Existing System conditions. There could be minor reductions in fish and/or invertebrate populations downstream of the diversion. The reductions in flow in this stream may be sufficient to cross an ecological tipping point.

MMI samples from Main Elk Creek indicate that it sometimes does not score above the threshold for attainment of the aquatic life use. The reductions in flow with the Proposed Action may increase the likelihood that MMI scores would be below the threshold.

Vasquez Creek

In Vasquez Creek below the Denver Water diversion (PACSM Node 2280), proposed flow reductions would be 27% in average years and 16% in wet years with no reductions in dry years (refer to Appendix H, Table H-3.8). In average and wet years, the greatest flow changes would occur in May. Peak flow would decrease by nearly 25 cfs (35%) in average years (refer to Appendix H, Table H-14.9). There is a seasonal bypass flow requirement of

8 cfs in summer and 3 cfs in winter downstream of the diversion. The number of days when the flow would be reduced to the minimum bypass would increase by one to two weeks on average.

Farther downstream at PACSM Node 2370, the Proposed Action would result in lower flows in the runoff period compared to Full Use of the Existing System conditions. Annual flows would be 32% lower in average years and 17% lower in wet years with no reductions in dry years. Increased flow diversions would be greatest during spring runoff months, but flow depletions in individual months would be as much as 43% (refer to Appendix H, Table H-3.10).

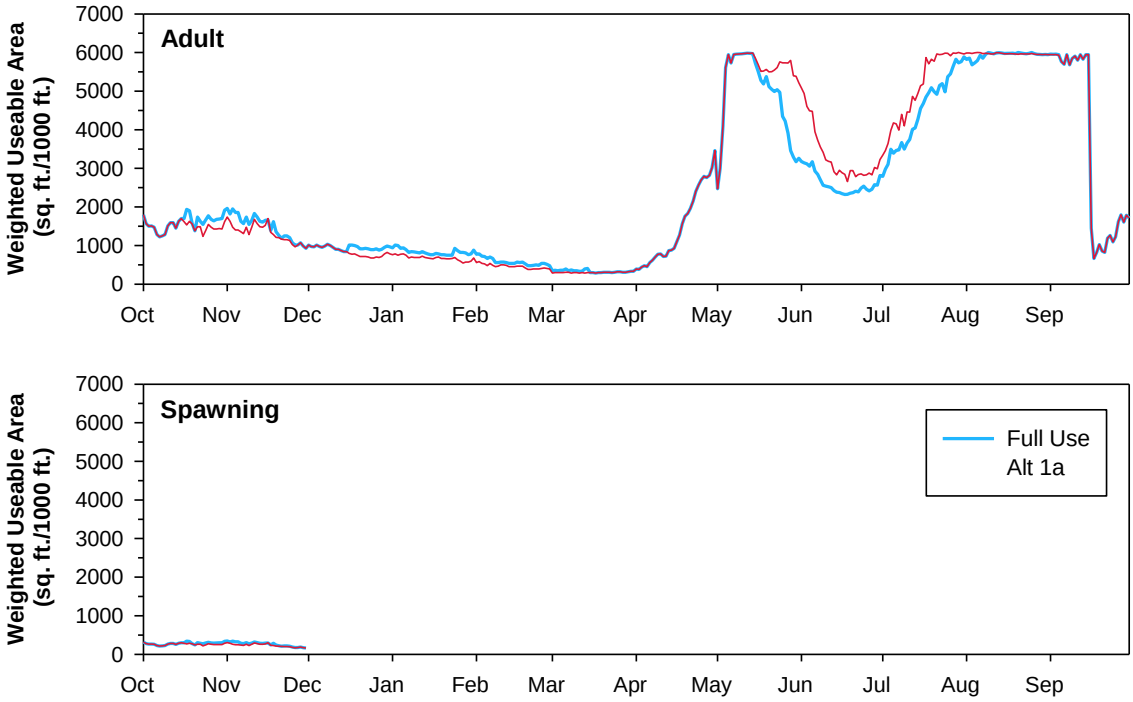
IHA analysis results for Vasquez Creek below the Denver Water diversion (PACSM Node 2280) show that the Proposed Action would result in no reduction in minimum flows, likely due to the bypass flow. The high flow peak frequency would decrease from 1 to 0 per year (i.e., peak flows that meet the high flow threshold would not occur annually). The durations of high flows, small floods, and large floods would be reduced by 13 to 68%.

PHABSIM habitat relationships were available for the adult and spawning life stages of brook trout in Vasquez Creek. Minimum habitat availability occurs during the lowest flows of the year in March for adult brook trout in Vasquez Creek (Figure 5.11-6), and habitat availability increases during spring runoff. There would be minimal changes to minimum or average habitat availability for brook trout in any year type because low winter flows would not change with the Proposed Action compared to Full Use of the Existing System.

No long-term changes in sedimentation or channel morphology are expected in Vasquez Creek (refer to Section 5.3). Changes in temperature or other water quality parameters are also not expected as a result of the Proposed Action (refer to Section 5.2). The lower runoff flows could tend to provide more favorable habitat for invertebrates in average and wet years. However, the large magnitude of flow changes, especially in the lower reaches of Vasquez Creek, would change the species composition of the benthic invertebrate community and may be low enough to exclude some rheophilic species.

The reduced flows and resulting macroinvertebrate community changes would have a minor adverse impact on aquatic resources in Vasquez Creek compared to Full Use of the Existing System. The decrease in wetted area associated with the increased diversions would probably lead to smaller macroinvertebrate populations likely with fewer EPT species and lower diversity. Recent MMI scores for Vasquez Creek were below the threshold for attainment and it is provisionally listed on the Section 303(d) List. The reductions in flows indicate that future scores would be below the threshold for attainment. Flow depletion information from Vasquez Creek at the Denver Water diversion suggests that this stream is very close to the 60% depletion thresholds of Carlisle et al. (2010) and Baran et al. (1995) and would cross these thresholds with Full Use of the Existing System and the Proposed Action. The stream would still maintain populations of fish and invertebrates but would likely cross an ecological tipping point with Full Use of the Existing System. The Proposed Action would further diminish the aquatic community.

Figure 5.11-6
WUA for Spawning and Adult Brook Trout in Vasquez Creek for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



Little Vasquez Creek

In Little Vasquez Creek (PACSM Node 2340), average annual flow would be 61% lower in average years and 38% lower in wet years. There would be no changes in dry years (refer to Appendix H, Table H-3.9). The additional diversions would occur mostly in the wet months. This stream has no bypass flow requirement although there is a 0.5 cfs bypass agreement. There is very low flow downstream of the diversion through the winter with Current Conditions but this stream supports fish and invertebrates downstream of the diversion. The Proposed Action would reduce the flows that pass the diversion in wet months, extend the period when little flow passes the diversion by one to two weeks on average, and have a minor adverse impact on aquatic resources in Little Vasquez Creek.

An increase in the number of low flow days could cause further declines in fish densities downstream of the diversion. Fish densities in Little Vasquez Creek have been lower than the regional average since 1992, probably because of low flows. It is likely that they will remain low or decrease further as a result of increased water diversion. Flow-based threshold effects are possible on Little Vasquez Creek because it is already near a tipping point.

Cooper Creek

Additional diversions on Cooper Creek would result in 31% lower flow in average years and 36% in wet years at PACSM Node 2380 on an average annual basis (refer to Appendix H, Table H-3.5). The diversions would mostly reduce flows during runoff and extend the period with no flow past the diversion by a few days to one week on average.

There is no bypass flow for this stream and it is fully diverted most of the time with low or no flow through the stressful winter period. The additional diversions during wet months would have a minor adverse impact for the Proposed Action compared to Full Use of the Existing System conditions. Because Cooper Creek has little remaining native flow and does not support fish, flow-based threshold effects are not likely under the Proposed Action; it is likely already past an ecological tipping point. Reductions in macroinvertebrate densities and changes in species composition are possible under the Proposed Action, given that the number of zero flow days would increase slightly and further limit the water and time available to support macroinvertebrates.

Jim Creek

The additional diversions in Jim Creek with the Proposed Action would result in 51% less water in average years and 30% in wet years (PACSM Node 2160) on an average annual basis (refer to Appendix H, Table H-3.3). The additional diversions would occur primarily in May, June, and July. Peak flows would be reduced by 5 cfs (39%) in average years (refer to Appendix H, Table H-14.9). There would be no additional diversions in dry years. There is no bypass flow for Jim Creek and it is fully diverted much of the year and this would be extended by a few more days. Jim Creek supports fish in the short section downstream of the diversion and likely has not crossed an ecological tipping point. There are inputs of water a short distance downstream of the diversion. This stream has very low or no flow through the winter just below the diversion, which probably represents the most stressful period for aquatic organisms.

IHA analysis results from PACSM Node 2160 show that minimum flows would be unaffected because the stream is often dry under Current Conditions. The Proposed Action would not change the magnitude but would decrease the duration of high flows and large floods by 11% and 17%, respectively, when they occurred compared to Full Use of the Existing System conditions.

The lower flows in wet months would allow more sediment to accumulate in the channel downstream of the diversion and allow accelerated vegetative encroachment of the stream channel (refer to Section 5.3). The additional diversions in wet months and the extension of the time of full diversion with the Proposed Action would have a minor adverse impact on aquatic resources. Additional flow-based threshold effects are unlikely in Jim Creek, given that it is 100% diverted much of the year and there are inputs of groundwater a short distance downstream of the diversion. However, an increase in zero flow days could cause a decrease in fish and macroinvertebrate densities. There may be some changes in species composition that would result in fewer EPT and rheophilic species.

North Fork Ranch and Dribble Creeks

Downstream of the Denver Water diversions on the North Fork Ranch Creek and Dribble Creek (PACSM Node 2490), the Proposed Action would result in 24% lower flow in average years and 10% in wet years on an average annual basis (refer to Appendix H, Table H-3.19). There would be no additional diversions in dry years. Additional diversions would be greatest during spring runoff. Average annual peak flows would be reduced by nearly 3 cfs (16%) (refer to Appendix H, Table H-14.9). These two streams have no bypass flows, are fully diverted for much of the year, and are past ecological

tipping points. North Fork Ranch creek supports fish and macroinvertebrates farther downstream of the diversion because of inputs of groundwater.

IHA analysis of PACSM Node 2490 shows that minimum flows would not be reduced, given the extent of current diversions. The timing and frequency of high flows would not change significantly, but duration would decrease by 27%. The magnitude and timing of small and large floods would not change under the Proposed Action, but the duration of both would decrease by 41% and 62%, respectively.

These streams have all of their flows diverted for much of the year. Additional diversions during the wet months would extend the dry period by approximately a week on average and up to several weeks in some years (refer to Section 5.1). However, because both of these streams are already severely diverted and past ecological tipping points, no flow-based threshold effects are expected as a result of the Proposed Action. Reductions in flow of this magnitude would have a minor adverse impact on the fish and invertebrate communities in North Fork Ranch Creek and on macroinvertebrates in Dribble Creek. Fish densities would likely not change appreciably, but an increase in the number of zero flow days may cause a decrease in macroinvertebrate densities.

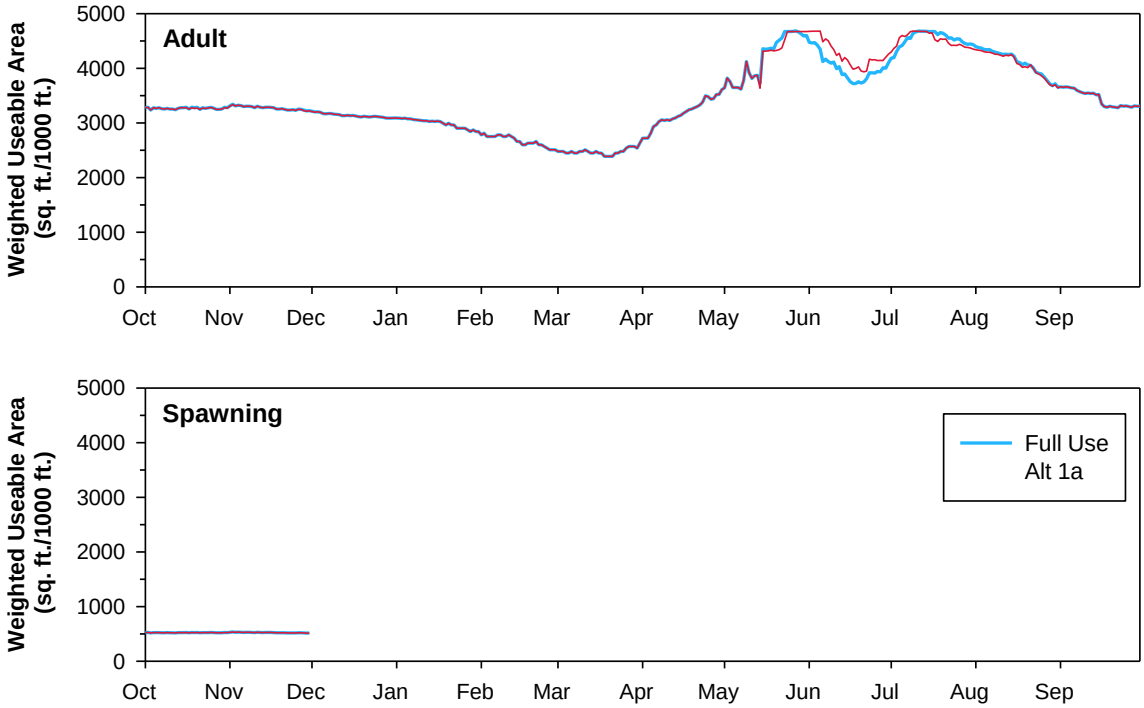
Main Ranch Creek

At Ranch Creek PACSM Node 2500 downstream of the Denver Water diversion, there would be 14% less water in average years and 7% less water in wet years with the Proposed Action (refer to Appendix H, Table H-3.20). Peak flows would be reduced by 4 cfs (16%) in average years (refer to Appendix H, Table H-14.9). There would be no additional diversions in dry years. The majority of the water would be diverted during spring runoff.

IHA analysis results from PACSM Node 2500 show that minimum flows would not be affected by the Proposed Action, due to the bypass flow requirement. High flows would continue to occur under the Proposed Action; the timing, magnitude, frequency, and duration would remain similar. The duration would decrease for small and large floods by 32% and 61%, but the magnitude and timing would remain unaffected.

A PHABSIM for brook trout was available for Ranch Creek. Minimum habitat availability for adult brook trout occurs in March and April at the lowest flows of the year, and availability is highest during spring runoff in median, wet, and dry years. Flows proposed under the Proposed Action do not produce any appreciable changes in minimum or average habitat availability for adult or spawning brook trout in median, dry, or wet years (Figure 5.11-7). The low flows in winter are probably the critical low habitat period in this stream for fish and probably also for invertebrates. The similar flows in these months with both the Proposed Action and Full Use of the Existing System conditions indicate that minimum habitat availability in winter would not change.

Figure 5.11-7
WUA for Spawning and Adult Brook Trout in Ranch Creek for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



Long-term sediment dynamics are not expected to change under the Proposed Action (refer to Section 5.3). Sediment transport capacity and supply would be reduced with predicted flow changes. Additional sediment deposition may occur in localized areas but deposition is expected to be limited in duration. Flows sufficient to mobilize sediment and maintain existing stream characteristics are predicted to remain. Ranch Creek commonly has exceedances of temperature criteria in late summer at low flows. Late summer low flows are not expected to change appreciably and high water temperatures would not change appreciably (refer to Section 5.2). Main Ranch Creek consistently supports fish in the lower sections due to inputs of groundwater and has not crossed an ecological tipping point. Although the depletion threshold of Baran et al. (1995) is not met, the threshold of Carlisle et al. (2010) is approached in dry years. However, the Proposed Action does not change flows enough in average or wet years to produce flow-based threshold effects and there would be no change in flow in dry years.

The Proposed Action would reduce flows below the diversion in wet months. This would extend the period of low flows in the stream by one week on average. The Proposed Action would have a minor adverse impact on the fish and invertebrate communities of Ranch Creek. MMI scores for samples from Ranch Creek were well above the threshold for attainment and this would not likely change with the Proposed Action.

Middle Fork and South Fork Ranch Creek

These streams are fully diverted at times and there are no bypass requirements. The additional diversions with the Proposed Action would result in 37% lower flows in average

years and 15% lower flows in wet years (PACSM Node 2520) on an average annual basis (refer to Appendix H, Table H-3.21) with no changes in dry years. Peak flows would be reduced by 10 cfs (29%) in average years (refer to Appendix H, Table H-14.9). These streams have very low or no flow through the winter, which probably represents the most stressful period for aquatic organisms.

IHA analysis of PACSM Node 2520 shows that decreases in minimum flows characteristics would not be affected, given the extent of current diversions, but zero flow days would increase slightly. The magnitude, duration, and timing of the high flows would not be affected by the Proposed Action. However, the duration of small and large floods would decrease by 46% and 73%, respectively.

The Proposed Action would not change flows in the winter in most years but the reduced flows past the diversions in wet months and the extension of the period when the streams are fully diverted by one to two weeks on average (refer to Section 5.1) would have a minor adverse impact in these two streams. Flow-based threshold effects are not expected with the Proposed Action because these streams are already severely diverted and past ecological tipping points. A minor decrease in macroinvertebrate densities is possible under the Proposed Action.

Wolverine Creek

There is no PACSM node for Wolverine Creek. We assume that more water would be diverted during the wet months similar to nearby streams. This very small stream has no bypass flow and is fully diverted much of the year with low or no flow through the winter. The additional diversions during the wet months with the Proposed Action would have a minor adverse impact compared to Full Use of the Existing System conditions. Flow-based threshold effects are not anticipated as a result of the Proposed Action because this stream is already severely diverted and past an ecological tipping point. Minor decreases in macroinvertebrate densities may occur as a result of a small increase in the number of zero flow days.

Cub and Buck Creeks

Additional diversions on Cub Creek and Buck Creek would reduce flows by 31% in average years and 27% in wet years (PACSM Node 2540) on an average annual basis primarily in May, June, and July with no additional diversions in dry years (refer to Appendix H, Table H-3.4). These two small streams have no bypass flow and are fully diverted much of the year, which would be extended for about a week on average, with low or no flow through the winter. The additional diversions during the wet months with the Proposed Action would have a minor adverse impact compared to Full Use of the Existing System conditions. Flow-based threshold effects are not anticipated as a result of the Proposed Action because these streams are already severely diverted and past tipping points. Minor decreases in macroinvertebrate densities may occur as a result of a small increase in the number of zero flow days.

Englewood Ranch Gravity System

The Englewood Ranch Gravity System includes diversions on Meadow, South Trail, North Trail, Hurd, Hamilton, Cabin, and Little Cabin creeks. The diversions on South and North Trail creeks also affect flows in Trail Creek. PACSM Node 2480 (refer to Appendix H,

Table H-3.18) models flow in these streams. With the Proposed Action, changes in average annual flow would be 3% in average years and wet years on an average annual basis with no additional diversions in dry years. The additional diversions would occur during spring runoff. The small changes in flow with the Proposed Action would have a negligible impact on fish and invertebrates in these streams. Current diversions on these streams do not approach any flow-based thresholds for population-level effects, and diversions under the Proposed Action are not sufficient to cross these thresholds. Therefore, no flow-based threshold effects are expected for these streams under the Proposed Action.

Fraser River Watershed Level Effects

Additional diversions of spring flows with the Proposed Action would decrease flows past the diversions in many of the tributary streams in the Fraser River watershed. Under Current Conditions (2006), the tributaries in the watershed have already been affected by the diversions included in the Project area as well as by many other diversions not part of the Project. These streams have also been affected by other watershed-scale activities including development, the establishment and maintenance of roads, and culverts. These activities have altered some ecological processes, especially connectivity of upstream and downstream sections of stream including transfer of nutrients and sediment transport. The Proposed Action would not add any new diversions or roads and would not change the existing patterns of connectivity. However, the reductions in the number of days when water passes the diversions would reduce, to some extent, the transport of fish, benthic invertebrates, nutrients, and sediment from upstream to downstream sections, which would be a minor adverse effect.

Williams Fork River

Headwaters to the South Fork

The Williams Fork River upstream of the South Fork was evaluated with PHABSIMs. Hydrology data from the Williams Fork above Darling Creek gage (PACSM Node 3600) were used to simulate habitat for adult and spawning life stages of brook trout. The hydrology data for the Proposed Action indicate average annual flow reductions of 2% in average and dry years and 2% in wet years with no reductions in dry years (refer to Appendix H, Table H-3.30). Peak flow in an average year would be reduced by 14 cfs (7%) (refer to Appendix H, Table H-14.9). Additional diversions would occur from May through August, and relative reductions would be largest in July. The Proposed Action would not increase the frequency and duration of dry years in the Williams Fork River and tributaries (refer to Section 5.1). The timing of the seasonal pattern of spring runoff would not change substantially although the magnitude and duration would be reduced in some years.

IHA analysis of flow at PACSM Node 3600 showed that 90-day minimum flows would decrease by 2%. Changes to high flow, small flood, and large flood IHA parameters would also be minimal, 7% or less.

The pattern of habitat availability for adult brook trout in Segment 1 of the Williams Fork River indicates minimum habitat during runoff in median, wet, and dry years. The reductions in runoff flows with the Proposed Action may decrease stressful conditions for brook trout, but minimum and average adult brook trout habitat availability would

experience minimal changes (1% or less) under the Proposed Action. Changes in spawning habitat would also be small: minimum and average spawning habitat availability would decrease by 3% in median years; no changes are expected in dry or wet years.

For aquatic resources, the small differences in flow for the Proposed Action would have a negligible impact compared to Full Use of the Existing System conditions. MMI samples from the Williams Fork River indicated attainment and the changes in flow are not expected to affect MMI scores. Because the current flow depletions from this stream do not approach either of the flow-based thresholds, and because additional proposed diversions are small, no flow-related threshold effects are expected with the Proposed Action.

South Fork to Colorado River

Downstream of the South Fork, reductions in flow with the Proposed Action would be minimal in the Williams Fork River. Near the Leal gage (PACSM Node 3750), average annual flow reductions would be 3% or less in all year types. Most of the additional diversions would be during runoff flow months. Reductions of this magnitude would have a negligible impact on aquatic resources in this section of the Williams Fork River.

Williams Fork Tributaries

The Proposed Action would include additional diversions of water from McQueary, Jones, Bobtail, and Steelman creeks, which form the headwaters of the Williams Fork River (PACSM Nodes 3100, 3150, 3200, and 3250). For these four streams the additional diversions would be up to 30% in average years and up to 10% in wet years (refer to Appendix H, Tables H-3.25 through H-3.28). There would be no additional diversion in dry years. Most of the water would be diverted during spring runoff. Peak flow in Bobtail Creek would be reduced by 7 cfs (14%) in average years (refer to Appendix H, Table H-14.9). There would be increased frequency of dry years compared to Full Use by approximately 2 years over the 45 year period of record (refer to Section 5.1). There are no bypass flows in these streams and they are fully diverted for much of the year. The additional diversions would extend the period of no flow past the diversions by approximately one month in these four streams. The hydrology data for the Williams Fork River at a point just downstream of these four tributaries (PACSM Node 3300, and Appendix H, Table H-3.29) indicate the additional diversions would result in 22% less water in average years and 8% less water in wet years. The timing of the seasonal pattern of spring runoff when flows bypass the diversions would not change substantially although the magnitude and duration would be reduced in some years.

IHA analysis results for Bobtail Creek (PACSM Node 3150) show that 90-day minimum flows would not be reduced, given the extent of current diversions. High flows would decrease in magnitude and duration under the Proposed Action by up to 23%. Small and large floods would not change with respect to magnitude or timing, but durations would decrease by 41% and 50%, respectively. Similar flow changes may occur in the other three tributaries.

Downstream of the Denver Water diversions on McQueary, Bobtail, and Steelman creeks, brook trout are the dominant fish species. Data were not available for Jones Creek, but this stream may also contain brook trout. Habitat simulation data are not available for these streams. R-2-Cross data for Bobtail Creek indicate that flows less than 1 cfs would not be

sufficient to fully maintain fish and invertebrates and this is probably true for the other tributaries. The low flows in winter in all four streams at a point downstream of their diversions are less than 1 cfs with Current Conditions and would be with Full Use of the Existing System conditions and are probably the most stressful period for the aquatic resources of these tributaries. However, similar to the Fraser River tributaries, these streams resume flow downstream of the diversions from groundwater, tributaries, and wetlands during times when they are fully diverted.

The flow reductions during runoff with the Proposed Action would have a minor adverse impact on the fish and invertebrate populations in McQueary, Jones, Bobtail, and Steelman creeks. Although there would be no change in the critical winter flows as there is already no flow past the diversion in winter, the Proposed Action would reduce the flow passing the diversions in wet months and extend the period when these streams are fully diverted, limiting the temporary use of some sections of stream by aquatic organisms and reducing the contributions of water to the gaining sections of stream. Because all of these streams are already severely diverted, no flow-based threshold effects are expected as a result of the Proposed Action. The increase in zero flow days could reduce fish and macroinvertebrate populations downstream of the diversions.

Williams Fork Reservoir

The operation of Williams Fork Reservoir would be similar to Full Use of the Existing System with the Proposed Action (refer to Section 5.2). There would be a negligible impact with the Proposed Action.

Colorado River

Hydrology data for two segments of the Colorado River were used to model habitat availability for brown and rainbow trout. Hydrology data from Colorado River at Windy Gap Reservoir (PACSM Node 1350), Colorado River upstream of Hot Sulphur Springs (PACSM Node 1400), and Colorado River downstream of Hot Sulphur Springs (PACSM Node 1425) were used in Segment 1 of the river. Hydrology data for the Colorado River at the Williams Fork confluence (PACSM Node 1430) and the Colorado River at Kremmling (PACSM Node 5020) were used in Segment 2 (refer to Appendix H, Tables H-3.31, H-3.32, and H-3.33). The Proposed Action would not increase the frequency and duration of dry years in the Colorado River (refer to Section 5.1).

There would be no long-term increase in sediment deposition with the Proposed Action. Flows would be sufficient throughout the two segments of the Colorado River to continue to mobilize sediment and the channel bed. Therefore, there would be no long-term increase in habitat for the *T. tubifex* that carry whirling disease. Water temperatures are expected to be similar to existing conditions on most days. Overall, the Proposed Action would not have an effect on whirling disease in the Colorado River. Adequate flood flows and the similarity in base flows in late summer and in the sediment transport capabilities of the Colorado River indicate that the Proposed Action would have no effect on Didymo as well. The Proposed Action would not change the current system of diversions and canals and would not introduce any new pathways for nuisance species distribution.

Segment 1, Windy Gap Reservoir to Williams Fork River

Hydrology data from Colorado River at Windy Gap Reservoir (PACSM Node 1350), Colorado River upstream of Hot Sulphur Springs (PACSM Node 1400), and Colorado River downstream of Hot Sulphur Springs (PACSM Node 1425) for the Proposed Action indicate average annual flow reductions of 6% in average years, 4% in wet years, and no reductions in dry years (refer to Appendix H, Table H-3.31). Peak flow reductions would be 142 cfs (19%) in average years (refer to Appendix H, Table H-14.9). The frequency of dry years would nearly double (refer to Section 5.1). Additional reductions would occur from May through July, and reductions would be largest in June. The hydrology data were used to simulate habitat for life stages of brown and rainbow trout. Three sets of WUA curves were available for Segment 1 of the Colorado River.

Habitat availability time series analyses from all three curves indicate that there will be minimal changes in WUA for brown trout under the Proposed Action (Figure 5.11-8). Minimum habitat availability changes would usually be less than 1% and would not exceed 3% in almost all cases. Time series analyses using the Chimney Rock curves suggested that minimum WUA for brown trout would increase by 26% for adults and by 25% for juveniles in median years. Changes in average WUA would not be more than 5% in any year type for any life stage. This suggests that flow reductions from the Project alternative would not have much effect on brown trout.

Most changes to habitat availability for rainbow trout with the Proposed Action would be 3% or less. This indicates that the Proposed Action would cause little change in habitat for rainbow trout (Figure 5.11-9). There would be a few larger changes in some year types for some life stages. Time series analyses the Lone Buck and Chimney Rock sites predicted increases in minimum habitat availability for spawning and juvenile rainbow trout of 15% to 26% in median years. Rainbow trout currently account for a small portion of the fish community compared to brown trout. However, if whirling disease-resistant rainbow trout begin to more successfully reproduce in the Colorado River, these changes in habitat availability may become more important.

The increased frequency of dry years would result in a variety of increases and decreases in trout habitat availability based on the relationships at the three sites. In many cases, habitat availability for juvenile brown and rainbow trout would be higher with the reduced runoff flows in dry years, while the lower flows would reduce average and minimum habitat availability for adult trout.

No quantitative habitat information is available for sculpin or *P californica*. Nehring et al. (2010) suggests that declines of sculpins and salmonflies in the Colorado River downstream of Windy Gap Reservoir are related to decreased flows. If there is a causal link between lower flows and sculpin and salmonfly declines, the Proposed Action could cause the declines to continue.

Figure 5.11-8
WUA for Three Life Stages of Brown Trout at the Lone Buck Site in Segment 1 of the Colorado River for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)

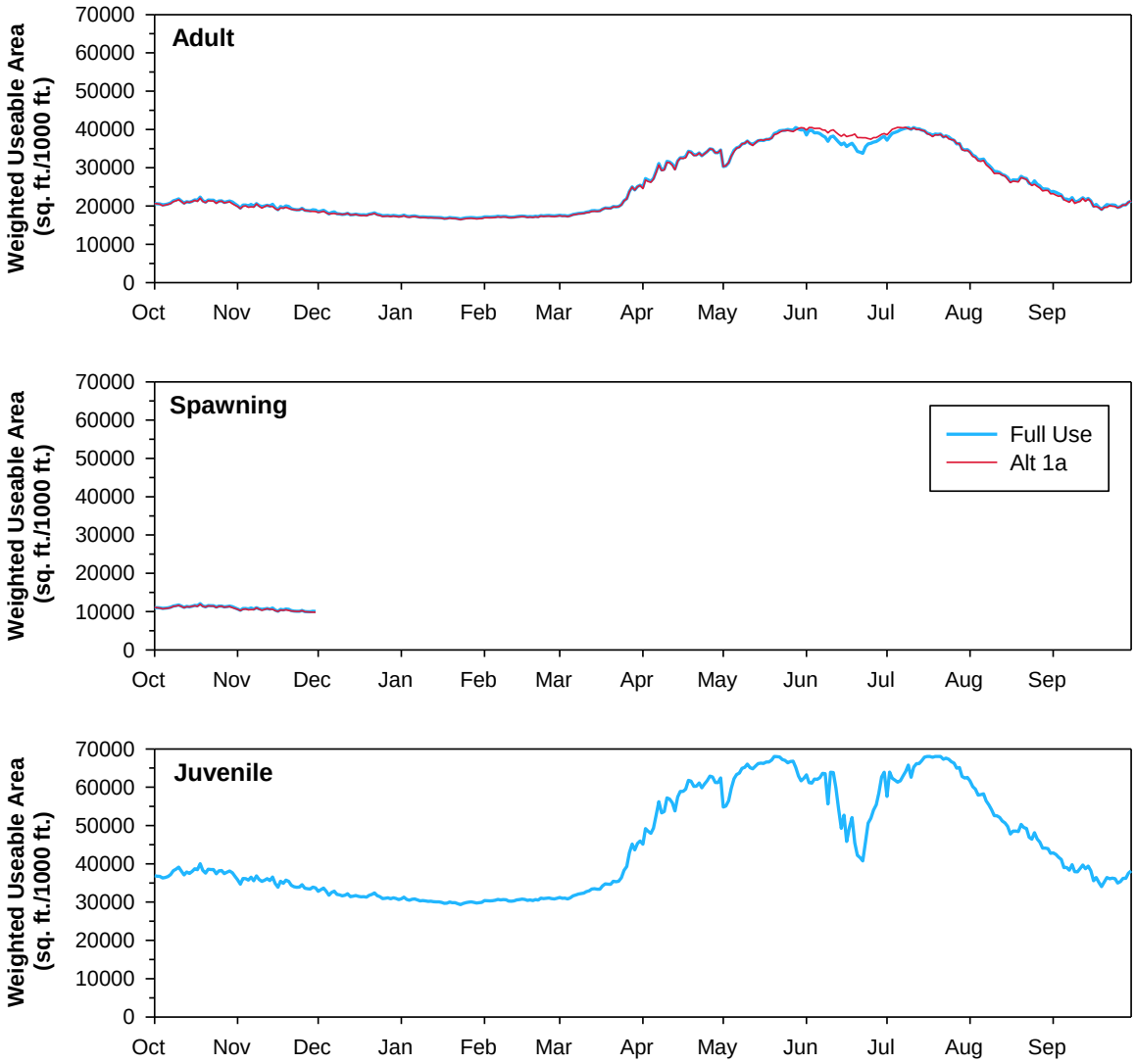
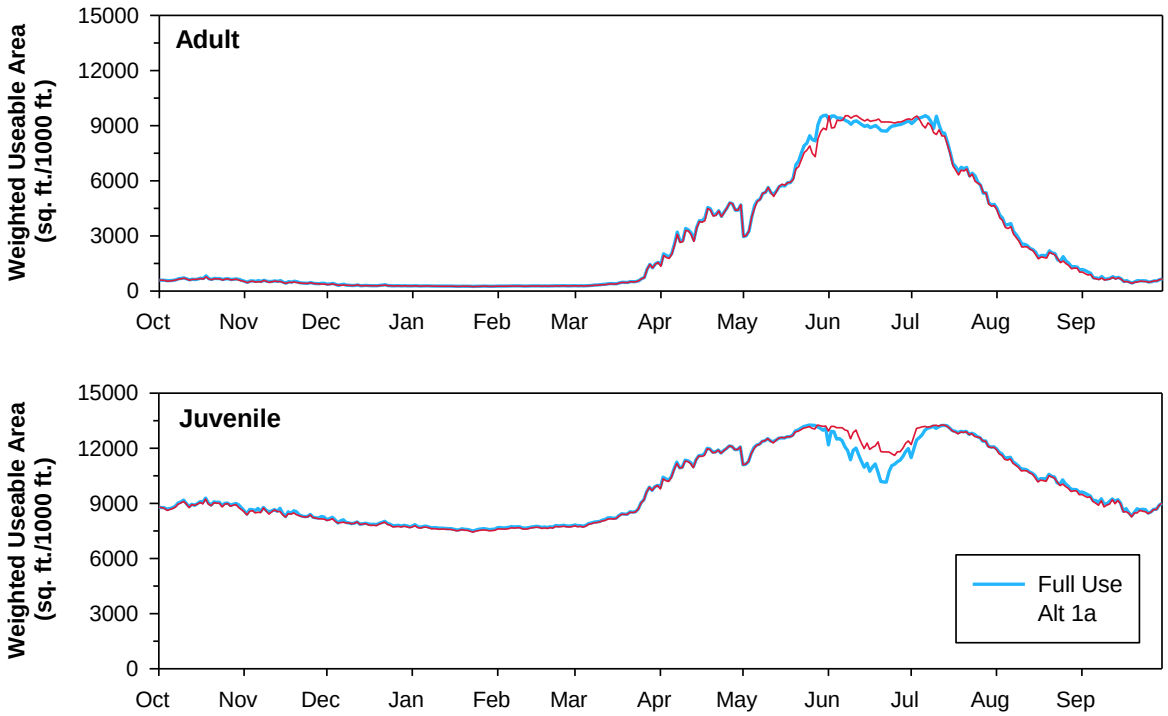


Figure 5.11-9
WUA for Two Life Stages of Rainbow Trout at the Lone Buck Site in Segment 1 of the Colorado River for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



No significant changes in sediment cycles or channel morphology are expected as a result of the Proposed Action (refer to Section 5.3). Water temperatures are already of concern in Segment 1 of the Colorado River (refer to Section 5.2). There have been a number of exceedances for DM and maximum weekly average temperature standards at multiple sites in this segment of the Colorado River between 2005 and 2010. Temperature exceedances only occurred on hot days when flows were 125 cfs or less, and the number of days during which flows are 125 cfs or less are expected to increase under the Proposed Action. However, water temperature is determined more by air temperature than by low flows, as discussed in more detail in the Water Quality section of the EIS (refer to Section 5.2) and no increase in the frequency of water temperature exceedances is expected.

Habitat availability analyses indicate that the Proposed Action would have minimal effect on brown and rainbow trout in Segment 1 of the Colorado River. Most of the changes in habitat would be minimal and most of the larger changes would result in higher habitat availability. There would also be minimal changes in channel morphology and water temperatures. As a result, the Proposed Action would have a negligible impact on aquatic resources in Segment 1 of the Colorado River. A portion of this segment of the river is on the Section 303(d) Monitoring and Evaluation List for low MMI scores. The changes with the Proposed Action would not likely affect MMI scores.

Because the current average annual flow depletions from this stream are estimated to be 66%, Segment 1 of the Colorado River is near a flow-based threshold. The minimal changes to habitat availability, channel morphology, and water temperatures indicate that the Proposed Action would not cause this segment of the Colorado River to cross an ecological tipping point.

Segment 2, Williams Fork River to Blue River

Changes in the annual hydrology of the Colorado River for the Proposed Action in the Colorado River at the Williams Fork confluence (PACSM Node 1430), would be 4% less in average years and 3% less in wet years. In dry years flows would not change compared to Full Use. Monthly depletions would primarily occur in June and July (refer to Appendix H, Table H-3.32). Changes in the Colorado River at Kremmling (PACSM Node 5020) would be similar: flows would be 2% less in average and wet years with no change in dry years (refer to Appendix H, Table H-3.33). Peak flows at these two nodes would be reduced by 18% and 11% in average years (refer to Appendix H, Table H-14.9).

Time series analyses of trout habitat availability from the Kemp-Breeze Site curves show no appreciable change in minimum or average WUA in any year type for brown trout. All of the changes in habitat availability would be 2% or less. The habitat availability time series using the Above Kemp-Breeze Ditch Site results in an increase in minimum adult habitat availability of 34% and juvenile habitat availability of 32% in median years. No other changes in for minimum habitat availability for other life stages would be more than 2% in any year type. Using the below Kemp-Breeze Ditch Site information, the time series shows changes of less than 2% except for a 37% increase in minimum juvenile habitat availability in median years. No changes to average brown trout habitat availability would occur with the Proposed Action. PHABSIM results indicate that average WUA would remain stable for brown trout if the Proposed Action were implemented.

Time series analyses from the Kemp-Breeze Site predict no changes in minimum or average rainbow trout habitat availability greater than 2% as a result of the Proposed Action. Analyses from the above Kemp-Breeze Ditch Site show large increases in minimum habitat availability (15% to 50%, depending on life stage) in median years. Analyses from the below Kemp-Breeze Ditch Site indicate a 16% increase in minimum spawning habitat availability and a 32% increase in juvenile habitat availability in median years as a result of the Proposed Action.

No significant changes in sediment cycles or channel morphology are expected as a result of the Proposed Action (refer to Section 5.3). Because water temperatures are already of concern in Segment 2 of the Colorado River, the effects of the Proposed Action could be moderate (refer to Section 5.2). There have been a small number of exceedances for the standards at multiple sites in this segment of the Colorado River between 2005 and 2010. Temperature exceedances only occurred on hot days when flows were 125 cfs or less, but the number of days during which flows are 125 cfs or less are expected to increase under the Proposed Action (refer to Section 5.2). However, no increase in the frequency of exceedances is expected (refer to Section 5.2).

Habitat availability time series analyses indicate that most of the changes would be minimal, generally less than 2%. Most of the changes that were larger indicated substantial increases in habitat availability, especially for rainbow trout. However, rainbow trout

account for a small portion of the fish community and the increases in habitat may not have a substantial effect on the total fish community. There are not expected to be changes in channel morphology or water temperatures that would affect aquatic resources. Therefore, the Proposed Action would have a negligible impact on aquatic resources in Segment 2 of the Colorado River.

Blue River

Four PHABSIM segments were evaluated on the Blue River. Hydrology data from the Dillon Reservoir Outlet (PACSM Node 4250) in Segment 1, the Blue River below Boulder Creek (PACSM Node 4500) in Segment 2, the Blue River below Green Mountain Reservoir (PACSM Node 4650) in Segment 3, and Blue River at Mouth (PACSM Node 4800) in Segment 4 were used for evaluation of flow changes and PHABSIMs. Habitat data were available for all life stages of brown trout in all four segments of the Blue River; habitat data were available for all life stages of rainbow trout in Segments 2 through 4. The Proposed Action would increase the frequency and duration of dry years in the Blue River in Segment 1 (refer to Section 5.1).

Blue River Segment 1, Dillon Reservoir to Rock Creek

The Proposed Action would result in an annual average of 5% less water in average years, no change in dry years, and 4% less water in wet years; reductions would be largest from May through August (refer to Appendix H, Table H-3.36). Reductions in peak flows in average years would be 52 cfs (8%) (refer to Appendix H, Table H-14.9). The Proposed Action would increase the frequency and duration of dry years in the Blue River in Segment 1 (refer to Section 5.1).

For brown trout, the Proposed Action would cause no appreciable changes in minimum habitat availability in any year type. All changes would be 1% or less. Changes in average habitat availability for all life stages would also be minimal, always less than 7% and usually 1% or less.

The greater frequency of dry years would increase habitat availability for brown trout by reducing flows during the spring runoff period. For adult, fry, and juvenile brown trout, minimum habitat availability for dry years would be approximately 80% to 100% higher compared to median years and up to 126% compared to wet years. For average habitat availability, dry years result in 17% to 38% higher availability than wet years for the three life stages of brown trout.

All of the changes in habitat availability would be minimal. There would be insignificant changes in sedimentation and channel morphology with the Proposed Acton (refer to Section 5.3). There would be negligible changes to water quality parameters (refer to Section 5.2). However, in years when Dillon Reservoir is full and spills, relatively warm water from the top of the reservoir enters the Blue River and raises the temperature to levels that may result in better growth of trout. With the Proposed Action, Dillon Reservoir spills would be nearly the same as for Full Use. These minimal changes in conditions would result in a negligible impact to aquatic resources in Segment 1 of the Blue River. Segment 1 of the Blue River is on the Monitoring and Evaluation List for low MMI scores. With the Proposed Action, MMI scores would likely continue to be below the threshold for attainment. This

segment of the Blue River is not near an ecological tipping point and these changes would not cause it to approach a threshold.

Blue River Segment 2, Rock Creek to Green Mountain Reservoir

The Proposed Action would result in similar changes in flow In Segment 2 as in Segment 1; 3% reductions in average and wet years and no changes in dry years. Most of the water would be diverted between May and August.

Time series analyses for all life stages of brown and rainbow trout indicate minimal changes of 1% or less in minimum and average habitat availability in Segment 2 of the Blue River (Figure 5.11-10). Sediment and channel morphology analyses indicate there will be no long-term changes to sediment cycling or channel morphology (refer to Section 5.3). There are not expected to be any substantial changes to most water quality parameters (refer to Section 5.2). Because only minimal changes in trout habitat availability and other conditions are expected, there would be a negligible impact to aquatic resources in Segment 2 of the Blue River if the Proposed Action is implemented.

Blue River Segment 3, Green Mountain Reservoir to Spring Creek

The Proposed Action would lead to average annual flow reductions of 2% in average years and wet years (PACSM Node 4650). Flow reductions would be greatest from June through August (refer to Appendix H, Table H-3.37). Peak flows in average years would be reduced by 2% (refer to Appendix H, Table H-14.9). The seasonal flow pattern in the Blue River downstream of Green Mountain Reservoir is somewhat different than for other large streams in the Project area. Lowest flows occur in April and May, prior to higher flows in June through the summer. Winter flows are relatively high compared to most other streams. This seasonal flow pattern would be maintained with Full Use of the Existing System and the Proposed Action.

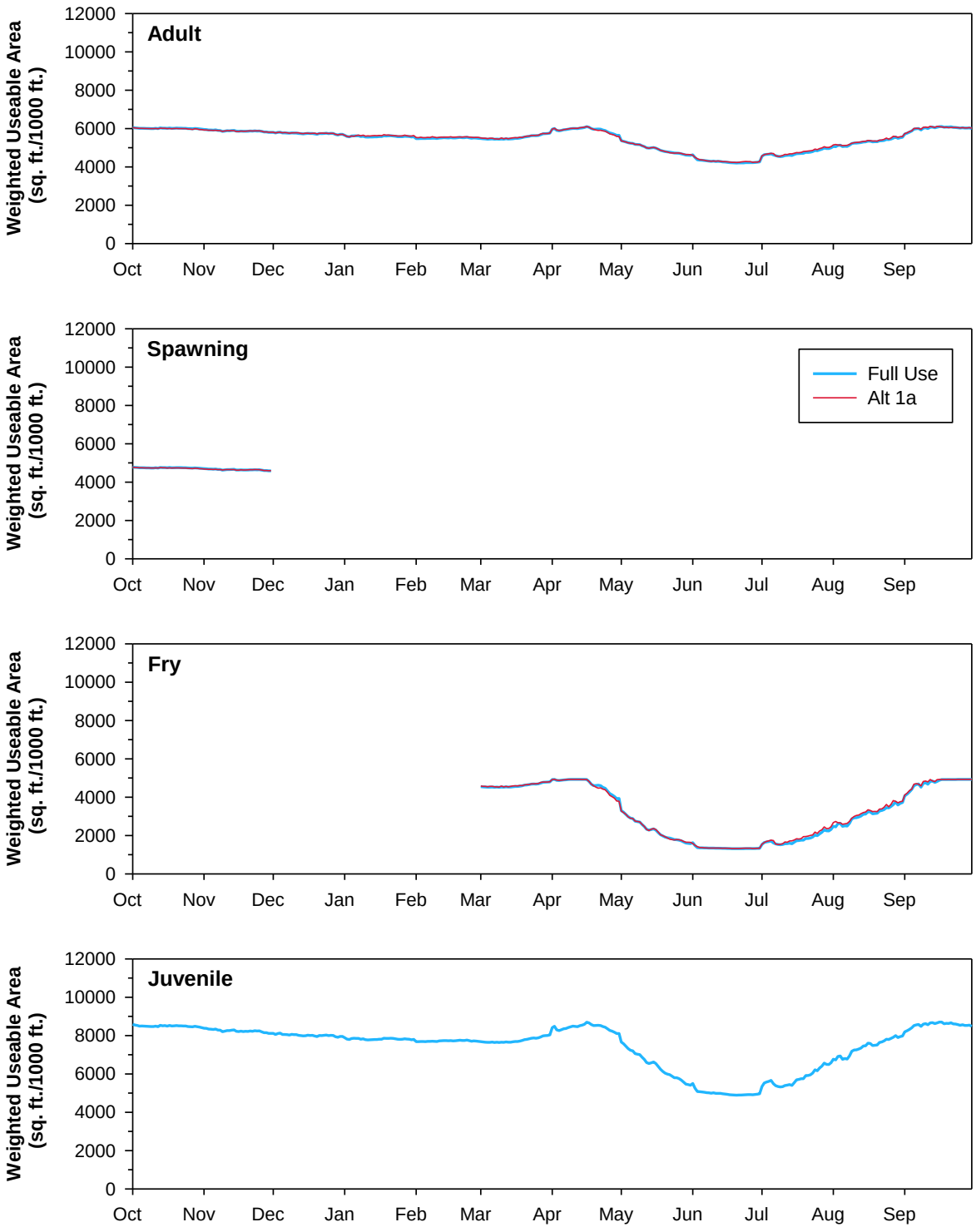
There would be no appreciable changes in brown trout or rainbow trout habitat availability with the Proposed Action. All changes would be 3% or less. The changes are not sufficient to have any effect on trout populations. There would be a negligible impact to aquatic resources with the Proposed Action in Segment 3 of the Blue River.

Blue River Segment 4, Spring Creek to Colorado River

The Proposed Action would result in average annual flows that would be 2% lower in average and wet years. PHABSIM data were available for brown trout and rainbow trout at two sites in Segment 4, the Blue Valley Ranch Middle Site and Blue Valley Ranch Lower Site. Time series analyses using brown trout WUA curves from the Middle Site indicate that the Proposed Action would result in small changes in habitat availability of 1% or less in most cases and less than 4% in all cases. Time series analyses using brown trout and rainbow trout WUA curves from the Lower Site indicate that there also would be no appreciable changes in minimum or average WUA as a result of the Proposed Action.

The projected changes in habitat availability for brown and rainbow trout in Segment 4 of the Blue River are minimal and indicate that there would be a negligible impact if the Proposed Action is implemented. There are expected to be negligible changes to populations of macroinvertebrates and fish.

Figure 5.11-10
WUA for Four Life Stages of Brown Trout in Segment 2 of the Blue River for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



South Boulder Creek

PHABSIM data were available for three segments of South Boulder Creek. Segments 1 and 2 include the stream between the Moffat Tunnel and Gross Reservoir, and Segment 3 is downstream of the reservoir. Hydrology data were available near Rollinsville (PACSM Node 57100) for Segment 1, at the Pinecliffe gage (PACSM Node 57120) for Segment 2, and downstream of Gross Reservoir (PACSM Node 57140) for Segment 3.

Segments 1 and 2, Upstream of Gross Reservoir

In these two segments, the Proposed Action would result in higher mean monthly flows in the runoff period and similar flows to Full Use of the Existing System conditions in other months. In average years, the average annual flows would be 11% higher at Rollinsville and 10% higher at Pinecliffe and mean monthly flows in June and July would be as much as 22% higher in Segments 1 and 2 in average years with the Proposed Action. At the Pinecliffe gage, average annual peak flows would increase by 117 cfs (16%) (refer to Appendix H, Table H-14.9). In dry years, average annual flows would not change. In wet years, flows would be 18% and 14% higher on an annual basis in Segments 1 and 2, respectively (refer to Appendix H, Table H-3.38).

With the higher mean monthly flows during runoff in Segment 1 with the Proposed Action, brook trout minimum adult WUA would decrease by 13% in wet years; all other changes in minimum habitat availability would be 4% or less. Decreases in average habitat availability would be 3% or less for all life stages in all year types.

For rainbow trout in Segment 1, reductions to minimum habitat availability would be 13% for adults and 18% for fry in wet years, but changes in minimum WUA would be 3% or less for all other life stages, regardless of year type. Changes in average WUA were negligible for all life stages in all year types. In Segment 2, changes in minimum and average WUA would be 3% or less for all life stages in all year types.

High flows would occur more often under the Proposed Action. The 5- and 10-year floods would be expected to occur every 4 and 7 years under the Proposed Action. As a result, bank erosion could increase, and further stabilization could become necessary (refer to Section 5.3). No changes to water quality would occur that could affect aquatic resources (refer to Section 5.2).

There would be mostly minimal changes in trout habitat availability. However, there would be increased bank instability in Segments 1 and 2 of South Boulder Creek, which could alter habitat somewhat. The increases in runoff flows could have an effect on benthic invertebrate populations as well. The Proposed Action would result in a minor adverse impact and could result in decreased density of macroinvertebrates, or macroinvertebrate community composition could shift towards species that prefer fast-moving water.

Segment 3, Downstream of Gross Reservoir

With the Proposed Action, annual flows would increase by 9% in average years, 17% in dry years, and 14% in wet years (refer to Appendix H, Table H-3.39). Peak flows would be reduced by 65 cfs (13%) in average years (refer to Appendix H, Table H-14.9). The existing and Full Use hydrographs have flows that are highest in spring, but they are extremely low in winter. With the Proposed Action, flows in average, dry, and wet years would be substantially different. Flows would increase from November through February;

the greatest increases (nearly 800% to 900%) would occur in January and February. Flows during runoff would be up to 23% lower.

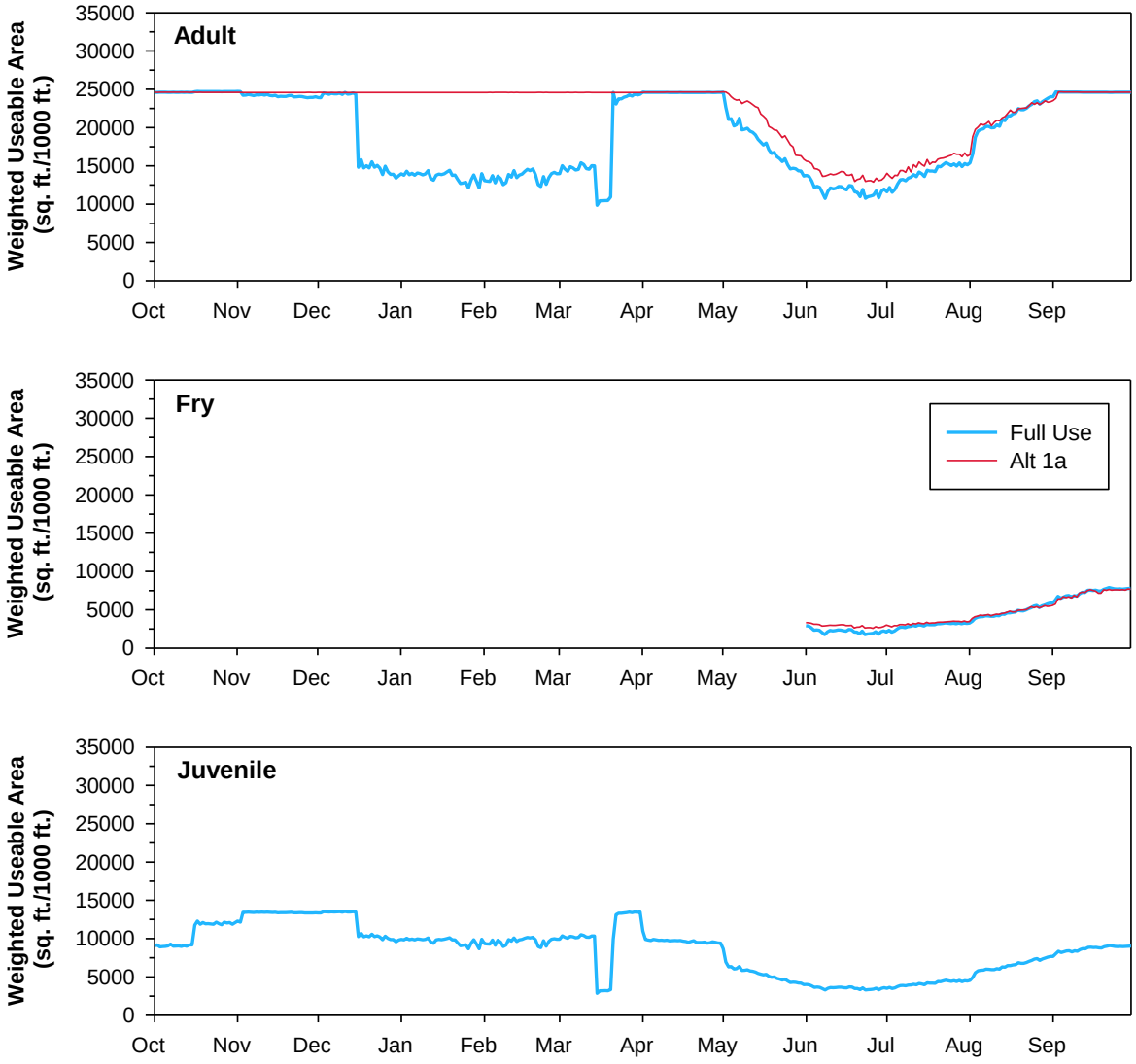
With Full Use of the Existing System conditions, the minimum habitat availability for rainbow trout adults (Figure 5.11-11), and juveniles occurs in the late winter and during spring runoff. With the Proposed Action, there would be increases in minimum habitat availability up to 126%. For adults, increases would be 31% in median years and 126% in dry years. Fry minimum habitat availability would increase by 48% in median years. Juvenile minimum habitat availability would also increase; predicted increases range from 11% (wet years) to 53% (dry years).

Average habitat availability would also increase for some life stages in all year types. In median years, adult average habitat availability would increase by 17%. Adult WUA would increase by 22% in dry years and by 14% in wet years. Changes for other life stages in dry and wet years would be 7% or less.

Winter flows would increase under the Proposed Action, but highest runoff flows would be reduced by 13%. The 5-year flood and the 10-year flood would not be expected to occur under the Proposed Action. These changes may decrease bank instability in Segment 3 of South Boulder Creek and reduce the need for further bank stabilization efforts (refer to Section 5.3). No changes to water quality would occur that could affect aquatic resources except for temperature (refer to Section 5.2). Water temperatures throughout the year are expected to be lower with the Proposed Action compared to Full Use of the Existing System conditions with the expansion of Gross Reservoir. Temperatures during the growing season for trout would be several degrees cooler and would be less favorable for growth. Cooler temperatures are expected throughout this segment downstream to the South Boulder Creek Diversion as there is little warming of the water in this segment (refer to Section 5.2).

The increases in winter flows would result in large increases in rainbow trout habitat availability and the small decreases in spring runoff flows would decrease conditions that may be stressful to early life stages of this species. The higher winter flows would likely alleviate winter low flow habitat limitations. However, the cooler temperatures throughout the year would limit trout growth and survival and likely dampen the beneficial effects of greater habitat availability. Higher winter flows and reduced peak flows would also provide more uniform flow conditions for benthic invertebrates. With less dramatic drying of the stream in winter months, Segment 3 of South Boulder Creek may support a higher density of macroinvertebrates or a more species-rich community including more rheophilic species. Community metrics such as diversity and the number of EPT species may increase. The increases in habitat availability for rainbow trout and macroinvertebrates indicate that the Proposed Action would have a minor beneficial impact on aquatic resources in Segment 3 of South Boulder Creek.

Figure 5.11-11
WUA for Three Life Stages of Rainbow Trout in Segment 3 of South Boulder Creek for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



North Fork South Platte River

There are two segments on the North Fork South Platte River with PHABSIMs. In Segment 1, hydrology data from the North Fork South Platte below Geneva Creek gage (PACSM Node 50700) were used for habitat simulation. In Segment 2, hydrology data from the North Fork South Platte above Pine (PACSM Node 50750) were used.

Segment 1, Roberts Tunnel to Buffalo Creek

The Full Use of the Existing System would result in many differences in flow compared to Current Conditions. However, the incremental changes in flow with the Proposed Action would be minor. The average annual flow between Full Use and the Proposed Action would increase by 3% in average years and 1% in dry years and would decrease by 2% in wet years (refer to Appendix H, Table H-3.41). Peak flows would increase by 9% (refer to Appendix H, Table H-14.9). Mean monthly flows would decrease in winter by as much as 37% (January and February of wet years), and they would increase during spring runoff by as much as 29% (May of average years).

Habitat simulation data were available for all four life stages of brown trout in Segment 1. With Full Use of the Existing System conditions, minimum habitat availability occurs during runoff in June for adult, fry, and juvenile brown trout. Changes in minimum habitat availability would be 9% or less in median and wet years. Reductions in habitat availability are would occur for all life stages in dry years: minimum WUA reductions would range from 10% to 15% depending upon life stage. Average habitat availability would be less affected. Reductions in average habitat availability would be 6% or less in all year types.

Although water quality may change due to changes in flow from the Roberts Tunnel, these changes will generally not lead to exceedances of Aquatic Life water quality standards. There could be increases in copper concentrations, which already sometimes exceed standards (refer to Section 5.2). Increased flows are expected to increase bank instability, and further bank armoring may be required to stabilize affected areas (refer to Section 5.3).

The changes in flow with the Proposed Action would result in mostly minimal changes in habitat availability for brown trout. The effects to brown trout could be exacerbated by localized bank instability and changes in water quality. These effects could lead to decreases in trout density in Segment 1 of the North Fork South Platte River. The increases in flows during runoff and increased concentrations of copper may result in lower density or fewer species of macroinvertebrates although there may be more rheophilic species. Overall, there would be a minor adverse impact in Segment 1.

Segment 2, Buffalo Creek to South Plate River

The effects of the Proposed Action on flows in Segment 2 of the North Fork South Platte River would be similar to those in Segment 1. The average annual flow would increase by 3% in average years, 1% in dry years and would decrease by 2% in wet years. Mean monthly flows would decrease in winter by as much as 32% (February of wet years), and they would increase during summer by as much as 18% in June and July of average and dry years.

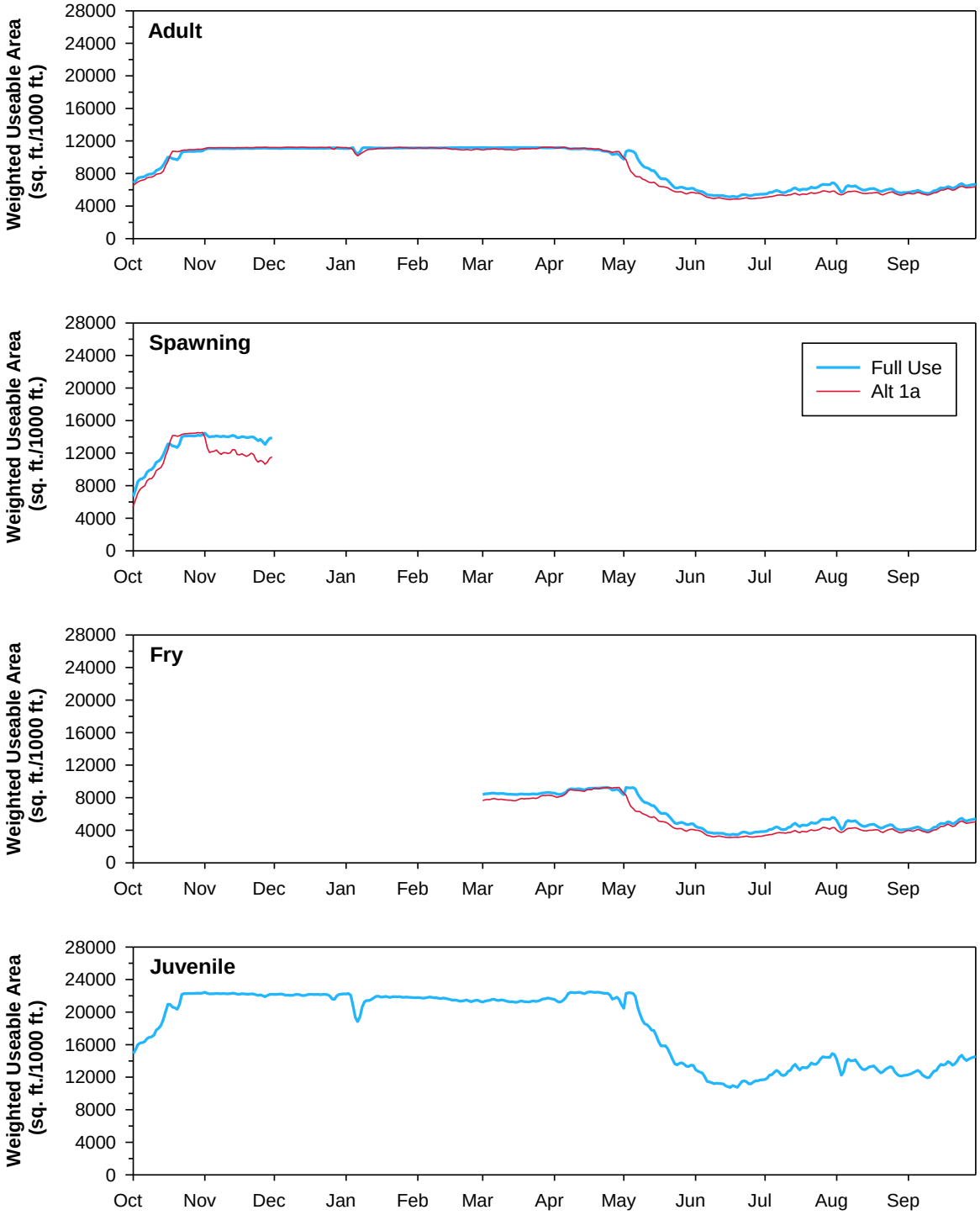
In Segment 2, lowest habitat availability occurs during high flows. Minimum habitat availability would decrease for all four life stages of brown trout (Figure 5.11-12). Predicted minimum habitat availability decreases by 18% for spawning in median years and

by 12% for juveniles and 24% for spawning in dry years. In wet years, only spawning habitat would be appreciably reduced, but losses would be 36%. Average habitat availability would not change by more than 9% for most life stages except for reductions of 10% for fry in median years and spawning in wet years.

Although water quality in Segment 2 of the North Fork South Platte River may be affected by changes in flows from Roberts Tunnel, no exceedances of Aquatic Life water quality standards are expected. The only potential exception is copper (refer to Section 5.2). Increased flows are expected to increase bank instability, and further bank armoring may be required to stabilize affected areas, but Segment 2 of the North Fork South Platte River will be less affected than Segment 1 (refer to Section 5.3).

Consistent losses in habitat for all life stages across some year types suggests that the Proposed Action will have a minor adverse effect on brown trout populations in Segment 2 of the North Fork South Platte River. The adverse effects to brown trout could be exacerbated by localized bank instability and could lead to decreases in trout density in Segment 1 of the North Fork South Platte River. The increase in flows and the possible increase in bioavailable copper would likely decrease invertebrate densities and species richness.

Figure 5.11-12
WUA for Four Life Stages of Brown Trout in Segment 2 of the North Fork South Platte River for a Median Year Under Full Use of the Existing System and the Proposed Action (2032)



South Platte River

Antero Reservoir to North Fork South Platte River

Flow changes to the South Platte River upstream of the North Fork would be minor. There would be no impact to aquatic resources to the river or the reservoirs in this section.

Segment 4, North Fork South Platte River to Strontia Springs Reservoir

The short segment of the South Platte River between the North Fork and Strontia Springs Reservoir would have increased flows with the Proposed Action. The changes are not modeled but may be less than 5% based on the flow changes in the North Fork. There is no fish habitat simulation available for this short segment. The small changes in hydrology likely will have a negligible impact to aquatic resources in this segment.

Segment 5, Strontia Springs Reservoir to Chatfield Reservoir

Hydrology at the Waterton gage (PACSM Node 51200) indicates a decrease in average annual flow of only 3% in average years. In dry and wet years, the changes in annual flow would be 2% or less and changes in some of the individual months would almost always be less than 10% (refer to Appendix H, Table H-3.45). Peak flow in an average year would be reduced by 38 cfs (9%) (refer to Appendix H, Table H-14.9).

PHABSIMs are available for life stages of brown and rainbow trout for Segment 5 of the South Plate River. The Proposed Action would result in minimal changes in habitat availability for most life stages of brown and rainbow trout. Most of the changes would be 7% or less except for increases in rainbow trout spawning habitat of 31% and 39% in median and dry years.

There would be no changes in water quality or channel morphology that would affect aquatic resources in this segment (refer to Sections 5.2 and 5.3). Most of the changes in habitat would be minimal. There would be a negligible impact to aquatic resources in Segment 5 of the South Platte River with the Proposed Action.

Segment 6, Chatfield Reservoir to Bear Creek

One PHABSIM habitat suitability relationship for Segment 6 was simulated for the section of the South Platte River downstream of Chatfield Reservoir using hydrology data from the South Platte River below Chatfield (PACSM Node 51290). Habitat simulation data were available for four life stages of rainbow trout. Rainbow trout populations are maintained by stocking in this segment and changes in habitat availability, especially for the spawning life stage, may not affect fish populations as directly as in sections of the Project area with self-sustaining populations of trout. Therefore, the habitat analysis for Segment 1 of the South Platte River incorporated a qualitative evaluation intended to apply to the broad range of species that are present in this segment.

Changes in mean annual flows would be 3% or less, in all years with little change flows in all months (refer to Appendix H, Table H-3.46). Minimum habitat availability with Current Conditions occurs during the low flow winter period for adult rainbow trout and likely for most other fish species in this segment. Flows in this segment of the river are commonly very low throughout the winter of all three year types. With Current Conditions, minimum habitat availability for most or all fish species and invertebrates probably occurs during the winter.

In dry years, adult and juvenile minimum habitat availability would increase by over 100%, but spawning habitat availability would decrease by 27%. In wet years, adult and spawning habitat availability would decrease by 34% and 12%, respectively. In median years, changes would be 1% or less for fry, juveniles, and adults. Average annual habitat availability for rainbow trout would be less affected by the Proposed Action. The changes in average habitat availability mostly would be 7% or less. Because the trout populations in this area are maintained by stocking juvenile and adult fish, changes in spawning or fry WUA would have negligible effects on the limited trout population.

There would be no water quality changes that would affect fish and invertebrates in this segment of the South Platte River (refer to Section 5.2). There likely would not be changes to channel morphology in this segment of the South Platte River with the Proposed Action due to the channelization along almost all of its length.

The increases in minimum habitat availability in this segment are largely due to increased flow in winter of dry years. This would result in a minor beneficial impact in Segment 6. Large historic changes to native flows and stream morphologies in plains streams such as the South Platte River restrict the current fish assemblage mainly to tolerant species. Many of the remaining native Great Plains fishes in the Project area can tolerate flashy flows and poor water quality (Cross and Moss 1987; Fausch and Bestgen 1997). These species also tend to have generalized habitat requirements and prolonged spawning seasons (Fausch and Bestgen 1997). These species weather abrupt changes in stream flow (i.e., floods, intermittency) and/or physicochemical conditions through refuging behaviors, rapid reproduction, and recolonization of extirpated areas (Dodds et al. 2004). Therefore, the Proposed Action should have a negligible effect on the South Platte River fish assemblage.

5.11.2 Alternative 1c

5.11.2.1 Gross Reservoir

The enlargement of Gross Reservoir would provide more habitat for fish and invertebrates. The final surface area of the reservoir would be approximately 650 acres, 53% larger than the existing reservoir. This would be a moderate beneficial impact to the reservoir fishery for Alternative 1c compared to existing and Full Use of the Existing System conditions. The beneficial impact would be slightly less than for the Proposed Action, which would result in Gross Reservoir enlarged to 842 acres.

Construction activities during enlargement would not substantially affect the normal operation of the reservoir. The fish and invertebrate communities in the reservoir would continue to function as normal.

5.11.2.2 Leyden Gulch Reservoir Site

With Alternative 1c, Leyden Gulch Reservoir would be created. This would represent a gain of approximately 331 acres of reservoir habitat available for fish, invertebrates, and other aquatic organisms. This would represent a minor beneficial impact of Alternative 1c compared to existing conditions. However, the public would not have access to the reservoir. This indicates that the reservoir fishery would not be managed and would probably include only a few fish species, with no recreational fishery. The creation of the

reservoir would inundate portions of Leyden Gulch. Past actions that have affected wetlands and riparian vegetation in the Leyden Gulch Reservoir area include construction of the existing Ralston Reservoir and other reservoirs, installation of culverts at road and railroad crossings, and changes in drainage patterns related to roads, railroads and other developments. This stream is ephemeral in this section and does not support aquatic life. A small spring pool on a south branch of Leyden Gulch would also be inundated under the new reservoir. This pool supports a limited community of aquatic organisms. The inundation of this pool would represent a minor adverse impact with Alternative 1c.

5.11.2.3 River Segments

Impacts to all river segments with Alternative 1c would be similar to those described for the Proposed Action.

5.11.3 Alternative 8a

5.11.3.1 Gross Reservoir

The enlargement of Gross Reservoir would provide more habitat for fish and invertebrates. The final surface area of the reservoir would be approximately 712 acres, 70% larger than the existing reservoir. This would be a moderate beneficial impact to the reservoir fishery for Alternative 8a compared to existing and Full Use of the Existing System conditions. The beneficial impact would be slightly less than for the Proposed Action, which would result in Gross Reservoir enlarged to 842 acres.

Construction activities during enlargement would not substantially affect the normal operation of the reservoir. The fish and invertebrate communities in the reservoir would continue to function as normal.

5.11.3.2 South Platte River Facilities

Alternative 8a would include approximately 5,000 acre-feet (AF) of storage capacity in reclaimed gravel pits adjacent to the South Platte River. The pits would typically fill with reusable effluent from November through April, when unused reusable effluent is available. Filling and operation of the gravel pit reservoirs would provide aquatic resources with approximately 5,000 AF of open water habitat. This habitat would likely be colonized by aquatic invertebrates and fish over time. This would represent a moderate beneficial impact of Alternative 8a.

The diversion structure for filling the gravel pit reservoirs would include a buried pipe connected from the South Platte River to a gravel pit. Direct minor adverse impacts on aquatic biological resources from construction of the diversion would include temporary disturbance in the South Platte River for the duration of construction.

5.11.3.3 Conduit O

Conduit O would cross several streams, including the South Platte River, containing communities of warmwater fish and invertebrates. Crossing of the streams would be open cut per Denver Water's standard practice. Each crossing would be completed in approximately 20 working days, depending on weather and other conditions. Therefore, direct minor adverse impacts on aquatic resources from construction would include temporary disturbance for the duration of construction.

5.11.3.4 River Segments

Impacts to all river segments with Alternative 8a would be similar to those described for the Proposed Action.

5.11.4 Alternative 10a

5.11.4.1 Gross Reservoir

Impacts to fish and invertebrate communities would be the same as described under Alternative 8a.

5.11.4.2 Denver Basin Aquifer Facilities

The proposed distribution pipelines would cross four streams, including the South Platte River, containing communities of warmwater fish and invertebrates. The types of temporary impacts would be similar to those described for Conduit O.

5.11.4.3 Conduit M

The alignment for Conduit M is the same for Conduit O between the Moffat Collection System delivery point and the intersection of 80th Avenue and Pierce Street. Streams crossed include Little Dry Creek, Clear Creek, and the South Platte River. The temporary, direct minor adverse impacts of construction activities on Conduit M for Alternative 10a on aquatic biological resources in these streams would be the same as described for Conduit O under Alternative 8a.

5.11.4.4 River Segments

Impacts to all river segments with Alternative 10a would be similar to those described for the Proposed Action.

5.11.5 Alternative 13a

5.11.5.1 Gross Reservoir

The enlargement of Gross Reservoir would provide more habitat for fish and invertebrates. The final size of the reservoir would be approximately 754 acres. This would be a moderate beneficial impact to the reservoir fishery for Alternative 13a compared to existing and Full Use of the Existing System conditions. The beneficial impact would be slightly

less than for the Proposed Action, which would result in Gross Reservoir enlarged to 842 acres.

Construction activities during enlargement would not substantially affect the normal operation of the reservoir. The fish and invertebrate communities in the reservoir would continue to function as normal.

5.11.5.2 South Platte River Facilities

The beneficial impacts from gravel pit storage would be similar to those described under Alternative 8a, except that only 3,625 AF of open water habitat would be created under Alternative 13a.

Additionally, the gravel pit pipeline would extend 5 miles to the northern Challenger Pit and would cross the South Platte River at Bridge Street. There would be temporary direct minor adverse impacts during construction at the crossing.

5.11.5.3 Conduit O

Impacts from construction of Conduit O would be the same as described for Alternative 8a.

5.11.5.4 River Segments

Impacts to all river segments with Alternative 13a would be similar to those described for the Proposed Action.

5.11.6 No Action Alternative

5.11.6.1 Depletion of Strategic Water Reserve Strategy

Under the No Action Alternative, Denver Water would continue to operate its existing system. The hydrology for the No Action Alternative would be much different compared to all other alternatives. Diversions from the Fraser and Williams Fork tributaries would be much less than for the action alternatives and, therefore, less water would be delivered to South Boulder Creek than for the other alternatives and Gross Reservoir would not be enlarged. The differences between the No Action Alternative and the other alternatives would not result in substantial differences in channel morphology impacts except in South Boulder Creek where the lower flows would have an insignificant impact compared to the increased erosion with the other alternatives (refer to Section 5.3). For water quality, the No Action Alternative would have similar impacts to the other alternatives. The impacts of changes in hydrology for the No Action Alternative on fish and invertebrates are discussed below. The impacts of the No Action Alternative compared to Full Use of the Existing System would have the same tipping point consequences as described for the Proposed Action. As explained for the Proposed Action, in almost all cases, there would be no changes that would be sufficient to cause a stream to cross an ecological tipping point.

Gross Reservoir

Gross Reservoir would not be enlarged with the No Action Alternative. Reservoir volume would generally be lower, by up to 11% in some months. The reservoir would also be

drawn down to the minimum pool approximately 50% more often. Water quality impacts may include a slight increase in phosphorus levels leading to slightly higher productivity than for the other alternatives which could be beneficial to the fishery. However, the lower volume of the reservoir indicates there would be a minor adverse impact to the fish and invertebrate community of Gross Reservoir with the No Action Alternative compared to Full Use of the Existing System conditions.

Fraser River

The No Action Alternative would divert more water from the Fraser River Basin tributaries in average and wet years compared to Full Use of the Existing System conditions. In general, flow depletions with the No Action Alternative would be approximately half that with the other alternatives and only slightly more than Full Use of the Existing System conditions. The flow reductions in the Fraser River would range from 2% at Granby (PACSM Node 2900) up to 7% downstream of the Denver Water diversion on the Fraser River (PACSM Node 2120) compared to Full Use of the Existing System conditions.

The differences in flow between the No Action Alternative and Full Use of the Existing System conditions would result in minimal differences in habitat availability.

In Segments 1 through 5 of the Fraser River, the changes in habitat availability for the life stages of brook, brown, and rainbow trout would all be 1% or less most of the time. These minimal changes in habitat availability would have a negligible impact on aquatic resources for the No Action Alternative, somewhat different than the pattern of adverse and beneficial impacts for the Proposed Action. However, under certain conditions, bypass flows may not be met below diversions in the Fraser River Basin. This could further reduce flows compared to existing and Full Use of the Existing System conditions of low habitat availability for fish and invertebrates. If bypass flows are not met, there would be additional adverse impacts to aquatic resources and possibly water temperature in the upper Fraser River.

Fraser River Tributaries

Reductions in flow in Fraser River tributaries between the No Action Alternative and Full Use of the Existing System conditions would be one third to one half as much as would be diverted with the Proposed Action. Compared to Full Use of the Existing System conditions, the No Action Alternative would divert approximately twice as much water in average and wet years. In dry years, there would be no additional diversions compared to Full Use of the Existing System conditions. The differences would not affect the low winter flows that are now present in many of these streams.

In many of the Fraser River tributaries, the increased diversions with the No Action Alternative are less than with the Proposed Action compared to Full Use of the Existing System conditions and would not be high enough to result in the minor impact predicted for the Proposed Action. These streams would have a negligible impact to aquatic resources with the No Action Alternative. This includes the St. Louis Creek tributaries, King Creek, Main Elk Creek and tributaries, Cooper Creek, Middle Fork and South Fork Ranch Creek, Wolverine Creek, Cub Creek, and Buck Creek. For these streams, there would be a negligible impact with the No Action Alternative different than the minor impact described for the Proposed Action.

In St. Louis Creek, the No Action Alternative would have reductions in flow due to additional diversions of 3% on an average annual basis compared to Full Use of the Existing System conditions. Habitat availability for brook trout would change by 3% or less for median, dry and wet years. As a result, habitat availability changes under the No Action Alternative would be similar to the Proposed Action. The No Action Alternative would have negligible impacts on fish and invertebrates in St. Louis Creek.

In Vasquez Creek, the additional diversions with the No Action Alternative would be 5% on average compared to Full Use of the Existing System conditions, much less than the additional diversion with the Proposed Action. Changes in habitat availability for brook trout would be negligible for the No Action Alternative. The No Action Alternative would have a negligible impact to aquatic resources compared to the moderate adverse impact for the Proposed Action.

In Jim Creek and Little Vasquez Creek, the changes in flow with the No Action Alternative would be less than for the Proposed Action, but would still be sufficient to result in a minor adverse impact. The impact would be similar to the impact for the Proposed Action.

In North Fork Ranch, Main Ranch, and Dribble creeks, the additional diversions with the No Action Alternative would be 8% or less compared to Full Use of the Existing System conditions, less than would be diverted for the Proposed Action. The No Action Alternative would have a negligible impact while the Proposed Action would have a minor adverse impact.

For the streams in the Englewood Ranch Gravity system, the additional diversions would be similar with the No Action Alternative and the Proposed Action. For both alternatives, there would be negligible impacts to aquatic resources.

Under certain conditions, bypass flows may not be met below diversions in the Fraser River Basin. This could further reduce flows compared to Current Conditions (2006) and Full Use of the Existing System conditions of low habitat availability for fish and invertebrates. If bypass flows are not met in some tributaries, there would be additional adverse impacts to aquatic resources in the tributaries.

Williams Fork River

Changes in Williams Fork River flows with the No Action Alternative would be minimal, usually 3% or less in all months, and about half that of the Proposed Action. Changes in the minimum habitat availability for brook trout would be less than 1% for both life stages in all year types. The No Action Alternative would have a negligible impact on the fish and invertebrate communities in the Williams Fork River, similar to the Proposed Action.

Williams Fork Tributaries

The No Action Alternative would divert more water from the Williams Fork tributaries in some months in average and wet years. However, the proposed flow changes would be approximately half that for the action alternatives in average and wet years. No additional flow reductions would occur in dry years. The No Action Alternative would divert approximately 5% more water on an average annual basis, but more in the runoff months, especially in May. The No Action Alternative would have a minor adverse impact on fish and invertebrates in the tributaries similar to the Proposed Action.

Colorado River

Reductions in flow with the No Action Alternative in the two segments of the Colorado River would be only slightly less than the reductions with the Proposed Action. Fish habitat availability for the two alternatives would be very similar. The No Action Alternative would have a negligible impact similar to impacts on fish and invertebrates in the Colorado River as the Proposed Action.

Blue River

Monthly reductions in Blue River flows under the No Action Alternative would be slightly higher than for the Proposed Action. The changes in flow would not result in changes in habitat availability for brown and rainbow trout compared to the Proposed Action. Therefore, the No Action Alternative would have similar negligible impacts to the Proposed Action in the Blue River.

South Boulder Creek

In all three segments of South Boulder Creek, the flows with the No Action Alternative would be similar to Full Use of the Existing System conditions. The increases in average annual flows would be 3% or less in Segments 1 and 2 upstream of Gross Reservoir and only 2% downstream of Gross reservoir in Segment 3. Monthly flows would vary by a greater magnitude; increases would be high in some winter months in Segment 3. The differences in flow would result in differences in channel morphology in South Boulder Creek. The changes in bank erosion for the Proposed Action would not occur with the No Action Alternative.

Changes in trout habitat availability from Full Use of the Existing System conditions would usually be less than 5% for all life stages of trout in Segments 1, 2, and 3 of South Boulder Creek. The No Action Alternative would have a negligible impact on the fish and invertebrate communities in Segments 1, 2, and 3 of South Boulder Creek. This would be different than the minor adverse impacts in Segments 1 and 2 and the minor beneficial impact in Segment 3 for the Proposed Action.

North Fork South Platte River

With the No Action Alternative, the increases in flow in the North Fork South Platte River would be only slightly larger than for the Proposed Action. This would have only a minimal effect on habitat availability, channel morphology, and water quality. The No Action Alternative would have minor adverse impacts to aquatic resources similar to the impacts for the Proposed Action.

South Platte River

Similar to the North Fork, with the No Action Alternative, the increases in flow in the South Platte River would be only slightly larger than for the Proposed Action. This would have only a minimal effect on habitat availability, channel morphology, and water quality. The No Action Alternative would have impacts to aquatic resources similar to the impacts for the Proposed Action.

5.11.6.2 Combination Strategy

There would be no significant differences to aquatic biological resources under the No Action Alternative Combination Strategy. In dry years, flow changes would be similar under either No Action Strategy. Refer to Section 5.1 for a discussion regarding the flow changes under the Combination Strategy for surface water resources.

Under the Combination Strategy, imposing restrictions would generally have the impact of reserving more water in storage; therefore, storage contents in Denver Water's reservoirs could be higher in dry years. Whether storage contents are higher depends on several factors. The amount and location of water reserved in storage would vary depending on the severity and duration of restrictions imposed, on storage conditions in Denver Water's North and South systems and on hydrologic conditions. Since storage contents could be higher with restrictions, Denver Water's diversions into storage after a drought could be less and stream flows could increase for a short duration after Denver Water's reservoirs refill. However, this would not occur if a reservoir is drained even with restrictions in place. Conversely, with greater restrictions, during a drought stream flows would be less in some streams as Denver Water would decrease its releases from storage and divert additional water if bypass flows are reduced. Decreases in stream flow because less water would be released from storage to meet demand applies to South Boulder Creek below Gross Reservoir, the North Fork South Platte River and South Platte River. Decreases in stream flow because bypass flows are reduced applies to several locations in the Fraser River Basin, the Blue River below Dillon Reservoir, and along the South Platte River below Eleven Mile Canyon Reservoir and Cheesman Reservoir, and at the Old Last Chance Ditch Diversion. Changes in stream flow between the two No Action Alternative strategies are not expected to be significant. If bypass flows are not met, there would be a minor adverse impact to aquatic resources in the affected streams.

5.11.7 Mitigation and Monitoring

The action alternatives would have slightly different combinations of beneficial and adverse impacts. Different mitigation would be appropriate for each alternative. However, there are several types of potential minimization and avoidance opportunities and compensatory mitigation that could be implemented with any of the action alternatives.

Minimization and avoidance techniques may include adjustments to operations that may benefit aquatic organisms. This would include changes to runoff flows or low winter flows to make these two critical periods less stressful for fish and invertebrates. Minimization may also include careful construction of South Platte River diversions so they are not barriers to the upstream migration of fish.

Appendix M contains conceptual mitigation proposed by Denver Water for the following unavoidable impacts to aquatic resources from the Proposed Action:

- Effects to aquatic habitat in the North Fork South Platte River downstream of the Roberts Tunnel outlet
- Effects to aquatic habitat in South Boulder Creek upstream of Gross Reservoir and downstream of the East Portal of the Moffat Tunnel

- Effects to flow and aquatic habitat in tributaries to the Fraser River

Proposed mitigation measures include establishing a viable Colorado River cutthroat fishery in a suitable location in Grand County and aquatic habitat improvements on South Boulder Creek downstream of Gross Reservoir.

The enlarged reservoir is expected to have short-term increases in levels of methylmercury. This is partially due to the inundation of terrestrial vegetation with the expanded reservoir. Denver Water will remove as much of the organic material (i.e., vegetation) as practicable from the inundation area prior to filling the reservoir. CPW will monitor and evaluate metal levels in fish tissue for five years after the initial fill of the enlargement. In addition, Denver Water will continue its current water quality monitoring program.

The Project hydrology would provide moderate beneficial impacts to the aquatic life of Gross Reservoir due to its larger size and to the section of South Boulder Creek downstream of the reservoir to Denver Water's diversion point due to much higher (up to 88 cfs) winter flows. The additional Environmental Pool would provide additional beneficial impacts to the aquatic organisms in Gross Reservoir. The additional storage would provide more area and volume to sustain these organisms, thus providing more habitat. In South Boulder Creek downstream of Denver Water's diversion, the changes in flow with the additional Environmental Pool would also provide beneficial impacts to aquatic life. The additional Environmental Pool would slightly reduce peak runoff flows and slightly increase low winter flows. Both of these changes in the stream hydrology are common mechanisms for increasing the habitat availability for aquatic organisms in streams. Decreasing high flows provides a less stressful environment for fish and benthic invertebrates by reducing water velocity and the chance that these organisms may by flushed from preferred habitat locations. Increasing flows in winter provides for greater depths and greater area for supporting aquatic organisms through the stressful low flow season. The results of the flow changes with the additional Environmental Pool may result in greater abundance of aquatic organisms in Gross Reservoir and in South Boulder Creek downstream of Denver Water's diversion.

5.11.8 Unavoidable Adverse Impacts

The direct adverse impacts due to construction would be unavoidable impacts to fish and invertebrates. This would include construction impacts during construction of stream crossings with Conduits O and M, and during construction of diversions on the South Platte River. These direct impacts would be temporary and have no long-term impact on the fish and invertebrate communities if the diversion structure on the South Platte River does not act as a barrier to fish migration. If the diversion acts as a barrier, this would also be an unavoidable adverse impact.

All of the action alternatives would increase diversions in all of the Fraser River and Williams Fork tributaries with Denver Water diversions and decrease flows in the upper Fraser River. All of the action alternatives would increase mean monthly flows during runoff in South Boulder Creek upstream of Gross Reservoir and in the North Fork South Platte River downstream of Roberts Tunnel. These increases would result in lower habitat suitability for fish and invertebrates.

Alternative 1c would inundate a small spring at the location of the proposed Leyden Gulch Reservoir. This would result in the loss of the limited community of aquatic organisms in the spring pool.

5.12 TRANSPORTATION

This section describes the direct and indirect impacts to transportation expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Four potential transportation issues were raised during scoping:

- Consideration of the relationship of the Project to the transportation and land use planning occurring in the northern Front Range.
- Impact of Gross Reservoir construction on local traffic, commuter ski traffic and on other projects such as C-470 construction.
- How and where construction vehicles, equipment, and materials would gain access to the shores of Gross Reservoir.
- The impact of Gross Reservoir expansion regarding traffic on access roads, highways, and roads up Coal Creek Canyon.

Issues related to the relationship of the Project to other land use planning and transportation projects are addressed in Section 4.6.12. A description of how and where construction vehicles would gain access to the shores of Gross Reservoir is presented in Section 2.3.2.1.

Potential impacts to transportation on roadways in the Project area are associated with temporary construction traffic, ongoing maintenance and operations of Project facilities, and recreational traffic at Gross Reservoir. Other transportation issues addressed in this section include construction workforce, construction equipment, haul trucks, roadway standards and surface conditions, maintenance and operations, and recreational traffic. Potential transportation issues vary by alternative and are discussed by component, where applicable. For all alternatives, the volume of traffic during construction could vary significantly from month to month and day to day, depending upon phasing and the type and number of construction activities taking place. The construction traffic analysis assumes that construction activities would be performed concurrently where possible. Construction traffic analysis focused on the “worst case” traffic conditions generated by construction traffic as the basis for evaluating traffic impacts. Table 5.12-1 compares peak vehicle trips for all alternatives as well as the peak number of vehicles traveling to the construction site. Estimates of the construction workforce and equipment for the Project were provided by the Board of Water Commissioners (Denver Water) (2006b, 2006c), and adjusted by Harvey Economics (Harvey Economics 2008) as described in Section 2.8.

Table 5.12-1
Peak Vehicle Trips by Alternative

Alternative		Peak Vehicles[1] Per Day	Peak-hour Vehicle Trips[2]
Proposed Action (Alternative 1a)			
Enlarged Gross Reservoir	Construction Workforce	101	202
	Construction Equipment	2	4
	Supply Trucks[3]	4	8
	Proposed Action Total	**107**	**214**
Alternative 1c			
Enlarged Gross Reservoir	Total	84	168
New Leyden Gulch Reservoir	Construction Workforce	240	480
	Construction Equipment	2	4
	Total	242	484
	Alternative 1c Total	**326**	**652**
Alternative 8a			
Enlarged Gross Reservoir	Total	96	192
South Platte River Facilities	Construction Workforce	130	260
	Construction Equipment	1	2
	Total	131	262
Conduit O	Construction Workforce	81	162
	Construction Equipment	1	2
	Total	82	164
	Alternative 8a Total	**309**	**618**
Alternative 10a			
Enlarged Gross Reservoir	Total	96	192
Denver Basin Aquifer Facilities	Construction Workforce	220	440
	Construction Equipment	2	4
	Total	222	444
Conduit M	Total	73	146
	Alternative 10a Total	**391**	**782**
Alternative 13a			
Enlarged Gross Reservoir	Total	98	196
South Platte River Facilities	Total	88	176
Conduit O	Total	69	138
	Alternative 13a Total	**249**	**498**

Notes:
[1]Peak Vehicles = Represents maximum amount of vehicles anticipated on roadways.
[2]Peak-hour Vehicle Trips = Represents workers commuting to the various construction sites and were estimated based on manpower estimates (refer to Section 2.8.6) and an average carpooling of 1.5 workers per vehicle.
[3]Supply trucks are shown for Gross Reservoir only because borrow material would be required to be transported on public roads from off-site locations for the majority of the year. See detailed description under Transportation Methodology. Transporting borrow material from off-site locations would not be required to construct Leyden Gulch Reservoir or the other facilities proposed in the other alternatives.

Implementation of any of the action alternatives would create temporary transportation impacts related to construction. Numerous road segments would need to be abandoned and relocated or newly constructed in order to facilitate construction activities at Gross Reservoir. For example, road segments would need to be relocated out of the proposed reservoir inundation boundary and out of the proposed footprints for the dam enlargement and spillway facilities. A portion of the existing access road would be relocated in two locations around the proposed auxiliary spillway. The relocated road characteristics would be similar to the existing road with gravel surface and a disturbance area of approximately 30 feet wide and 2,300 feet long. North and south of Gross Dam, two road segments would be abandoned due to inundation. Both of these segments, which provide access to the dam, would be relocated. Approximately 1,500 feet of the north abutment access road (Dam Relocated Access Road) would be relocated to the east at an elevation 100 feet higher than the existing access road. Approximately 1,500 feet of the south abutment access road (Dam Relocated Access Road) would be relocated south of the existing access road. Both relocated road segments would be gravel surfaced and approximately 30 feet wide. All abandoned road segments above the high water line would be restored using techniques such as re-grading and seeding.

Methodology

Construction Workforce

Workers commuting to construction sites were estimated based on manpower estimates (refer to Section 2.8.6) and an average carpooling of 1.5 workers per vehicle. Estimated daily average and peak traffic trips are summarized in Table 2-18 in Section 2.8.5.

Construction Equipment

A wide variety of machinery would be used for construction activities. On-site construction equipment necessary to support the action alternatives are listed in Table 2-17 in Section 2.8.4. Construction equipment would travel little or no mileage off site on public roads, but they would be running full-time during construction.

Supply Trucks for Gross Reservoir Enlargement

It is estimated that construction-related traffic would consist of the following general categories. Haul trucks (15 cubic yards capacity) would import concrete material using public roads from off-site locations 260 days per year (flyash, aggregate, and cement). It is assumed that 60 percent (%) of the concrete material would be found on site (aggregate), and 40% (aggregate, flyash, and cement) would be hauled from an off-site location. Commercial suppliers in the Longmont area are assumed for purposes of the EIS analysis (48 miles one-way between Gross Reservoir and Longmont as defined in Section 2.8.5).

5.12.1 Proposed Action (Alternative 1a)

Expansion of the dam, reservoir, and related facilities as described in Chapter 2 is expected to be completed within a 4.1-year (49 month) period (refer to Table 2-15). Concrete placement at Gross Dam and other facilities would take place when temperatures are above freezing, generally April through November.

Construction-Related Traffic Impacts

Construction Workforce Travel Trips

The total size of the workforce varies by month up to approximately 151 workers. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 101 vehicles (202 vehicle trips), resulting in temporary moderate impacts.

Construction Equipment Travel Trips

Due to the varying amount of construction equipment needed and the absence of a detailed mobilization schedule, the equipment is assumed to be mobilized over a 2-day period at the beginning of the Project, and demobilized over a 2-day period at the end of the Project. An estimated 39 pieces of equipment are required for the dam and reservoir construction. This equates to an average of approximately 20 pieces of equipment transported per day, during the 2-day mobilization and 2-day demobilization period. Assuming 10% occur during the peak hours, there would be 4 peak-hour trips for construction equipment, resulting in temporary minor impacts. Denver Water conducted a detailed haul route study as part of the Federal Energy Regulatory Commission (FERC) re-licensing application process (HDR 2012). As part of this study, Denver Water evaluated industry criteria as defined by the American Association of State Highway and Transportation Officials (AASHTO) for adding a climbing lane to Colorado State Highway (SH) 72. The study determined that a climbing lane is not justified per the AASHTO criteria based on the existing traffic volumes obtained by CDOT and the estimated Project volumes. The study identified alternatives for providing passing opportunities along SH 72 including enhancing existing pullouts and/or shoulder sections. Denver Water is currently discussing with CDOT these alternatives and other traffic control options to safely accommodate construction traffic on SH 72.

Supply Delivery Trips

As with the construction equipment, the amount of construction supply deliveries needed varies significantly over the construction period. The number of deliveries ranges from a daily average of 22 deliveries (44 vehicle trips) per day, up to a peak of 37 deliveries (74 vehicle trips) per day. Assuming 10% of these trips occur during the peak hour, the highest number of peak-hour trips per day is 8 for supply deliveries.

Based on the relationship of workforce, equipment, and supply delivery trips, the highest number of trips for dam and reservoir construction is about 214 peak-hour vehicle trips. This number of trips has negligible impact on the operating conditions (i.e., level of service) of the freeways, major arterials, and minor arterials that serve the Gross Reservoir site. The roadways that would be affected during construction of the dam and reservoir are County Road (CR) 77S and SH 72. SH 93, SH 128, U.S. Highway (US) 287, Arapahoe Road (US 287 bypass to County Line Road), County Line Road, and CR 2050 would be affected by haul and supply delivery traffic.

Most of the roadways serving the Gross Reservoir site are in good condition and designed to accommodate large, heavy construction vehicles. However, Gross Dam Road (CR 77S) is a steep, curvy unpaved road. Although Gross Dam Road is maintained in good condition, heavy equipment and haul trucks could cause rutting in the unpaved road

segments of this route. Denver Water would improve the roads, as required by Boulder County and CDOT, in the Project area to accommodate construction activities.

The temporary moderate indirect impacts to traffic operations would be passenger vehicle delays due to queuing behind slower-moving haul and supply vehicles on two-lane roads, and queuing at intersections where large vehicle turn movements are more difficult. Traffic on Gross Dam Road is predominantly recreational and typically does not occur during peak-hour times. During construction, dam access would be limited to all traffic. The frequency (times per day) and duration (total minutes) of traffic delays, and the numbers of people affected by them, pose no significant indirect impacts.

Tree Removal and Disposal

In order to minimize problems with floating debris, decaying vegetation and water quality concerns, all trees would be removed within the area of proposed inundation. It is assumed trees would be removed between the normal pool elevation (7,282 feet) and 7,410 feet. Tree removal and residue disposal would be completed during the overall construction period, and would take approximately 6 to 8 months to complete (Land Stewardship Associates, LLC 2008). Additional traffic would occur that has not been included in Table 5.12-1 because the amounts would vary depending on which disposal options would be selected. Options for disposal include use of air curtain destructors to incinerate the material on-site and disposal of the ash in a landfill, grinding whole trees and removing the chips to a landfill, hauling whole trees to a landfill, and/or removal and sale of forest products (logs and firewood). Hauling whole trees to a landfill would require the most heavy truck traffic, and incinerating the trees and site and disposal of ash in a landfill would require the least. Additional traffic would occur from the tree harvest workforce and equipment.

Roads used for access would include Flagstaff Road (CR 77) east and north of the dam, Gross Dam Road (CR 77S) from SH 72, and CR 97, and CR 68. Additional traffic from tree removal and disposal would also occur on SH 72 and SH 93. Although CR 77 is used for vehicular access, logging truck access is prohibited. The closest landfill that accepts whole trees is located near the intersection of SH 72 and SH 93, and other landfills are located at much greater distances. Tree harvesting and removal would also use several existing unpaved and four-wheel drive roads on U.S. Forest Service (USFS) lands, as well as several new temporary access roads that would be built within the reservoir expansion area and the existing reservoir area, which would need to be partially drawn down during tree harvest. Some portions of the existing roads at the reservoir would need to be improved to accommodate the heavy equipment required for tree removal. Traffic related to tree removal would result in moderate temporary impacts.

Maintenance and Operations

No change from Current Conditions (2006) in maintenance and operation trips for the dam and reservoir are anticipated once construction activities are complete. The Colorado Department of Transportation (CDOT) is responsible for maintenance of the State highways. Boulder County is responsible for maintenance of CR 77S from SH 72 to the railroad tracks. Denver Water is currently in discussions with Boulder County to address

possible impacts to the portion of CR 77S maintained by Boulder County. Denver Water currently maintains Gross Dam Road from the railroad track crossing to Flagstaff Road.

Recreational Traffic

At the anticipated normal water elevation of 7,406 feet, an enlarged Gross Reservoir under the Proposed Action is anticipated to have a surface area of approximately 842 acres. This represents an additional 424 acres, approximately double the existing surface area of the reservoir. Prior to 2005 no water boating was permitted at the reservoir. Per the FERC Gross Reservoir Recreation Management Plan, car top boating is now allowed from Memorial Day through the end of September each year (Denver Water 2008a). Enlarging the surface area of the reservoir would provide substantial additional space on which people can recreate via car top boating. Additionally, reservoir enlargement would create additional shoreline. The enlarged reservoir is anticipated to have approximately 13.9 miles of shoreline, representing approximately 2.8 miles more of shoreline than exists currently. The presence of additional shoreline may provide additional dispersed shoreline recreation opportunities such as fishing. However, no additional developed recreation sites are planned in accordance with Denver Water's FERC license.

The additional recreation opportunities (increased surface area and shoreline) created as a result of an enlarged reservoir may result in some increased use and therefore may increase traffic on certain roads leading to the reservoir. As explained in Section 5.15, a major increase in visitation is not expected because the overall attractiveness of Gross Reservoir to recreation users is not expected to substantially change. Much of the shoreline would remain steep and seasonal fluctuations in water levels would continue. In addition, Denver Water intends to adhere to its Recreation Management Plan, which was approved by FERC with considerable stakeholder and agency input (Denver Water 2008a). Denver Water has not proposed to increase parking spaces, season of use, and/or hours of operation, or changes to the types of activities that are currently allowed. Under the Proposed Action, vehicle access to Gross Reservoir would remain unchanged via the existing north and south public access points. During construction, however, recreational access in the area of the dam would be limited. The north side of the reservoir would still be accessible by Flagstaff Road (CR 77) from Boulder.

The parking lot located east of the existing spillway would be covered by the dam raise buttress and would be relocated. The existing access road would be widened adjacent to the dam to provide site parking and vehicle turnarounds.

Traffic related to recreational activities would be routed as described in Section 2.3.2 and would experience delays during construction due to queuing behind slower-moving equipment and haul trucks on two-lane roads, and queuing at intersections. Many of the same physical roadway conditions that are issues for construction (e.g., sharp turns) vehicles also apply to recreational traffic and would result in moderate temporary impacts.

Safety and Emergency Access at Gross Reservoir

Comments related to bike safety were received on the Draft EIS. Denver Water evaluated establishing a bike path and determined that this option would not be feasible due to space constraints and cost. The U.S. Army Corps of Engineers (Corps) assumes that construction contractors would comply with health and safety plans and codes instituted by their

respective companies and Denver Water. A contractor hired by Denver Water would be in charge of construction activity, including safety compliance. Denver Water also plans to have staff on-site during construction.

With the exception of limited road closures planned near the dam, emergency vehicles would have access to the same response routes during construction that currently exist. If an emergency vehicle needs access to a closed road, access would be granted. Additionally, construction contractors would pull over to allow emergency response vehicles to pass as needed.

5.12.2 Alternative 1c

5.12.2.1 Gross Reservoir

The potential impacts to transportation resulting from Alternative 1c are generally the same as those described for the Proposed Action, except with a shorter construction period. On-site construction equipment would be the same as those described for the Proposed Action. The construction workforce would vary up to approximately 119 workers versus 151 for the Proposed Action. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 79 vehicles (158 vehicle trips). The number of supply deliveries would average 17 deliveries per day, up to a peak of 28 deliveries (56 vehicle trips) per day. Assuming 10% of these trips occur during the peak hour, the highest number of peak-hour trips per day is 6 for supply deliveries.

Enlargement of Gross Reservoir under Alternative 1c is expected to be completed within 3.1 years (37 months). Thus, temporary impacts from construction would last 1 year less than under the Proposed Action.

5.12.2.2 Leyden Gulch Reservoir Site

The proposed Leyden Gulch Reservoir and related facilities as described in Chapter 2 are expected to be completed within a 3.5-year (42 months) period.

Unlike the expansion of Gross Reservoir, transporting borrow material from off-site locations would not be required to construct a new Leyden Gulch Reservoir as the needed material would be quarried on site. Construction-related traffic would primarily consist of workers commuting to and from the construction site.

Construction-Related Traffic Impacts

Construction Workforce Travel Trips

The total size of the workforce varies by month up to approximately 360 workers versus 151 for the Proposed Action. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 240 vehicles (480 vehicle trips), resulting in temporary minor impacts.

Construction Equipment Travel Trips

An estimated 46 pieces of equipment are required for the new reservoir construction. All equipment for the construction is assumed to be mobilized in 2 days at the beginning of construction, and demobilized in 2 days at the end of construction. This equates to an average of approximately 23 pieces of equipment transported per day, during the 2-day mobilization or demobilization period. Assuming 10% occur during peak hours, there would be 2 peak-hour trips for mobilization and de-mobilization for a total of 4 peak-hour trips for construction equipment, resulting in temporary minor impacts.

Based on the relationship of workforce and equipment, the total highest number of trips for dam and reservoir construction is about 484 peak-hour vehicle trips. This number of trips has no significant impact on the operating conditions (i.e., level of service) of the freeways, major arterials, and minor arterials that serve the Leyden Gulch Reservoir site.

The roadway that would be temporarily affected during construction of the reservoir is SH 93. The proposed dam footprint overlaps a portion of SH 93. Thus, approximately 4,000 feet of SH 93 would be permanently relocated. The SH 93 re-alignment would be constructed before the dam embankment. The construction of the SH 93 re-alignment would pose no significant traffic delays as the existing SH 93 would remain in service while the realignment is constructed.

Access to the proposed Leyden Gulch Dam would be available via a north crest access road adjacent to SH 93, north of the dam and via a south crest access road, located west of the tunnel portal infrastructure as described in Chapter 2. Roadways serving the Leyden Gulch Reservoir site are in good condition and designed to accommodate large, heavy construction vehicles.

The indirect temporary impacts to traffic operations would be relatively minor passenger vehicle delays due to queuing behind slower-moving construction equipment vehicles. The frequency and time duration of these traffic delays, and the numbers of people affected by them, pose no significant impacts.

Maintenance and Operations

The current staff at the Ralston Reservoir Facility would operate and maintain the new Leyden Gulch Reservoir using existing roads or Denver Water access roads between the two reservoirs. Thus, none to negligible impacts to transportation resulting from operations and maintenance activities at the Leyden Gulch Reservoir site are anticipated.

Recreational Traffic

No recreational facilities or public access would be provided at the proposed Leyden Gulch Reservoir.

5.12.3 Alternative 8a

5.12.3.1 Gross Reservoir

The potential impacts to transportation resulting from Alternative 8a are generally the same as those described for the Proposed Action, except with a shorter construction period. Enlargement of Gross Reservoir under this alternative is expected to be completed within a 3.2-year (38 months) period. Temporary impacts from construction would last 11 months less than under the Proposed Action. On-site construction equipment and supply deliveries would be the same as those described for the Proposed Action. The construction workforce would vary up to approximately 135 workers. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 90 vehicles (180 vehicle trips).

5.12.3.2 South Platte River Facilities

The proposed South Platte River Facilities including the diversion structure, the Advanced Water Treatment Plant (AWTP), and dechlorination facility would be expected to be completed within 2.5 years (30 months). Construction-related traffic would primarily consist of workers commuting to and from the construction site.

Construction-Related Traffic Impacts

Construction Workforce Travel Trips

The total size of the workforce varies by month up to approximately 195 workers. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 130 vehicles (260 vehicle trips), resulting in temporary minor impacts.

Construction Equipment Travel Trips

An estimated 12 pieces of equipment are required for the construction. All equipment for the construction is assumed to be mobilized in 1 day at the beginning of construction, and demobilized in 1 day at the end of construction. Assuming 10% occur during the peak hour, there would be 1 peak-hour trip each for mobilization and demobilization for a total of 2 peak-hour trips for construction equipment, resulting in temporary minor impacts.

Based on the relationship of workforce and equipment, the total highest number of trips for construction is about 262 peak-hour vehicle trips. This number of trips has no significant impact on the operating conditions (i.e., level of service) of the freeways, major arterials, and minor arterials that serve the Project area. The roadways that would be most affected during construction of the South Platte River Facilities are US 85 and local roads in the Brighton area.

Construction access would be obtained using existing paved and unpaved roads in Adams County. Roadways serving the Project area are in good condition and designed to accommodate large, heavy construction vehicles.

The indirect temporary impacts to traffic operations would primarily be passenger vehicle delays on local roads due to queuing behind slower-moving construction equipment vehicles, and higher-than-average volumes of commuter traffic during peak construction.

Maintenance and Operations

The South Platte River Facilities would operate only during dry years or emergencies. The staff needed to operate these facilities would come from existing Denver Water Facilities when needed. Thus, none to negligible impacts to transportation resulting from operations and maintenance activities at the South Platte River Facilities are anticipated.

Recreational Traffic

No recreational facilities or public access would be provided at the South Platte River Facilities.

Conduit O

A new pipeline constructed from the AWTP to the Moffat Collection System would be expected to be completed within 2.5 years (30 months). Major conduit construction would occur at production rates ranging from about 500 to 1,200 feet per day depending on localized conditions, so that a particular stretch of roadway would typically be impacted by pipeline construction for less than 1 week. Crossings of railroads and major roads would be bored and jacked per Denver Water's standard practices. Each crossing would be completed within approximately 20 working days depending on weather and flow conditions. Pipeline construction would result in moderate impacts to traffic.

Construction-Related Traffic Impacts

Construction Workforce Travel Trips

The total size of the workforce varies by month up to approximately 122 workers. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 81 vehicles (162 vehicle trips), resulting in temporary minor impacts.

Construction Equipment Travel Trips

An estimated 12 pieces of equipment are required for the construction. All equipment for the construction is assumed to be mobilized in 1 day at the beginning of construction, and demobilized in 1 day at the end of construction. Assuming 10% occur during the peak hour for mobilization and demobilization, there would be 2 peak-hour trips for construction equipment.

Based on the relationship of workforce and equipment, the total highest number of trips for construction is about 52 peak-hour vehicle trips. This number of trips has no significant impact on the operating conditions (i.e., level of service) of the freeways, major arterials, and minor arterials that serve the Project area. Major transportation corridors crossed would be three railroad grades, two highways (Interstate [I-] 25 and US 36), and seven major arterials (Sheridan Boulevard, Wadsworth Boulevard, Federal Boulevard, Kipling Street, 104th Avenue, 120th Avenue, and Washington Street).

Construction access would be obtained using existing roads in the area. Roadways serving the Project area are in good condition and designed to accommodate large, heavy construction vehicles.

The indirect moderate temporary impacts to traffic operations would be primarily passenger vehicle delays on local roads due to queuing behind slower-moving construction equipment vehicles, and higher-than-average volumes of commuter traffic during peak construction.

Maintenance and Operations

As with the other South Platte River Facilities, Conduit O would operate only during dry years or emergencies. The staff needed to operate and maintain Conduit O would come from existing Denver Water Facilities when needed and use existing roads in the Project area as access. Thus, none to negligible impacts to transportation resulting from the operations and maintenance of Conduit O are anticipated.

5.12.4 Alternative 10a

5.12.4.1 Gross Reservoir

The potential impacts to transportation resulting from Alternative 10a are the same as those described for Alternative 8a.

5.12.4.2 Denver Basin Aquifer Facilities

The proposed Denver Basin Aquifer Facilities are expected to be completed within a 2.5 year period (30 months). Construction of the distribution pipeline would vary by location and diameter of pipe, but would average approximately 25 to 35 days per mile for in-street construction. Well drilling would average 2 weeks per well. The three injection/recovery wells at each site would be drilled consecutively. The construction time of each well house would range from 30 to 60 days and would initially coincide with the well drilling activities. Construction of Denver Basin Aquifer Facilities would result in temporary moderate impacts.

Construction-Related Traffic Impacts

Construction Workforce

The total size of the workforce varies by month up to approximately 330 workers. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 220 vehicles (440 vehicle trips), resulting in temporary minor impacts.

Construction Equipment Travel Trips

An estimated 17 pieces of equipment are required to construct the Denver Basin Aquifer Facilities. All equipment for the construction is assumed to be mobilized in 1 day at the beginning of construction, and demobilized in 1 day at the end of construction. Assuming 10% occur during the peak hour, there would be a total of 4 peak-hour trips for construction equipment, resulting in temporary moderate impacts.

Based on the relationship of workforce and equipment, the total highest number of trips for Alternative 10a construction is about 444 peak-hour vehicle trips. This number of trips has no significant impact on the operating conditions (i.e., level of service) of the freeways, major arterials, and minor arterials that serve the study area. Regional and local roads in the Denver Metropolitan area would temporarily be affected during construction of the proposed Denver Basin Aquifer Facilities.

Construction access would be obtained using existing roads in the area. Roadways serving the Project area are in good condition and designed to accommodate large, heavy construction vehicles.

The indirect temporary impacts to traffic operations would be passenger vehicle delays due to queuing behind slower-moving construction equipment vehicles and higher-than-average volumes of commuter traffic during peak construction. The frequency and time duration of these traffic delays, and the numbers of people affected by them, pose no significant impacts.

Maintenance and Operations

The Denver Basin Aquifer Facilities would operate only during dry years or emergencies. The staff needed to operate these facilities would come from existing Denver Water Facilities when needed and use existing roads in the Denver Metropolitan area as access. Thus, none to negligible impacts to transportation resulting from operations and maintenance activities for the Denver Basin Aquifer Facilities are anticipated.

Recreational Traffic

Access to public parks would not be changed under Alternative 10a. Traffic related to recreational activities at city parks may experience negligible to minor temporary delays during construction due to an increased volume of construction-related traffic in localized areas.

5.12.4.3 Conduit M

A new 18.5-mile long pipeline connecting the new AWTP and the Moffat Collection System as described in Chapter 2 is expected to be completed within a 2.5-year period (30 months). The potential impacts to transportation resulting from Alternative 10a are generally the same as those described for Conduit O under Alternative 8a. Construction equipment would be the same as described for Conduit O. The construction workforce would vary up to approximately 108 workers. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 72 vehicles (144 vehicle trips). Major roadways affected by Conduit M would be I-25, I-76, Sheridan Boulevard, Wadsworth Boulevard, Washington Street, York Street, Federal Boulevard, and Broadway Street.

5.12.5 Alternative 13a

5.12.5.1 Gross Reservoir

The potential impacts to transportation resulting from Alternative 13a are generally similar to those described for the Proposed Action, except for a shorter construction period. Enlargement of Gross Reservoir under this alternative is expected to be completed within a 3.6-year period (43 months). Temporary impacts from construction would last 6 months less than under the Proposed Action. On-site construction equipment and supply deliveries would be the same as described for the Proposed Action. The construction workforce would vary up to approximately 138 workers. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 92 vehicles (184 vehicle trips).

5.12.5.2 South Platte River Facilities

Potential impacts to transportation resulting from the South Platte River Facilities for Alternative 13a are generally the same as those described for Alternative 8a. On-site construction equipment would be the same as described in Alternative 8a. The construction workforce would vary up to approximately 131 workers. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 87 vehicles (174 vehicle trips).

5.12.5.3 Conduit O

Potential impacts to transportation resulting from construction of Conduit O for Alternative 13a are generally the same as those described for Alternative 8a. On-site construction equipment would be the same as described in Alternative 8a. The construction workforce would vary up to approximately 102 workers. Assuming that there are 1.5 workers per vehicle and that most or all workers travel during the peak hour, the number of peak-hour vehicle trips for the workforce could be up to approximately 68 vehicles (136 vehicle trips).

5.12.6 No Action Alternative

Since no construction activities would occur under the No Action Alternative, no direct or indirect impacts to transportation resources are anticipated. Traffic associated with operations and maintenance of existing facilities would remain unchanged.

5.12.7 Mitigation and Monitoring

The Corps acknowledges that there may be delays caused by slow-moving construction vehicles on CR 77S, SH 72, SH 93, and other roads in the Project area. Denver Water will work with Jefferson and Boulder counties to address local traffic concerns. Possible measures include:

- Provide adequate public notices through newspapers and local signs to warn motorists of future detours and/or road closures.
- Limit any major disruption of traffic to off-peak hours as much as possible to alleviate congestion and reduce economic impacts to business in the Project area.
- Minimize average delay times to the traveling public. For example, Denver Water is evaluating alternatives for reducing construction traffic delays, including constructing and/or improving turnouts on SH 72 for slow-moving traffic and encouraging contractors to carpool to the site.
- Use of appropriate Best Management Practices to reduce impacts from dust emissions, sedimentation, and erosion.
- Perform construction vehicle maintenance and refueling operations at a designated area away from sensitive wildlife habitat, wetlands, and other waters of the U.S.

Refer to Denver Water's Conceptual Mitigation Plan for the Proposed Action for more mitigation measures pertaining to traffic at Gross Reservoir (Appendix M).

5.12.8 Unavoidable Adverse Impacts

There are no significant, adverse long-term impacts for either construction traffic or recreational traffic that cannot be mitigated.

5.13 AIR QUALITY

This section describes the direct and indirect impacts to air quality expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Concerns were raised during scoping regarding impacts of the Gross Reservoir expansion on air quality (e.g., dust and other pollutants caused by construction activities and increased traffic). Potential air quality impacts are evaluated and compared between the alternatives in Sections 5.13.1 through 5.13.6.

Short-term direct air quality impacts for the Moffat Project are related primarily to construction activities. Construction emissions include exhaust emissions from heavy-duty construction equipment, exhaust emissions from construction workers' vehicles and delivery vehicles, and fugitive dust emissions. Details of the construction emission calculations are presented in Appendix I, Air Quality Data.

5.13.1 Proposed Action (Alternative 1a)

5.13.1.1 Gross Reservoir

Total emissions from the 77,000 acre-feet (AF) expansion of the dam and reservoir were calculated based on proposed equipment used over the 49-month (4.1 years) construction schedule. Average annual emissions in a 12-month period were calculated by the following formula:

$$\textbf{Total emissions (tons/project)} * \frac{\textbf{12 months/year}}{\textbf{49 months/project}} = \textbf{Annual emissions (tons/year)}$$

This procedure allows the comparison of annual emissions with the conformity *de minimis* levels to determine if the Project needs to undergo conformity analysis. Refer to Section 3.13.4 for details on qualitative conformity.

Table 5.13-1 summarizes estimated emissions from construction to enlarge Gross Dam and Reservoir. Most construction equipment exhaust emission factors are conservatively based on Tier 1 emission factors from Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling (EPA 2004). On-road exhaust emissions from workers commuting to the construction site and from delivery vehicles are estimated using emission factors provided by the Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division (APCD) (CDPHE 2006). Fugitive dust emissions are based on a variety of sources listed in footnotes included in Appendix I.

For the dam and reservoir expansion, average annual emissions of carbon monoxide (CO) and oxides of nitrogen (NO_x) are greater than the conformity *de minimis* levels of 100 tons per year (tpy). Therefore, the Proposed Action would undergo a general conformity analysis to ensure that the region remains in compliance with the National Ambient Air Quality Standards (NAAQS).

Table 5.13-1
Construction Emissions for the Proposed Action – Gross Reservoir

Source	Total Emissions (tons)							
	Criteria Pollutants						HAPs	GHGs
	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	Total	CO_2e
Construction Equipment Exhaust	392.47	318.58	18.47	17.91	6.00	46.17	0.48	24,041.66
Portable Diesel Engine Exhaust	15.49	71.89	5.10	5.10	4.75	5.73	0.06	2,511.62
On-road Exhaust								
Worker Commuting	59.22	4.38	0.11	--	0.04	4.53	0.22	42.60
Delivery Vehicles	27.18	28.59	0.87	0.36	1.25	3.63	0.28	10.44
Fugitive Dust								
Wind Erosion	--	--	3.22	0.48	--	--	--	--
Material Handling	--	--	--	--	--	--	--	--
Paved Roads	--	--	156.36	22.58	--	--	--	--
Unpaved Roads	--	--	105.98	10.59	--	--	--	--
Rock Crushing/Screening	--	--	3.33	--	--	--	--	--
Concrete Batching	--	--	22.35	22.35	--	--	--	--
Total Emissions (tons)	**494.36**	**423.44**	**315.79**	**79.37**	**12.04**	**60.06**	**1.04**	**26,606.32**
Project years:	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Average Annual Emissions (tons per year)	**120.58**	**103.28**	**77.02**	**19.36**	**2.94**	**14.65**	**0.25**	**6,489.35**

Notes:
CO = carbon monoxide
GHG = greenhouse gases
HAP = hazardous air pollutants
NO_x = oxides of nitrogen
$PM_{2.5}$ = particulate matter less than 2.5 microns in diameter
PM_{10} = particulate matter less than 10 microns in diameter
SO_2 = sulfur dioxide
VOC = volatile organic compounds

Additional impacts would occur from tree removal and residue disposal. Based on a preliminary analysis, approximately 50,000 tons of forest residue would be generated from clearing at Gross Reservoir. A traditional slash pile and burn approach to disposing the residue is not viable at Gross Reservoir due to air quality concerns and regulations. Options for disposal include use of air curtain destructors to incinerate the material on site, grinding whole trees and removing the chips to a landfill, hauling whole trees to a landfill, and/or removal and sale of forest products (logs and firewood). Temporary air quality impacts would occur under all options from fugitive dust and vehicle emissions. Use of air curtain destructors could potentially require an air quality permit. Tree removal and disposal at Gross Reservoir would take approximately 6 to 8 months to complete (Land Stewardship Associates, LLC 2008).

U.S. Environmental Protection Agency's (EPA's) "major source" emissions thresholds for hazardous air pollutant (HAPs) are 10 tpy for a single HAP or 25 tpy for any combination of HAPs. The EPA Greenhouse Gases (GHG) Final Rule states that new facilities with GHG emissions of at least 100,000 tpy carbon dioxide equivalent (CO_2e) and existing facilities with at least 100,000 tpy CO_2e making changes that would increase GHG emissions by at least 75,000 tpy CO_2e are required to obtain Prevention of Significant

Deterioration (Major Source) permits. As shown in the Table 5.13-1 above, the HAPs and GHGs total emissions for this Project are well below the major source status thresholds for permitting requirements.

During the construction phase of the Proposed Action, air quality impacts would be minor. Negligible air quality impacts are expected during operation. Recommended mitigation measures and control plans for both fugitive dust and combustion emissions are discussed in Section 5.13.7.

5.13.2 Alternative 1c

5.13.2.1 Gross Reservoir

Total and average emissions for the 40,700 AF expansion of Gross Reservoir were calculated using the same approach used for the Proposed Action, but assuming a 37-month (3.1 years) construction schedule. The types of air quality impacts are similar to, but less than the Proposed Action due to the smaller reservoir enlargement size. Table 5.13-2 summarizes estimated emissions from the expansion of the reservoir.

Table 5.13-2
Construction Emissions for Alternative 1c – Gross Reservoir

Source	Total Emissions (tons)							
	Criteria Pollutants						HAPs	GHGs
	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	Total	CO_2e
Construction Equipment Exhaust	296.35	240.56	13.95	13.53	4.53	34.86	0.36	18,153.91
Portable Diesel Engine Exhaust	15.49	71.89	5.10	5.10	4.75	5.73	0.06	2,511.62
On-road Exhaust								
Worker Commuting	44.72	3.31	0.08	--	0.03	3.42	0.17	32.16
Delivery Vehicles	15.86	16.68	0.51	0.21	0.73	2.12	0.17	6.09
Fugitive Dust								
Wind Erosion	--	--	2.43	0.36	--	--	--	--
Material Handling	--	--	--	--	--	--	--	--
Paved Roads	--	--	99.84	14.37	--	--	--	--
Unpaved Roads	--	--	79.50	7.94	--	--	--	--
Rock Crushing/Screening	--	--	1.95	--	--	--	--	--
Concrete Batching	--	--	13.11	13.11	--	--	--	--
Total Emissions (tons)	**372.42**	**332.44**	**216.47**	**54.62**	**10.04**	**46.13**	**0.76**	**20,703.78**
Project years:	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Average Annual Emissions (tons per year)	**120.14**	**107.24**	**69.83**	**17.62**	**3.24**	**14.88**	**0.25**	**6,678.64**

Notes:
CO = carbon monoxide
GHG = greenhouse gas
HAP = hazardous air pollutant
NO_x = oxides of nitrogen
$PM_{2.5}$ = particulate matter less than 2.5 microns in diameter
PM_{10} = particulate matter less than 10 microns in diameter
SO_2 = sulfur dioxide
VOC = volatile organic compound

5.13.2.2 Leyden Gulch Reservoir Site

Total and average emissions for a new Leyden Gulch Reservoir (31,300 AF) were calculated using the same approach used for the Gross Reservoir emissions, but assuming a 42-month (3.5 year) construction schedule. Table 5.13-3 summarizes estimated emissions from the construction of the proposed reservoir.

Table 5.13-3
Construction Emissions for Alternative 1c – Leyden Gulch Reservoir Site

Source	Total Emissions (tons)							
	Criteria Pollutants						HAPs	GHGs
	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	Total	CO_2e
Construction Equipment Exhaust	396.53	321.88	18.66	18.10	6.06	46.65	0.48	24,290.29
Portable Diesel Engine Exhaust	--	--	--	--	--	--	--	--
On-road Exhaust								
Worker Commuting	112.51	8.33	0.20	--	0.07	8.61	0.42	80.93
Delivery Vehicles	--	--	--	--	--	--	--	--
Fugitive Dust								
Wind Erosion	--	--	2.76	0.41	--	--	--	--
Material Handling	--	--	0.29	0.04	--	--	--	--
Paved Roads	--	--	95.28	13.24	--	--	--	--
Unpaved Roads	--	--	1,525.95	152.59	--	--	--	--
Rock Crushing/Screening	--	--	--	--	--	--	--	--
Concrete Batching	--	--	--	--	--	--	--	--
Total Emissions (tons)	**509.04**	**330.21**	**1,643.14**	**184.38**	**6.13**	**55.26**	**0.90**	**24,371.22**
Project years:	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Average Annual Emissions (tons per year)	**145.44**	**94.35**	**469.47**	**52.68**	**1.75**	**15.79**	**0.26**	**6,963.21**

Notes:
CO = carbon monoxide
GHG = greenhouse gas
HAP = hazardous air pollutant
NO_x = oxides of nitrogen
$PM_{2.5}$ = particulate matter less than 2.5 microns in diameter
PM_{10} = particulate matter less than 10 microns in diameter
SO_2 = sulfur dioxide
VOC = volatile organic compound

For Alternative 1c, average annual emissions of CO, NO_x and particulate matter less than 10 microns in diameter (PM_{10}) from both reservoir sites are greater than the conformity *de minimis* levels of 100 tpy as shown in Tables 5.13.-2 and 5.13-3. Therefore, this alternative would undergo a general conformity analysis to ensure that the region remains in compliance with the NAAQS. Total emissions for HAPs and GHGs are well below the major source status for permitting requirements.

During the construction phase of Alternative 1c, air quality impacts would be minor. Negligible air quality impacts are expected during operation. Section 5.13.7 discusses recommended mitigation measures and control plans for both fugitive dust and combustion emissions.

5.13.3 Alternative 8a

5.13.3.1 Gross Reservoir

Total and average emissions for the 52,000 AF expansion of Gross Reservoir were calculated using the same approach used for the Proposed Action, but assuming a 38-month (3.2 years) construction schedule. The types of air quality impacts are similar to, but less than the Proposed Action due to the smaller reservoir enlargement size. Table 5.13-4 summarizes estimated emissions from the expansion of the reservoir.

Table 5.13-4
Construction Emissions for Alternative 8a – Gross Reservoir

Source	Total Emissions (tons)							
	Criteria Pollutants						HAPs	GHGs
	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	Total	CO_2e
Construction Equipment Exhaust	304.36	247.07	14.32	13.89	4.65	35.81	0.38	18,644.55
Portable Diesel Engine Exhaust	15.49	71.89	5.10	5.10	4.75	5.73	0.06	2,511.62
On-road Exhaust								
Worker Commuting	45.92	3.40	0.08	--	0.03	3.51	0.17	33.03
Delivery Vehicles	20.12	21.17	0.64	0.26	0.93	2.69	0.20	7.73
Fugitive Dust								
Wind Erosion	--	--	2.50	0.37	--	--	--	--
Material Handling	--	--	--	--	--	--	--	--
Paved Roads	--	--	117.51	16.96	--	--	--	--
Unpaved Roads	--	--	84.78	8.47	--	--	--	--
Rock Crushing/Screening	--	--	2.44	--	--	--	--	--
Concrete Batching	--	--	16.38	16.38	--	--	--	--
Total Emissions (tons)	**385.89**	**343.53**	**243.75**	**61.43**	**10.36**	**47.74**	**0.81**	**21,196.93**
Project years:	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Average Annual Emissions (tons per year)	**120.59**	**107.35**	**76.17**	**19.20**	**3.24**	**14.92**	**0.25**	**6,624.04**

Notes:
CO = carbon monoxide
GHG = greenhouse gas
HAP = hazardous air pollutant
NO_x = oxides of nitrogen
$PM_{2.5}$ = particulate matter less than 2.5 microns in diameter
PM_{10} = particulate matter less than 10 microns in diameter
SO_2 = sulfur dioxide
VOC = volatile organic compound

5.13.3.2 South Platte River Facilities

Total and average emissions for the South Platte River Facilities and Conduit O were calculated using the same approach used for the Gross Reservoir emissions, but assuming a 30-month construction schedule (2.5 years). Table 5.13-5 summarizes estimated emissions from the construction of these pipelines.

Table 5.13-5
Construction Emissions for Alternative 8a – South Platte River Facilities

Source	Total Emissions (tons)							
	Criteria Pollutants						HAPs	GHGs
	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	Total	CO_2e
Construction Equipment Exhaust	113.96	92.50	5.36	5.20	1.74	13.41	0.14	6,980.68
Portable Diesel Engine Exhaust	--	--	--	--	--	--	--	--
On-road Exhaust								
Worker Commuting	62.24	4.61	0.11	--	0.04	4.76	0.23	4.85
Delivery Vehicles	--	--	--	--	--	--	--	--
Fugitive Dust								
Wind Erosion	--	--	--	--	--	--	--	--
Material Handling	--	--	2.67	0.40	--	--	--	--
Paved Roads	--	--	52.71	7.32	--	--	--	--
Unpaved Roads	--	--	336.66	33.66	--	--	--	--
Rock Crushing/Screening	--	--	--	--	--	--	--	--
Concrete Batching	--	--	--	--	--	--	--	--
Total Emissions (tons)	**176.20**	**97.11**	**397.51**	**46.58**	**1.78**	**18.17**	**0.37**	**6,985.53**
Project years:	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Average Annual Emissions (tons per year)	**70.48**	**38.84**	**159.00**	**18.63**	**0.71**	**7.27**	**0.15**	**2,794.21**

Notes:
CO = carbon monoxide
GHG = greenhouse gas
HAP = hazardous air pollutant
NO_x = oxides of nitrogen
$PM_{2.5}$ = particulate matter less than 2.5 microns in diameter
PM_{10} = particulate matter less than 10 microns in diameter
SO_2 = sulfur dioxide
VOC = volatile organic compound

For Alternative 8a, average annual emissions of CO, NO_x, and PM_{10} from both sites are greater than the conformity *de minimis* levels of 100 tpy, as shown in Tables 5.13-4 and 5.13-5. Therefore, this alternative would undergo a general conformity analysis to ensure that the region remains in compliance with the NAAQS. Total emissions for HAPs and GHGs are well below the major source status for permitting requirements.

During the construction phase of Alternative 8a, air quality impacts would be minor. Negligible air quality impacts are expected during operation. Section 5.13.7 discusses recommended mitigation measures and control plans for both fugitive dust and combustion emissions.

5.13.4 Alternative 10a

5.13.4.1 Gross Reservoir

Total and average emissions for the 52,000 AF expansion of Gross Reservoir under Alternative 10a are the same as described for Alternative 8a.

5.13.4.2 Denver Basin Aquifer Facilities

Total and average emissions for the Denver Basin Aquifer Facilities and Conduit M were calculated using the same approach used for the Gross Reservoir emissions, but assuming a 30-month (2.5 years) construction schedule. Table 5.13-6 summarizes estimated emissions from this construction.

Table 5.13-6
Construction Emissions for Alternative 10a – Denver Basin Aquifer Facilities

Source	Total Emissions (tons)							
	Criteria Pollutants						HAPs	GHGs
	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	Total	CO_2e
Construction Equipment Exhaust	410.25	333.02	19.31	18.73	6.27	48.26	0.50	25,130.90
Portable Diesel Engine Exhaust	--	--	--	--	--	--	--	--
On-road Exhaust								
Worker Commuting	93.66	6.93	0.17	--	0.06	7.16	0.35	67.37
Delivery Vehicles	--	--	--	--	--	--	--	--
Fugitive Dust								
Wind Erosion	--	--	--	--	--	--	--	--
Material Handling	--	--	5.48	0.83	--	--	--	--
Paved Roads	--	--	79.31	11.02	--	--	--	--
Unpaved Roads	--	--	663.93	66.39	--	--	--	--
Rock Crushing/Screening	--	--	--	--	--	--	--	--
Concrete Batching	--	--	--	--	--	--	--	--
Total Emissions (tons)	**503.91**	**339.95**	**768.20**	**96.97**	**6.33**	**55.42**	**0.85**	**25,198.27**
Project years:	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Average Annual Emissions (tons per year)	**201.56**	**135.98**	**307.28**	**38.79**	**2.53**	**22.17**	**0.34**	**10,079.31**

Notes:
CO = carbon monoxide
GHG = greenhouse gas
HAP = hazardous air pollutant
NO_x = oxides of nitrogen
$PM_{2.5}$ = particulate matter less than 2.5 microns in diameter
PM_{10} = particulate matter less than 10 microns in diameter
SO_2 = sulfur dioxide
VOC = volatile organic compound

For Alternative 10a, average annual emissions of CO, NO_x, and PM_{10} from both sites are greater than the conformity *de minimis* levels of 100 tpy, as shown in Tables 5.13-4 and Table 5.13-6. Therefore, this alternative would undergo a general conformity analysis to ensure that the region remains in compliance with the NAAQS. Total emissions for HAPs and GHGs are well below the major source status for permitting requirements.

During the construction phase of Alternative 10a, air quality impacts would be minor. Negligible air quality impacts are expected during operation. Section 5.13.7 discusses recommended mitigation measures and control plans for both fugitive dust and combustion emissions.

5.13.5 Alternative 13a

5.13.5.1 Gross Reservoir

Total and average emissions for the 60,000 AF expansion of Gross Reservoir were calculated using the same approach used for the Proposed Action, but assuming a 43-month (3.6 years) construction schedule. The types of air quality impacts are similar to, but less than the Proposed Action due to the smaller reservoir enlargement size. Table 5.13-7 summarizes estimated emissions from the expansion of the reservoir.

Table 5.13-7
Construction Emissions for Alternative 13a – Gross Reservoir

Source	Total Emissions (tons)							
	Criteria Pollutants						HAPs	GHGs
	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	Total	CO_2e
Construction Equipment Exhaust	344.41	279.57	16.21	15.72	5.27	40.52	0.42	21,097.78
Portable Diesel Engine Exhaust	15.49	71.89	5.10	5.10	4.75	5.73	0.06	2,511.62
On-road Exhaust								
Worker Commuting	51.97	3.85	0.09	--	0.03	3.98	0.20	37.38
Delivery Vehicles	22.77	23.95	0.73	0.30	1.05	3.04	0.25	8.74
Fugitive Dust								
Wind Erosion	--	--	2.83	0.42	--	--	--	--
Material Handling	--	--	--	--	--	--	--	--
Paved Roads	--	--	132.97	19.19	--	--	--	--
Unpaved Roads	--	--	94.44	9.44	--	--	--	--
Rock Crushing/Screening	--	--	2.78	--	--	--	--	--
Concrete Batching	--	--	18.70	18.70	--	--	--	--
Total Emissions (tons)	**434.64**	**379.26**	**273.85**	**68.87**	**11.10**	**53.27**	**0.93**	**23,655.52**
Project years:	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Average Annual Emissions (tons per year)	**120.73**	**105.35**	**76.07**	**19.13**	**3.08**	**14.80**	**0.26**	**6,570.98**

Notes:
CO = carbon monoxide
GHG = greenhouse gas
HAP = hazardous air pollutant
NO_x = oxides of nitrogen
$PM_{2.5}$ = particulate matter less than 2.5 microns in diameter
PM_{10} = particulate matter less than 10 microns in diameter
SO_2 = sulfur dioxide
VOC = volatile organic compound

5.13.5.2 South Platte River Facilities

Total and average emissions for the South Platte River Facilities and Conduit O were calculated using the same approach used for the Gross Reservoir emissions, but assuming a 30-month (2.5 years) construction schedule. Table 5.13-8 summarizes estimated emissions from the construction of these pipelines.

Table 5.13-8
Construction Emissions for Alternative 13a – South Platte River Facilities

Source	Total Emissions (tons)							
	Criteria Pollutants						HAPs	GHGs
	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	Total	CO_2e
Construction Equipment Exhaust	113.96	92.50	5.36	5.20	1.74	13.41	0.14	6,980.68
Portable Diesel Engine Exhaust	--	--	--	--	--	--	--	--
On-road Exhaust								
Worker Commuting	53.78	3.98	0.10	--	0.03	4.11	0.20	38.68
Delivery Vehicles	--	--	--	--	--	--	--	--
Fugitive Dust								
Wind Erosion	--	--	--	--	--	--	--	--
Material Handling	--	--	3.03	0.46	--	--	--	--
Paved Roads	--	--	45.54	6.33	--	--	--	--
Unpaved Roads	--	--	377.98	37.79	--	--	--	--
Rock Crushing/Screening	--	--	--	--	--	--	--	--
Concrete Batching	--	--	--	--	--	--	--	--
Total Emissions (tons)	**167.74**	**96.48**	**432.01**	**49.78**	**1.77**	**17.52**	**0.34**	**7,019.36**
Project years:	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Average Annual Emissions (tons per year)	**67.10**	**38.59**	**172.80**	**19.91**	**0.71**	**7.01**	**0.14**	**2,807.74**

Notes:
CO = carbon monoxide
GHG = greenhouse gas
HAP = hazardous air pollutant
NO_x = oxides of nitrogen
$PM_{2.5}$ = particulate matter less than 2.5 microns in diameter
PM_{10} = particulate matter less than 10 microns in diameter
SO_2 = sulfur dioxide
VOC = volatile organic compound

For this alternative, average annual emissions of CO, NO_x, and PM_{10} from both sites are greater than the conformity *de minimis* levels of 100 tpy, as shown in Table I-1.6 of Appendix I. Therefore, this alternative would undergo a general conformity analysis to ensure that the region remains in compliance with the NAAQS. Total emissions for HAPs and GHGs are well below the major source status for permitting requirements.

During the construction phase of Alternative 13a, air quality impacts would be minor. Negligible air quality impacts are expected during operation. Section 5.13.7 discusses recommended mitigation measures and control plans for both fugitive dust and combustion emissions.

5.13.6 No Action Alternative

There are no ground-disturbing activities associated with the No Action Alternative; thus no impacts to air quality are anticipated as a result of the Moffat Project.

5.13.7 Mitigation and Monitoring

Particulate (Fugitive Dust)

Since the Project area exceeds 25 contiguous acres, one or more land development permits would be required from the CDPHE APCD. As part of the land development permit application for the proposed activities, the Board of Water Commissioners (Denver Water) or its contractor would prepare a Fugitive Dust Control Plan. The Plan would outline specific steps that would be taken to minimize fugitive dust generation. Table 5.13-9 lists potential control measures that could be employed as needed to minimize fugitive dust.

Table 5.13-9
Possible Control Measures to Minimize Fugitive Dust

Fugitive Dust Source	Possible Control Measures
Unpaved Roads	Watering and/or application of chemical stabilizers as necessary. Speed limit signs would be posted and limits would be enforced.
Paved Roads	Prevention of mud and dirt carryout onto paved roads.
Disturbed Areas	Watering, soil compaction, speed limits, wind breaks, and/or revegetation may be employed as needed and as appropriate for site conditions.
Active Construction Areas	Watering would be employed as appropriate. Under extreme conditions (e.g., high winds), temporary curtailment of earth-moving activity may be deemed necessary.
Haul Trucks	Covering both on-site and off-site haul trucks as needed and as appropriate.

Emission calculations for fugitive dust assume that all exposed areas would be watered as needed to provide a 25 percent (%) reduction of windblown fugitive dust.

The concrete batch plant would require a CDPHE APCD air quality permit if emissions exceed the permitting threshold of 5 tpy of actual PM_{10} emissions. Control measures to limit the particulate emissions would be imposed as a condition of the permit.

Combustion Emissions

The main sources of combustion emissions (PM_{10}, sulfur dioxide [SO_2], NO_x, volatile organic compound [VOC], and CO) are exhaust emissions from heavy-duty construction equipment and commuting construction workers. Due to the NO_x emissions exceeding 100 tpy for each alternative, the CDPHE APCD may require preparation of a plan for minimizing emissions from heavy-duty (non-road) equipment. If the CDPHE APCD or the EPA requires such a plan, it may need to address the following topics:

- The extent to which the non-road equipment used on the Moffat Project would comply with increasingly stringent EPA emission standards.
- Documentation from the contractor as to whether the non-road engines or vehicles used on the Project have complied, or would comply, with manufacturer recalls involving such engines or vehicles.
- Description of any programs or measures in place to ensure that equipment is maintained and tuned per manufacturer's specifications.

- Description of other measures that would be taken to reduce exhaust emissions from construction equipment including use of diesel catalytic converters, minimizing idle time, etc.
- Description of any programs or measures (such as ride-sharing) to reduce worker trips.

5.13.8 Unavoidable Adverse Impacts

Construction activities would lead to short-term increases of particulate matter (PM_{10}) and gaseous pollutants (NO_x, CO, SO_2, and VOCs). These emissions would temporarily elevate pollutant concentrations in the immediate vicinity of the construction activities. Minor impacts are expected during construction activities throughout most of the construction period. However, moderate effects with regard to PM_{10} and particulate matter less than 2.5 microns per diameter ($PM_{2.5}$) may occur on some windy days when significant fugitive dust may be apparent and may travel beyond the construction site.

The general conformity process would ensure that construction emissions would not cause exceedances of the NAAQS. During the general conformity process, the CDPHE APCD would review the Moffat Project and its alternatives to determine if the Project conforms to the State Implementation Plans (SIP) for NO_x, CO, and PM_{10}. During its conformity analysis, the CDPHE APCD would determine if the Project's estimated emissions are included in the State's emission inventory. If Project emissions (in conjunction with other known projects) do not exceed the SIP budget, the Project conforms to the SIP and the Project can go forward without change. If the CDPHE APCD determines that Project emissions could cause significant adverse air quality impacts, the agency can request mitigation to reduce Project emissions.

With regard to long-term impacts, the Moffat Project would cause relatively small increases in fugitive dust and personal vehicle emissions. Fugitive dust emissions are largely unavoidable because they depend, in part, on the extent of bare soil exposed by fluctuation of the water level in the reservoir. Constant revegetation would not be feasible. Increases in personal vehicle emissions would be small compared to total vehicle emissions in the Denver Metropolitan area. Negligible long-term impacts are expected.

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5.14 NOISE

This section describes the direct and indirect noise impacts expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. One comment was raised regarding noise during scoping that pertained to the Gross Reservoir expansion, and pertains to construction equipment operational noise. This issue is evaluated in Section 5.14.1. Additional potential noise-related impacts that may result from the construction and operation of the various alternatives components are described in Sections 5.14.2 through 5.14.6.

Noise levels are regulated in the State of Colorado and in Boulder County with the objective of protecting the public from injury and annoyance (Boulder County 1992; Colorado Revised Statutes [C.R.S.] Title 25-12-103; EPA 1974). As a general approach to evaluating noise, levels predicted to exceed background are evaluated to determine whether county or State standards or other relevant guidelines could be exceeded. Noise standards and guidelines are summarized in Table 5.14-1.

Table 5.14-1
Noise Standards and Guidelines

Affected Resource	Noise Level (dBA)	Comments/Reference
Residential Areas, Outdoor Exposure	55 dBA L_{eq}, 7:00 a.m. – 7:00 p.m. 50 dBA L_{eq}, 7:00 p.m. – 7:00 a.m.	Protect from annoyance where quiet is a basis for use (EPA 1974). Applies at 25 feet from property line (C.R.S. 25-12-103). See also Areas Affected by Construction.
Residential Areas, Indoor Exposure	45 dBA, L_{dn}	Protect from annoyance where quiet is a basis for use (EPA 1974).
Public Areas, Continuous "Background" Exposure	70 dBA, L_{eq}, 24-hour period	Protect from hearing damage (EPA 1974). Applies at 25 feet from property line.
Public Areas, Peak Exposure	120 dBA, L_{eq}, 24-hour period	Protect from hearing damage based on sudden short-term exposure (EPA 1974).
Areas Affected by Construction	80 dBA L_{eq}, in residential zones, 7:00 a.m. – 7:00 p.m. 75 dBA L_{eq}, in residential zones, 7:00 p.m. – 7:00 a.m.	Boulder County permitted construction noise (Boulder County 1992, C.R.S. 25-12-103). (OSHA PEL is 90 dBA for workers.) Measured at residential property boundary.
Public Property, Off-road	78 dBA (all motor vehicles)	Measured at 50 feet from source (Boulder County 1992).
Public Roads	86 dBA (vehicles $\leq$ 35 mph) 88 dBA (vehicles > 35 mph) 80 dBA (motorcycles $\leq$ 35 mph 84 dBA (motorcycles > 35 mph)	Measured at 50 feet from lane of travel (Boulder County 1992, C.R.S. 25-12-103).

Notes:

$\leq$	=	less than or equal to	L_{eq}	=	equivalent sound level, time averaged over a period of emission
>	=	greater than	mph	=	miles per hour
C.R.S.	=	Colorado Revised Statutes	OSHA	=	Occupational Safety and Health Administration
dBA	=	A-weighted decibel scale	PEL	=	permissible exposure level
L_{dn}	=	day-night average sound level			

All of the action alternatives would experience temporary noise impacts associated with construction activities. The equipment used to construct the Project facilities (e.g., loaders, backhoes, scrapers, generators, etc.) generally operate between 70 to 90 A-weighted decibel scale (dBA). These noise levels are estimated at 50 feet from the sources and diminish rapidly at greater distances. As a general rule, when the radius or distance that a sound wave travels has doubled, the sound level is reduced by 6 dBA (Whitaker and Benson 2002). Less developed portions of the Project area that are now relatively quiet would generally be more affected by new sources of noise than the urbanized areas due to the characteristic of sound waves heard from multiple sources not being directly additive. This characteristic is explained further in Section 3.14.1. Portions of the Project area currently experiencing background noise typical of urban locations would experience minimal change from current levels.

Any Project-related impacts from noise are anticipated to be temporary and direct and are described in the sections below. Indirect impacts from noise are not anticipated.

5.14.1 Proposed Action (Alternative 1a)

Enlarging Gross Reservoir under the Proposed Action would require approximately 39 pieces of equipment operating over a 49-month (4.1 years) construction period, followed by operation of the dam and reservoir. Operational noise would be generated from sources such as the pump station, generators, and commuting traffic. Noise associated with the Proposed Action is compared by on- and off-site construction related sources, and dam and reservoir operation.

On-site Construction-Related Noise

The numbers, types, and manner of use of equipment proposed to build the dam and reservoir and associated facilities are described in Section 2.8.4. Assumptions for analysis of on-site construction noise for the Proposed Action are:

- Construction would occur year-round and would be completed within a 49-month period (4.1 year). Most construction would occur during the day; however, double or triple shifts up to 24 hours per day operation are possible. Work hours for all construction would be limited in conformance with applicable local ordinances.
- Construction equipment would travel little or no mileage off site on public roads, but they would be running full time during construction activities.
- Access to the construction areas would be restricted so that the public cannot come into close proximity of loud operating equipment.
- Earth-moving equipment such as loaders, backhoes, scrapers, and heavy trucks would be used; this equipment generally operates within a sound range of 70 to 90 dBA.
- Other stationary and materials handling equipment such as generators, air compressors, rock crushers, and concrete mixers would be used; this equipment generally operates in the range of 70 to 90 dBA to the property line.
- No occupied residences are located within 2,000 feet of the dam construction area.

- Construction equipment used by contractors is assumed to function as designed and conform to applicable noise emission standards.

The proposed activities associated with the enlargement of Gross Reservoir are not predicted to exceed relevant standards or guidelines. On-site construction noise may periodically exceed the EPA noise threshold of 70 dBA for public exposure, but the public would not be exposed to these levels on a continuous basis. The noise levels described are predicted at distances of less than 50 feet from the source and would be temporary and remote. Sound travels omni-directionally (i.e., does not travel upward or downward), which means that it dissipates outward in all directions the further away from its source it travels (generally sound levels are reduced by 6 dBA when the radius of distance that a sounds wave travels has doubled). Thus, at distances greater than 50 feet, noise levels would diminish rapidly. Noise impacts are anticipated to be temporary and moderate during on-site construction.

Tree Removal

Additional noise impacts would occur from tree removal and residue disposal at Gross Reservoir. In order to minimize problems with floating debris, decaying vegetation and water quality concerns, all trees would be removed within the area of proposed inundation. It is assumed trees would be removed between the normal pool elevation (7,282 feet) and 7,410 feet. This activity would take approximately 6 to 8 months to complete (Land Stewardship Associates, LLC 2008). On-site temporary noise impacts would occur from timber harvest, yarding, and use of temporary roads. Noise levels would be similar to other construction activities and are not expected to exceed relevant standards and guidelines. Off-site impacts would occur from trucks hauling the forest residue (ash, chips, whole trees, logs, and/or firewood) to sites where they would be disposed or sold. Roads used for access would include Flagstaff Road (County Road [CR] 77) east and north of the dam, Gross Dam Road (CR 77S) from SH 72, CR 97, and CR 68, State Highway (SH) 72, and SH 93. Impacts are anticipated to be temporary and moderate.

Blasting

Blasting would occur when onsite aggregate quarries are in operation (approximately the first year of aggregate processing) and in the early phases of construction related to the dam foundation excavation. Typically the frequency of blasting is every 3 to 4 days due to the time it takes to drill the blast holes. Blasting would occur only during daylight hours. Safety precautions would be taken to keep unauthorized personnel away from blast areas. Blasts would be designed such that holes are appropriately spaced, loaded and stemmed to prevent air blast, excessive vibration and to limit any fly rock migrating outside of the blast zone. The blasting agent used would likely be ANFO (Ammonium Nitrate Fuel Oil), which when handled appropriately is a relatively safe and stable product used in construction and quarrying operations throughout the United States. The blast would be designed to produce relatively low vibrations (ground motions) and blasting adjacent to the dam would be controlled to prevent any damage to the dam or the existing foundation. All blasting would be designed and overseen by a Colorado-licensed Blasting Engineer. Blasting would be designed specifically for Gross Dam and would only create ground vibrations and land motion appropriate for the dam structure to sustain. A seismograph would be used to monitor ground motions and air pressure (noise) vibrations produced from the blasting

operations to ensure that acceleration thresholds are not exceeded. The Board of Water Commissioners (Denver Water) plans to implement confined charge blasting for dam construction to minimize noise creating temporary moderate impacts.

Off-site Construction-Related Noise

Off-site construction-related noise is predicted from increased traffic using site access roads. Residential areas may be affected by construction traffic during day-time hours. Projections for estimated peak-hour construction trips are described in Section 2.8.5 and evaluated in Section 5.12. Assumptions for the analysis of off-site construction noise are:

- Types of traffic making daily or regular trips to the site include construction workers' vehicles, concrete mixers, and haul trucks carrying borrow material, fly ash, and cement to the site.
- Access roads most frequently used would be SH 72, CR 77S (Gross Dam Road), SH 128, and US 287.

The noise impacts from construction traffic would contribute to the overall background noise levels in the Gross Reservoir study area and are anticipated to be temporary and minor. The degree that background noise levels may increase would be consistent with variation in the construction schedule. For example, the number of haul trips ranges from 22 deliveries (44 vehicle trips) per day, to 37 deliveries (74 vehicle trips) per day. Construction traffic noise is predicted to comply with county ordinance requirements.

Post-Construction Activities

The post-construction operations and maintenance workforce for the enlarged Gross Reservoir would not change from Current Conditions (2006) and is not anticipated to create more noise. Recreational vehicle traffic is estimated at 21,975 vehicles annually. The types of motorized vehicles permitted within the Gross Reservoir study area for recreation are relevant to the analysis. Motorized water craft, such as speed boats or jet skis, are not permitted at Gross Reservoir, except for emergency rescue vehicles. Off-road vehicles, however, are allowed on the land surrounding the reservoir. Speed limits enforced within the recreation area would ensure that loud motorized vehicles, such as motorcycles, do not exceed relevant noise criteria or constitute a public nuisance.

Based on these operating assumptions, no long-term noise impacts are anticipated from operation of the dam, reservoir, and associated facilities.

5.14.2 Alternative 1c

5.14.2.1 Gross Reservoir

Construction equipment needs for enlarging Gross Reservoir are the same as those described for the Proposed Action; however, the construction period would be shorter for Alternative 1c (37 months or 3.1 years). Post-construction activities at a 40,700 acre-feet (AF) Gross Reservoir would also be the same as described for the Proposed Action. Noise levels for the dam and reservoir area would be similar to less than those analyzed for the Proposed Action.

5.14.2.2 Leyden Gulch Reservoir Site

Constructing a dam and reservoir at Leyden Gulch would take 42 months (3.5 years). Additionally, construction of the proposed Leyden Gulch Reservoir would require the relocation of 4,000 feet of SH 93, the relocation of approximately 1 mile of the existing South Boulder Diversion Canal, and construction of an outlet tunnel and buried pipelines connecting to Conduits 16 and 22. Post-construction activities at Leyden Gulch would be similar to the operations and maintenance described for Gross Reservoir. No recreational facilities or public access would be provided at the proposed Leyden Gulch Reservoir site; thus, no noise impacts would be associated with recreational activities. The construction activity noise associated with Alternative 1c would be limited to short-term moderate, adverse impacts during construction.

5.14.3 Alternative 8a

5.14.3.1 Gross Reservoir

This alternative would require a 38-month (3.2 years) construction period, followed by operation of the dam, reservoir, and a new water treatment facility. Construction equipment needs for the enlargement of Gross Reservoir are the same as the Proposed Action; however, the construction period would be shorter (38 months or 3.2 years) under Alternative 8a. Operation of the dam, reservoir, and associated facilities would generate noise from sources such as the pump station, generators, and recreation area traffic. Noise levels for the dam and reservoir area would be similar or less than those analyzed for the Proposed Action.

5.14.3.2 South Platte River Facilities

As stated in Section 2.5.2, it is assumed that when Denver Water acquires the gravel pits they would be completely mined, reclaimed for use as a water storage facility, and empty. Thus, minor temporary noise-related impacts would result from construction of the gravel pits. Minimal noise would be generated from the Advanced Water Treatment Plant (AWTP), which would only operate in dry years when water deliveries are made to the South Boulder Diversion Canal and would result in a minor impact. Also, the AWTP would be equipped with sound mitigation features to comply with applicable local noise ordinances.

5.14.3.3 Conduit O

It would take approximately 12 different pieces of equipment 30 months (2.5 years) to construct Conduit O. Noise impacts associated with truck traffic and increases in workforce related traffic would be intermittent and minor during this time period. Conduit O would only operate during dry years or emergencies. The staff needed to operate Conduit O would come from within the existing Denver Water Facilities, when needed. Noise associated with construction activity occurring within the urban portions of Conduit O would be negligible in the context of the Denver Metropolitan area. The rural portions of Conduit O are likely to be moderately affected by temporary construction noise than the more developed areas. Three pump stations would be located along Conduit O.

Each pump station would be enclosed in a building and would be equipped with sound mitigation features to comply with applicable noise ordinances.

5.14.4 Alternative 10a

5.14.4.1 Gross Reservoir

Construction equipment needs for the enlargement of Gross Reservoir are the same as the Proposed Action; however, the construction period would be shorter (38 months or 3.2 years) under Alternative 10a. Operation of the dam, reservoir, and associated facilities would generate noise from sources such as the pump station, generators, and recreation area traffic. Noise levels for the enlargement of Gross Reservoir under Alternative 10a would be similar or less than those analyzed for the Proposed Action.

5.14.4.2 Denver Basin Aquifer Facilities

Construction of the injection/extraction wells and associated facilities would require the use of 17 pieces of equipment that would generate intermittent noise over 30 months (2.5 years). The construction activity associated with the aquifer storage and recovery (ASR) system is anticipated to be short term and minor in the urban context of Denver. As stated in Section 2.6.2, deep wells require submersible pumps; therefore, pump noise generation during pump operation would be negligible. Additionally, in years when the stored water is not used, no water would be injected into the Denver Basin aquifers. Thus, it is anticipated that negligible noise would be generated during operation of the ASR system. Noise generated from the AWTP would be similar to those described for Alternative 8a.

5.14.4.3 Conduit M

It would require 12 pieces of equipment to construct Conduit M over a 30-month period (2.5 years). Noise impacts associated with truck traffic and small increases in workforce related traffic would be intermittent and minor during this time period. Conduit M would only operate during dry years or emergencies. The staff needed to operate Conduit M would come from within the existing Denver Water Facilities, when needed. Noise associated with construction activity occurring within the urban portions of Conduit M would be negligible in the context of the Denver Metropolitan area. The rural portions of Conduit M are likely to be moderately affected by temporary construction noise than the more developed areas. Three pump stations would be located along Conduit M. Each pump station would be enclosed in a building and would be equipped with sound mitigation features to comply with applicable noise ordinances.

5.14.5 Alternative 13a

5.14.5.1 Gross Reservoir

Construction equipment needs for the dam and reservoir area are similar to those for the Proposed Action; however, the construction period would be shorter (43 months) under Alternative 13a. Operation of the dam, reservoir, and associated facilities would generate

noise from sources such as the pump station, generators, and recreation area traffic. Operational and maintenance noise levels would be similar or less than those analyzed for the Proposed Action.

5.14.5.2 South Platte River Facilities

The noise levels and associated short-term impacts described for Alternative 8a for the operation of the South Platte River Facilities are the same as Alternative 8a.

5.14.5.3 Conduit O

The noise impacts associated with the construction and operation of Conduit O under Alternative 13a are the same as those described under Alternative 8a.

5.14.6 No Action Alternative

There are no ground-disturbing activities associated with the No Action Alternative; thus, no noise impacts are anticipated.

5.14.7 Mitigation and Monitoring

Engineering and administrative controls that may be implemented to minimize noise impacts include modifying the construction equipment or the work area to make it quieter, substituting construction-related equipment with quieter equipment, retro-fitting equipment with mufflers, modification of backup alarm systems on construction equipment and vehicles, shutting down noisy equipment when not needed, limiting work hours for certain construction activities. New facilities, such as the AWTP, would be equipped with sound mitigation features to comply with local noise ordinances. No additional mitigation or monitoring activities are identified based on the assumptions used to analyze noise. If assumptions for recreational use of the area should change to allow motorized watercraft or all-terrain vehicles, the anticipated noise levels would need to be reviewed with respect to the noise standards and guidelines.

5.14.8 Unavoidable Adverse Impacts

Noise from construction is unavoidable, but is a short-term impact that is not predicted to be significant for any action alternatives. Very slight increases in background noise from recreational traffic at Gross Reservoir are expected to occur if the reservoir is enlarged. In the context of future plans for the overall area, the overall noise impacts associated with the dam and reservoir are not predicted to have adverse impacts.

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5.15 RECREATION

This section describes the direct and indirect impacts to recreation that may occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Several recreation issues were raised during scoping related to various elements of the Moffat Project:

- Impacts of river depletions on water-related recreation (e.g., fishing, rafting) and snowmaking capacity of the local ski industry
- Impacts of Gross Reservoir expansion or construction activities on:
  - traffic and public services
  - current natural and man-made recreational features
  - adjoining open space
  - existing recreation management plans

This section evaluates the potential Project impacts on recreational use, particularly boating and fishing that would occur between Full Use of the Existing System and Full Use with a Project Alternative (2032). The acres assume disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).

In order to fully assess how the Project components would impact recreation, a number of analysis methods were used including: field assessments and observations, review of depletion data (Platte and Colorado Simulation Model [PACSM] results), in-person and telephone interviews with recreation users and agency personnel, research and review of optimal recreation use conditions, and literature reviews.

Although flow changes would occur on many stream segments within the upper Fraser and Williams Fork river basins, only those segments where more than incidental boating use occurs are addressed. Many stream segments, such as the Fraser River above Winter Park, Ranch Creek, St. Louis Creek, and other upper reaches in the basin are too small to support boating use. Therefore, this section only evaluates boating on portions of the Fraser, Colorado, and Blue rivers on the West Slope. On the East Slope, where both stream flow increases and decreases would occur, boating on South Boulder Creek and the North Fork South Platte River were evaluated. While impacts to recreational fishing use are addressed for all potentially affected stream segments in this section, impacts to the quality of individual fishery habitats are addressed under Section 4.9.1.

5.15.1 Proposed Action (Alternative 1a)

5.15.1.1 Gross Reservoir

Three recreation facilities and use areas would not be permanently impacted by the Proposed Action: South Boulder Creek Outlet, the upper portions of the Winiger Ridge Access and Recreation Area, and the majority of the North Shore Recreation Area. The

Proposed Action, however, would have direct and indirect impacts on both current and future recreation opportunities at Gross Reservoir. All impacts to recreation uses would be temporary, but are major and last the length of the construction period, which is anticipated to last approximately 4 years.

There are nine designated recreation sites at Gross Reservoir. Three of these sites serve as the primary recreation areas and access points for on-water use, such as car-top boating, and include the following:

- Dam and Haul Road Recreation Areas – Site access in these areas would be temporarily and directly impacted by dam construction activities. The Board of Water Commissioners (Denver Water) would either restrict site access or completely close the area during construction. This would be a temporary major impact.
- Peninsula Recreation Area – The Peninsula Recreation Area would not be disturbed as a result of construction activities. Denver Water anticipates keeping this area open until the final phases of construction when the area would be relocated. This would be a temporary major impact.

Post-construction, seven of the nine recreation areas would be inundated under the Proposed Action, and result in a moderate temporary impact to recreation. These facilities include:

- Dam Recreation Area
- Haul Road Recreation Area
- Peninsula Recreation Area/Trails below North Shore picnic areas
- Rocky Point
- South Boulder Creek Inlet
- Winiger Gulch Inlet
- Winiger Ridge Recreation Area

All inundated recreation facilities at these locations would be relocated to sites above the proposed high waterline to allow for the continuation of their current uses. The relocation would occur sometime during the construction period. It is not known at this time exactly when relocations would occur, but Denver Water expects that the relocations would be completed during the final cleanup and restoration phases of construction. Figures 5.15-1 through 5.15-3 conceptually illustrate how facilities at the Dam, Haul Road, and Peninsula Recreation Areas might be relocated to allow for continuation of their current uses (Denver Water 2008c). While portions of Rocky Point, Winiger Gulch Inlet, Winiger Ridge, and South Boulder Creek Inlet recreation areas would also be inundated, relocation of facilities is minor, consisting mainly of trail realignments, thus conceptual illustrations are not included.

Under the Proposed Action, approximately 400 acres of U.S. Forest Service (USFS) land would be inundated, which would include inundation of Forsythe Falls, a popular hiking destination. Forsythe Falls is located at the terminus of Forsyth Canyon Creek off the

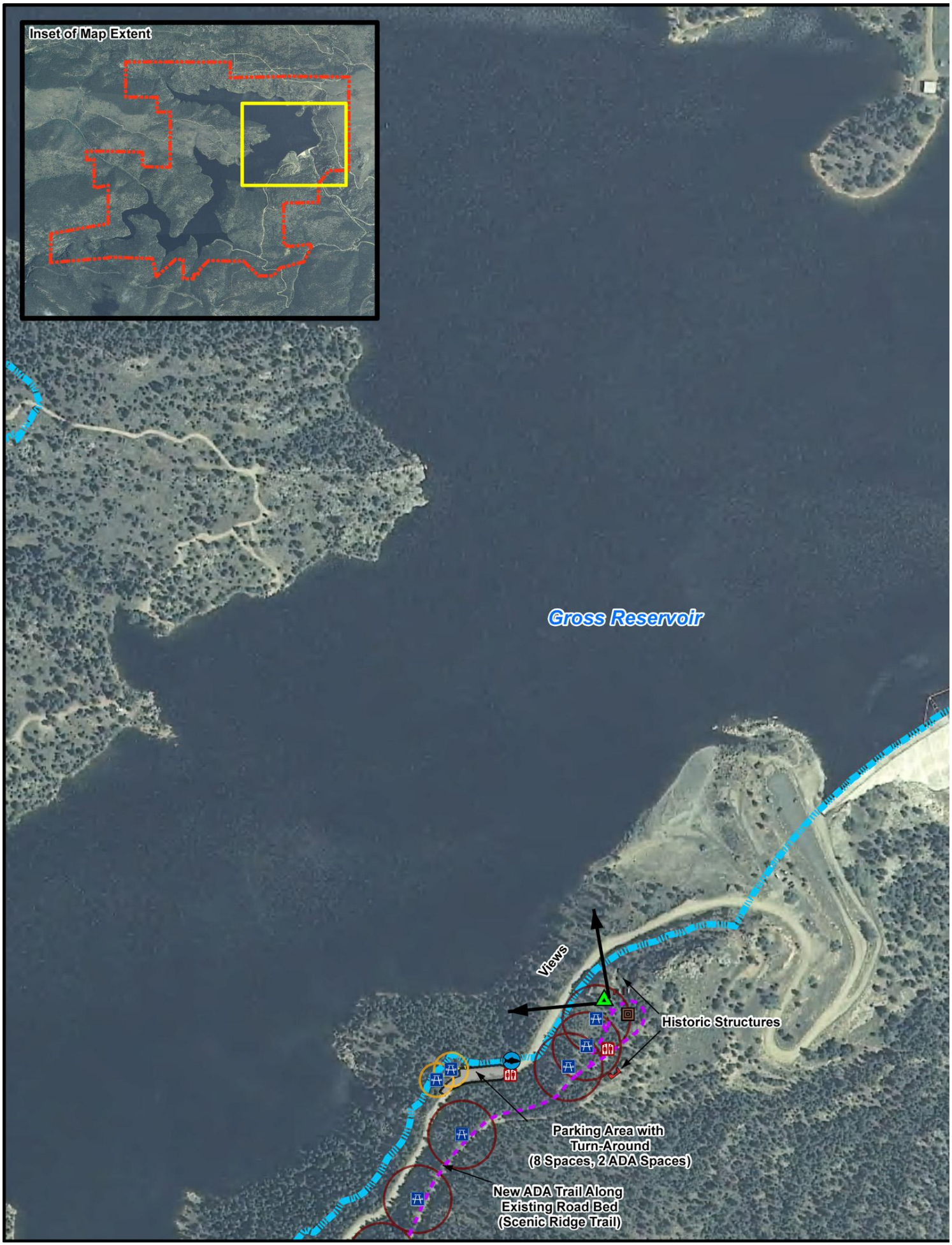
northern arm of Gross Reservoir. It is a primary destination for hikers at Gross Reservoir and its inundation would constitute a major long-term impact.

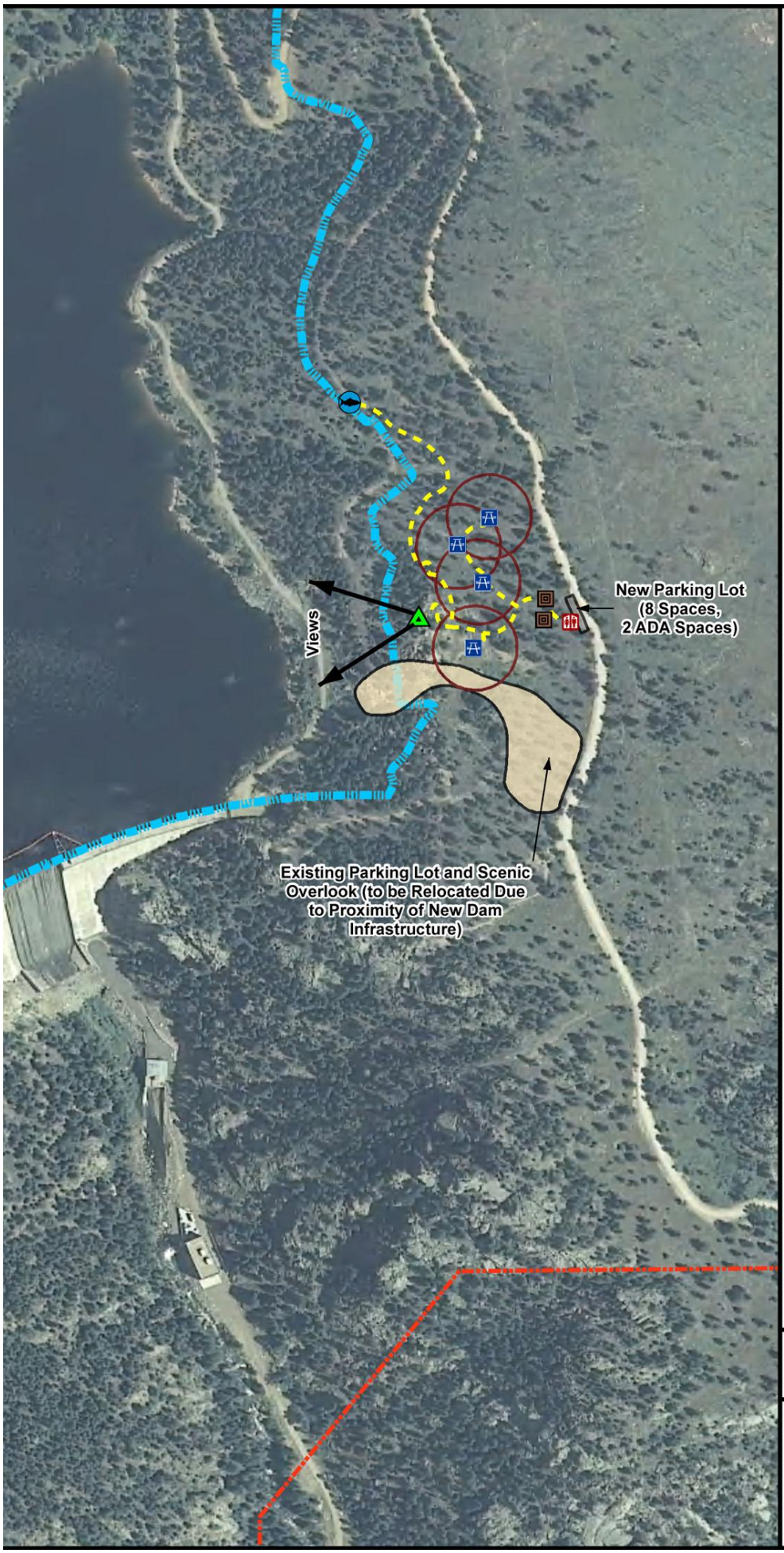
As part of Gross Reservoir enlargement, Denver Water will need to apply to the Federal Energy Regulatory Commission (FERC) for a hydropower license amendment (see Section 2.3.2.1). This would include changes to the approved Gross Reservoir Recreation Management Plan, to reflect the relocation of recreation facilities needed as a result of inundation (Denver Water 2004b). The FERC relicensing effort at Gross Reservoir in 1999 resulted in a new license issued in 2001, which mandated the development of a Recreation Management Plan (Article 416). The management plan was approved by FERC in 2004 (Denver Water 2004b). As part of this management plan, upgrades and improvements of various recreation sites have been ongoing. Prior to inundation, these facilities would need to be relocated and completed above the new high water line. At a minimum, each relocated recreation area should provide for the specific opportunities and facilities outlined in the Recreation Management Plan.

Vehicle access to Gross Reservoir would remain open during the construction period; however, various road segments would be temporarily closed for safety reasons. Denver Water intends to keep recreational facilities open as much as possible during construction without compromising public safety or construction progress. Certain areas would be restricted or temporarily closed during construction and tree removal. The picnic areas at the Dam Recreation Area would likely be closed during most of the construction period due to the close proximity to the dam. The Haul Road Recreation Area would be closed during certain phases of construction due to the proximity to the proposed quarry and spoil areas. All recreation areas could be temporarily affected during tree removal activities.

Other potential impacts to recreation and access may occur along State Highway (SH) 72 in Coal Creek Canyon, between SH 93 and the western portion of Gross Dam Road, which would be utilized as an aggregate haul route for dam construction material. As such, the presence of additional heavy truck traffic may present a temporary moderate adverse impact on the recreational experience and safety to road bicyclists who utilize this road.

Other impacts of an enlarged Gross Reservoir include indirect minor, beneficial impacts resulting from the creation of additional recreation opportunities due to an enlarged reservoir surface and extended shoreline. At the anticipated normal water elevation of 7,406 feet an enlarged Gross Reservoir is anticipated to have a surface area of approximately 842 acres. This represents an additional 424 acres, approximately doubling the existing surface area of the reservoir. Prior to 2005 no water boating was permitted at the reservoir. Per the FERC Gross Reservoir Recreation Management Plan, car-top boating is allowed from Memorial Day through the end of September each year. Enlarging the surface area of the reservoir would provide a substantial amount of additional space on which people can recreate via car-top boating. Relocated recreational facilities would not be flooded by the Environmental Pool.


Inset of Map Extent
Gross Reservoir
Views
Historic Structures
Parking Area with
Turn-Around
(8 Spaces, 2 ADA Spaces)
New ADA Trail Along
Existing Road Bed
(Scenic Ridge Trail)



Gross Reservoir Study Area
Proposed Single Picnic Site
Proposed Group Picnic Shelter/Site
Proposed Scenic Overlook
Proposed Fishing Access
Restrooms
Proposed Hiking Trail
Proposed Multi-Purpose Trail (ADA)
100' Buffer of Proposed Picnic Site
50' Buffer of Proposed Picnic Site
Proposed Parking Area
Location of Existing Infrastructure to be Relocated
Historic Structure
Impact Area

Reference:
Data based on Gross Reservoir Recreation Relocation Plan, Denver Water 2008a.

Aerial photography from USDA (2009).

Notes:
Inset map is at 1:63,360 scale.

N
W E
S

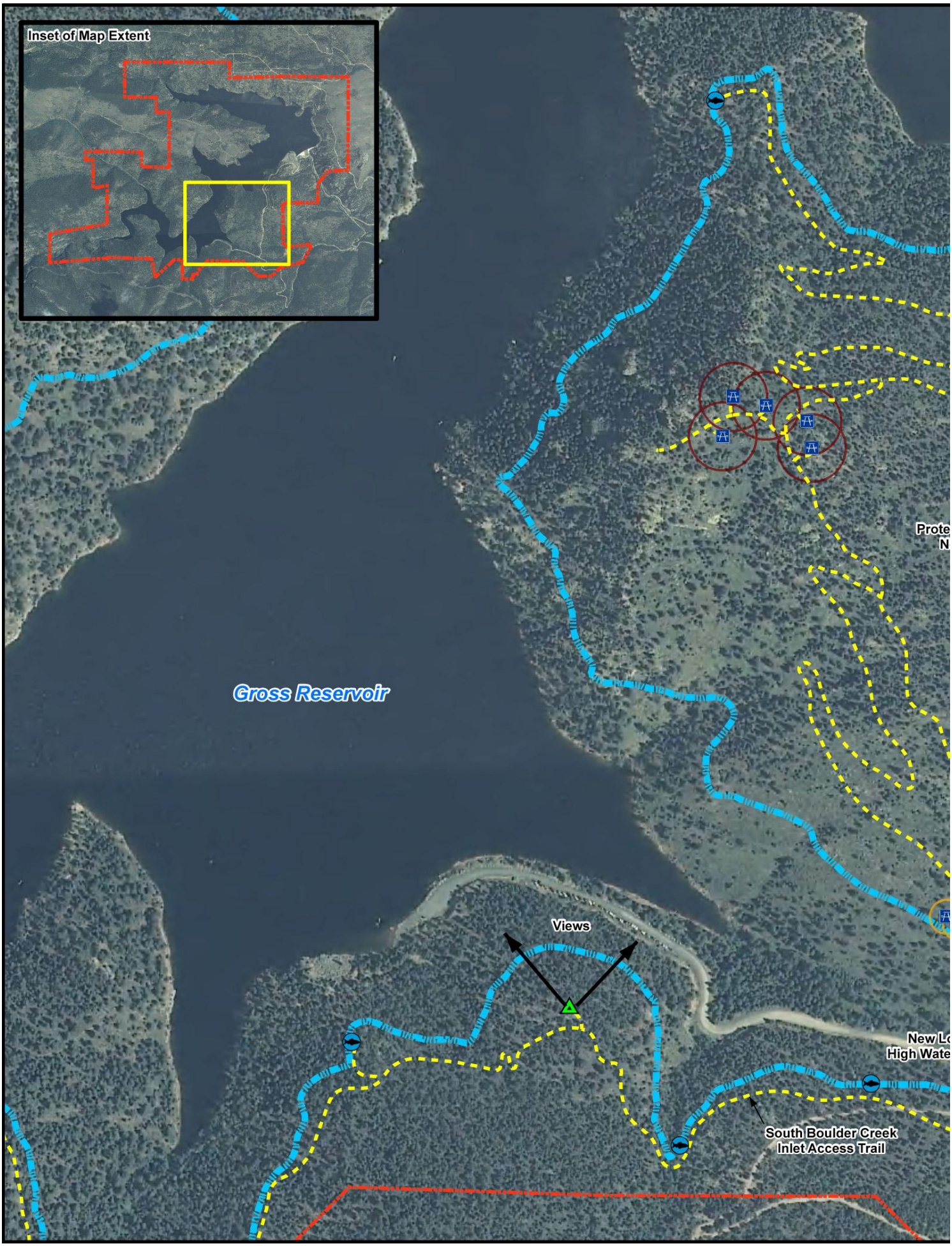
350 0 350 Feet

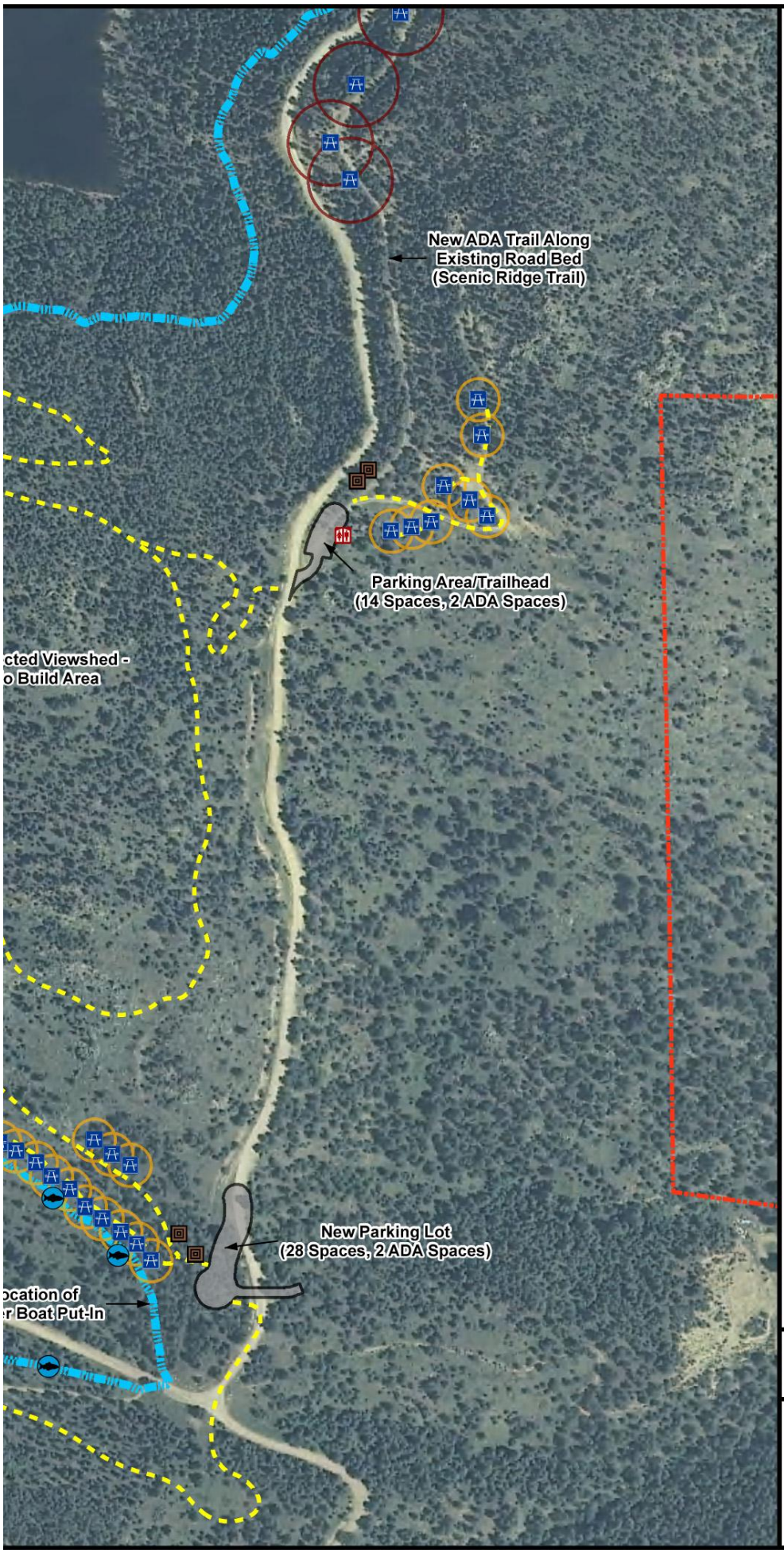
1:4,200

Moffat Collection System Project FEIS

Figure 5.15-1
Conceptual Recreation Relocation Plan - Dam Area, Gross Reservoir

3/13


Inset of Map Extent
Gross Reservoir
Views
South Boulder Creek
Inlet Access Trail



Gross Reservoir Study Area
Proposed Single Picnic Site
Proposed Group Picnic Shelter/Site
Proposed Scenic Overlook
Proposed Fishing Access
Restrooms
Proposed Hiking Trail
100' Buffer of Proposed Picnic Site
50' Buffer of Proposed Picnic Site
Proposed Parking Area
Impact Area

Reference:
Data based on Gross Reservoir Recreation Relocation Plan, Denver Water 2008a.

Aerial photography from USDA (2009).

Notes:
Inset map is at 1:63,360 scale.

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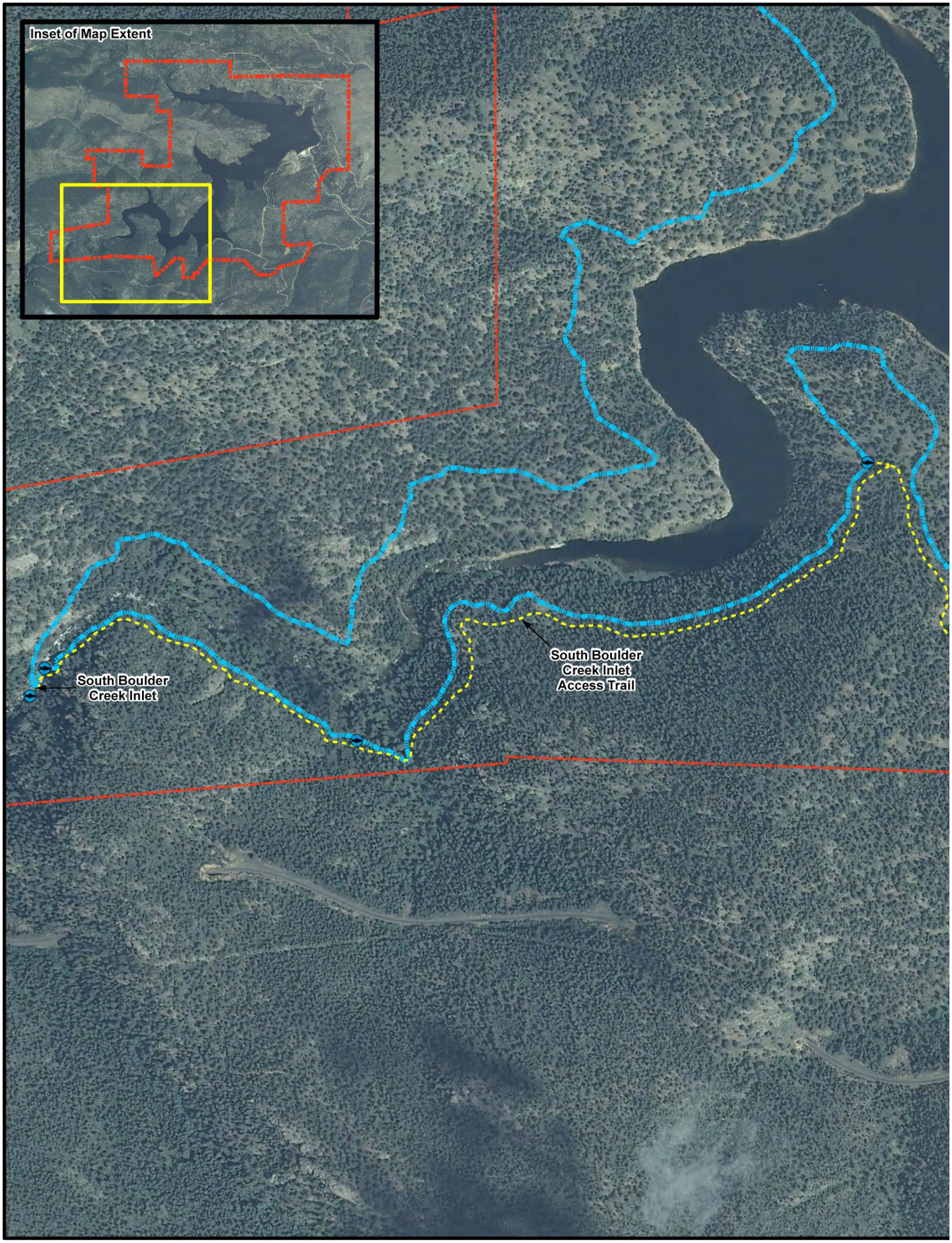
Moffat Collection System Project FEIS

Figure 5.15-2
Conceptual Recreation Relocation Plan - Haul Road and Peninsula Areas, Gross Reservoir

3/13


Inset of Map Extent
South Boulder
Creek Inlet
South Boulder
Creek Inlet
Access Trail

Gross Reservoir Study Area
Proposed Fishing Access
Proposed Hiking Trail
Impact Area

Reference:
Data based on Gross Reservoir Recreation Relocation Plan, Denver Water 2008a.

Aerial photography from USDA (2009).

Notes:
Inset map is at 1:63,360 scale.

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Feet

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Moffat Collection System Project FEIS

Figure 5.15-3
Conceptual Recreation Relocation Plan - S. Boulder Creek Inlet Area, Gross Reservoir

3/13

Additionally, reservoir enlargement would create additional shoreline. At the anticipated normal water elevation of 7,406 feet, the enlarged reservoir would have an associated 13.9 miles of shoreline, representing an additional 2.8 miles more of shoreline than exists currently. The presence of additional shoreline may provide more dispersed shoreline recreation opportunities, such as additional fishing access, and would be a beneficial minor long-term impact. Relocated recreational facilities would not be flooded by the Environmental Pool.

It is possible that the additional recreation opportunities created as a result of an enlarged reservoir may result in some increased use. A larger reservoir available with increased boating and additional fishing access may broaden its appeal to recreationists in the area. However, the amount of seasonal fluctuation and other operational conditions are not anticipated to make the reservoir any more attractive for boating and other recreational uses than it currently is. As a result, the Proposed Action is not anticipated to result in a substantial increase in use. The larger area available for this type of dispersed recreation should offset any negative impacts to the recreation experience resulting from increased use. Beyond the developed recreation areas defined in the FERC Gross Reservoir Management Plan, no additional developed recreation sites are planned.

As described in Chapter 2, operations of Gross Reservoir would change with implementation of the Proposed Action. Overall, these operational modifications, including increased storage levels, are not expected to notably change the seasonal pattern of filling and drawdown that already occurs. Therefore, operations are not anticipated to have an impact on recreational use at Gross Reservoir.

Temporary impacts to recreational activity due to construction at Gross Reservoir may conflict with the recreational guidelines, goals, or objectives identified in the Arapaho & Roosevelt National Forests (ARNF) Land and Resource Management Plan (USFS 1997b). However, because recreational use at the enlarged Gross Reservoir would only minimally vary from current levels and types, no long-term conflicts with the recreational guidelines, goals, or objectives identified in the ARNF Land and Resource Management Plan or the Boulder County Comprehensive Plan are expected.

5.15.1.2 River Segments

Recreation on numerous drainages would be affected by additional diversions or increases in flow. Several of these drainages provide a variety of recreational opportunities at the regional and local scale. These recreational opportunities include water dependent activities, such as boating and fishing, as well as other activities that are not dependent on water flows, such as mountain biking, hiking, and nature viewing. With respect to these activities, the presence of rivers and streams contributes to the visual setting in which they are taking place and subsequently to the overall recreation experience. Refer to Section 5.11 for a further discussion of the fisheries habitat and related impacts and Section 5.17 for further discussion on impacts to the visual setting.

Fraser River

Under adequate water conditions, the Fraser Canyon segment offers a high quality boating experience. Some sources indicate that the optimum flow range for kayaks through Fraser

Canyon is 400 to 700 cubic feet per second (cfs) (Hydrosphere 2003). The Grand County Stream Management Plan defines the optimum flow range as 400 to 900 cfs (Grand County 2010). Other sources indicate that the canyon segment is difficult to run when flows are less than 400 cfs (American Whitewater 2006). Typically, flows above 400 cfs only occur in May, June, and July in an average or wet year (Fraser River below Crooked Creek). For purposes of assessing impacts in the Environmental Impact Statement (EIS), the flow range provided in the Grand County Stream Management Plan was utilized.

Over the 45-year period of record that was evaluated, the average flow under Full Use of the Existing System conditions through Fraser Canyon is 287 cfs in May, 476 cfs in June, and 162 cfs in July. In a wet year, the average monthly flow is 516 cfs in May, 1,026 cfs in June, and 386 cfs in July. Therefore, a wet year offers a more extended season (in excess of 60 days) with opportunities for an adventurous boating experience during the high flows of May through July.

By the year 2032 with implementation of the Proposed Action, flows in the Fraser River would be diminished. For the Fraser Canyon segment, the average normal year flow in June would drop from 476 to 388 cfs, representing a 19 percent (%) depletion (Table H-3.22). A more detailed comparison is provided in Table 5.15-1. In an effort to characterize a "normal" year and compare pre- and post-Project conditions, one year per decade over the period used for modeling in the PACSM (1946 through 1991) were randomly selected for further review. The five years selected do not represent either unusually wet or dry years.

Table 5.15-1
Fraser River below Crooked Creek,
Full Use of the Existing System vs. the Proposed Action (2032),
Number of Days at a Given Flow Rate for Kayaking*

Year	Optimum Flows (400-900 cfs)	
	Full Use of the Existing System	Proposed Action (2032)
1957	37	38
1966	0	0
1975	10	4
1987	25	10
1991	11	6
1946-1991	789	632

Source: PACSM Results (Node 2810).
Notes:
*No flow range information shown for rafting for this river segment due to lower use levels.
Years were randomly selected to represent normal pre-Project conditions.
1946-1991 is a summary of the 45 year period used for the Platte and Colorado Simulation Model.

Table 5.15-1 indicates that flow conditions vary widely even under normal conditions. For example, in 1966 the model shows no flows above 400 cfs; therefore, conditions would not have supported boating use that year under either Full Use of the Existing System or under the Proposed Action. In other years, the number of days within the optimum flow range would drop, ranging from a decrease of 5 days in 1991 to 15 days in 1987. In one of the 5 years reviewed (1957), the number of days with flows falling within the optimum range would increase by one.

Examining the flow change effects for all of the PACSM output over the course of the full 45 years of record (1946 through 1991), implementation of the Proposed Action would result in a total of 632 days that fall within the optimum flow range of 400 to 700 cfs. This equates to an overall average of 14 days per year. When compared to Full Use of the Existing System for the full period of record, there are a total of 789 days within the desired flow range, for an average of 17.5 days per year. This represents a drop in available use days at the optimum flow range of approximately 3.5 days per year.

Implementation of the Proposed Action would also reduce the number of days in average years with flows above 700 cfs, thus reducing the number of days when the river could be used by more advanced kayakers.

In wet years, the Proposed Action would reduce the average monthly flow in May and June by 9% and 11%, respectively, as compared to Full Use of the Existing System, resulting in average monthly flows of 470 cfs in May and 912 cfs in June. The impact on boating use, however, would be negligible. Under both Full Use and post-Project conditions, wet years produce an extended boating season, in excess of 60 days with flows above 350 cfs, and with a similar pattern of flows. Most days that are boatable in wet years for both Full Use and post-Project conditions would occur on days when flows are in excess of 700 cfs. The main difference is that the very highest flows would be consistently reduced.

The Proposed Action would have no impact on boating in dry years since no changes in flow would occur compared to Full Use of the Existing System.

Overall, the Proposed Action would have a long-term adverse impact on boating on the Fraser River. These impacts would include a reduction in the average number of days when boating could occur within the optimum flow range in the Fraser Canyon, as well as the length of the boating season. There would also be a reduction in the highest flows, resulting in fewer days on average with flows in excess of 700 cfs. However, these higher flow levels would continue to occur in wet years. Given the low use levels for boating in this segment, coupled with a loss of approximately 3.5 days per year to boat within optimum flow levels, this represents a loss of approximately 17% of available use days. As such, this would be considered a moderate to major long-term impact. Project impacts to fishing are almost entirely dependent on the level of effect flow modifications would have on the health on the fishery. As described in Section 5.11 effects to species composition, population levels and other factors related to the health of the fishery are expected to be minor. Flow reductions during periods of higher flows are not expected to adversely affect the quality of the fishing experience. In some cases, flow reductions during periods of high flow may actually provide a minor beneficial effect to the quality of fishing. Reduced flows can expose areas along the river that are typically inundated under higher flows, and would consequently make them accessible to anglers. Additionally, fish tend to lose energy while fighting higher energy flows, thus a reduced flow may make them more active. The Proposed Action would have no impact on fishing in dry years. Overall, the Project would have a negligible to minor effect on fishing in the Fraser River.

Section 5.11 indicates the Proposed Action would have minor adverse impacts on the fish communities in North Fork Ranch Creek. There may be an associated minor adverse impact on the quality of the recreation fishing experience in this stream.

Snowmaking at local ski resorts occurs primarily from October through December. The PACSM results indicate that there would be very minor depletions (1-2%) occurring during these months under the Proposed Action beyond the Full Use of the Existing System. Therefore, the Proposed Action would not affect snowmaking activities.

Williams Fork River

No impacts are expected to occur to the quality of the fishing experience along the Williams Fork River as a result of the Proposed Action.

Colorado River

The Colorado River downstream of Kremmling through Gore Canyon is a heavily used recreational area for a variety of boating uses. American Whitewater indicates that a desirable flow range for rafting extends from a minimum of 700 cfs to a maximum of 2,000 cfs (American Whitewater 2006). A more recent study identified 800 to 1,250 cfs as the optimum flow range for rafts (Grand County 2010). The flow ranges identified in the Grand County Stream Management Plan were used for evaluating potential impacts to rafting and kayaking.

Under Full Use conditions in normal years, the Colorado River below Kremmling reaches optimum flows for boating during much of the peak season from May through September, and can far exceed optimum levels in wet years.

When Denver Water makes Full Use of the Existing System, flows in the Colorado River would be diminished. Under the Proposed Action, average monthly flows would drop during the summer season by 1% in May and August, to 6% in June and 5% in July. Over the period of record, the number of days when flows fall within the desirable range of 800 to 1,250 cfs would decrease only slightly, dropping from 3,948 to 3,937 days, a change of less than 1 day per year on average. In the specific years shown in Table 5.15-2, several years show either a slight decline or slight increase, though one year (1991) shows a decrease of 20 days.

Table 5.15-2
Colorado River below Kremmling,
Full Use of the Existing System vs. the Proposed Action (2032),
Number of Days at a Given Flow Rate for Rafting and Kayaking

Year	Optimum Flows (800-1,250 cfs)	
	Full Use of the Existing System	Proposed Action (2032)
1957	78	77
1966	60	62
1975	102	108
1987	91	93
1991	55	35
1946-1991	3,948	3,937

Source: PACSM Results (Node 5020).
Notes:
Years were randomly selected to represent normal pre-Project conditions.
1946-1991 is a summary of the 45 year period used for the Platte and Colorado Simulation Model.

The number of days falling within the minimum and maximum flow range would remain very similar, though the distribution would change in any given year, increasing in some years and dropping in others.

Although the Proposed Action would divert a larger volume in wet years than in average years, the percent of flow reduction declines slightly because of the higher overall flows that occur in these years. For the wet years that were evaluated, comparing Full Use of the Existing System to implementation of the Proposed Action, the average monthly flow change during the period May to September ranges from -1 to -4% with the highest decrease of 4% occurring in June with flows dropping from 6,091 cfs to 5,819 cfs. With flows this high, a change of this degree will be unnoticeable to recreationists, and would have a negligible impact on the boating experience.

The Proposed Action would have no impacts on boating in dry years.

Overall, the Proposed Action would have none to negligible impacts on boating use on the Colorado River in wet and average years.

No impacts to fishing on the Colorado River are anticipated.

Blue River

Two river segments were considered in the analysis for the EIS, including the segment between Dillon and Green Mountain reservoirs and the segment downstream of Green Mountain. The Grand County Stream Management Plan identified an optimum flow range of 600 to 1,000 cfs for kayaking and 700 to 1,400 cfs for rafting (Grand County 2010). These flow ranges were used to determine the number of days with optimum flows under both Full Use and with Project conditions for both segments. This information is summarized in Table 5.15-3.

Table 5.15-3
Blue River Near Boulder Creek,
Full Use of the Existing System vs. the Proposed Action (2032),
Number of Days at a Given Flow Rate for Boating

Year	Optimum Flows (600-1,000 cfs) Kayaking		Optimum Flows (700-1,400 cfs) Rafting	
	Full Use of the Existing System	Proposed Action	Full Use of the Existing System	Proposed Action
1957	17	19	8	11
1966	0	0	0	0
1975	10	2	13	6
1987	29	30	26	28
1991	4	4	9	6
1946-1991	459	419	585	533

Source: PACSM Results (Node 4500).
Notes:
Years were randomly selected to represent normal pre-Project conditions.
1946-1991 is a summary of the 45-year period used for the Platte and Colorado Simulation Model.

As indicated in the table, the number of days when flows are within the optimum range decreases with implementation of the Proposed Action in some years and increases in others, though the degree of change is not notable in most years. The greatest change occurs in 1975 when the number of days with optimum flows drops by 8 days for kayaking and by 7 days for rafting.

Over the entire 45-year modeling period, the number of days that fall within the optimum range would fall from 459 to 419 days for kayaking, which on average would be less than 1 day per year. For rafting, a similar degree of change would occur, with a reduction of 52 days over the period of record, or just over 1 day on average. This degree of change can be considered a minor adverse impact on recreational boating.

No impacts are expected to occur to the quality of the fishing experience along the Blue River as a result of the Proposed Action.

South Boulder Creek

Segments above and below Gross Reservoir receive some use by expert kayakers able to handle the Class IV+ whitewater that occur along these portions of the creek. Flows would increase as a result of the Proposed Action (2032) compared with Full Use of the Existing System, with flow increases during higher flow months (May through July) ranging from 7% to 17% above Gross Reservoir. Immediately below Gross Reservoir, flows would decrease during higher flow months (May through July) from 10 to 23%. Further downstream, the degree of flow change would diminish, dropping to 5% or less. These flow changes would have an impact to boating during the peak summer season.

The upper South Boulder Creek segment (Pinecliffe to Gross Reservoir) would be affected by the Proposed Action through increased flows, primarily during the summer months, with the greatest change occurring in June when average monthly flows would increase by 16% over flows associated with Full Use of the Existing System. Although the number of days with very high flows would increase during June, possibly curtailing use on some days by all but the most expert of boaters, the overall impact would be to shift use to periods later in the season. Increased flows in July and later in the summer would extend the boating season on this segment and would therefore not result in a loss of boating opportunities. The overall impact on boating resulting from increased flows would be minor to moderate and beneficial.

However, due to the expansion of Gross Reservoir, approximately 0.47 mile of South Boulder Creek upstream of Gross Reservoir would be inundated. This stretch of South Boulder Creek is the lower end of a popular recreational whitewater kayaking run known as the RIMBY (Right In My Backyard) rapid. This section is renowned on the Front Range as one of the few challenging runs for expert boaters, and is especially attractive due to its proximity to the Front Range. Inundation of this stretch of South Boulder Creek would constitute a major long-term impact on whitewater boating.

The lower South Boulder Creek segment (Gross Reservoir through Eldorado Canyon) is an expert kayak run that would be influenced by the Proposed Action. At the South Boulder Creek near Eldorado Springs gage, average flows would be slightly reduced during the boating season as a result of the Proposed Action. Monthly average flows would drop by 5% in May and 4% in June as compared to Full Use of the Existing System, resulting in

flows rates of 148 cfs and 266 cfs, respectively. One source indicates that the optimum flow range for this segment is 150 to 300 cfs (Southwest Paddler 2007). The impact on boating use would be negligible.

It is expected that there would be minor adverse impacts to the quality of fishing along portions of upper South Boulder Creek from the Moffat Tunnel to Gross Reservoir. Section 5.11, suggests there is expected to be a long-term effect that would result in a decrease of fish habitat availability along this stretch. The reductions in habitat availability for adult brook and rainbow trout along this segment as a result of the Proposed Action may impact fish populations compared to Full Use of the Existing System. A potential reduction in the fish habitat availability would have a negative impact on the quality of the fishing experience.

There may be a minor beneficial effect to the fishing experience on lower South Boulder Creek below Gross Reservoir as a result of higher density fish populations due to reduced flows during runoff, particularly during the peak runoff month of June, as well as increased flows during winter months. Both of these differences would tend to provide more favorable conditions for fish. As described in Section 5.11, increases in habitat availability for rainbow trout indicate that the Proposed Action would have a beneficial impact on fish populations on this segment of South Boulder Creek, compared to Full Use of the Existing System Flow reductions during periods of high flow may actually provide a minor beneficial effect to the quality of fishing (refer to the Fraser River discussion).

North Fork South Platte River

This river segment includes two reaches that receive boating use: one extending from Bailey to Pine and the second reach extending from Buffalo Creek to the confluence with the mainstem South Platte River.

The 10.5-mile Bailey to Pine reach is a combination of Class IV and V rapids. With implementation of the Proposed Action, this reach would see a major increase in flows during the months of May through August, reaching the highest monthly average flow of 490 cfs in June. These increases would have a moderate to major beneficial impact on boating use, prolonging optimum boating flows throughout the summer. In May, the flows will increase by 20%, from 275 to 330 cfs from Full Use of the Existing System to implementation of the Proposed Action.

The Buffalo Creek to mainstem South Platte River reach is a combination of Class III and IV whitewater. The minimum recommended flow level for boating is approximately 400 cfs (American Whitewater 2006). These flows generally occur only during the months of May and June. On average, the Proposed Action (2032) would increase flows in this segment, increasing monthly averages from 442 cfs under Full Use of the Existing System in June to 490 cfs. The flow changes would have a moderate to major beneficial impact on boating use on this segment.

At the North Fork South Platte River below Geneva Creek gage, the Proposed Action would increase flows during the summer months with the greatest increase occurring in May when the average monthly flow would increase by 29% as compared to the Full Use of the Existing System. This increase may shift the timing of use somewhat during the

summer season, but overall would have moderate to major beneficial impacts on boating use.

The increases in flow would not have a major impact on the quality of fishing along the North Fork South Platte River. Flow increases may make it slightly more difficult to fish during periods of high flow, particularly in May, but the overall impact would be minor, resulting in a shift in the period of use to later in the season.

South Platte River

Some kayaking occurs on the South Platte River downstream of the confluence with the North Fork South Platte River to Strontia Springs Reservoir. During the period of highest flows (May and June), average monthly flows would be reduced by 2% and 5%, respectively. On average, flows would decrease by 3% between the months of May and September (Table H-3.45). This would be a minor degree of change and a minor adverse effect for boaters who enjoy higher flow levels. American Whitewater (2006) indicates that 150 cfs is the minimum flow level for kayaks in the South Platte River above Strontia Springs Reservoir, a flow level that under Full Use of the Existing System extends from May through August. While there would be a slight (4%) decrease in flow in August under the Proposed Action (2032), the impact to the length of the boating season would be negligible and vary from year to year.

There may be a minor beneficial effect to the fishing experience on the South Platte River as a result of slightly reduced flows. Flow reductions during periods of high flow may actually provide a minor beneficial effect to the quality of fishing (refer to the Fraser River discussion above).

5.15.2 Alternative 1c

5.15.2.1 Gross Reservoir

The impacts to recreation under Alternative 1c would be essentially the same as described for the Proposed Action. The slightly smaller surface size and lower dam height of Gross Reservoir with Alternative 1c would not substantially change the recreational environment of the Project site. A smaller surface area than the Proposed Action would provide less additional on-water recreation opportunity; however, it would still be more than what is currently being provided. This alternative would also provide a shoreline of approximately 12.9 miles, approximately 0.6 mile less than under the Proposed Action.

5.15.2.2 Leyden Gulch Reservoir Site

The construction of a new reservoir at Leyden Gulch would have little impact on existing recreation since the Project site is currently undeveloped rangeland with no developed recreation opportunities or public access. As discussed in Chapter 2, the development of recreation facilities at Leyden Gulch Reservoir is not an aspect of this alternative. Denver Water has indicated that no recreation opportunities would be provided at Leyden Gulch Reservoir and public access to the site would be prohibited. Therefore, there would be no change in the current recreational character at the Leyden Gulch Reservoir site.

There would be a temporary impact to road bicyclists who utilize SH 93 due to its realignment and the reservoir construction. Although SH 93 would remain in service while the alignment is being constructed, there would be a noticeable increase in heavy truck traffic along the roadway. This traffic would continue while the road is being realigned as well as throughout the construction of the reservoir. The presence of additional heavy truck traffic along this roadway would present additional safety hazards as well as potentially diminishing the overall recreation experience for road cyclists.

The Jefferson County Open Space Master Plan has identified the Leyden Gulch area as a "potential open space preservation area" as part of Coal Creek Canyon Park (Jefferson County 2008). The proposed reservoir at Leyden Gulch would potentially conflict with the Master Plan vision for this area. Two Trails 2000 segments are also planned through the study area to enhance trail connectivity to Coal Creek Canyon and other open space properties. Construction of the Leyden Gulch Reservoir would have a minor impact on the future alignment of these trails.

5.15.2.3 River Segments

Impacts to all river segments under Alternative 1c would be similar to those described for the Proposed Action.

5.15.3 Alternative 8a

5.15.3.1 Gross Reservoir

The impacts to recreation under Alternative 8a would be essentially the same as described for the Proposed Action. The slightly smaller surface size and lower dam height of Gross Reservoir with Alternative 8a would not substantially change the recreational environment of the Project site. A smaller surface area than the Proposed Action would provide less additional on-water recreation opportunity; however, it would still be more than what is currently being provided. This alternative would also provide a shoreline of approximately 13.2 miles, approximately 0.2 mile less than under the Proposed Action.

5.15.3.2 South Platte River Facilities

Gravel Pit Storage Facilities

For purposes of this EIS, the Worthing, North Tower and South Tower pits are identified as representative gravel pits that could be converted into storage pit facilities. The final combination of gravel pit lakes would be determined during the design phase if Alternative 8a is permitted. Of these pits, active recreation is currently associated only with the Worthing Pit. The Worthing Pit is used for water skiing, and several trailers are used for seasonal residences on the north side of the lake. There would be no public access or recreational use permitted if these pits were converted to storage use with Alternative 8a. As such, there would be a major long-term impact on the existing recreation opportunities at the Worthing Pit; water skiing and the existing trailers used as seasonal residences would no longer be permitted. A portion of the proposed South Platte Heritage Project Trail Corridor would traverse the center of the gravel pit disturbance area, along the river. Additionally, a right-of-way (ROW) trail and trailhead are proposed along 120th Avenue at

the northern edge of the Project area (Adams County 1998, 1999, 2012). Construction and storage preparation at these gravel pits may conflict with the proposed alignments of these trail corridors.

Gravel Pit Pipeline

The pipeline connecting the gravel pits would be installed within existing roadways from the Worthing Pit north to the North Tower Pit along Brighton Road. There may be a temporary disturbance to bicyclists who use this roadway during construction. It is not anticipated that there would be any additional impacts to recreation resulting from the construction or operation of this pipeline.

Diversion Structure

Under Alternative 8a, a new diversion structure would be constructed in the South Platte River near the Worthing Pit Storage Facility. The diversion would extend across the active South Platte River channel. The Adams County Regional Park is located on the west side of the South Platte River, although no disturbances to park users are expected as a result of construction and operation of this diversion. This river segment is used for kayaking and other water-based activities, primarily confined to the west bank. The installation of a diversion structure at this location would temporarily prohibit kayaking while under construction. Since the presence of several other engineered structures exists along this stretch of river, the construction of this diversion is not expected to permanently impact kayaking or the recreation experience. Paddlers would be forced to portage around the diversion structure, as they must with the other engineered structures; however, its presence is not expected to have a negative impact on kayaking. Only temporary disruptions to fishing are expected during construction of this diversion.

Water Treatment Plant

The construction of a new Advanced Water Treatment Plant adjacent to Worthing Pit would have no impacts on existing recreation since this site has no developed recreational facilities.

Dechlorination Facility

A small dechlorination facility would be constructed on less than 1 acre near the Moffat Collection System Delivery Point. It is not expected that the construction or operation of this facility would have any impacts on recreation in the area.

5.15.3.3 Conduit O

Although Conduit O would be constructed in existing streets, it would cross or be located in proximity to several parks and recreation areas in the cities of Arvada, Brighton, and Thornton (refer to Section 3.15). Organized and passive recreational activities may be temporarily affected by construction activities during conduit installation. However, no long-term impacts to recreation are expected as a result of Conduit O. The delivery pipeline would parallel existing road ROWs and would not significantly interfere with any potential future recreation activities. The pipeline corridor would cross a proposed Adams

County trail, a proposed trail along 104th Avenue, and a proposed trail along 120th Avenue; however, these segments have not yet been constructed. Construction of Conduit O may also create a temporary disturbance to bicyclists who use the same roadways where the pipeline would be buried. Conduit O would cross the South Platte River and other drainages. Crossings of these waterways would require construction via an open cut on the channel. This would temporarily preclude recreational use of the river for activities such as kayaking while construction is ongoing. It would also preclude recreational fishing in the immediate vicinity of the open cut during construction.

5.15.3.4 River Segments

Impacts to all river segments under Alternative 8a would be similar to those described for the Proposed Action.

5.15.4 Alternative 10a

5.15.4.1 Gross Reservoir

The impacts to recreation under Alternative 10a would be the same as described for Alternative 8a.

5.15.4.2 Denver Basin Aquifer Facilities

The specific locations of the well sites have not been identified; however, based on the representative sites described in Chapter 2 the wells would primarily be located within existing City and County of Denver parks and golf courses. Construction of well sites in any developed park would permanently remove approximately 0.5 acre from use for recreation, and would temporarily remove 0.9 acre for use during construction. As described in Section 3.15, parks identified as potential well site locations vary in size and recreation amenities offered. Several parks are very small and the presence of an additional structure would create more of a major impact than those located at larger parks. Actual siting of the facilities would occur during pre-construction design and planning, and would include coordination with park or facility managers. As described in Chapter 2, well locations that interfere with park uses or create other conflicts would be avoided.

5.15.4.3 Conduit M

Although Conduit M would be constructed in existing streets, it would cross or come in proximity to several parks and recreation areas in the cities of Arvada and Westminster. The temporary impacts to recreational activities during conduit installation are the same as described for Conduit O. The pipeline corridor would cross proposed and existing bike lanes at multiple locations.

5.15.4.4 River Segments

Impacts to all river segments under Alternative 10a would be similar to those described for the Proposed Action.

5.15.5 Alternative 13a

5.15.5.1 Gross Reservoir

The impacts to recreation under Alternative 13a would be essentially the same as described for the Proposed Action. The slightly smaller surface size and lower dam height of Gross Reservoir with Alternative 13a would not substantially change the recreational environment of the Project site. A smaller surface area than the Proposed Action would provide less additional on-water recreation opportunity; however, it would still be more than what is currently being provided. This alternative would also provide a shoreline of approximately 13.3 miles, approximately 0.1 mile less than under the Proposed Action.

5.15.5.2 South Platte River Facilities

Impacts would be the similar to those described for Alternative 8a. This alternative, however, would require the conversion of agricultural water rights to municipal or other non-irrigation uses. Because the areas that would be removed from agricultural production are not likely to support existing recreational uses, the conversion of agricultural water rights would not impact recreational opportunities.

5.15.5.3 Conduit O

Impacts would be the same as described for Alternative 8a.

5.15.5.4 River Segments

Impacts to all river segments under Alternative 13a would be similar to those described for the Proposed Action.

5.15.6 No Action Alternative

Impacts resulting from the No Action Alternative would be same as was described in Section 4.6.15.6.

5.15.7 Mitigation and Monitoring

The primary mitigation for recreational uses is the redevelopment of inundated facilities at Gross Reservoir to sites above the proposed high waterline as shown conceptually on Figures 5.15-1 through 5.15-3. This would allow for the continuation of current uses, although there may be some short-term disruptions and a gap between the closure of existing sites and the opening of newly relocated sites. Each relocated recreation area would provide for the specific opportunities and facilities outlined in the Gross Reservoir Recreation Management Plan (Denver Water 2004b). The relocation of recreation facilities would occur sometime during the construction period. It is not known at this time exactly when relocations would occur, but Denver Water expects that the relocations would be completed during the final cleanup and restoration phases of construction.

Any existing or planned trails that would be affected by Project activities would be replaced in kind.

Well houses proposed for development in City and County of Denver parks under Alternative 10a would be located away from use areas, or other areas in which there might be a conflict with recreational activity. Planning of the actual location of the well houses would be done in coordination with park and facility managers.

Overall, the additional Environmental Pool would have a minor adverse impact to recreation, specifically kayaking on South Boulder Creek, as a result of reduced flows. Flows are projected to decrease by as much as 12 cfs at both the Gross Reservoir Outflow and the Eldorado Canyon gage in May with the additional Environmental Pool. May is a primary use period for kayaking along South Boulder Creek and the optimum flow range for kayaking is 150 to 300 cfs. A reduction of 12 cfs at the Eldorado Canyon gage would reduce flows from 148 cfs under the Proposed Action to 136 cfs with the additional Environmental Pool. This would reduce flows further out of the optimum range for kayaking. No other recreational impacts, adverse or beneficial, are expected as a result of the additional Environmental Pool at Gross Reservoir.

5.15.8 Unavoidable Adverse Impacts

There would be moderate adverse unavoidable impacts to existing recreational facilities at Gross Reservoir due to the expanded inundation area; however, all of the facilities would be relocated and the recreational use restored. There would be an unavoidable long-term moderate to major adverse impact on boating on the Fraser River due to a reduction in the average number of days when boating could occur within the optimum flow ranges, as well as a reduction in the length of the boating season. There would be unavoidable minor adverse impacts to the quality of fishing along upper South Boulder Creek as a result of reductions in habitat availability. There would also be unavoidable major adverse impacts to whitewater boating on the lower-end of the upper stretch of South Boulder Creek due to inundation of the Right In My Backyard (RIMBY) rapid. There would be an unavoidable loss of recreational opportunity at the Worthing Pit for Alternatives 8a, 10a, and 13a.

5.16 LAND USE

This section describes the direct and indirect impacts to land use that may occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Land use issues documented during scoping included:

- Impacts on land development in Grand County due to the additional water diversions.
- Impacts of additional firm yield in the Board of Water Commissioners' (Denver Water's) supply on growth and development in the northern part of the Denver Metropolitan area.
- Quarrying or mining in the vicinity of Gross Reservoir.
- Compliance with local land use planning code, comprehensive plan guidelines, and U.S. Forest Service (USFS) management objectives.

Current and planned land uses in relation to each Project component are evaluated in Sections 5.16.1 through 5.16.6. The scoping issue relating to water availability and growth is discussed in the paragraphs below.

Several recent studies have suggested that there is no substantive causal relationship between population growth and the development of water, or vice versa. One such study is summarized as follows:

> *The relationship between water and growth in the modern West is often misunderstood. Historically, it has been assumed that water development was a necessary precursor to growth and, similarly, that a lack of water development could act as a deterrent to growth. While these premises may have been true at one time, recent experience in Colorado and other western States shows both ideas are now unsupportable. To the contrary, many of the regions showing the highest rates of growth in the West – from Douglas County, Colorado to Las Vegas, Nevada – show the opposite trend; growth is actually highest in some of the driest regions. Similarly the veto of the proposed Two Forks Dam on the Front Range by the Environmental Protection Agency in 1990 certainly did not deter growth in the Denver Metropolitan area. Examples also suggest that an abundance of water is often insufficient to stimulate growth. The experience of Pueblo, Colorado is illustrative (Nichols et al. 2001).*

Numerous other studies analyzing the relationship between growth and water reach similar conclusions, such as Western Land Use Trends and Policy: Implications for Water Resources (Riebsame 1997); Atlas of the New West (Center of the American West 1997); and Water in the West: The Challenge for the Next Century (Western Water Policy Review Advisory Commission 1998). This growth issue was evaluated and dismissed by the U.S. Army Corps of Engineers (Corps) during the National Environmental Policy Act of 1969, as amended, analysis of the Two Forks Dam and Reservoir Project in 1988 – "As a result of including the No Federal Action scenario, the Corps was able to answer a major question then being asked – would growth continue in the Denver Metropolitan area without Federal

approval of a major water supply project. The evaluation of the No Federal Action scenario determined that growth would occur regardless of Federal action" (Corps 1998).

Impacts to land use would occur if the Moffat Project conflicts with adopted planning goals or policies, terminates or has a major impact on existing land uses, or results in changes that would interfere with planned land uses in the area. To assess impacts to existing and planned land uses, parcel ownership data, management and planning documents (including zoning regulations), aerial imagery, and recent development proposals were reviewed.

5.16.1 Proposed Action (Alternative 1a)

5.16.1.1 Gross Reservoir

Existing Land Uses

Overall, impacts to existing land uses at or adjacent to Gross Reservoir are expected to be minor. Recreation is the primary non-water storage use at Gross Reservoir. Construction activities would have site-specific, direct land use impacts, primarily relating to recreation access and use areas. The construction of minor road relocations at the Gross Dam and the proposed auxiliary spillway site would result in temporary impacts to recreational users. Temporary and permanent direct impacts to recreation resulting from the implementation of the Proposed Action are discussed in Section 5.15.

A small Denver Water maintenance building at the Peninsula Recreation Area would be directly impacted by inundation as a result of the Proposed Action. The building houses critical maintenance equipment for the reservoir as well as a rescue boat that needs to be readily accessible in the event of an emergency. Denver Water would ultimately relocate the maintenance building; the exact location, size, and design of the building would be determined at the time of relocation.

Construction-related activities (e.g., increases in noise and dust) would temporarily impact adjacent land uses including the Lakeshore residential subdivision. Although the impacts may present temporary inconveniences, none of these impacts would be long term or impede existing or future land uses during or following the construction period. Approximately 15 acres of private land within the southern Project area boundary would need to be acquired.

Under the Proposed Action, no areas of the Winiger Ridge Natural Landmark would be inundated. There would be no impacts to Boulder County Open Space properties.

Management of USFS lands (Thorodin Geographic Area) within and adjacent to the study area boundary are subject to Management Area 3.5 direction, Forested Flora and Fauna Habitats. Management objectives in this area emphasize maintaining and improving wildlife and plant habitats and promoting recreational use in the Winiger Ridge area during the summer and fall. Conflicts with USFS management direction include minor, permanent impacts to wildlife and plant habitats (refer to Sections 5.7 and 5.9) and temporary impacts to recreational objectives for the duration of Project construction.

Haul road traffic would result in temporary, minor impacts to local traffic circulation patterns in and near the urbanized areas of Broomfield, Lafayette, Erie, Longmont, and

Arvada along U.S. Highway (US) 287, State Highway (SH) 128, and SH 93 and in the Coal Creek Canyon along SH 72. Dust pollution, noise, and ground vibrations from loaded haul trucks may affect existing commercial, retail, and residential uses along the route. Haul traffic may also result in temporary passenger vehicle delays, detours, and relocated access to homes and businesses. Workers carpooling to the various construction sites would further increase traffic volumes along roadways accessing Gross Reservoir. Although most construction-related work is anticipated to occur during the day, some double and triple work shift may be temporarily required; these extended construction periods would increase commuter traffic on access roads at all times of day. This commuter vehicle increase represents an impact to local transportation, and subsequently, local land uses. Increased traffic volumes may result in temporary delays and circulation problems that may force existing commuters to use alternate routes. Changes in traffic volumes and patterns may affect local businesses (particularly retail and commercial) by either increasing patronage and access or diverting long-term regular customers to other retailers.

Planned Land Use

Generally, land use within the Gross Reservoir area is stable with only minor development or changes planned, such as individual residential building/improvement permits. There would be no impacts to planned land uses as a result of the Proposed Action with the Environmental Pool for mitigation, with the exception of planned, but not yet built, recreational facilities identified in the Recreation Management Plan (Article 416 of the Federal Energy Regulatory Commission License; Denver Water 2004e). Recreation impacts are discussed in Section 5.15. The Proposed Action would require the acquisition of approximately 15 acres of private lands within the southern Project area boundary. At this time, it is not possible to know the future land uses or the interests of respective property owners; however, long-term adverse effects would occur if the landowners had intended uses other than selling to Denver Water for reservoir related uses.

River Segments

Facility development associated with the Proposed Action would be limited to those items previously discussed, all of which would be located on the East Slope. There would be no facility development in Grand County or other locations on the West Slope, and therefore, no direct effects on land use at these locations. Impacts associated with increased stream diversions, which are discussed in recreation, visual resources, and other resource sections, would not be of a magnitude that would result in land use changes at any location.

Water rights for existing agriculture, municipal, and other uses would be protected under Colorado water law. Municipal and agricultural diversions per Colorado water law (Colorado Revised Statutes [C.R.S.] § 37-92-102(2)(b)) would remain responsible for developing a reasonable means of diversion for their water.

Current impacts on irrigation structures and irrigation practices caused by low flow conditions during the late summer and in dry years are partially due to diversions by the existing Moffat Project as well as other upstream diversions, including Windy Gap and Colorado-Big Thompson Project diversions. The proposed Moffat Project would have little to no impact on flows during the late summer and in dry years; therefore, impacts on irrigation structures and practices would not be exacerbated by the proposed Moffat Project.

The proposed Moffat Project would not cause additional flow reductions during those times since there would be no *additional* diversions attributable to the Moffat Project in late summer months or in dry years because Denver Water would have already diverted the maximum amount physically and legally available under their existing water rights without additional storage on-line. Appendix Table H-3.1 shows additional diversions through the Moffat Tunnel would occur primarily during the months of May, June, and July in average and wet years. During other months, there would be little to no additional water diverted. Furthermore, Denver Water's out-of-priority diversions from the Fraser River Basin would be replaced with releases from Williams Fork Reservoir, resulting in no net change in Colorado River flows upstream of these pumps due to out-of-priority Moffat Collection System diversions in dry years.

5.16.2 Alternative 1c

5.16.2.1 Gross Reservoir

The potential land use impacts at Gross Reservoir associated with Alternative 1c, are similar to those described for the Proposed Action, but less ground-disturbing activity would be necessary for the smaller expansion (40,700 acre-feet [AF]).

5.16.2.2 Leyden Gulch Reservoir Site

Existing Land Uses

Overall, existing land use impacts resulting from Alternative 1c are expected to be minor.

Temporary land use impacts would be typical of construction activities; primary direct impacts would include increased noise, dust, and traffic. The new reservoir would be constructed immediately south of the Union Pacific Railroad; there would be no impacts to the railroad as a result of the Project.

Currently, the area in the vicinity of proposed dam and spillway has been zoned by Jefferson County as Agricultural District 2; the majority of surrounding lands is in agricultural use or has been purchased for open space. The inundation of Leyden Gulch would result in minor losses of livestock grazing opportunities (approximately 36 animal unit months per year).

Residential land uses in nearby developments (within approximately 0.5 mile of proposed reservoir pool), Blue Mountain Estates and Jefferson Center Highlands, would not be impacted by Project construction; however, these residences would be affected by altered views (refer to Section 5.17). Three occupied residences, located within ⅛ mile of the proposed spillway, would experience temporary increases noise and dust levels during Project construction. These impacts would be temporary. Alternative 1c would require the acquisition of approximately 327 acres of private land (various owners). At this time, it is not possible to know the future land uses or the interests of respective property owners; however, long-term adverse effects would occur if the landowners had intended uses other than selling to Denver Water for reservoir related uses. Home relocations or condemnations would not be necessary. One unoccupied agricultural building would need

to be either demolished or relocated prior to inundation. Historical significance, if any, of this building is addressed in Section 5.18.

Planned Land Uses

Land use in the Leyden Gulch area is currently stable but the potential for future development is moderate to high. The greatest potential determinant of change in the area would be future industrial/office redevelopment area at the intersection of SHs 72 and 93 as identified in local planning documents, including the City of Arvada Comprehensive Plan (City of Arvada 2005).

The proposed Leyden Gulch Dam footprint overlaps a portion of SH 93. Approximately 4,000 feet of SH 93 would need to be permanently relocated. The realignment of SH 93 would be constructed before construction of the dam embankment. The existing SH 93 would remain in service while the realignment is constructed; it is estimated that construction of the realignment would take approximately 180 days to complete. The existing portion of SH 93 would be removed after the completion of the realignment. Highway realignment and construction of the Leyden Gulch Dam would result in temporary minor traffic delays and possible temporary traffic detours.

Development of the Jefferson Parkway Project, which would be located approximately one mile south and east of the reservoir site, would likely influence future land use in the vicinity, though much of the area is in some form of protected status and local plans call for directing future development to the intersection of SHs 72 and 93.

Currently, there is no commercial or retail development along the Parkway in the vicinity of the Leyden Gulch Reservoir site. As such, there would be no adverse impacts to local businesses or retailers. However, as noted, the Jefferson Center Urban Renewal Plan aims to stimulate development of underutilized lands (approximately 2,000 acres) east of SH 93 at SH 72 by creating a commercial and industrial center (Arvada Urban Renewal Authority 2009). The intersection of SHs 72 and 93 is zoned for commercial development by the City of Arvada and several subdivisions are planned in the region. Although the majority of the Project vicinity remains unincorporated, it is highly probable that residential growth would continue westward from Westminster, Arvada, Wheat Ridge, and Golden, with commercial and industrial development along SHs 72 and 93. At this time, it is unknown how much development would have occurred in the vicinity of the proposed Leyden Gulch Reservoir site at the onset of Project construction. However, for the purposes of this analysis, it is assumed that local, city, and county development activities would be underway, if not mature, by the start of development of the Jefferson Parkway and reservoir construction. These uses may promote additional traffic through the area which, in concert with highway construction delays, would potentially result in adverse minor impacts.

Ownership of the highway realignment corridor is comprised of municipal lands and public right-of-way (ROW). ROW through municipal properties would need to be acquired prior to construction. Regional impacts of these acquisitions are expected to be negligible.

Community and county-wide planning efforts, including the North Plains Community Plan (contributing document to the Jefferson County Comprehensive Plan [Jefferson County 2012]) have noted the importance of preserving local viewsheds and acquiring new open

space properties west of SH 93. The study area is identified as a "potential open space preservation area" and two Trails 2000 segments are planned to cross the study area in order to enhance trail connectivity to the Coal Creek Canyon and open space properties in northern Jefferson County (City of Arvada 2012). Construction of a new reservoir in Leyden Gulch would present a minor adverse impact to the future alignment of these trails.

No off-site borrow material hauling would be required under this alternative. The types of impacts increased commuter and supply vehicle traffic would be similar to the Proposed Action.

5.16.3 Alternative 8a

5.16.3.1 Gross Reservoir

The potential land use impacts at Gross Reservoir associated with Alternative 8a are similar to those described for the Proposed Action, but less ground-disturbing activity is necessary for the smaller expansion (52,000 AF).

5.16.3.2 South Platte River Facilities

Diversion and Gravel Pit Pipeline Conveyance

Diversion and conveyance facilities would be located in an area of active gravel mining and other light industrial uses west of Brighton Road (SH 22). As such, there would be no adverse permanent impacts as a result of the diversion or conveyance systems in this area.

Water Treatment Plant

The new Advanced Water Treatment Plant (AWTP) would occupy approximately 4 acres adjacent to the Worthing Pit and would consist of several buildings and structures no more than two stories in height (about 25 to 30 feet). The Worthing Pit is located just south of the Brighton municipal boundary, in an area of active gravel mining and other light industrial uses. The current 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 (Adams County 2007a). Several small mining operation facilities, including fixed and mobile offices, and several private residences are located in and around these gravel pit sites. Structure design criteria, such as sound mitigation and architectural styling as discussed in Section 2.5.2.2, would ensure that the AWTP would have no adverse impact on existing or future land uses and would be consistent with current county zoning.

Gravel Pits

Gravel pit storage would be located at existing gravel extraction lakes in areas currently characterized by industrial and agricultural uses. As such, there would be negligible impacts to existing land uses. However, recreational uses of the Worthing Pit would be adversely affected by this alternative. Potential impacts to recreation opportunities and recreation-related uses are described in Section 5.15.3.2.

All of the four storage areas are located within the City of Brighton Rivers and Lakes Joint Planning Area (City of Brighton 2009). This joint City/County planning area stipulated that

if development occurs, it should be at the lowest densities possible with clustering used so as to preserve large open tracts. Maintaining the existing gravel lakes for storage under this alternative would not be in conflict with the Planning Area stipulations. The South Tower Pit is also subject to the Willow Bay Planned Unit Development agreement; the current zoning for this area includes a combination of residential, parks, and open space (City of Brighton 2006). Use of the South Tower Pit for water storage purposes would not conflict with existing or planned land uses.

5.16.3.3 Conduit O

Construction of Conduit O would result in temporary minor, adverse impacts. Because the conduit would be constructed in existing streets and ROWs, lane closures and traffic detours would be necessary to accommodate construction activities. Reduced or modified access may temporarily affect retail and commercial land uses along the conduit alignment.

Temporary impacts related to conduit construction would include temporary lane closures on Brighton Road and, depending on the time of year, may require that irrigation be stopped for the period of construction. The Brighton Road corridor between Brighton and Hazeltine Heights receives heavy industrial traffic. Lane closures or traffic delays may require the use of alternative routes in the area, including roads through large-lot residential and agricultural residential areas. Conduit construction would occur 500 to 1,200 feet per day depending on location; on any particular segment of roadway pipeline construction impacts would typically occur for less than 1 week (refer to Section 5.12.3.3).

5.16.4 Alternative 10a

5.16.4.1 Gross Reservoir

The potential land use impacts at Gross Reservoir associated with Alternative 10a are the same as those described for Alternative 8a.

5.16.4.2 Denver Basin Aquifer Facilities

The AWTP would be located in the vicinity of the existing Denver Water Recycling Plant. Approximately 7 acres (4 acres of permanent impacts for the AWTP, plus 3 acres for temporary construction activities) of property would be necessary to accommodate the proposed plant. This property would be located in an existing industrial district, on or adjacent to lands that have already been impacted by existing industrial development. Temporary construction impacts are expected; however, because the new AWTP is compatible with surrounding uses, there would be no long-term impacts.

Injection/recovery sites would consist of three wells per cluster. 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 proposed 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. Because the wells are intended to be constructed individually as needed, short-term construction related direct impacts would occur throughout the life of the Project. Construction activities would result in temporary

direct impacts at the well sites including noise, dust, and temporary closures. Long-term and permanent impacts to uses of these City and County of Denver properties are expected to be minor and primarily related to diminished recreational experiences or aesthetics, as discussed in Sections 5.15 and 5.17. Prior to construction activities, City and County of Denver approval would be needed.

Consistent with the impact analysis presented in Sections 5.15 and 5.17, well sites would be incompatible with the character and typical uses of some of the smaller or focus-specific (e.g., sculpture park, memory garden, etc.) parks and would result in major permanent impacts to the use and intent of these areas. In the case of smaller, focus-specific parks, well sites, and facilities would substantially alter park functionality and experience. Larger, city or regional parks could absorb, although not without some minor degree of permanent impact, well infrastructure into existing developed areas such as parking lots or bathhouses or use natural topography and/or vegetation to screen impacts of new well facilities. Permanent impacts in the larger, city or regional parks would be minor.

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. The network also 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 duration of distribution pipeline construction would vary by location and by the diameter of pipe, but would average approximately 25 to 35 days per mile for in-street construction. Temporary impacts would be related to traffic delays, noise, lane closures, and potential detours. Commercial and retail uses would experience major, but short-term adverse impacts if detours and lane closures resulted in the loss of business opportunities or patronage.

5.16.4.3 Conduit M

The potential impacts to land use resulting from Alternative 10a are generally the same as those described for Conduit O under Alternative 8a.

5.16.5 Alternative 13a

5.16.5.1 Gross Reservoir

The potential land use impacts at Gross Reservoir associated with Alternative 13a are similar to those described for the Proposed Action, but less ground-disturbing activity is necessary for the smaller expansion (60,000 AF).

5.16.5.2 South Platte River Facilities

Many of the impacts would be similar to those described for the Alternative 8a. The primary land use impact associated with this alternative would be the conversion of agricultural water rights to municipal and other urban uses. It is anticipated that approximately 3,900 acres of agricultural land would be affected by conversion of existing water rights. The type of water shares acquired and other variables cannot be determined

until the actual purchase investigations are underway. However, it is likely that agricultural water rights transfers under Alternative 13a would occur in Weld County, which is losing agricultural lands at a rapid rate. In the 15-year period between 1987 and 2002, Weld County alone lost 271,491 acres of agricultural land (Environment Colorado Research and Policy Center 2006). In this context, the amount of land that may be affected by the Moffat Project is relatively minor, and some, if not a majority of these lands would likely be converted to nonagricultural uses by ongoing trends towards urbanization. The timing and location of these conversions is unknown and cannot be accurately predicted. Overall, the acreage proposed for conversion under Alternative 13a would represent a negligible to minor contribution to existing trends.

Some of the lands that could no longer be irrigated due to the removal of water rights might remain in agricultural use such as dryland cultivation or pastureland. However, these uses are typically less productive than irrigated farmland.

5.16.5.3 Conduit O

The potential impacts to land use resulting from Alternative 13a are the same as those described for Conduit O under Alternative 8a.

5.16.6 No Action Alternative

There would be no direct, measurable impacts to land use as a result of the No Action Alternative since there would be no ground-disturbing activities.

5.16.7 Mitigation and Monitoring

Standard construction practices and additional protection measures are identified throughout the alternative descriptions in Chapter 2. Specific sediment and erosion control measures and pipeline construction methods are addressed in Sections 2.8.2 and 2.8.3. The following mitigation measures are proposed for Alternatives 8a, 10a, and 13a in addition to the protection measures identified in Chapter 2:

- Develop vegetation screening, greenways, or recreation facilities at or near gravel pits to be consistent with the City of Brighton Comprehensive Plan: "….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 such as the Heritage Trail Plan."

5.16.8 Unavoidable Adverse Impacts

For the life of the Project, land developed for the alternative component features (dams, facilities, wells, etc.) would be unavailable for any other land use development.

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5.17 VISUAL RESOURCES

Potential visual resource issues identified during scoping included:

- How the enlargement of Gross Reservoir and the construction of a new Leyden Gulch Reservoir would relate to current natural and man-made recreational features and the visual integrity of adjoining open space.
- Impacts on the "Front Range Backdrop" that may result from the Moffat Collection System Project (Moffat Project or Project).
- Impacts on Grand County's scenic characteristics and attractions, including water courses affected by the Project.

Sightseeing, hiking, outdoor tourism, nature-viewing, and other scenery-dependent outdoor activities are highly valued by the public in many areas within the Project area. The potential Project impacts on outdoor recreation uses and associated tourism activities are described in detail in Section 5.15. This section describes the potential short- and long-term visual impacts to the existing landscape character and how that character is perceived via natural and man-made viewpoints, viewsheds, and scenic features.

The extent to which the proposed Moffat Project would affect visual resources depends on the amount of visual contrast created between the proposed Project facilities and the existing landscape character (refer to Section 3.17). The resource would be impacted if visual change in the landscape had a negative impact on existing viewpoints, high quality scenery, or impacted the view from the setting of visually sensitive land uses. Types of visual contrast include modifications to the existing form, line, color, and texture of landforms, vegetation, and structures. Potential contrasts considered the setting's visual absorption capacity, or the feasibility of restoring or maintaining acceptable degrees of scenic quality. Impacts were also determined based on whether the predicted visual contrast caused by each Project alternative would be consistent with management guidelines for each affected area.

Photographic simulations were prepared for the Gross Reservoir and Leyden Gulch Reservoir sites. The simulations were based on preliminary engineering information, and were prepared by collecting global positioning system points at Key Observation Points (KOPs), rendering Project components in Visual Nature Studio and Adobe Photoshop, and adding the rendered items to photographs taken from each KOP. The photographic simulations were used to help evaluate the degree of change in landscape character.

The degree of visual contrast considered field evaluations, viewing distance, primary activity of viewers, viewpoint use frequency, duration of view, number of viewers, relationship to constituent values, and visual absorption capacity, and existing scenic quality. Major impacts were identified where the proposed alternative components would create readily apparent and substantial contrasts in the foreground (within 0.5 mile) of residences, designated recreational use areas, scenic viewpoints or scenic travelways. Minor impacts were identified where the proposed alternative components would create slight but detectible contrasts in the foreground (within 0.5 mile) of residences, designated recreational use areas, scenic viewpoints or scenic travelways. Moderate impacts were identified where the proposed alternative components would create readily apparent and

moderate contrasts in the foreground (within 0.5 mile) of residences, designated recreational use areas, scenic viewpoints or scenic travelways. Negligible impacts were identified where the proposed alternative components would create very little to no change in the landscape character viewed by the public due to either distance, topography, or vegetation, areas of high visual absorption capacity, or low scenic quality.

In each alternative, the degree of contrast resulting from the Project was also compared with pertinent management guidelines to determine whether the degree of contrast is within or exceeds the allowable degree of visual contrast for the area. Major impacts would occur where Project actions substantially conflicts with management guidelines or policy plans, such as where the Project would result in a long-term adverse effect on public land with high visual quality objectives. Moderate conflicts would occur where the Project would affect lands with moderate visual quality objectives. No impacts would occur where the Project would affect private lands that are not managed for scenic values, or lands already degraded by uses that are out of character with the surrounding environment uses.

5.17.1 Proposed Action (Alternative 1a)

5.17.1.1 Gross Reservoir

As described in Section 3.15, past Board of Water Commissioners (Denver Water) visitor surveys indicate that Gross Reservoir's most desirable attributes are its feeling of remoteness, the general 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. Surveys further indicate that 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. Due to the recreational nature of use and the scenic amenities valued by residents, user sensitivity to visual change is considered to be high.

The primary components of the Proposed Action would permanently modify the existing visual condition in the following ways:

- Approximately 465 acres of forested shoreline and existing viewpoints and use areas would be directly affected and permanently inundated by the enlarged reservoir.
- Trees would be removed up to an additional 4 feet above the new normal pool elevation (7,406 feet).
- The existing reservoir elevation would be raised 124 feet above the existing normal water level.
- Creation of approximately 13.9 miles of shoreline, representing approximately 2.8 miles more of shoreline than exists currently.
- The concrete dam would be raised 131 feet to an ultimate dam crest height of 471 feet that is approximately 1,840 feet long and 25 feet wide. The enlarged dam would also have a wider foundation at the Boulder Creek outlet than currently exists.
- A new auxiliary spillway would be constructed south of the dam.

- Development of a primary quarry with a cut slope of 20 percent (%) and terraced horizontal benches.
- Relocation of existing recreation and visitation facilities.
- Relocation of existing dam and spillway access roads.
- Disturbance and restoration of four construction staging areas.
- Disturbance and restoration of borrow material areas.
- Disturbance and restoration of stockpile and spoil areas and associated haul roads.
- Changes in reservoir elevations (releases, storage, fill rates).
- Reservoir operations (traffic, monitoring, minor repair and maintenance activities).

Visual Contrast Impacts

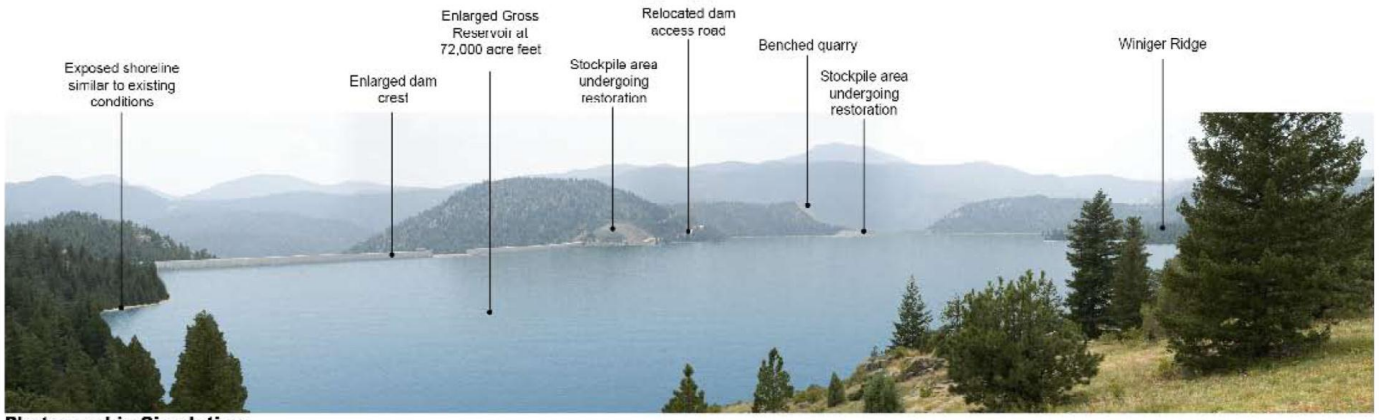
Temporary construction activities would create major adverse temporary direct impacts to visual resources at Gross Reservoir. Activities include quarries and borrow areas, construction staging and parking areas, a temporary concrete production plant, heavy machinery traffic, blasting, dam construction, stockpile and spoil areas, vegetation removal, temporary and permanent road construction, and associated temporary haul roads, all of which would exhibit dust and bare soils to viewers. These activities would be incompatible with the recreational and scenic nature of the area, and would be a major short-term impact.

Long-term direct impacts to visual resources at Gross Reservoir would include changes in scale to the shoreline, reservoir elevation, and dam profile; permanent inundation of scenic areas; relocation of existing facilities and roads; disturbed areas undergoing restoration; and a new auxiliary spillway.

Figure 5.17-1 shows a photographic simulation of the enlarged Gross Reservoir (additional 77,000 acre-feet [AF]). Primary differences between the existing landscape character and the simulated condition are the scale of the reservoir body, an elongated shoreline, a wider and higher dam crest, and new visual relationships of the reservoir to topographical features. The “bathtub ring” effect resulting from changes in reservoir elevations (e.g., releases, storage, fill rates) is not illustrated in the photographic simulation. The amount of bare earth exposed by the “bathtub ring” effect would vary depending on reservoir operations. The unattractive visual contrast created by reservoir fluctuations would be similar to the Current Conditions (2006).

The enlargement considerably alters the frame of reference (or cognitive map) for viewers, as popular viewpoints from eight of the nine designated recreation areas would be inundated. Viewers would need to create a new cognitive map, or a mental structure to record and recall spatial knowledge about Gross Reservoir’s physical environment, based on the new viewpoints and viewsheds. Some existing scenic areas and new views with potentially high scenic quality could be created. Similarly, some lands with resource damage due to unmanaged use would be hidden from view. For example, portions of Forsythe Canyon and South Boulder Creek Inlet, which have very high scenic quality, would be directly affected by inundation, as would the Peninsula Recreation Area, which has been moderately affected by human uses and erosion. More specifically, Forsythe

Existing Conditions



Photographic Simulation

Note: 77,000 AF of additional storage as seen from the North Shore Recreation Area Parking Lot.

Moffat Collection System Project FEIS

Figure 5.17-1
Photographic Simulation of the Proposed Action at Gross Reservoir

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Falls, which is located at the terminus of Forsythe Creek off the northern arm of Gross Reservoir, would be inundated. Forsythe Falls is a popular destination for many hikers at Gross Reservoir due to its scenic nature, and its inundation would constitute a major long-term impact.

Lands above the proposed normal water level with high scenic quality would not be impacted, although they would be perceived differently from new viewpoints and within a new context. Overall, the existing landscape character (e.g., clear water reservoir, rocky shorelines, and steeply sloped forested hillsides set against high mountain peaks) would be retained.

The majority of existing recreational use areas would be inundated under the Proposed Action, resulting in the relocation and reconstruction of all recreational use areas to some degree and several major access roads. Abandoned road segments and temporary construction roads remaining above the proposed high water level would be reclaimed. Roads, parking lots, and recreational use areas would be replaced in accordance with the Gross Reservoir Recreation Management Plan (Denver Water 2004b, 2008a). Under these guidelines, the desired landscape character of new recreational use areas would continue to be achieved over time, resulting in improvements to several existing degraded areas. However, due to the steep slopes and rocky soils in many parts of the study area, the new north and south dam relocated access road including parking lots may require moderate to highly visible cut-and-fills to accommodate road grades. Permanent road relocations would be considered a minor to moderate adverse impact.

Other lands disturbed during construction that would remain above the proposed high water level include the portions of the main quarry site, auxiliary spillway, staging areas, and stockpile areas. Approximately 30 acres of permanent disturbance would remain above the high water level.

Post-construction, the upper portion of the quarry site would remain visible above the enlarged reservoir's water surface. Appendix M contains conceptual mitigation proposed by Denver Water for the Project and incorporates several techniques to comprehensively address this visual impact, including the use of rock stain to reduce the degree of contrast created by newly exposed bedrock, as well as other techniques such as sculpting the exposed rock to mimic a natural landform and selective planting to break up the scale of the disturbance. Effective mitigation measures would reduce visual impacts to a level that would be consistent with a high scenic integrity objective. Conversely, an inability to effectively implement these mitigation measures would result in a major permanent impact that would be visible to boaters, adjacent residential areas, and from other viewpoints surrounding the reservoir.

The auxiliary spillway constructed of riprap and concrete would be located in a natural topographic saddle through an open, ponderosa pine/grassland savannah, which currently contains one access road. The auxiliary spillway would create a major permanent impact due to the degree of change in landscape character.

The remaining lands disturbed during construction above the proposed high water level are staging and stockpile areas in the vicinity of the Dam Recreation Area and South Boulder Creek. In conjunction with the main quarry, the dam staging and stockpile areas would be

the most visible effect in the study area, attracting attention in the foreground from North Shore/Peninsula, Forsythe Canyon, and Winiger Ridge, and for over a mile east of Gross Reservoir on Gross Dam Road. The South Dam Recreation Area's long-term appearance after reclamation consisting of highly modified landforms, uneven vegetation, and barren slopes of loose and light-colored material extending into the reservoir would be similar to the Current Conditions (2006), resulting in a minor adverse temporary impact. Below the dam, the South Boulder Creek construction staging areas after reclamation would be less visible and create minor adverse contrasts, as they occur in an area of restricted public access and existing powerplant and utility facilities.

Under the Proposed Action, the dam axis, arch radius, crest width, materials, and downstream slope would remain similar to the existing visual conditions, but at a larger scale. The dam height would be increased by approximately 131 feet and the crest length would be lengthened by several hundred feet. As a result, the enlarged dam would become more visible from some roads and other viewpoints within the Project vicinity. While this would constitute a major change compared to Current Conditions (2006), the dam has been in use for over 50 years and in that time has become an acceptable architectural element of the landscape character; thus the dam raise itself would result in a minor visual impact.

Management Guideline Impacts

Under the Proposed Action, no areas of the Winiger Ridge Natural Landmark or 250 foot buffer zone surrounding the landmark would be inundated as described in the Environmental Resources Element of the Comprehensive Plan and shown on the Zoning District Maps of Boulder County.

Scenery guidelines in the Denver Water Article 414 Visual Resource Protection Plan and U.S. Forest Service (USFS) Arapaho & Roosevelt National Forests Plan require that "the overall landscape character around the reservoir should remain natural appearing with limited human intervention," (Denver Water 2004b), and that the valued landscape character appear intact. The scenic integrity objectives for the USFS land that would be disturbed by the quarry state that "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). It is not possible to completely mitigate the major short-term direct construction impacts in order to meet these objectives.

Long-term impacts would only partially meet the desired future condition. The new shoreline and recreational use areas would retain the existing, valued landscape character. The new water elevation, reservoir size, and dam would not be "at such a scale that they are not evident" in the short term, but would become less evident in the long term as viewers became accustomed to the new reservoir size. The quarry, if effectively reclaimed, would "repeat the form, line, color, texture, and pattern common to the landscape character…[in such a way] that they are not evident." The auxiliary spillway, however, would not be compliant with management guidelines and would be considered a major, adverse long-term impact.

5.17.1.2 River Segments

There is a strong correlation between flow levels and how viewers rate the aesthetic appearance of a given stream. Low flows (primarily in winter and early spring months), when much of the channel is not occupied by water and the stream has a "dried up" appearance, are generally rated lower in aesthetic quality than higher flow conditions. Similarly, peak flow levels are also generally rated lower in aesthetic quality than normal flow levels. For example, a study of the Cheoah River in North Carolina that used visual preference survey techniques found that viewers nearly doubled their preference ratings for each successive flow increase between a low flow of 25 cubic feet per second (cfs) up to 230 cfs. However, as flows increased above 230 cfs, there was a rapid drop in the preference ratings as flows increased to 670, 950 and ultimately 1,130 cfs (EDAW 2002).

The conclusions in the North Carolina study are supported by similar results from other studies conducted in the western United States (U.S.). For example, a study on the Cache la Poudre River in Colorado showed that scenic quality ratings increased as flow increased, but only to a certain point. In the Colorado study, this point occurred at approximately 1,300 cfs, or 65% of the average flow in June. Scenic quality ratings decreased at flows above 1,300 cfs (Brown and Daniel 1991). Another example involved a study on the Virgin River in Zion National Park, which showed that during periods of low flow, small increases in flow resulted in a dramatic increase in aesthetic quality ratings. However, there was little or no improvement in ratings at medium and high flows (Whittaker and Shelby 2002). As Litton reported, the lower aesthetic quality ratings may be attributable to the fact that higher flows tend to drown out riffles, pools, and other features of interest within the stream channel (Litton 1984).

The Moffat Project would have a varying level of effect on stream flows, diminishing flows at some locations and increasing flows at other locations and at different times of the year. In general, the Moffat Project would have only a minor effect on flow levels during periods of low flows, when streams are most sensitive to visual change. Most of the flow changes would occur during periods of naturally higher flows (May, June, and July). The resulting flows would still be within the range of natural variability, both seasonally and from year to year, that is acceptable to and expected by most viewers, as described in Section 3.17.5. The visual experience in mountain communities often contributes to a diverse recreation experience, and to some extent, helps to characterize surrounding land uses. Given the high amount of visitation in some mountain communities for recreation, tourism and as retirement and vacation destinations, flow reductions in certain times of year may have minor, indirect effects to overall experience for visitors and residents. Exceptions to these general statements are addressed in more detail in the following sections, considering Full Use of the Existing System and implementation of a Project alternative (2032).

As discussed in Section 5.8, reduced flows are not anticipated to cause any landscape scale changes in riparian vegetation communities. Therefore, the Moffat Project is not expected to adversely affect the visual quality of any stream corridors through modification of existing vegetation.

For each of the following river segments, anticipated visual resource changes associated with flow changes between Full Use of the Existing System to the year 2032 with a Project alternative are discussed.

Colorado River

When comparing Full Use of the Existing System to the Proposed Action, all flow depletions (all months of all years) would be below the level of perceptible change. For example, at Hot Sulphur Springs, average flows in May would drop by less than 5% and by less than 1% at Kremmling. Flows during periods of low flow, i.e., fall to winter, would show little or no change. As such, there would be no impacts to visual resources or aesthetics on this river segment resulting from the Proposed Action compared to Full Use.

Fraser River

When comparing Full Use of the Existing System to the Proposed Action, flow changes on the Fraser River would result in visual or aesthetic impacts in May, June, and July of an average year. The intensity of the impact would be greatest near the Winter Park gage and would diminish downstream towards the Granby gage. Exact percentages vary, but flow reductions near the Winter Park gage would be about as much as 43% in June in average years under the Proposed Action compared to Full Use of the Existing System. These reductions in average monthly flows would be detectable and even apparent to many observers. However, as noted in studies cited at the beginning of this section, flow reductions during periods of high flow may not be perceived as adverse.

Downstream of Crooked Creek, impacts would be further reduced and would be detectable only to skilled observers. For example, flows in June below Crooked Creek would drop from 476.3 cfs under Full Use to 387.6 with the Proposed Action, a reduction of 19%. At locations higher in the basin, little or no reduction in flows would occur during periods of low flow, i.e., during the fall and winter months.

As no additional diversions are planned in dry years under the Proposed Action compared to Full Use of the Existing System, it is not anticipated that there would be any flow changes at this time when the river would be most vulnerable to visual change. For example, in the low flow period August through December, flows near Winter Park would be almost identical for Full Use and the Proposed Action, with a slightly higher reduction occurring in January when flows would drop from 4.0 cfs under Full Use to 3.9 cfs with the Proposed Action. A similar pattern would result at locations further downstream.

Williams Fork River

Flow changes between Current Conditions (2006) and the Proposed Action would exhibit a similar pattern to that described on the Fraser River. In the upper basin, the greatest absolute flow changes would occur in June and July. For example, average flows in June under Project implementation would drop from 87.3 cfs at Full Use to 69.3 cfs near the Steelman Creek gage, a reduction of approximately 21%. The reduction from Full Use above the Darling gage would be from 162.8 to 144.9 cfs, or 11%. Overall, when comparing Full Use of the Existing System to the Proposed Action at most locations, flow changes associated with Project implementation would be minor and largely limited to periods of high flows when changes are less perceptible and not likely to be noticed by most observers. Flow reductions during periods of low flow would be minimal at all locations on the Williams Fork; however, any reductions in flows during these periods would be considered adverse. When comparing Full Use of the Existing System to the Proposed Action, no flow changes would occur above William Fork Reservoir during dry

years. The only flow decrease in dry years would be a flow reduction of 1% in July below Williams Fork Reservoir under the Proposed Action.

Blue River

Blue River flows are highly variable between seasons and years because of the dam releases from Dillon and Green Mountain reservoirs. When comparing Full Use of the Existing System to the Proposed Action, flow changes (including depletions and increases) as a result of the Proposed Action would be imperceptible in all months of all years, except in October of wet years above Green Mountain Reservoir (15%) below the confluence with Boulder Creek. This change would be within the range of normal variability and would also be consistent with changes as a result of frequent dam releases and the seasonal drop-off in flows (i.e., transition into winter low flows). As such, impacts to visual resources on the Blue River above Green Mountain Reservoir would be negligible. Below Green Mountain Reservoir, the flow changes would be below the level of perceptible impacts.

South Boulder Creek

South Boulder Creek would serve as the conduit for increased West Slope diversions under Full Use of the Existing System. When comparing Full Use of the Existing System to the Proposed Action above Gross Reservoir, minor flow increases in South Boulder Creek would be imperceptible to casual observers with the exception of June, when flow increases would be 106 cfs (17%) and 153 cfs (32%) in average and wet years. Overall, visual impacts to South Boulder Creek above Gross Reservoir would be minor and beneficial.

When comparing Full Use of the Existing System to the Proposed Action, reservoir outflow changes would be significantly higher in winter months (i.e., low flow periods) of all years immediately below Gross Reservoir. Average year flows are projected to increase by as much as 865% from 10 cfs to 88 cfs below the dam in January. These additions, while high in the winter, are characteristic of early spring flows and though perceptible would not create an adverse effect.

When comparing Full Use of the Existing System to the Proposed Action, no perceptible impacts to stream appearance or other visual resources would result downstream (near Eldorado Springs gage).

North Fork South Platte River

When comparing Full Use of the Existing System to the Proposed Action, summer flows would increase, resulting in an additional 13 to 29% during the summer months from May through August below the Geneva Creek gage. A decrease of winter flows of as much as 30% would also occur from November through March. These decreases would result in adverse minor to moderate impacts to visual resources.

South Platte River

When comparing Full Use of the Existing System to the Proposed Action, flow changes on the South Platte River, with the exception of immediately below Chatfield Reservoir, would be imperceptible to the casual observer, in which case no additional impacts are expect to

occur to visual resources. Under the Proposed Action, flows on the South Platte River below Chatfield Reservoir (but above Denver gage) would increase by approximately 25% during the months of December and January in average years, about 30% during the months of January and April in dry years, and 27% in December of wet years, resulting in a minor beneficial effect on aesthetic quality along this reach. Flow depletions in all other months of all years would be imperceptible to casual observers.

5.17.2 Alternative 1c

5.17.2.1 Gross Reservoir

The slightly smaller surface size and lower dam height of Gross Reservoir under this alternative would not substantially change from the visual impacts described under the Proposed Action.

5.17.2.2 Leyden Gulch Reservoir Site

As described in Section 3.16, the scenic quality of Leyden Gulch Reservoir site itself is low due to the uniform vegetation. However, when experienced in context with the varied topography around Leyden Creek, the steep uplift of the Laramie Formation hogback to the east, and panoramic views of the Front Range mountain backdrop to the west, the overall landscape has a high degree of scenic interest. The reservoir site is highly visible. 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.

The primary components of Alternative 1c would permanently modify the existing visual condition in the following ways:

- Inundation of 332 acres at a normal water level
- 177-foot high, 5,400-foot long, and 40-foot wide earthfill dam
- Dam spillway structure and outlet works
- Relocation of approximately 4,000 feet of State Highway (SH) 93
- New buried pipelines and a tunnel
- New concrete diversion box structure inlet for the South Boulder Diversion Canal
- Increase in paved and impervious surfaces
- Five new access roads
- Decrease in flows and potential riparian vegetation changes downstream of the Leyden Gulch un-named drainage
- Changes in reservoir elevations (releases, storage, fill rates)
- Reservoir operations (traffic, monitoring, minor repair and maintenance activities)
- Site fencing

- Service lighting
- Aboveground wood-post transmission line (12 kilovolts) (alignment to be determined)
- Long-term restoration of three staging areas

Visual Contrast Impacts

Temporary construction activities such as the realignment of SH 93, borrow area and dam foundation excavation, construction staging, stockpile and spoil areas, vegetation removal, heavy machinery traffic, pipeline and tunnel construction, and access and haul road construction would exhibit dust and bare soils to viewers creating short-term direct impacts to visual resources. These activities would be highly visible to travelers along SH 93 and SH 72, from residences, and to passive recreational users of adjacent open space. These activities would create a major degree of contrast (or incompatibility) with the recreational and scenic nature of the area.

The most visible primary components of a new reservoir facility would include the earthfill dam, dam spillway structure and outlet works, relocation of SH 93, an increase in reinforced or impervious surfaces, new access roads, site fencing, service lighting, aboveground wood-post transmission line, and ongoing restoration of three staging areas.

Most views along SH 93 are directed towards the ponderosa pine-dominated Front Range backdrop or the Laramie Formation hogback, one of the most striking landforms experienced in the 20-mile drive between the cities of Boulder and Golden along SH 93. A new dam would lie in the immediate foreground adjacent to and above travelers on SH 93, and with contrasting lines, textures, and scale compared to the Current Conditions (2006). The crest of the dam would rise approximately 200 feet above SH 93, creating a tunnel effect and obstructing existing views of the Front Range to viewers for a distance of over 4,000 feet. The relocated section of SH 93 would lie 400 feet to the east of its existing alignment, within 150 horizontal feet of the north-south rock faces, with cut slopes and a disturbance area within 50 feet of the steep Laramie Formation walls. The revegetated downstream face of the earthfill dam would be highly visible and appear as a grass-covered, engineered slope.

The reservoir body, while a new feature to Leyden Gulch, would appear compatible with and potentially be an improvement to the open, rangeland character of the region which is already consists of scattering of open water storage facilities, such as Francis Smart Reservoir, Marshall Lake, Tucker Lake, and Blunn Reservoir, and numerous other man-made water bodies visible from SH 93. The change in visual condition, while not directly impacting local government open space properties, modifies the context in which they are viewed. Rather than being perceived as one continuous prairie/rangeland, man-made reservoir facilities could appear to fragment the viewshed. However, to the average viewer, the predominant views available of the new reservoir would not allow the entire water body to be seen within Leyden Gulch; rather views from SH 93 would be directed toward the earthfill dam. Partial views of the water body would be seen from SH 93 and SH 72.

Figure 5.17-2 shows a photographic simulation of the new Leyden Gulch Reservoir at 31,300 AF. Primary differences between the existing landscape character and the simulated condition are the new reservoir water body, dam crest, and inlet tower. From this viewpoint, weak and moderate visual contrasts would be created by the new access roads, site fencing, service lighting, aboveground wood-post transmission line, and ongoing restoration of three staging areas. In summary, a new reservoir at Leyden Gulch would result in a major degree of permanent contrast from the existing scenic attributes and a loss of important views to scenic areas from some viewpoints.

Management Guideline Impacts

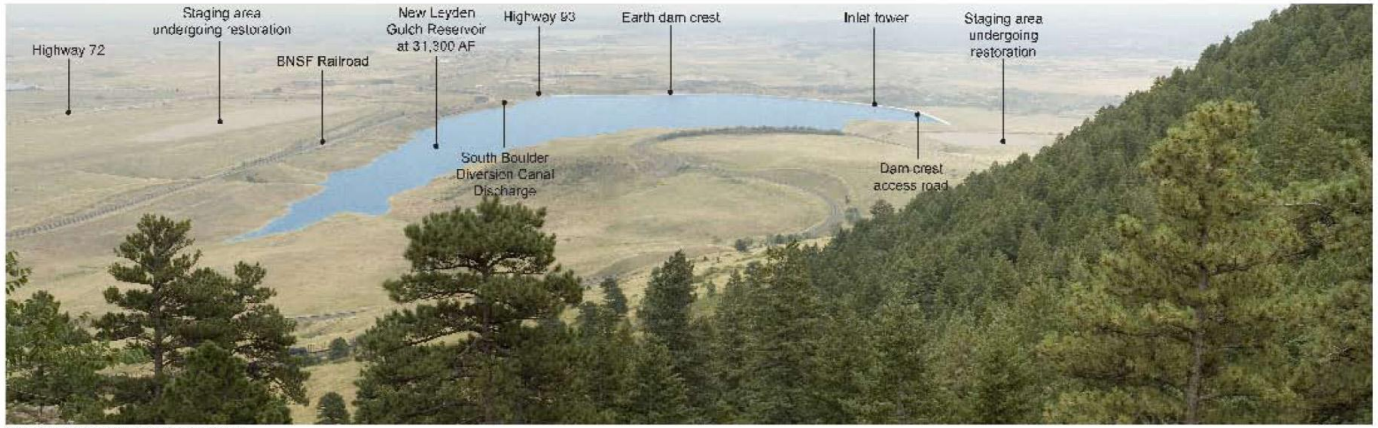
Boulder County and Jefferson County open space programs have acquired properties to the immediate north and south as part of the Front Range Mountain Backdrop/Foreground Preservation Project to ensure that the foothills, hogbacks, and other key Front Range visual areas are protected. Preserving view corridors have been a primary purpose of the Jefferson County open space program for over 25 years (Jefferson County 2008), and similar policies are reflected in the Jefferson County Comprehensive Plan (Jefferson County 2012), and City of Arvada Comprehensive Plan. These plans state that scenic views along highways should be protected, including Colorado SH 93, (Jefferson County 2006b). The Arvada plan states "Arvada would identify and maintain appropriate mountain view corridors from public streets and places as new development occurs" (City of Arvada 2005). Construction of a reservoir and dam at Leyden Gulch would result in a marked change in visual environment by obstructing views, converting a natural-appearing setting to a more developed condition, and potentially degrading scenic features. Therefore, it would not be compliant with existing management and policy guidance, and would be considered a long-term impact.

The potential visual impacts of both an enlarged Gross Reservoir and a new Leyden Gulch Reservoir as proposed in Alternative 1c would be more substantial than the visual impacts of alternatives that include only one reservoir.

5.17.2.3 River Segments

Alternative 1c would create similar visual impacts on river segments as those described for the Proposed Action.

Existing Conditions



Photographic Simulation

Note: 31,300 AF of storage as seen from Eastridge Road.

Moffat Collection System Project FEIS

Figure 5.17-2
Photographic Simulation of the Proposed Leyden Gulch Reservoir

9/4/12

5.17.3 Alternative 8a

5.17.3.1 Gross Reservoir

The slightly smaller surface size and lower dam height of Gross Reservoir under this alternative would not substantially change the visual impacts described under the Proposed Action.

5.17.3.2 South Platte River Facilities

Visual Contrast Impacts

The primary components of the South Platte River Facilities (South Platte River Diversion, gravel pit storage, and the Advanced Water Treatment Plant [AWTP]) would occur in an active and historic gravel mining and agricultural district that has been highly modified to exhibit an engineered rather than natural appearance. Consequently, scenic quality is generally low, visual absorption capacity is high, and user sensitivity is low. An exception to this is the South Platte River channel, oxbows, and restored gravel pits with mature vegetation that provide visual interest, especially along the western shoreline and bluffs that constitute the Adams County Regional Park. For the purposes of this visual assessment, existing gravel pit facilities representative of the proposed Project gravel pits and facilities are analyzed. The actual location and configuration of the gravel pits and associated facilities would be determined during the design phase.

The 150-foot long concrete diversion would direct flows into a gravel mining area on the eastern side of the South Platte River. It would be sited adjacent to the Adams County Regional Park, and would be highly visible from park facilities, campgrounds, and the South Platte River Trail, a regional multi-use trail that serves as the basis for the future South Platte Greenway. Construction of the diversion would result in a major adverse temporary degree of contrast to the Current Conditions (2006). During operations, the diversion would create a moderate degree of long-term contrast to visual resources against the restored western shoreline and sinuous river channel.

The pipeline between the diversion and gravel pit storage would not be visible from the recreational use areas except during construction, when it would create a negligible degree of short-term visual contrast.

Utilizing available water storage capacity in previously constructed gravel pits would improve the scenic quality of the study area. This would result in minor beneficial long-term visual improvements.

Advanced Water Treatment Plant

Four acres adjacent to the Worthing Pit would be converted to an AWTP, consisting of several buildings and structures no more than two stories in height (about 25 to 30 feet). Building architecture would be designed to be consistent with the surrounding area. Visual contrast resulting from the new facilities would be negligible as residential and gravel processing buildings of similar scale and architecture currently exist within the study area.

Dechlorination Facility

This unlit concrete structure would be visible along SH 72 east of the Leyden Gulch Reservoir site, a regional transportation corridor that is rapidly urbanizing. Short-term visual contrast would result during construction; however, there would be no long-term effect as the facility is of comparable size and scale with nearby buildings.

Management Guideline Impacts

The existing lakes in the unincorporated Project vicinity, including those within the Adams County Regional Park, were all created through gravel mining activities (Adams County 1999). Water storage activities (including river diversions) are allowable uses in the Adams County development regulations for the Project area (Adams County 2005). The Adams County Regional Park Master Plan acknowledges the short-term construction impacts relating to gravel mining and water storage operations and anticipates their future positive contributions to the scenic and recreational character of the area in 10 to 20 years. Therefore, while construction of the South Platte River diversion and AWTP would create short-term contrasts to the existing visual resources, the Project does not conflict with the scenic management guidelines for the area.

5.17.3.3 Conduit O

Conduit O would be constructed within existing road right-of-ways (ROWs) (curb-to-curb) and the final alignment would be selected to minimize interferences with environmentally sensitive areas or watercourses. Construction of the water delivery pipelines and temporary staging areas would cause temporary visual impacts due to the construction activity and the soil disturbance. If it were necessary to extend construction beyond a roadway due to the final alignment, the newly constructed pipeline ROW would contrast visually with the adjacent vegetation and be apparent to nearby viewers until revegetation efforts are completed. For open cut crossings of rivers and streams, riparian vegetation would be removed resulting in a break in continuous tree canopies, creating a minor degree of contrast. Visual contrasts would gradually decrease as the ROW revegetated, which would occur within one to three growing seasons. Small, aboveground facilities, such as pump stations, control valves, blow-offs, etc., would be visible within or immediately adjacent to streets. These facilities would cause only a minor degree of contrast; long-term impacts would be minor or negligible. Construction activities would result in no permanent surface disturbance or negligible long-term visual contrasts.

5.17.3.4 River Segments

Alternative 8a would create similar visual impacts on river segments as those described for the Proposed Action.

5.17.4 Alternative 10a

5.17.4.1 Gross Reservoir

The slightly smaller surface size and lower dam height of Gross Reservoir under this alternative would not substantially change from the visual impacts described under the Proposed Action.

5.17.4.2 Denver Basin Aquifer Facilities

The specific locations of the 27 well facilities (81 individual wells) located throughout more than 20 City and County of Denver properties have not been identified. These facilities would be developed over the life of the Project. However, based on the representative sites, it is likely that well sites would be located in or near areas sensitive to visual impacts, such as City of Denver parks that are managed to optimize a specific recreational experience. As these properties are highly valued public recreational and gathering sites in the Denver Metropolitan area, visual absorption capacities in the parks are low. Adverse impacts from the visual contrast created by well clusters would vary based on their placement within each park as well as the size and type of park. Generally, the smaller parks and special interest locations (such as sculpture parks or memory gardens) would experience adverse impacts to visual character. Larger parks that offer a variety of built amenities or a diversity of topography and vegetation for screening would experience minor impacts.

Approximately 36 miles of 12- to 48-inch pipeline would be buried in city streets and urban utility corridors within existing road ROWs/easements to connect to Denver Basin aquifer well sites. Construction of the pipelines and temporary staging areas would cause temporary direct effects due to the construction activity and the soil disturbance. If it were necessary to extend construction beyond a roadway due to the final alignment, the newly constructed pipeline ROW would contrast visually with the adjacent vegetation and be apparent to viewers until revegetation efforts are completed. Visual contrasts would gradually decrease as the ROW vegetation re-established, which would occur within one to three growing seasons. Construction activities would result in no permanent surface disturbance (i.e., negligible long-term visual contrasts).

Four acres adjacent near the Denver Water Recycling Plant would be converted to an AWTP, consisting of several buildings and structures no more than two stories in height (about 25 to 30 feet). The exact location of the building would be determined during the design phase. Building architecture would be designed to be consistent with the surrounding area, which is dominated by heavy industrial and manufacturing uses. No visual contrast would result from the new facilities as industrial buildings of similar scale and architecture currently exist within the Project area.

5.17.4.3 Conduit M

Impacts to visual resources for Conduit M would be the same as those described for Conduit O under Alternative 8a.

5.17.4.4 River Segments

Alternative 10a would create similar visual impacts on river segments as those described for the Proposed Action.

5.17.5 Alternative 13a

5.17.5.1 Gross Reservoir

The slightly smaller surface size and lower dam height of Gross Reservoir under this alternative would not substantially change from the visual impacts described under the Proposed Action.

5.17.5.2 South Platte River Facilities

Impacts to visual resources by the South Platte River Facilities would be the same as those described for Alternative 8a. Transfer of agricultural water rights on about 3,900 acres would primarily affect irrigated croplands. However, the exact location of these areas cannot be identified at this time. Generally, the types of visual impacts would be expected to include conversion of irrigated cropland to dryland cultivation and/or urban development. Either scenario has the potential to affect scenic character in the area. The conversion to dryland agricultural uses or pasture grasslands would likely result in an increase in noxious weed infestations and urban development would create contrasts with the otherwise rural or scenic qualities. Some emergent wetlands would also convert to grassland when water sources are removed. These changes are likely to be perceived by viewers as an adverse impact on visual resources

5.17.5.3 Conduit O

Impacts to visual resources for Conduit O under Alternative 13a would be the same as those described for Alternative 8a.

5.17.5.4 River Segments

Alternative 13a would create similar visual impacts on river segments as those described for the Proposed Action.

5.17.6 No Action Alternative

As there would be no ground-disturbing activities, there would be no direct impacts to visual resources as a result of the No Action Alternative. However, minor indirect impacts to visual resources would occur at Gross Reservoir as a result of more frequent and prolonged drawdowns. The area between the normal water elevation and the minimum drawdown level would remain barren of vegetation and would create unattractive visual contrasts for observers, particularly recreationists.

With the exception of mandatory restrictions imposed during Stages 3 and 4 drought periods, visual resources in the vicinity of Project components and throughout the greater Project service area would remain largely unchanged under the No Action Alternative. In

both Stages 3 and 4 droughts, lawn watering would be prohibited. Under Stage 3 drought restrictions, trees, shrubs, and high-use public turf areas would be limited to watering once per week. As discussed in Section 5.7, this would result in temporary stresses to irrigation dependent vegetation. Subsequently, visual resources may be impacted in the more serious stages of drought and mandatory restrictions because of the temporary die-back or browning of vegetation cover. Public areas, such as parks, would experience only minor impacts during the Stage 3 droughts and would likely recover once restrictions were lifted. However, under Stage 4 drought restrictions, all outdoor watering would be prohibited, including trees, shrubs, and high-use public turf areas. The scenic and aesthetic qualities of public parks, golf courses, and greenways would experience moderate to major adverse effects by the watering ban because of prolonged die-back, browning, or even mortality of landscaping plants.

With respect to stream flow modifications, Project impacts would be the same as was described for the No Action Alternative in Section 4.6.17.6.

5.17.7 Mitigation and Monitoring

Possible mitigation measures to minimize impacts to visual resources may include:

- The Gross Reservoir Visual Resource Protection Plan should be updated and followed in developing new recreational use areas, roads, and other Project facilities.
- The contours, topsoil, and vegetation of the Gross Reservoir dam staging area should be restored to approximate adjacent Current Conditions (2006).
- The quarry and auxiliary spillway would be mitigated, as practicable, through contouring, rock sculpting, topsoil reclamation, selective plantings, and rock staining so that new rock faces and concrete surfaces blend with existing, adjacent rock outcroppings. These mitigation measures would be developed further in conjunction with USFS.
- Ground disturbance, including shrub and tree removal should be minimized, to the fullest extent possible.
- The U.S. Department of the Interior, Bureau of Reclamation should re-contour disturbed land along the delivery pipelines, and other aboveground facilities to the original approximate conditions.
- Revegetation should proceed as soon as practicable, and plant species should be selected to complement Current Conditions (2006) or adjacent vegetation.
- Well houses and the dechlorination facility would be designed to blend as much as reasonably possible with the surrounding natural setting or adjacent architecture.
- Yard lights used for nighttime lighting of facilities should be downcast types, minimizing upward diffusion of lights.

5.17.8 Unavoidable Adverse Impacts

Alternative 1c would result in an unavoidable change to the visual character of Leyden Gulch. The existing native vegetation and landform in the gulch areas would be inundated by the proposed reservoir and visually changed to a water storage feature.

All action alternatives would result in unavoidable changes to the scenic quality of Gross Reservoir. The existing native vegetation and landform in the quarry, auxiliary spillway area, and dam staging and stockpile areas would be changed to engineered features.

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5.18 CULTURAL/HISTORICAL/PALEONTOLOGICAL RESOURCES

This section describes the direct and indirect impacts to cultural, historic, and paleontological resources expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Three potential cultural/historical resources issues were documented during the scoping process:

- Impacts of a Gross Reservoir enlargement on inundating archaeological and historical resources.
- Impacts on remnants of American Indian Tribal activity in Leyden Gulch and historic ranching and cattle grazing at the site.
- Impacts on historic mining structures from possible relocations of State Highway (SH) 93 and the Denver and Rio Grande Railroad under Alternative 1c. (Relocation of a portion of the railroad is no longer a component of Alternative 1c.)

This section evaluates the potential for Moffat Project effects to significant prehistoric and historic sites and to traditional cultural properties. Prehistoric and historic sites and traditional cultural properties are considered significant if they are listed in or eligible for listing in the National Register of Historic Places.

Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA) requires Federal agencies to consider any impacts a project with Federal involvement would have on significant cultural resources. The Advisory Council on Historic Preservation (ACHP) has set procedures (36 Code of Federal Regulations [CFR] 800) to be followed to determine the impact a project may have on significant cultural resources and how to mitigate that impact if it is determined to be adverse. In compliance with 36 CFR 800 and 33 CFR Part 325 Appendix (including the April 25, 2005 Corps' Interim Guidance), the Board of Water Commissioners (Denver Water), the U.S. Army Corps of Engineers (Corps), Colorado State Historic Preservation Officer (SHPO), ACHP, U.S. Forest Service (USFS), Boulder, Colorado Historic Preservation Advisory Board, and various American Indian Tribes have prepared a draft Programmatic Agreement (PA) for cultural resources that stipulates how significant cultural resources are to be treated, including site avoidance or protection measures and data recovery (refer to Appendix L). The Federal Energy Regulatory Commission (FERC) also has Section 106 compliance responsibilities for impacts associated with the selected alternative to historic properties within the Project boundary of the licensed hydroelectric facility. However, FERC chose not to be a signatory to the PA and preferred that Denver Water demonstrate compliance with Section 106 of the NHPA in its license amendment application using the cultural resources provisions in the Project license. The PA will serve as the official compliance document for Section 106 of the NHPA and would be referenced in the Record of Decision for the Moffat Project, if an action alternative is permitted as an outcome of this National Environmental Policy Act of 1969, as amended (NEPA) process. The PA also identifies the actions that would need to be taken by Denver Water in the event that inadvertent discoveries of cultural resources or human remains are made during construction or operation of the Project.

5.18.1 Proposed Action (Alternative 1a)

5.18.1.1 Gross Reservoir

Expansion of the dam, reservoir, and related facilities would permanently affect the dam and reservoir itself (site 5BL10210) and a portion of the Resumption Flume (site 5BL7019.1). These impacts are considered to be a major and permanent impact and treatment of this impact would be required before construction begins. Enlargement of Gross Reservoir would have no impact on paleontological resources, nor would there be any impact to cultural or archaeological resources from inundation.

5.18.2 Alternative 1c

5.18.2.1 Gross Reservoir

The impacts to Gross Reservoir under Alternative 1c are the same as those described for the Proposed Action.

5.18.2.2 Leyden Gulch Reservoir Site

Eighteen significant cultural and historic sites are located within the Area of Potential Effects (APE) for the construction of the proposed Leyden Gulch Reservoir site. Alternative 1c would have temporary impacts to three significant sites and permanent impacts to six significant sites. The remaining nine sites would not be impacted. These impacts and their impacts are summarized in Table 5.18-1 and discussed further below.

Table 5.18-1
Summary of Impacts to Significant Sites from Leyden Gulch Reservoir

Site Number	Site Type	Impact Type	Proposed Mitigation Measures
5JF314	Independence Mine	No impact	None
5JF516	South Boulder Diversion Canal	Permanent/Moderate	Preparation of Historic Context for Moffat Collection System
5JF2224.3	Clear Creek-Ralston Canal	Temporary/Negligible	None
5JF2346.4	Railroad Segment	No impact	None
5JF2346.8	Railroad Segment	No impact	None
5JF2402	Clay Mine	No impact	None
5JF4304	Prehistoric Open Camp	No impact	None
5JF4305	Prehistoric Open Camp	Permanent/Major	Data Recovery
5JF4308	Prehistoric Open Camp	No impact	None
5JF4309	Historic Artifacts and Features	No impact	None
5JF4314	Prehistoric Open Camp	No impact	None
5JF4315	Prehistoric Open Camp	Permanent/Major	Data Recovery
5JF4318	Historic Artifact Scatter	Permanent/Major	Archival Research and Data Recovery

Table 5.18-1 (continued)
Summary of Impacts to Significant Sites from Leyden Gulch Reservoir

Site Number	Site Type	Impact Type	Proposed Mitigation Measures
5JF4320	Historic Artifacts and Features	Permanent/Major	Archival Research and Data Recovery
5JF4321	Abandoned Clay Mine	Permanent/Major	Archival Research, Level I Documentation, Data Recovery
5JF4363.1	Wagon Road	No Impact	None
5JF4398	Abandoned Clay Mine	Temporary/No Impact	Avoidance Measures
5JF4399.1	Ralston Dam Spillway	Permanent/Negligible	None

Nine of these sites would not be subject to either permanent or temporary impacts. Therefore, the construction of a new Leyden Gulch Reservoir would not affect these properties and no mitigation measures would be required.

The following six historic and cultural sites would be subject to permanent impacts:

- The segment of the South Boulder Diversion Canal (site 5JF516) that currently runs through a siphon that is located in the proposed reservoir pool area would be abandoned and partially removed, which would constitute an adverse impact. Because this resource is buried, *in situ* documentation would not be feasible; therefore, the preparation of a historic context on the Moffat Collection System is proposed as a mitigation measure to treat the moderate impact to the South Boulder Diversion Canal.
- A prehistoric archaeological camp (site 5JF4315) is located in the proposed reservoir pool area that would be destroyed by construction, which would constitute an adverse impact. Archaeological data recovery excavation of this site, in coordination with the SHPO and American Indian Tribes, is proposed as a mitigation measure to treat the major impact.
- Historic archaeological sites (sites 5JF4318 and 5JF4320) are located in the proposed dam and reservoir pool areas, respectively, that would be destroyed by construction, which would constitute an adverse impact. Archival research and archaeological data recovery excavation of these sites are proposed as mitigation measures to treat the major impact.
- An abandoned clay mine (site 5JF4321) that would be impacted by the base of the proposed dam and the associated re-alignment of SH 93, which would constitute an adverse impact. Archival research, archaeological data recovery excavation, and Level I documentation of this site are proposed as mitigation measures to treat the major impact.
- An access road to the South Tunnel Portal would be constructed to connect to an existing road that crosses the Ralston Dam Spillway (site 5JF4399.1). Although this would be a permanent impact because the access is connecting to an existing road that already crosses the spillway, it is considered to be a negligible impact.

The following three cultural and historic properties would be subject to temporary impacts:

- The Clear Creek-Ralston Canal (site 5JF2224.3) would be impacted by construction of the cut and cover pipeline to Conduits 16 and 22. The canal would be restored to its original condition and therefore would be a negligible impact.
- A prehistoric archaeological camp (site 5JF4305) is located in the temporary construction impact area near the proposed reservoir pool. While the impact itself will be temporary in nature, it is likely that the site would be permanently destroyed by construction activities, which would constitute a major impact. Archaeological data recovery excavation of this site, in coordination with the SHPO and American Indian Tribes, is proposed as a mitigation measure to treat the adverse impact.
- An abandoned clay mine (site 5JF4398) is located along the edge of the temporary construction area for cut and cover pipeline to Conduits 16 and 22. The site boundary would be marked off and construction activities would be directed to avoid this site thereby avoiding any impacts to it.

Although no paleontological resources have been identified within the APE of Alternative 1c, the area is underlain by the Pierre Shale, which is characterized as Class I (i.e., areas that are known or are likely to produce abundant significant fossils that are vulnerable to surface disturbing activities) for paleontological resources. Therefore, awareness training of construction personnel and paleontological monitoring are recommended as mitigation measures.

During the initial scoping, concerns for impacts to prehistoric archaeological sites and historic ranching sites were expressed. While Alternative 1c would have adverse impacts to a few pre-historic sites and historic ranching sites, the adverse impacts would be appropriately treated prior to construction activities in accordance with a PA among the Corps, SHPO, and other parties.

5.18.3 Alternative 8a

5.18.3.1 Gross Reservoir

The impacts to Gross Reservoir under Alternative 8a are the same as those described for Alternative 1c.

5.18.3.2 South Platte River Facilities

No significant cultural, historical, or paleontological resources are known to exist within the APE that would be impacted by the South Platte River Facilities. A specific archaeological survey was not conducted for Alternative 8a. It is unlikely, however, that significant archaeological resources are present in this area underlain by recent alluvial deposits and has been subjected to reworking by the South Platte River and ground-disturbing activities in recent times.

5.18.3.3 Conduit O

Five significant sites are located with the APE for the construction of Conduit O. This alternative would have temporary impacts to three significant cultural and historic resources

and permanent impacts to two significant historic resources. These impacts and their impacts are summarized in Table 5.18-2 and discussed further below.

Table 5.18-2
Summary of Impacts to Significant Sites from Conduit O

Site Number	Site Type	Impact Type	Proposed Mitigation Measures
5AM39	Prehistoric Open Camp	Temporary/No impact	None
5AM899	House	Temporary/No impact	None
5JF516	South Boulder Diversion Canal	Permanent/Moderate	Level II Documentation
5JF2209	House	Temporary/No impact	None
5JF2346.7	Railroad Segment	Permanent/Negligible	None

The following two historic sites would be subject to permanent impacts:

- A segment of the South Boulder Diversion Canal (site 5JF516) would provide a terminal for Conduit O through a small concrete box constructed into the bank of the canal. This would constitute a moderate impact that would be treated through Level II documentation of this segment of the canal prior to construction.
- A segment of the Denver, Northwestern, and Union Pacific (site 5JF2346.7) would be crossed by Conduit O using Denver Water's standard bore and jack method, which would have a negligible impact on this historic property.

Three historic and cultural sites would be subject to temporary indirect impacts: a prehistoric archaeological site (site 5AM39), and two residential structures (sites 5AM899 and 5JF2209) that are located near the proposed construction corridor for the conduit. Direct impacts to these historic properties would be avoided; therefore, there would be no impact.

Conduit O would have no impact on paleontological resources.

5.18.4 Alternative 10a

5.18.4.1 Gross Reservoir

The impacts to Gross Reservoir under Alternative 10a are the same as those described for the Proposed Action.

5.18.4.2 Denver Basin Aquifer Facilities

Sixteen significant historic sites are located with the APE for the construction of the Denver Basin Aquifer Facilities. Construction of the facilities would have permanent impacts to all sixteen of the sites. These impacts and their impacts are summarized in Table 5.18-3 and discussed further below.

Table 5.18-3
Summary of Impacts to Significant Sites from Denver Basin Aquifer Facilities

Site Number	Site Type	Impact Type	Proposed Mitigation Measures
5AM125	Riverside Cemetery	Permanent/Negligible	Sensitive siting of treatment plant
5DV.50	City Park	Permanent/Negligible	Sensitive siting or use of well vaults
5DV.5306	Alamo Placita Park	Permanent/Negligible	Sensitive siting or use of well vaults
5DV.5308	Congress Park	Permanent/Negligible	Sensitive siting or use of well vaults
5DV.5313	Cranmer Park	Permanent/Negligible	Sensitive siting or use of well vaults
5DV.5320	Highland Park	Permanent/Negligible	Sensitive siting or use of well vaults
5DV.5333	Washington Park	Permanent/Negligible	Sensitive siting or use of well vaults
5DV.5339	Sloan's Lake Park	Permanent/Negligible	Sensitive siting or use of well vaults
5DV.5314	Downing Street Parkway	Permanent/Negligible	None
5DV.5315	East 4th Avenue Parkway	Permanent/Negligible	None
5DV.5316	East 6th Avenue Parkway	Permanent/Negligible	None
5DV.5317	East 7th Avenue Parkway	Permanent/Negligible	None
5DV.5318	East 17th Avenue Parkway	Permanent/Negligible	None
5DV.5323	Monaco Street Parkway	Permanent/Negligible	None
5DV.5325	Montview Boulevard Parkway	Permanent/Negligible	None
5DV.5330	Speer Boulevard Parkway	Permanent/Negligible	None

A new AWTP would be constructed on a site located next to Riverside Cemetery (site 5AM125). It is anticipated that the AWTP would occupy approximately 4 acres of a 7-acre site. This would provide room to locate the plant in a manner sensitive to any potential visual or auditory impacts to the cemetery that would result in no adverse impact to the historic property. AWTP design would be consistent with the surrounding area, which is dominated by heavy industrial and manufacturing uses. Well sites would be located in seven city parks that have been determined to be historic properties (sites 5DV.50, 5DV.5306, 5DV.5308, 5DV.5313, 5DV.5320, 5DV.5333, and 5DV.5339). The well house would be sited in a manner sensitive to the historic setting of these parks, or where there could be potential conflicts, a well vault would be installed instead of a well house. The advantage of the well vault is that the structure would be primarily underground, and therefore, not visible to the public. Use of these measures would result in negligible impacts to these historic properties. The distribution pipeline serving the wells would be placed in city streets. Eight of these streets have been identified as contributing elements to the Denver Parks and Parkway System National Register District (sites 5DV.5314, 5DV.5315, 5DV.5316, 5DV.5317, 5DV.5318, 5DV.5323, 5DV.5325, and 5DV.5330). Because the pipeline would be buried and the streets restored to their pre-construction condition, this would result in negligible impacts to these historic properties.

The paleontological potential for the areas that would be impacted by the construction of these facilities is rated as Class III; therefore, their construction is unlikely to result in any impacts to significant paleontological resources.

5.18.4.3 Conduit M

Four significant sites are located within the APE for the construction of Conduit M. This conduit would have temporary impacts to one significant historic site and permanent impacts to three significant historic sites. These impacts and their impacts are summarized in Table 5.18-4 and discussed further below.

Table 5.18-4
Summary of Impacts to Significant Sites from Conduit M

Site Number	Site Type	Impact Type	Proposed Mitigation Measures
5AM1292	Gardner Ditch	Permanent/Negligible	None
5JF516	South Boulder Diversion Canal	Permanent/Moderate	Level II Documentation
5JF2209	House	Temporary/None	None
5JF2346.7	Railroad Segment	Permanent/Negligible	None

The following three historic sites would be subject to permanent impacts:

- A segment of the Gardner Ditch (site 5AM1292) would be impacted by cut and cover construction of Conduit M. The ditch would be restored to its original condition and therefore the impact would be negligible.
- A segment of the South Boulder Diversion Canal (site 5JF516) would provide a terminal for Conduit M through a small concrete box constructed into the bank of the canal. This would constitute a moderate impact that would be treated through Level II documentation of this segment of the canal prior to construction.
- A segment of the Denver, Northwestern, and Union Pacific (site 5JF2346.7) would be crossed by Conduit M using Denver Water's standard bore and jack method, which would have a negligible impact on this historic property.

One of these historic sites would be subject to temporary indirect impacts. Site 5JF2209 is a residential structure that is located near the proposed construction corridor for the conduit. Direct impacts to this historic property would be avoided; therefore, there would be no impact.

Conduit M would have no impact on paleontological resources.

5.18.5 Alternative 13a

5.18.5.1 Gross Reservoir

The impacts to Gross Reservoir under Alternative 13a are the same as those described for the Proposed Action.

5.18.5.2 South Platte River Facilities

No significant cultural, historical, or paleontological resources are known to exist in the area that would be impacted by these facilities. While a specific archaeological survey has not been undertaken in this area, it is unlikely that significant archaeological resources are

present due to the facts that area is underlain by recent alluvial deposits and has been subjected to reworking by the South Platte River and ground-disturbing activities in recent times.

5.18.5.3 Conduit O

Impacts cultural, historical and paleontological resources related to Conduit O are the same as those discussed above for Alternative 8a.

5.18.6 No Action Alternative

Operational changes associated with the No Action Alternative are not anticipated to have impacts of any type on cultural, historical or paleontological resources.

5.18.7 Mitigation and Monitoring

Possible mitigation and monitoring of impacts on cultural or paleontological resources may include:

- Development of a PA to provide a framework for monitoring the recommended mitigation measures and addressing any additional discoveries (refer to Appendix L)
- Preparation of Historic Context for Gross Dam and Reservoir
- Avoidance measures, where possible
- Data recovery excavations at prehistoric archaeological sites
- Archival research, Level I documentation, and data recovery excavations at historic archaeological sites
- Level II documentation of proposed impacts to South Boulder Diversion Canal
- Sensitive siting or use of well vaults in historic Denver parks under Alternative 10a

5.18.8 Unavoidable Adverse Impacts

The following unavoidable adverse impacts are expected on cultural or paleontological resources:

- Impacts to archaeological sites
- Data recovery at archaeological sites
- Enlargement of Gross Reservoir Dam
- Modifications to the South Boulder Diversion Canal

5.19 SOCIOECONOMICS

There are certain attributes or parameters associated with each Moffat Collection System Project (Moffat Project or Project) alternative which would cause socioeconomic effects: construction requirements, facility operational requirements, and the stream diversions which provide the water supply. In addition to these socioeconomic impact drivers, the Project effects upon other resources, including recreational, land use, transportation, and visual resources, may ultimately have ramifications to socioeconomic conditions. This section identifies and evaluates these socioeconomic impacts as projected for each alternative.

Construction requirements for the alternatives were originally provided by the Board of Water Commissioners (Denver Water) and have been reviewed and analyzed by the Environmental Impact Statement (EIS) Team as set forth in the Memorandum of Adjustments to Cost, Employment and Wage Data for the Moffat Collection System Project EIS (Harvey Economics 2008). All dollar amounts are expressed in 2006 constant dollars. All employment figures are expressed as full time equivalents. Estimated land acquisition requirements for each alternative are identified in Section 5.16.

The Platte and Colorado Simulation Model (PACSM) results comparing flows under the Full Use of the Existing System with flows under Full Use with a Project Alternative (2032) were also used to support the analysis of impacts under each alternative. As described in Section 5.1, Full Use of the Existing System reflects the operation of Denver Water's system without a Moffat Project alternative online. At that point, Denver Water would maximize the yield of their existing water supplies using their current facilities and infrastructure. The Full Use of the Existing System scenario also includes other entities' actions or projects that are anticipated to occur in the foreseeable future. In the case of Grand County water and wastewater treatment providers, build-out populations and water demand data are included in the Full Use of the Existing System.

Impact intensity categories (no impact, negligible, minor, moderate, and major impact) are defined in the introduction to Chapter 5. The level of impact for socioeconomic resources or measures is based on the size of the specific impact in relation to the larger economic environment. For example, the employment or income generated in the Denver Metropolitan area from a specific alternative would be compared to the total employment or income of the Denver Metropolitan area to determine the impact intensity. The impacts are evaluated in comparison to existing conditions (refer to Section 3.19). Socioeconomic impacts are identified as occurring during the construction period or during the operational phase for each alternative and are identified as temporary or permanent.

The socioeconomic impact analyses, presented completely and sequentially for each alternative within the designated Primary Impact Areas (PIAs) and Secondary Impact Areas (SIAs) are composed of the following socioeconomic resources: economic conditions, demographic conditions, environmental justice, housing conditions, fiscal conditions, public facilities and services, and financial impacts to Denver Water customers. The socioeconomic analyses and results presented in this section reflect only the impacts of the Moffat Project.

5.19.1 Proposed Action (Alternative 1a)

5.19.1.1 Economic Conditions

Employment and Business Activity – PIAs, Boulder County, and Denver Metropolitan Area

The Proposed Action would generally impact employment and business activity in the Denver Metropolitan area and Boulder County. The construction workforce would come mainly from the Denver Metropolitan area and Boulder County and the majority of employee spending would occur at businesses in that area. In addition to construction workers hired directly for work on Gross Reservoir, additional jobs would be created as a result of Denver Water's purchases and because of construction spending and worker spending. Denver Water would purchase the majority of required materials and supplies from companies in the Denver Metropolitan area and surrounding counties. Impacts to employment and business activity in the Denver Metropolitan area resulting from the Proposed Action would be positive and temporary and would mainly occur during the construction period under the Alternative 1a.

The Gross Reservoir PIA is primarily residential along with a few businesses. A small number of businesses in the PIA may benefit from spending by construction workers as they commute between the reservoir and the Denver Metropolitan area. Construction workers would most likely access the reservoir construction area from State Highway (SH) 72 and Gross Dam Road to the south, although any workers commuting from the Boulder area may use Flagstaff Road for access (Kishel 2006). Businesses along these routes may experience temporary increases in sales during the construction period.

An analysis of the impacts of construction and operations on employment and business activity in the Denver Metropolitan area is provided below, including direct, induced, and total effects. Direct impacts are those stemming directly from each of the alternatives, such as the reservoir contractor employees. Induced effects refer to the impacts created by the direct effects, such as expenditures of the direct employees circulating in a given local economy generating other expenditures, employees, and personal income. Adding direct to induced effects arrives at total effects or impacts.

Construction-Related Employment and Business Activity

During the approximately 4-year construction phase of the Proposed Action, the number of workers employed each quarter would increase from about 16 in the first quarter of Year One to a peak of about 151 workers in the first quarter of Year Three. After that point, construction employment would gradually decrease until construction was completed shortly after Year Four. The skills and trades of workers required for construction activity in the Proposed Action reflects those of the available construction workforce in the Denver Metropolitan area and Boulder County. In 2011, there were over 62,000 people employed in the construction industry in Denver Metropolitan area counties. Due to the size, availability and skills of the construction workforce, the majority of construction workers required would likely come from the Denver Metropolitan area. At the peak of construction, the 151 workers employed would account for less than half of 1 percent (%)

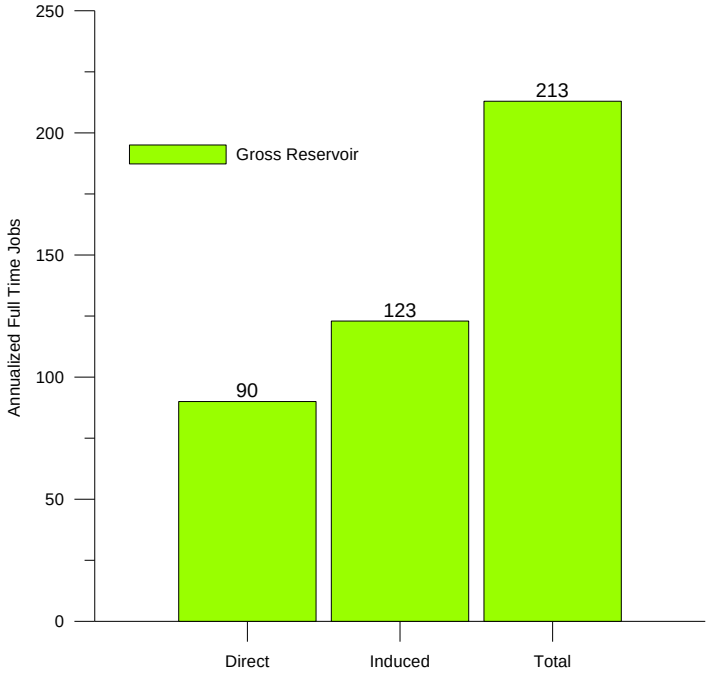
of total construction workers in the Denver Metropolitan area.[1] Construction employment for the Proposed Action would be temporary.

The induced employment created as a result of the construction would provide about 120 additional jobs per year within a number of different industries in the Denver Metropolitan area. Induced job opportunities would also be largely temporary. Induced jobs would either be eventually phased out or would be supported by means other than Denver Water's expenditures. Total employment in the Denver Metropolitan area included 1.3 million people in 2011.

The direct and induced employment created as a result of the Proposed Action would have a positive though negligible and temporary impact on the Denver Metropolitan area.

Figure 5.19-1 shows the average annual direct construction employment and the average annual induced employment created as a result of construction activity in the Proposed Action.

Figure 5.19-1
Annual Employment Generated from Construction Activities in the Proposed Action



Source: MWH, 2006; Denver Water, 2007e; Harvey Economics, 2007.
Note:
Construction activities would occur over a 4.2-year period for the Proposed Action.

Personal Income

The average hourly wage for construction workers hired for the reservoir enlargement would be about $32, with wages ranging from about $40 an hour for surveyors to about $19 an hour for general laborers. Total wages for these workers would average about

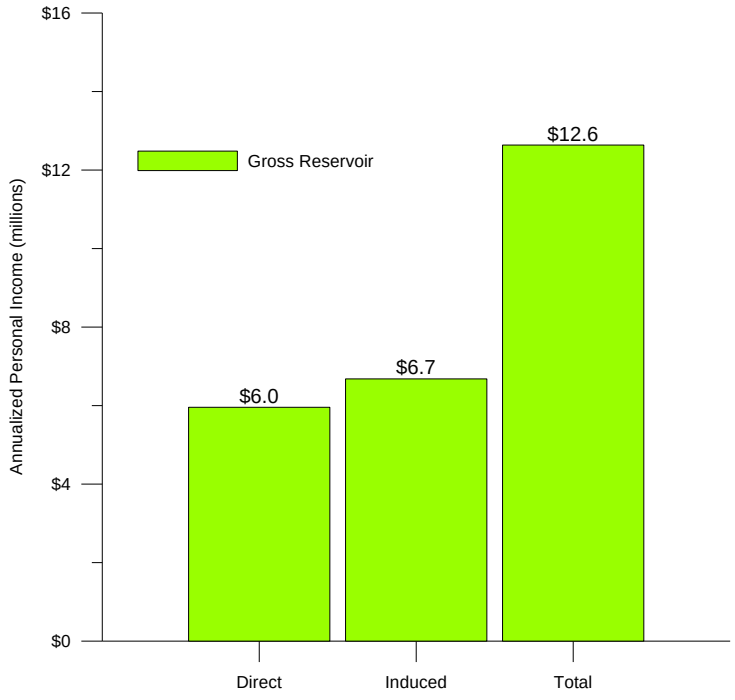
[1]The 151 workers amounts to 0.24% of total 2011 construction employment in the Denver Metropolitan area. If employment in the construction industry in the area grows, the number of workers directly employed to work on Gross Reservoir will account for an even smaller percentage of the total.

$6.0 million per year over the Proposed Action construction period (MWH 2007; Harvey Economics 2008).[2] Denver Water's quarterly expenditures on wages and salaries to construction workers would increase from about $250,000 in the first quarter of Year One to a peak of about $2.5 million in the first quarter of Year Three.

Induced employment wages could range considerably depending on the type of job created or the industry. Total induced employment earnings are estimated to total about $6.7 million per year.[3]

Again, it should be noted that the income of directly hired construction workers and that of the induced workforce would be temporary and would occur within the approximately 4 year construction period. The majority of the direct and induced income created as a result of the reservoir expansion would likely be spent within the Denver Metropolitan area and Boulder County, but a small portion would potentially be spent in other areas of Colorado as well as out of State. Figure 5.19-2 shows the average annual direct income and the average annual induced income created as a result of the enlargement of Gross Reservoir under the Proposed Action.

Figure 5.19-2
Annual Income Generated from Construction Activities in the Proposed Action



Source: MWH, 2006; Denver Water, 2007e; Harvey Economics, 2007.
Notes:
Construction activities would occur over a 4.2-year period for the Proposed Action.
Due to rounding, figures may not add up to total shown.

[2]Average annual wages are reported in constant 2006 dollars.

[3]Economic multipliers for the construction industry were obtained from the Colorado Department of Local Affairs (2003) and applied by Harvey Economics (2007). The estimated wages for induced employees are reported in constant 2006 dollars.

Annual direct personal income created under the Proposed Action would account for about two tenths of 1% of total compensation paid to construction employees in the Denver Metropolitan area.[4] The annual total personal income created under the Proposed Action would account for less than a one tenth of 1% of total compensation paid to all working persons in the Denver Metropolitan area.[5] Therefore, the personal income created as a result of the Proposed Action would have a negligible, positive, but temporary, impact on the Denver Metropolitan area.

Total Economic Output

Total construction costs include direct construction costs as well as engineering and environmental costs. Direct construction costs include all expenditures related to site preparation, including the cost of tree removal. The socioeconomic analysis focuses on direct construction costs since other costs may be cash or non-cash items. Non-cash items would not contribute to local expenditures on goods and services. Cash items in the engineering and environmental cost categories may be out of State expenditures, which would not contribute to local economic output.

Direct construction costs associated with the Proposed Action would total about $110.1 million over the 4 year construction period, or about $26 million per year, including labor and non-labor costs.[6] The majority of materials and supplies would be purchased from businesses within the Denver Metropolitan area, although a small portion would be purchased in surrounding counties. For example, sand and gravel would likely be purchased from commercial suppliers in the Longmont area.

In addition to direct spending on goods and services (including labor) for the expansion of Gross Reservoir, induced sales of goods and services would result from construction worker spending and spending of induced employees. Total sales of goods and services would amount to about $62 million per year for the 4 year construction period as a result of the Proposed Action. Figure 5.19-3 shows the annual direct spending by Denver Water for construction activities, the annual induced spending and the total annual economic output generated by the construction activities in the Proposed Action.

Total sales exceeded $157 billion for Denver Metropolitan area businesses in 2011. Total annual economic output produced under the Proposed Action would account for less than a tenth of 1% of total sales in the Denver Metropolitan area.[7] The economic output created as a result of the Proposed Action would have a negligible but positive and temporary impact on the Denver Metropolitan area.

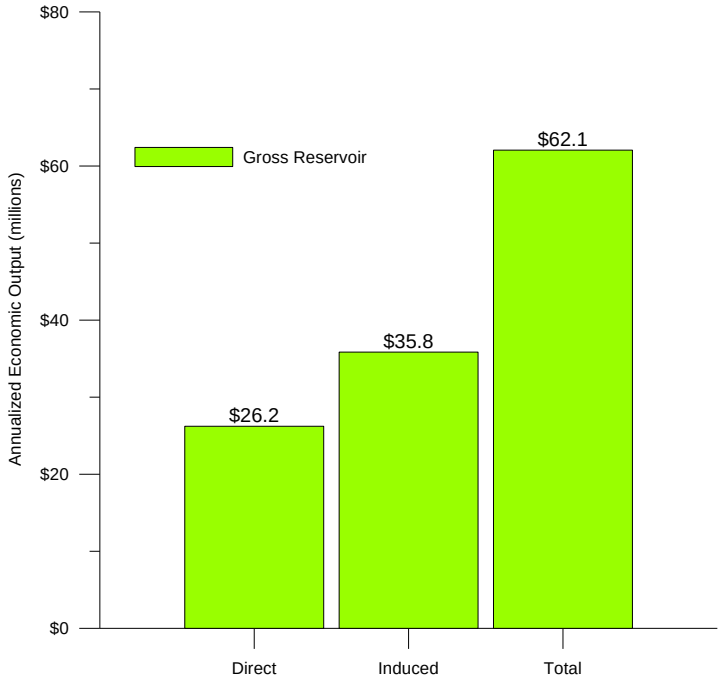
[4]Compared to 2011 data, $6 million amounts to about 0.19% of total compensation for all construction workers in the Denver Metropolitan area.

[5]Compared to 2011 data, $12.6 million amounts to about 0.02% of total compensation for all workers in the Denver Metropolitan area.

[6]Direct construction costs presented here do not include mobilization costs. Mobilization costs include bonds and insurance.

[7]Compared to 2011 data, $62.1 million amounts to about 0.04% of total sales in the Denver Metropolitan area.

Figure 5.19-3
Annual Economic Output Generated from Construction Activities in the Proposed Action for the Four-Year Construction Period



Source: MWH, 2006; Denver, Water 2007e; Harvey Economics, 2007.
Notes:
Construction activities would occur over a 4.2-year period for the Proposed Action.
Due to rounding, figures may not add up to total shown.

Operational Phase Employment and Business Activity

No permanent employment opportunities would be created as a result of the operation of Denver Water's Facilities in the Proposed Action. The staff that is currently employed to operate and maintain the existing Gross Reservoir would also operate and maintain the enlarged reservoir and associated facilities. Denver Water would only purchase a small amount of additional materials for facility operations. The minimal amount of additional spending would not stimulate the creation of any new jobs.

Employment and Business Activity – Grand County

Several influences potentially affecting employment and business activity in Grand County were examined: (1) physical construction activities occurring within the county, (2) changes in recreational behavior by residents or visitors, (3) shortages to local water providers serving residences and businesses, and (4) reduced availability of water supplies to agricultural users. Impacts to employment and business activity in Grand County would be negligible under the Proposed Action based in the following information:

- No construction activity would occur in Grand County to provide additional jobs or economic stimulus to businesses.

- No measurable changes in water-based recreational activity in Grand County would be expected as a result of the Proposed Action based on the impact analysis conclusions provided in Section 5.15, which addresses boating and fishing activity and Section 5.11, which addresses impacts to fish habitat and populations. The results of the recreation and aquatic resources analyses are summarized below for each river segment.

Fraser River

The Proposed Action would result in negligible impacts on boating in wet years and no impacts to boating in dry years. However, in average years, there would be a moderate to major long-term adverse impact to boating opportunities on the Fraser River resulting from a reduction in the number of days with flow levels that support boating use. On average, the number of days within the optimal flow range for boating (400 to 700 cubic feet per second [cfs]) would drop from 17.5 to 14 per year. However, there is little boating use overall, and no commercial boating, on the affected section of river, indicating that socioeconomic impacts from the reduced number of optimal boating days would be minimal. The small number of boaters potentially affected by reduced flows in the Fraser River would not have enough socioeconomic effect to result in measurable impacts to the Grand County economy. It is also likely that the majority of private boating that does occur on the Fraser River consists of local residents, whose daily expenditures related to boating activity would be much smaller than those of visitors; this would further minimize any economic impacts of reduced boating opportunities.

As stated in Section 5.15, the Proposed Action would have a negligible to minor impact to fishing on the Fraser River in wet and average years and no impact to fishing in dry years. Flow reductions during periods of high flow are not expected to adversely affect the quality of the fishing experience and may result in minor beneficial impacts if typically inundated areas along the river become exposed or fish become more active. Section 5.11 indicates that effects to species composition, population levels and other factors related to the health of the fishery are expected to be minor on the Fraser River mainstem. Reductions in peak runoff flows could increase habitat availability for some fish species in certain stream segments. Fish communities in several Fraser River tributaries would experience minor adverse impacts, which could result in minor adverse impacts to the fishing experience. No data exists on the number of anglers that fish in these tributaries; therefore, changes in recreational activity on these tributaries were not quantified. The fish communities of other Fraser River tributaries would experience no impacts. Overall, changes in fishing activity on the Fraser River and tributaries would be minimal, resulting in little to no socioeconomic impact. Impacts to local businesses catering to boaters or anglers on the Fraser River would be negligible under the Proposed Action as would the impacts to other types of businesses associated with tourism or recreation, such as restaurants or hotels.

Colorado River

Under the Proposed Action, the number of days when Colorado River flows would fall between 800 and 1,250 cfs, the optimal range for rafting on the Colorado, would decrease by about 1 day per year in an average year. No impacts to boating would occur in dry years and no change in the number of days of optimal boating flows or in the boating experience is anticipated during wet years. Overall, there would be negligible or no impact to boating on the Colorado River in wet and average years.

The Proposed Action would result in negligible changes to water quality, riparian vegetation or channel morphology that would affect fish in the Colorado River. Reductions in peak runoff flows would tend to benefit fish, but the changes would be minor and limited to average years. Few impacts to the fishing experience are anticipated as a result of the Proposed Action.

Impacts to local businesses catering to boaters or anglers on the Colorado River would be negligible under the Proposed Action as would the impacts to other types of businesses associated with tourism or recreation, such as restaurants or hotels.

Williams Fork River

No commercial or private boating occurs on the Williams Fork River; therefore, the Proposed Action would have no socioeconomic effect related to boating on this river.

The Proposed Action would have negligible impacts to aquatic resources in the Williams Fork River. The small flow changes under the Proposed Action would have negligible impacts on fish health and populations levels. Additionally, changes to water quality, riparian vegetation or channel morphology are not expected to affect fish in this river. Flow reductions would have a minor adverse impact on fish in several Williams Fork tributaries. Overall, no impacts to the quality of the fishing experience are expected as a result of the Proposed Action; therefore, no socioeconomic impacts related to fishing on the Williams Fork are anticipated.

Dillon Reservoir

Although located in Summit County, recreational opportunities at Dillon Reservoir provide a tourist draw to the larger region. Under the Proposed Action, the elevation of the reservoir would decrease by between 1 and 3 feet between May and January in those years in which diversions would occur. This change in elevation would not affect the type of recreational activities at the reservoir or the number of people that would use the reservoir. The marinas and boat ramps would continue to be useable and the reservoir would continue to be open to a variety of activities. No impacts to businesses providing services to visitors would be expected from the change in elevation of the reservoir.

Land-based recreational activity (i.e., hiking, mountain biking or scenic sightseeing), is also an important component of the Grand County culture and economy. No measureable changes in tourist visitation or activity; in resident participation in these activities; or in the quality of these activities are anticipated under the Proposed Action. Therefore, socioeconomic impacts related to changes in land-based recreational activity would be little to none. These conclusions are based on the following information:

Visual Resources

The visual experience in mountain communities often contributes to a diverse recreational experience. Additionally, there is a strong correlation between flow levels and how viewers rate the aesthetic appearance of a given stream. Flow changes attributable to the Proposed Action in the Fraser River above Crooked Creek would result in moderate adverse visual or aesthetic impacts in May, June, and July of average and wet years; flows in these months would not drop to the levels of dry year flows and would not fundamentally alter the character of the stream, but would be detectable. Visual impacts below Crooked Creek would be negligible to minor and detectable only to skilled observers. In all other months,

flow changes would be imperceptible to the casual observer. Overall, no impacts to visual resources or aesthetics would occur on the Colorado River; flow reductions would only be perceptible to skilled observers in June of average years at Hot Sulphur Springs. Along the Williams Fork River, flow changes would be minor and largely limited to periods of high flows; these changes would not likely be noticeable to most observers.

It is unlikely that detectable flow changes in specific portions of the Fraser River over a three month period in late spring and early summer would deter a measureable number of visitors or residents from participating in land-based recreational activities or deter tourists from visiting Grand County in general.

Riparian and Wetland Areas

The existence and quality of riparian and wetland vegetation may also affect the visitor or recreational experience. Reduced flows under the Proposed Action are not expected to cause any landscape scale changes to riparian vegetation communities. Impacts to riparian vegetation on the upper Fraser River are expected to be negligible to minor, no measureable impacts are expected on the lower Fraser River and impacts to riparian vegetation along the Fraser River tributaries would be negligible. Impacts to riparian vegetation along the Colorado River would be negligible and no measureable adverse impacts would result along the Williams Fork River.

Wildlife

Changes in river flows would not have a noticeable impact on wildlife habitat or wildlife species in the vicinity of the Fraser, Colorado, or Williams Fork rivers.

- Almost all Grand County water providers are expected to experience water shortages in the future, as they approach build-out. Build-out demands for Grand County water providers are incorporated into the Full Use of the Existing System scenario; shortages under that scenario, as well under the Full Use with a Project Alternative with reasonably foreseeable future actions (2032) are shown in Table 4.3.1-3. Even so, it is unlikely that build-out would be achieved by 2032. The Proposed Action would result in 6 acre-feet (AF) of additional shortage to the Grand County Water and Sanitation District (GCWSD).[8] The additional shortage of 6 AF of water for one water provider is not expected to hinder development or economic growth in Grand County. Grand County water providers are discussed further in Section 5.19.1.6.
- Agricultural irrigators who use meadow pumps to pump water from stream systems to their fields occasionally have problems with pumps going dry; these problems only occur in dry years late in the irrigation season, generally between July and September. No additional diversions would occur in dry years under the Proposed Action; therefore, the Proposed Actions would not impact the operations of meadow pumps for irrigators in Grand County. Section 5.2 indicates that the Proposed Action would not result in any noticeable additional sedimentation that would affect the operations of irrigation ditches, pumps or other agricultural water distribution infrastructure.

[8]See Section 5.19.1.6 for an explanation of the additional 6 AF of water shortage to Grand County Water and Sanitation District.

- The Proposed Action would not affect the factors that influence power supplies and power prices in Grand County. Grand County residents and businesses would not experience changes in power prices as a result of the Proposed Action.
- Retail sales data indicate that the December to March period is peak tourist season for Grand County and that May and June have the least visitation.[9] Therefore, the Proposed Action would not impact stream flows at times of peak tourist interest.
- Based on the information presented above, socioeconomic impacts to Grand County businesses resulting from the Proposed Action would be negligible. No construction activity or operational employment would occur in Grand County; no changes to tourist visitation or spending patterns are anticipated for the county; no changes in recreational activity are expected; one water provider would face a small water shortage and no agricultural irrigators would experience water shortages as a result of the Proposed Action; and power prices would not be impacted.

5.19.1.2 Demographic Conditions

Changes in population, other demographic characteristics, or housing characteristics generally occur as a result of the types of economic impacts described above as well as other site-specific or alternative-specific details, such as changes in recreational opportunities, land use, or visual appeal.

Population of the Gross Reservoir PIA

The Proposed Action would not change the population within the Gross Reservoir PIA. No homes would be demolished, inundated, or relocated as a result of the reservoir enlargement. Therefore, no residents would be required to move out of the PIA as a result of the Proposed Action. Additionally, no new residents would be expected to move into the PIA and no additional homes would be built in the PIA as a result of construction activities or operation of the enlarged reservoir. Construction workers would generally travel to the construction site each day from the Denver Metropolitan area and would not relocate to the PIA. No additional Denver Water or other employees would be required to operate or maintain the enlarged reservoir. Although temporary construction period activities would be a nuisance to local residents, it is unlikely that construction would cause permanent residents to leave the area.

Gross Reservoir is currently open to the public for recreation and other activities. While the potential exists for increased visitation and recreational activity at the enlarged reservoir due to the increased surface area and shoreline, it is unlikely that either the permanent or seasonal population of the PIA would increase because of the enlargement.

Construction Phase Impacts Experienced by Gross Reservoir PIA Residents. Certain residents of the PIA are concerned about the impacts of construction activity on the quiet, rural character of the area and on their quality of life during the construction phase.[10] Some residents of the PIA would be affected by construction activities at Gross Reservoir due to

[9]Colorado Department of Revenue, Monthly Sales Tax Statistical Summaries, 2008 and 2009.

[10]The Preserve Unique Magnolia Association (PUMA) is comprised of a group of residents living in the area north and west of Gross Reservoir, one part of the PIA. PUMA's Magnolia Environmental Preservation Plan describes the environmental and cultural resources of the area and includes various policy recommendations for preserving these resources, www.puma-net.org/popupmepppol.htm.

their relatively close proximity to the construction sites. Construction activities at Gross Reservoir are described in detail in Sections 2.3 and 2.8; these activities would generally occur year round. On-site activities would include the following:

- Foundation excavation and preparation.
- Construction of service and auxiliary spillways. The service spillway would be incorporated into the raised section of the dam; the final location of the auxiliary spillway has not been determined, but could be about 1 mile south of the dam.
- Concrete placement for the dam raise.
- Development of aggregate quarry sites along the southeast shore of the reservoir and excavation of borrow materials. The majority of material would be produced prior to the start of construction, which would necessitate the development of two stockpile areas for storage of borrow materials. These would also be located on the east side of the reservoir.
- A rock-processing operation would be located at the larger stockpile area. Aggregate production would occur primarily during the day; however, extended operations, up to 24 hours per day, could be required at times.
- Operation of a temporary concrete production plant. The plant would likely be operated up to 24 hours a day during the approximately April through November concrete placement period.
- Development of spoil areas and staging areas. The concrete plant, job trailers and equipment yard would be located at various staging areas.
- Tree removal and disposal using a variety of techniques. Tree removal would likely require a combination of hand felling, helicopter yarding and rubber-tired tractor use. Disposal options include on-site burning, grinding trees for transportation to landfills, or hauling intact forest residue to landfills.
- Relocation or new construction of various road segments to facilitate construction operations. Several roadways would be permanently relocated, either due to inundation or to accommodate the auxiliary spillway; temporary new roadways would be constructed to provide hauling access between the quarry areas, stockpile areas, and the dam raise site.
- Relocation of a number of recreational sites and facilities above the high water line due to inundation.

In addition to on-site activities, supplemental borrow materials would be hauled to the dam area from off-site locations on approximately 260 days per year. Flyash and cement would also be hauled to Gross Reservoir. Various supply trucks would make daily trips to construction sites to deliver materials. Construction workers would commute to Gross Reservoir daily. Construction traffic is discussed in Section 2.8.5.

Under the Proposed Action (Alternative 1a), socioeconomic impacts to residents of the Gross Reservoir PIA would be short term and minor to moderate based on the following conclusions:

- Construction activities would be temporary, occurring over a period of about 4 years.
- As described in Section 3.14, residential development within the PIA consists of mountain homes for year round and seasonal residents on dispersed 35 acre lots and in subdivisions. The 60-lot Lakeshore Park subdivision is located on the north side of the reservoir, the Aspen Meadows and Forsythe Rock subdivisions are located to the east of the reservoir and the rural communities of Miramonte, Wondervu, Cedar Ridge Estates, and Juniper Heights are located to south. Other than the Lakeshore Park subdivision, these communities are quite small and are generally comprised of only a few homes. Each of these areas can be accessed by various State highways and county and local roads, as described in Section 3.12, and shown in Figure 3.12-1. Residents of these areas would not have to drive by the construction sites to reach their homes or commute to work.
- According to Section 5.12 the combination of worker vehicles commuting to construction sites along Gross Reservoir, haul trucks delivering imported aggregate and other supply delivery trucks would result in negligible impacts to operating conditions of the freeways, major arterials and minor arterials that serve the Gross Reservoir site. However, temporary moderate impacts to traffic operations would include passenger vehicle delays due to queuing behind slower moving haul and supply vehicles on two lane roads and queuing at intersections where large vehicle turn movements are more difficult.[11] The number of commuting workers would vary by month over the construction period, as described in Section 2.8.6; about 11 vehicles would carry commuting workers to Gross Reservoir construction sites on the least active day and about 101 vehicles on the peak day. Aggregate haul trucks would average about 22 trips per day, with 37 trips on the peak day. Tree removal and disposal would result in additional traffic, but would occur only over a 6 to 8 month period.[12] These numbers compare to average annual daily traffic on SH 72 of about 4,800 vehicles just west of SH 93 and about 3,800 vehicles west of Twin Spruce Road in 2009.[13] No traffic volume data exists for county roads; however, traffic on Gross Dam Road is predominantly recreational and typically does not occur during peak hour times. The majority of construction traffic would likely access Gross Reservoir from the south via SH 72 and County Road (CR) 77S (Gross Dam Road); roads to the north of the reservoir, including CR 77 (Flagstaff Road), would experience much lighter construction traffic volume. Denver Water is responsible for road maintenance on Gross Dam Road and would be responsive to any maintenance issues resulting from construction truck traffic.
- Section 5.13, states that during the construction phase of the Proposed Action, air quality impacts would be minor and would be the result of construction equipment exhaust, portable diesel engine exhaust, commuting vehicles, fugitive dust, rock crushing activities and tree residue disposal. Increases in particulate matter (fugitive dust) and gaseous pollutants would occur in the immediate vicinity of the construction activities, except on windy days when particulate matter may travel beyond the

[11]The frequency and duration of traffic delays were not quantified as part of this EIS, but were determined to pose no significant impacts.

[12]The volume of traffic associated with tree removal and disposal would depend on the disposal option(s) selected; this has not yet been determined.

[13]Colorado Department of Transportation; Statistics, Maps and Data, www.coloradodot.info/.

construction site. Various mitigation measures, discussed in Section 5.13.7 may further minimize the impacts of fugitive dust and combustion emissions.

- Construction activity noise would result from equipment operation and increased traffic volumes. Section 5.14, states that overall the construction activities associated with the Gross Reservoir enlargement are not predicted to exceed relevant standards or guidelines. On-site construction noise may periodically exceed the U.S. Environmental Protection Agency noise threshold for public exposure; however, public access to construction areas would be restricted, which would minimize the exposure and therefore impacts of loud operating equipment. Noise resulting from equipment operation would occur at distances of less than 50 feet from the source; at distances greater than 50 feet, noise levels diminish rapidly. Noise associated with tree removal and residue disposal is not expected to exceed relevant standards and guidelines. Construction traffic noise would contribute to overall background noise levels, but this noise is anticipated to be minor and in compliance with county ordinance requirements.
- Section 5.15 describes the impacts to the nine designated recreation sites at Gross Reservoir and access to these sites. The Dam and Haul Road Recreation Areas, which serve as two of the three primary recreation areas for on-water use, would either have restricted site access or close completely during construction, resulting in a major temporary impact. The Peninsula Recreation Area is the third primary recreation area for on-water use; this site would be open during the majority of the construction period, but would be closed and relocated during the final phases of construction, also resulting in a major temporary impact. Six of the nine total recreation areas would be relocated during the final phases of construction due to eventual inundation. Vehicle access to Gross Reservoir would remain open via the north and south access points during the construction period; however, several road segments which provide access to recreation sites would need to be relocated along with the relocation of these sites, due to inundation. Additionally, heavy truck traffic may present a temporary moderate adverse impact on the recreational experience and safety of road bicyclists on SH 72, which would be used as an aggregate haul route for imported aggregate materials.
- According to Section 5.17 visitor surveys indicate that Gross Reservoir's most desirable attributes are its feeling of remoteness, the general 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. Residents value the recreational nature of the area and the scenic amenities. Temporary construction activities, described previously, would create major adverse short-term impacts to visual resources. The quarry site would not be reclaimed post-construction, but mitigation activities would reduce the visual impacts at that site. The auxiliary spillway would create an isolated major adverse long-term impact. It is assumed that the changes in visual quality would only be apparent to visitors located directly along the reservoir's shoreline and not from the vantage point of any surrounding residences.

Based on the information presented above, construction activities would affect only a small number of local residents in the Gross Reservoir PIA. The majority of construction related traffic would occur on SH 72 and Gross Dam Road. Although construction vehicles may slow traffic on SH 72 at certain times, these vehicles, plus commuting construction

workers, would be only a small portion of total traffic. Additionally, the majority of traffic on Gross Dam Road is related to recreation, and is not residential or commuting traffic. Changes in air quality and noise would occur within a limited area in the immediate vicinity of the construction sites. Impacts to the aesthetics of the area would likely not be visible to residences surrounding the reservoir. Therefore, impacts to local residents would be short term and minor to moderate.

Population of the Denver Metropolitan Area

Neither the construction activities nor the operation of the enlarged Gross Reservoir in the Proposed Action would change the population within the Denver Metropolitan area. As described previously, the majority of construction workers would likely be hired from the existing construction labor force in the Denver Metropolitan area. Given the small size of the workforce required for the construction of the Proposed Action compared to the existing construction workforce in the Denver Metropolitan area, the expansion of Gross Reservoir would be expected to attract few, if any, people to relocate to the Denver Metropolitan area for employment. The small number of specialized workers that might relocate would likely be spread out over the region and would not cause a noticeable impact on the population of any individual Denver Metropolitan area county.

It is likely that growth will occur within the Denver Metropolitan area without an expansion of Gross Reservoir (DRCOG 2005). The increased storage capacity of Gross Reservoir and the availability of additional or more reliable water supplies for Denver Water customers resulting from the Proposed Action would not cause growth in the Denver Metropolitan area. Denver Water is only one of many water providers in the Denver Metropolitan area and an increase in the water supply or firm yield for any one of these providers would not be an incentive for regional growth.

Population of Grand County

The population of Grand County would not be expected to change as a result of the Proposed Action for several reasons. As discussed in Section 5.19.1.1 no additional jobs would be created or lost in Grand County and existing businesses would experience negligible impacts as a result of the changes to recreational activity. Permanent residents would not be expected to relocate due to the negligible to minor impacts anticipated for recreational opportunities. No municipal or other water providers, with one exception (GCWSD, which would face minor Project-related shortages), would experience water shortages as a direct result of Denver Water's river diversions. Therefore, their customers would not be affected by the Proposed Action. Impacts to water providers and other public service providers are discussed in detail in Section 5.19.1.6. Grand County has a large seasonal population and a number of second homeowners. These part-time residents likely value the rural mountain character and recreational opportunities in the county. Under the Proposed Action, impacts to water-based recreational opportunities, including boating and fishing, are mixed as discussed in Section 5.15. The number of optimal boating days would decrease on the Fraser River, but would increase slightly on the Colorado River; reductions in peak runoff flows would tend to benefit fish communities, and hence fishing opportunities, in some areas, but fish in tributaries may be adversely affected. In terms of the visual impact of flow reductions (Section 5.17), changes would generally only be

noticeable to skilled observers. Overall, no change in the number of seasonal residents in Grand County would be expected under the Proposed Action.

The quality of life in Grand County and the lifestyle of residents is not expected to change as a result of the Proposed Action.

Other Demographic Characteristics

As described above, the populations of the Gross Reservoir PIA, Boulder County, Denver Metropolitan area counties, and Grand County would not change as a result of the Proposed Action. Therefore, the demographic characteristics of those populations as described in Section 3.19, would not be expected to change as a result of the Proposed Action. This Alternative would not affect the migration patterns, ethnic composition, or age distribution of the residents of these areas. Commuting patterns would remain unchanged for all residents with the exception of a small number of construction workers in the Denver Metropolitan area who would temporarily commute to the reservoir site. Commuting patterns of Gross Reservoir PIA residents are not expected to change as a result of construction activities or operations. A summary of the impacts of the Proposed Action on the demographic characteristics of affected areas is shown in Table 5.19-1.

Table 5.19-1
Changes to Demographic Conditions from the Proposed Action

	Gross Reservoir PIA	Boulder County	Denver Metropolitan Area	Grand County
Population	No impact	No impact	No impact	No impact
Migration Patterns	No impact	No impact	No impact	No impact
Ethnicity	No impact	No impact	No impact	No impact
Age Distribution	No impact	No impact	No impact	No impact
Commuting Patterns	Minor to moderate, temporary	Negligible, temporary	Negligible, temporary	No impact

Source: Harvey Economics, 2007.
Note:
PIA = Primary Impact Area

5.19.1.3 Environmental Justice

Executive Order 12898, entitled Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, mandates Federal agencies to make achieving environmental justice part of their mission. Agencies are required to identify and correct programs, policies, and activities that have disproportionately high and adverse human health or environmental effects on minority and low-income populations.

Impacts to environmental justice populations were considered as part of the environmental analyses to ensure that these populations do not receive a disproportionately high number of adverse environmental or human health impacts from the Proposed Action. Extensive socioeconomic and demographic data were studied to determine if the Proposed Action would adversely affect a disproportionate number of specially designated communities. No specific ethnic or otherwise classified groups of PIA or Denver Metropolitan area, residents would be disproportionately impacted by construction or operational activities in the Proposed Action. No environmental justice issues would arise as a result of this alternative.

5.19.1.4 Housing Conditions

Housing Units

The number of existing housing units in the Gross Reservoir PIA, the Denver Metropolitan area, and Grand County would not change as a result of the Proposed Action. As described above, the population in these areas would not increase as a result of any of the activities in the Proposed Action. Therefore, no additional housing units would be built as a result of this alternative. A small number of construction workers could potentially relocate to the Denver Metropolitan area and would temporarily require housing. Given the number of housing units available in Denver Metropolitan area counties, no impact to the housing market would occur. No housing units would be demolished or relocated within the Gross Reservoir PIA or any other area as a result of the reservoir expansion. Given that the demographic characteristics of the population would not change under the Proposed Action, the composition of types of housing available in the PIA and the Denver Metropolitan area would not be expected to change as a result of this Alternative.

Vacancy Rates

Vacancy rates in affected areas would not change as a result of the Proposed Action. Given that the population and number of housing units in these areas would not change as a result of this Alternative, vacancy rates would also be unaffected. The small number of construction workers that would potentially relocate to the Denver Metropolitan area would not cause a noticeable decrease in vacancy rates given the number of available housing units in the area. Residents of the Gross Reservoir PIA are unlikely to move out of the area in response to construction activities, although these activities are likely to pose nuisances and inconveniences throughout the approximately 4 year construction period.

Home Values

In general, the purchase of property is a long-term investment; home values in the Gross Reservoir PIA are not likely to be affected by temporary construction activities, except for a small number of homes accessed by Gross Dam Road (CR 77S). The population and demographics of the PIA would remain unchanged as a result of the Proposed Action; however, construction activities would result in certain temporary inconveniences to some residents of the PIA, including increased traffic volume and a short-term reduction in recreational opportunities. As described previously in the Demographic Conditions section, several small communities are located to the north, east, and south of Gross Reservoir. None of these residences would be affected by noise or dust generated by construction activities due to the distance between homes and construction sites along the reservoir. Additionally, construction activity would not likely be visible from these residences. Homes on the northern side of the reservoir could be accessed using Flagstaff Road from Boulder, which would avoid the majority of construction traffic. Therefore, the Proposed Action is not expected to affect home values of residences in that area. Approximately 50 homes in the PIA are only accessible by using Gross Dam Road; of these homes, about 20 require 1,000 feet or less of driving on Gross Dam Road.[14] Residents of these homes

[14] "Southern portion of Gross Reservoir PIA", 39° 55' 38.07" N and 105° 20' 51.61" W, Google Earth map, image date December 31, 2001, accessed March 2011.

would have to contend with increased traffic volumes, including slow moving trucks. The majority of construction traffic would consist of construction workers commuting to and from construction sites on weekday mornings and late afternoons; construction traffic would likely be light to none on weekends. The inconvenience of increased and slow traffic on curvy Gross Dam Road could potentially reduce the number of home sales or result in lower sales prices in the short term; however, home values are based on a number of factors and any change in home values due to temporary construction activities is likely to be minor. Once construction has been completed, home sales transactions and prices are expected to return to normal. Overall, for the PIA, impacts to home values would be negligible and short term; a small number of homes along Gross Dam Road may experience minor to moderate short-term impacts to property salability, either price or the ability to sell.

The populations of Boulder County and Denver Metropolitan area counties would remain unchanged and demand for homes in these areas would not increase or decrease as a result of the Proposed Action. Neither temporary construction activities nor the long-term operation of the enlarged reservoir would affect home values in these areas.

The overall demand for homes in Grand County, including both primary residences and seasonal homes, would not change as a result of the Proposed Action. The rural mountain character of the county, including the existence of rivers and streams, would not change and recreational opportunities would be largely unaffected by the Proposed Action. Therefore, the desirability of Grand County as a place to live would also be unaffected by the Proposed Action; as a result, home values would not be impacted by the Proposed Action. The value of properties directly surrounding Grand Lake is also affected by the water quality and clarity in the lake. The Proposed Action would not result in any additional reductions in water clarity in Grand Lake.

Table 5.19-2 presents the impacts of the Proposed Action on the housing characteristics of affected areas.

Table 5.19-2
Changes to Housing Conditions from the Proposed Action

	Gross Reservoir PIA	Boulder County	Denver Metropolitan Area	Grand County
Housing Units	No impact	No impact	No impact	No impact
Vacancy Rates	No impact	No impact	No impact	No impact
Home Values	Minor to moderate, temporary impacts for a small number of homes along Gross Dam Road	No impact	No impact	No impact

Source: Harvey Economics, 2007.
Note:
PIA = Primary Impact Area

5.19.1.5 Fiscal Conditions of Public Entities Other than Denver Water

Operating Revenues

Local jurisdiction revenues are generated from numerous sources, which mainly include various taxes and fees. Generally, the largest revenue producers for counties and cities include property taxes and sales or use taxes, respectively. Denver Water is also exempt from paying State and some Federal excise taxes. Denver Water pays Federal excise taxes on fuel for vehicles used primarily on roadways, but does not pay Federal excise tax on fuel for vehicles and equipment used primarily for off-road use, for example heavy construction equipment (Denver Water 2006f). As described in Chapter 2, an average of 22 haul and concrete trucks would travel to and from the Gross Reservoir site each day. Denver Water would be responsible for fuel taxes related to those trips; however, that amount is expected to be negligible as trucks would travel relatively short distances from within the Denver Metropolitan area or other nearby surrounding counties.

In certain circumstances, Denver Water may have agreements with other cities and local governments that exempt it from paying local taxes, but in other cases, construction-related purchases might generate sales or use taxes. When there is no specific agreement in place, Denver Water would be required to pay local sales taxes, assuming the local agency's taxing ordinance does not prohibit taxation of other local agencies (Denver Water 2006f). The majority of materials and supplies are typical construction materials which can be purchased from companies in the Denver Metropolitan area. However, specific suppliers of required materials have not been identified. Sales and use tax rates differ by county and city, and therefore the amount of sales tax revenue generated by the Proposed Action was not estimated.

Denver Water's expenditures as well as induced expenditures occurring under the Proposed Action would likely be spread out over the entire Denver Metropolitan area. These expenditures would have a positive effect on the revenues of local governments; however, these impacts are expected to be quite small for each individual jurisdiction. Increased sales tax revenues would be temporary and would occur during the construction phase of the Proposed Action. As discussed above, Denver Water anticipates purchase of a minimal amount of materials for operations. A minor, temporary positive impact on the revenue base of local governments in the Denver Metropolitan area is expected from the Proposed Action.

As a municipal entity, Denver Water's Facilities are not subject to property tax. Denver Water does not pay any property taxes on the land it owns at the Gross Reservoir site in Boulder County. Denver Water owns or has obtained easements to the majority of the acreage that would be inundated for the reservoir expansion in the Proposed Action. However, an additional 15 acres of private property would need to be purchased. Boulder County and public agencies within the county would experience the following losses in annual property tax revenues as a result of the purchase of the 15 acres:

- Boulder County – $60
- Boulder County RE-2 School District – $101[15]

[15]The State of Colorado guarantees a certain amount of funding per student to each school district and would make up losses to districts up to that guaranteed amount.

- Coal Creek Canyon Fire District – $21

These effects are considered negligible compared with the size of the budgets for these entities.

Property values and property tax rates for private residents and businesses in Boulder County, Denver Metropolitan area counties, and Grand County would not be affected by the Proposed Action. No loss of property tax funding would accrue to service providers or to any special districts in the Denver Metropolitan area or in Grand County as a result of the Proposed Action.

Operating Expenditures

Activities occurring under the Proposed Action would only be expected to impact operating expenditures related to road and bridge maintenance. These expenditures would be mainly due to the haul trucks transporting borrow material between the Longmont area and Gross Reservoir and to the concrete trucks traveling back and forth to the construction site. Haul and concrete trucks are estimated to average 22 trips per day for 260 days per year. Fly ash would also be transported to Gross Reservoir during construction, although the number of fly ash truck trips is unknown. The identified route for haul trucks carrying borrow material from Longmont is 48 miles one way, on an interstate highway, state highways, and county roads. Vehicles transporting concrete and fly ash would likely come from various places in the Denver Metropolitan area, traveling mainly on city, State, and county roads. As stated in Section 5.12, "most of the roadways serving the Gross Reservoir site are in good condition and designed to accommodate large, heavy construction vehicles. Although Gross Dam Road (CR 77S) is maintained in good condition, heavy equipment and haul trucks could cause rutting in the unpaved road segments of the haul route."

In addition to haul trucks, an average of 60 vehicles carrying commuting workers would come from all over the Denver Metropolitan area, eventually funneling into SH 72 and CR 77S to access the construction site. Average daily traffic on SH 72, west of SH 93, ranges from about 3,000 vehicles per day to over 5,000 vehicles per day, depending on location. The number of haul trucks and commuter vehicles required under the Proposed Action would have a negligible impact on traffic volume on SH 77. Truck and commuter traffic would have a more noticeable presence on CR 77S due to the smaller number of vehicles that currently travel that road; however, average daily traffic volume data for CR 77S was not available for analysis.

The Colorado Department of Transportation (CDOT) is responsible for maintenance of State highways. Total expenditures in CDOT's proposed 2008-2009 budget amount to about $1.3 billon (CDOT 2007). Over $382 million of that amount is allocated to System Quality, which includes "activities, programs and projects that maintain the function and aesthetics of the existing transportation infrastructure" (CDOT 2007). This includes road surface treatments, local bridge maintenance, and other road maintenance. In addition to System Quality expenditures, an additional $51 million is allocated to maintenance expenditures as part of Safety and Mobility expenditures. The Proposed Action would have a negligible effect on CDOT expenditures.

CR 77S leading up to the reservoir is located in Boulder County; Denver Water is responsible for maintenance of that road and any related expenditures.

The impact to roads and bridges from the number of haul trucks and commuter vehicles required for the Gross Reservoir enlargement would be temporary and negligible to minor. Any CDOT or Boulder County expenditures related to road or bridge maintenance due to the reservoir expansion would likely account for a negligible portion of total expenditures.

Impacts to roads and road expenditures would likely be negligible during operations since Denver Water does not anticipate any additional trips to the reservoir for maintenance or operation once construction is complete, compared to current levels. There is potential for some additional recreational traffic once construction is complete, due to the increased surface area of the reservoir and the expanded shoreline. However, any increase in recreational traffic would be quite small and is not likely to cause a noticeable impact to roads or required road maintenance.

Capital Outlays

Capital outlay expenditures for local public entities would not be impacted by the Gross Reservoir expansion. No new roads, Water Treatment Plants (WTP), Wastewater Treatment Plants (WWTPs), or other facilities would be required by these entities as a result of the reservoir expansion.

5.19.1.6 Public Facilities and Services

The public facilities and services described in Section 3.17.1 include police services, fire departments, health services, libraries, water providers, wastewater treatment, solid waste disposal, and educational services. Impacts to public services are generally the result of changes in population or changes in funding. Population changes are not expected as a result of the Proposed Action. Property tax revenue would be decreased by a small amount for some Boulder County services. Other temporary effects on services might occur during the construction phase. The impact of Denver Water's diversions on other water and wastewater utilities was also examined.

Service Specific Impacts

The impact of the Proposed Action on each type of service provider is discussed below and summarized in Table 5.19-3. Water and wastewater treatment providers in Grand County have been discussed separately from other water and wastewater treatment providers because of river diversions that originate in Grand County.

Table 5.19-3
Summary of the Impacts of the Proposed Action on Public Facilities and Services

Public Facilities and Services	Gross Reservoir PIA	Boulder County	Denver Metropolitan Area	Grand County
Police Departments	No impact	Minor, temporary	No impact	No impact
Fire Departments	Minor, temporary	No impact	No impact	No impact
Health Services	No impact	No impact	No impact	No impact
Libraries	No impact	No impact	No impact	No impact
Water Providers	No impact	Positive or no impact	Positive or no impact	Negligible impact
Wastewater Treatment	No impact	No impact	No impact or negligible	No impact
Solid Waste Disposal	No impact	No impact	No impact	No impact
Education	No impact	No impact	No impact	No impact

Source: Harvey Economics, 2007.
Notes:
Denver Water and water providers that are Denver Water customers will experience positive impacts from the Proposed Action, while other water providers will be unaffected.
PIA = Primary Impact Area

Police Departments

Increased traffic and construction activity in the vicinity of Gross Reservoir would generate a small, temporary increase in service requirements from the Boulder County Sheriff's Department. With an increase in truck traffic and commuting workers, the need for traffic law enforcement and response to accidents increase. Given the level of projected traffic volume attributable to the Gross Reservoir enlargement, these demands are likely to be minor and temporary. The Boulder County Sheriff's Department should be able to accommodate these service increases. It is unlikely that construction activity would generate any crime in the Gross Reservoir PIA; workers would commute back and forth to residences in the Denver Metropolitan area and would not remain in the PIA outside of working hours.

The Department is partially funded through Boulder County property tax revenues. Revenues to Boulder County would be reduced by about $60 per year as a result of the 15-acre land purchase and removal from the tax rolls; any funding changes to the Sheriff's Department would have a negligible impact on the Department's budget.

Fire Departments

Similarly, the demands on the Coal Creek Canyon Volunteer Fire Department, the Cherryvale Fire Protection District, and the High Country Fire Protection District would potentially increase by a small amount during the construction phase of the Gross Reservoir enlargement, stemming from emergencies at the site or along commuting routes. These fire protection agencies should be able to adequately respond to potential emergencies and additional demands are likely to be minor and temporary.

The revenue loss of about $21 per year to the Coal Creek Canyon Volunteer Fire Department as a result of the 15-acre land purchase and resulting loss to the tax rolls would have a negligible impact on the Department's budget.

Health Services

In the event of construction accidents or other health service emergencies, emergency services and health care providers would experience increased demands. The Boulder Community Hospital in Boulder is the closest to the reservoir site and would have the capacity and ability to provide services to injured construction workers or other workers associated with the reservoir expansion without detriment to their current operations or patients. Exempla Lutheran Medical Center in Wheat Ridge as well as other hospitals and healthcare providers in Jefferson County and other Denver Metropolitan area counties would also be able to care for injured construction workers. Any construction worker or other person in need of medical attention would carry medical insurance to pay for the required services.[16]

Libraries

There would be no impacts or change in funding to libraries in Boulder County, the Denver Metropolitan area, or Grand County as a result of the Proposed Action.

Education

The RE-2 school district in Boulder County would experience an annual reduction in revenue of about $101 from property tax losses; however, the State would make up that amount in guaranteed funding, so there would be no impact to the District.[17] School districts in the Denver Metropolitan area and Grand County would not be impacted or experience any change in funding as a result of the Proposed Action.

Denver Metropolitan Area and Boulder County Water Providers

The PACSM flow data was used to analyze impacts to these water providers as a result of the Proposed Action. A detailed description and explanation of flow changes in rivers affected by the Proposed Action is provided in Section 5.1 and information on the effects of flow changes to groundwater resources is included in Section 5.4. In short, Denver Water would divert water from the Fraser River, Williams Fork River, and South Boulder Creek in average and wet years. The majority of water would be diverted in wet years following dry years. Water would mainly be diverted in the spring and early summer months with little to no flow change in any river in the fall and winter months. Denver Water would not divert any additional water in dry years.

There would be no decrease in the quantity of water available via wells within the Gross Reservoir PIA as a result of the reservoir expansion or river diversions in the Proposed Action. Flows in South Boulder Creek above Gross Reservoir would increase in average and wet years when Denver Water would divert additional water from the Fraser and Williams Fork rivers; however, there would be no change in flows in dry years. Average monthly flows below Gross Reservoir would increase from September through March and decrease from April through August. Average monthly flows at the South Boulder Creek

[16]Workers compensation would also be available to pay for medical services.

[17]The State of Colorado guarantees a certain amount of funding per student to each school district and would only be obligated to make up losses to districts up to that guaranteed amount. Districts that collect revenues in excess of the guaranteed funding amount would only be eligible for State reimbursement of losses if the loss caused total funding to dip below guaranteed levels.

near Eldorado Springs gage would decrease slightly in March, May, and June and would be unchanged or would increase in other months as discussed in Section 5.1.

Water providers in Boulder County and other Denver Metropolitan area counties that are not Denver Water customers would not be impacted by the activities in the Proposed Action. These providers would continue to be able to serve their customers with the same level of water service as without the reservoir expansion and additional river diversions. Many water providers in the Denver Metropolitan area obtain water supplies from sources other than the Blue River, Fraser River, Williams Fork River, South Boulder Creek, or South Platte River. Average monthly flows in the South Platte River below Chatfield Reservoir and at the Denver gage would generally decrease slightly in the late spring and summer months and would increase in winter months. Average monthly flows in the South Platte River at the Henderson gage near Brighton would decrease by about 1% in May and June and remain unchanged or increase in other months as discussed in Section 5.1.

Denver Water and its customers would benefit from the availability of additional water in Gross Reservoir and from the avoidance of the potential risks and vulnerabilities described in Chapters 1 and 2.

Grand County Water Providers

Grand County water providers that rely on water from the Fraser River have raised concerns about the impact of the Proposed Action on their ability to meet customer demands. Section 5.1 provides a detailed explanation of flow changes under the Proposed Action, including changes in the Fraser River and tributaries. Table 4-3.1-3 provides information on future water demands and the expected shortages facing each Grand County water provider under Full Use of the Existing System and Full Use with a Project Alternative (2032), both of which incorporate all Grand County build-out demands. GCWSD and the Town of Fraser would experience the greatest shortages under Full Use of the Existing System, 358 AF and 247 acre-feet per year (AF/yr), respectively. Other water providers would face smaller shortages, ranging from 1 AF up to 70 AF/yr. These shortages would likely occur in dry years or in winter months and would occur for a variety of reasons, including lack of legal rights or lack of physical water. The impact of the Proposed Action on Grand County water providers is based on comparison of river flows under Full Use of the Existing System and Full Use with a Project Alternative (2032). Under the Proposed Action, Denver Water would divert additional water from the Fraser and Williams Fork rivers only during wet and average years. No water would be diverted in dry years. Additionally, diversions would generally occur between May and July with the majority of diversions occurring in June and minimal, if any, diversions taking place in other months. The May through July period is also when river flows are at their greatest due to snowmelt and runoff. Denver Water's diversions would coincide with these increased flows. Although Fraser River flows would be reduced in some months and in certain years due to the additional diversions of the Proposed Action, these specific changes would not place additional burden on Grand County water providers. The PACSM results show that the Proposed Action would not increase shortages for any Grand County water provider, with the exception of the GCWSD. That district's future water shortage would increase by 6 AF, from 358 to 364 AF, as a result of the Proposed Action, as shown in Table 4.3.1-3. Under Full Use with a Project Alternative (2032), the GCWSD would likely

make additional infrastructure investments to mitigate potential water shortages; potential investments include a $2 million pump station and pipeline to enable use of their conditional Fraser River water rights (refer to Section 5.1 for more detail).[18] Investment in new infrastructure would likely result in increases in the local mill levy, as well as in water rates and tap fees.

The Proposed Action would have no discernible effects on downstream groundwater users; however, the relationship between surface water and groundwater in Grand County is unclear due to elevation differences in various locations.

The additional water diversions under the Proposed Action would not affect the water market or the cost of acquiring additional supplies for Grand County water providers. Denver Water's water rights in the region are already accounted for in water values and supplies. Overall, the ability of Grand County water providers to meet future customer demand would not be impacted by the additional Denver Water diversions from the Fraser River or the Williams Fork River that would occur for the Proposed Action.

Denver Metropolitan Area and Boulder County Wastewater Treatment

The river diversions that would occur as part of the Proposed Action would not cause dilution problems for WWTPs in the Denver Metropolitan area or Boulder County. WWTPs that serve residents of these areas would continue to provide treatment at the same level of service as prior to the reservoir expansion and additional Grand County river diversions. Several WWTPs discharge effluent into rivers that would be unaffected by Denver Water's diversions. A number of other Denver Metropolitan area municipalities and sanitation districts send their wastewater to the Denver's Metro Wastewater Reclamation District Plant (Metro WWTP) for treatment. The portion of the South Platte River into which the Metro WWTP discharges its effluent would experience minimal changes in flows from the Proposed Action. Between October and April, flows in the South Platte River at the Denver gage would not change or would increase compared to the baseline scenario; between May and September flows at the Denver gage would decrease by 1 or 2% as compared to the baseline scenario. South Platte River flows at the Henderson gage, near Brighton, would decrease by 1% in May and June and would otherwise remain unchanged or increase. These small decreases in flow would produce negligible impacts at most for wastewater treatment operations at the Metro WWTP or at other plants.

Grand County Wastewater Treatment

Grand County WWTPs that discharge treated wastewater into the Fraser River watershed are listed in Section 3.2.5.1. National Pollutant Discharge Elimination System (NPDES) permit requirements for these wastewater treatment facilities are based on acute and/or chronic low flows in the Fraser River and relevant tributaries, which generally occur in winter months and in dry years. Denver Water's diversions as part of the Proposed Action would take place mainly between May and July in wet and average years and no diversions would occur in dry years. Therefore, low flows occurring during winter months under the Full Use of the Existing System would not be impacted by the diversions of the Proposed Action. Section 4.2 compares the acute and chronic low flows for the relevant WWTPs

[18]Bruce Hutchins, Superintendent, Grand County Water and Sanitation District, March 18, 2011.

under Full Use of the Existing System and Full Use with a Project Alternative (2032). Acute and chronic low flows for Grand County WWTPs would not be exacerbated under the Proposed Action; no flow related impacts to discharge permits would be due to the Proposed Action. The Proposed Action is anticipated to have little to no effect to water quality or to the permitted operations of these plants. Therefore, no economic impacts to Grand County WWTPs are anticipated as a result of the Proposed Action.

A comparison of river flows under Full Use of the Existing System and Full Use with a Project Alternative (2032) for each alternative is provided in Section 5.1 and in Appendix H. The PACSMs indicate that the changes in Fraser River, Ranch Creek, and Crooked Creek flows under the Proposed Action would not affect the ability of Grand County's water treatment facilities to treat and discharge effluent, as compared to the Full Use of the Existing System.

Section 5.2 provides additional discussion on potential impacts to wastewater treatment providers. That section compares modeled stream flows and the percentage of streams that could be wastewater (based on estimated plant flows and acute low river flows) under Full Use of the Existing System and the Proposed Action. The results of the analysis indicate no finding of change in the percentage of various Fraser River stretches that could be made up of effluent and concludes that no impact to wastewater treatment facility discharge permits is expected under the Proposed Action, compared to the conditions of the Full Use of the Existing System.

Solid Waste Disposal

During the construction period, some construction associated waste may be disposed of at Boulder County or Denver Metropolitan area landfills. Denver Water would be responsible for any applicable fees for waste disposal and no landfills would be adversely impacted by the construction activities of the Proposed Action. No additional waste would be generated or disposed of at any landfills during operations.

Table 5.19-3 provides a summary of the impacts of the Proposed Action on public facilities and services in the Gross Reservoir PIA, Boulder County, the Denver Metropolitan area, and Grand County.

5.19.1.7 Financial Impacts to Denver Water Customers

Denver Water would be responsible for total construction costs of an estimated $140 million and annual operations and maintenance (O&M) costs of about $291,000 under the Proposed Action. Construction and O&M costs would be paid for with Denver Water revenues, including those collected from water sales, new connection fees, bond proceeds, and other sources.

Capital and O&M expenditures undertaken by Denver Water as a part of the Proposed Action would result in increases in water rates and new tap connection fees (known as System Development Charges [SDC]) for Denver Water customers as described below. SDCs were evaluated for typical single family residences with ¾-inch connections (referred to as ¾-inch SDC equivalent). To estimate those effects, the EIS Project Team worked with the Denver Water Finance Department to project the increases in rates and SDC. Denver Water's standard rate-making assumptions and procedures were followed in making

these projections, with two exceptions. First, all new capital requirements were borrowed and then paid for with SDC and water rates. This assumption facilitated a meaningful comparison between the No Action and the action alternatives. Secondly, the financial impacts on rate-payers were cast in a comparative manner in which the effects of each alternative are compared with the No Action Alternative which required no additional direct capital or operating costs, tantamount to Current Conditions (2006).

Water Rates

Under the Proposed Action, the average cost per 1,000 gallons of water would increase by about 55% through 2017, from a 2008 rate of $2.38 to $3.68 in 2017. This compares with a 52% increase under the No Action Alternative. Water rates would increase between 3% and 7% annually through 2017. This would be similar to annual increases under the No Action Alternative. These impacts to Denver Water and its customers are considered minor.

New Connection Charges

Under the Proposed Action, SDCs would increase by about 4% compared to 2008 SDC amounts (same as the No Action Alternative). The ¾-inch SDC equivalent price would be $7,718 under the Proposed Action. This compares with $7,424 under the No Action Alternative. These impacts on Denver Water and its new customers are considered minor.

Outstanding Debt

In addition, Denver Water's outstanding debt balance would increase by about 25% by 2017 under the Proposed Action, compared to the current 2008 balance. The outstanding debt balance relates to Denver Water's ability to borrow money for other projects and needs. In fact, Denver Water might employ other financing strategies to stretch out the debt and otherwise manage its debt more effectively. However, a more important measure of Denver Water's borrowing capacity is the debt to net fixed asset ratio which refers to the book value of on-going, "hard" assets. Under the Proposed Action this ratio would be about 19% by 2017. This effect is considered to be a minor impact, since this additional debt is not expected to impinge on Denver Water's future capital investment program.

5.19.1.8 Summary of Socioeconomic Impacts of the Proposed Action

Overall, the majority of socioeconomic impacts resulting from the Proposed Action would be temporary and tied to the construction period (Table 5.19-4).

Table 5.19-4
Summary of Socioeconomic Impacts of the Proposed Action

	Gross Reservoir PIA	Boulder County	Denver Metropolitan Area	Grand County
Demographic Conditions	Minor, temporary	No impact	No impact	No impact
Housing Conditions	Negligible, temporary	No impact	No impact	No impact
Economic Conditions	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	No impact
Fiscal Conditions	Negligible	Negligible	Negligible	No impact
Water Providers	No impact	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water Customers; No impact for others	Negligible impact, permanent
Other Public Facilities and Services	Minor or No impact	Minor or No impact	No impact	No impact
Water Rates and Tap Fees	No impact	No impact	Permanent, minor negative	No impact

Source: Harvey Economics, 2007.
Note:
PIA = Primary Impact Area

These temporary impacts would be positive in nature, but relatively minor and include the following:

- An average of 213 new jobs would be created during the construction period, which would result in over $12.5 million in annual employment-related income.
- Denver Water would spend over $72.5 million on materials and supplies during the construction period, much of it in the Denver Metropolitan area and surrounding counties.
- Purchases made by Denver Water for labor and materials plus spending by persons employed as a result of the Proposed Action would amount to economic output of about $62 million per year during the construction period.
- The positive impacts to revenues of public entities from increased sales tax collections could not be quantified, but would be negligible. Impacts to expenditures of public entities would be related to road and bridge maintenance and would be negligible.
- Several public service providers would experience negligible or minor increases in demands during the construction period.

Long-term permanent socioeconomic impacts of the Proposed Action would include:

- Denver Water and its customers would experience a long-term and positive impact from a more reliable water supply.
- An increase of $1.30 per 1,000 gallons by 2017 and an increase of about $300 in tap fees for Denver Water customers. These impacts are considered minor.

- A $60 loss of annual funding to Boulder County and a $21 loss of annual funding to the Coal Creek Canyon Volunteer Fire Department. These funding losses are negligible, given their respective annual budgets.

5.19.2 Alternative 1c

5.19.2.1 Economic Conditions

Employment and Business Activity – PIAs, Boulder County, and Denver Metropolitan Area

Alternative 1c would generally impact employment and business activity in Boulder County and the Denver Metropolitan area as described for the Proposed Action. The Leyden Gulch Reservoir site PIA includes small portions of Arvada and Golden, but is mainly rural and includes relatively few businesses. Commuting construction workers may spend a small amount of money in the PIAs, but the majority of worker spending and Denver Water spending would occur in the Denver Metropolitan area.

A 4,000 foot section of SH 93 would have to be permanently relocated due to construction of the Leyden Gulch Dam. Traffic would continue to use the existing portion of the highway until the new section of highway was completed, at which point traffic would be routed onto the realignment. At no point would any portion of SH 93 be closed to the public or to through traffic and access to local businesses would not be affected.

Construction-Related Employment and Business Activity

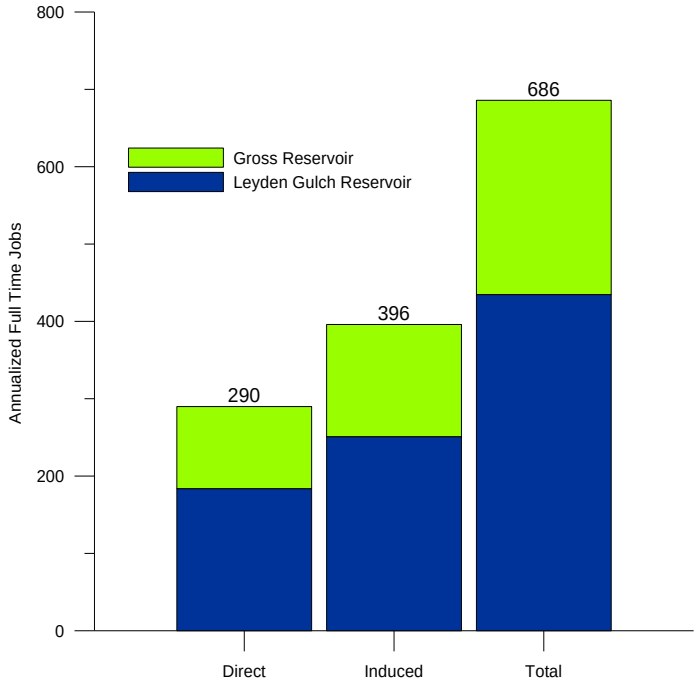
Denver Water would spend about $127 million for non-labor related costs, predominately for materials and supplies, to support the construction activity in Alternative 1c. Spending for materials and supplies would occur as described for the Proposed Action.

During the approximately 3.5-year construction phase of Alternative 1c, an average of 290 construction workers would be employed each year. In the peak quarter, 478 workers would be employed, or less than 1% of all construction workers in the Denver/Boulder Metropolitan Statistical Areas (MSAs).[19] The types of workers employed would be similar to those employed under the Proposed Action. The induced employment created as a result of the construction operation would create almost 400 additional jobs per year within a number of different industries in the Denver Metropolitan area. Construction employment and induced employment would be largely temporary, as described for the Proposed Action.

Figure 5.19-4 shows the average annual direct construction employment resulting from the Leyden Gulch Reservoir construction and Gross Reservoir expansion and the average annual induced employment created as a result of construction activity in Alternative 1c.

[19]The 478 workers amount to 0.77% of total 2011 construction employment in the Denver/Boulder Metropolitan area. If employment in the construction industry in the area grows, the number of workers directly employed to work on Gross and Leyden Gulch reservoirs will account for an even smaller percentage of the total.

Figure 5.19-4
Annual Employment Generated from Construction Activities in Alternative 1c



Source: MWH, 2006; Denver Water, 2007e; Harvey Economics, 2007; 2008.
Notes:
Construction activities would occur over a 3.5-year period for Alternative 1c.
Due to rounding, figures may not add up to total shown.

Personal Income

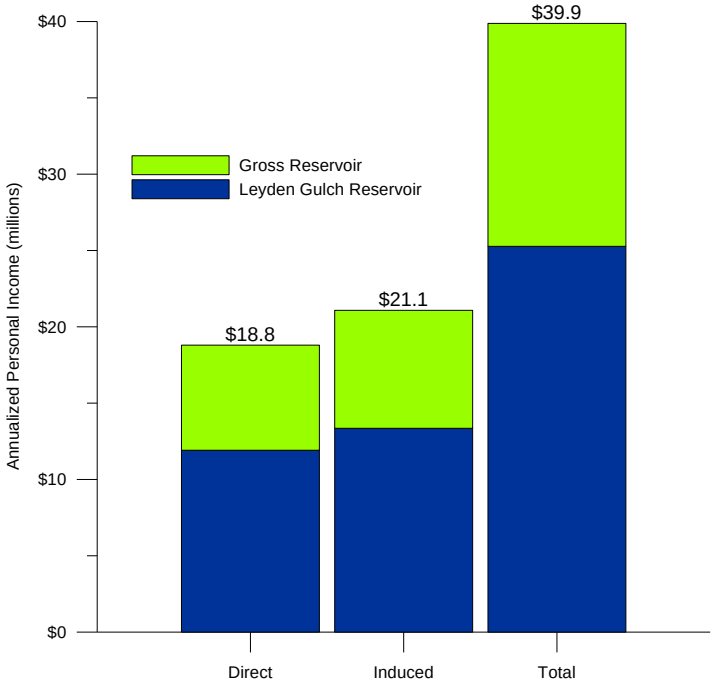
Total wages for construction workers would average about $18.8 million per year over the approximately 3.5-year construction period (MWH 2006; Harvey Economics 2008).[20] Average hourly wages for different types of construction workers would be the same as described for the Proposed Action. Quarterly expenditures on wages and salaries would increase from about $812,000 in the first quarter of Year One to a peak of about $7.7 million in the fourth quarter of Year Two. Wages of induced employees would range considerably, depending on the type of job created or the industry, but are estimated to total about $21 million per year.[21]

Figure 5.19-5 shows the average annual direct income and the average annual induced income created as a result of construction activities in Alternative 1c.

[20]Average annual wages are reported in constant 2006 dollars.

[21]Economic multipliers for the construction industry were obtained from the Colorado Department of Local Affairs (2006) and applied by Harvey Economics 2007. The estimated wages for induced employees are reported in constant 2006 dollars.

Figure 5.19-5
Annual Income Generated from Construction Activities in Alternative 1c



Source: MWH, 2006; Denver Water, 2007e; Harvey Economics, 2006.
Notes:
Construction activities would occur over a 3.5-year period for Alternative 1c.
Due to rounding, figures may not add up to total shown.

The annual total personal income created under Alternative 1c would account for less than one tenth of 1% of total compensation paid to all working persons in the Denver and Boulder Metropolitan areas.[22] Therefore, the personal income created as a result of Alternative 1c would have a negligible positive impact on the Denver Metropolitan area.

Total Economic Output

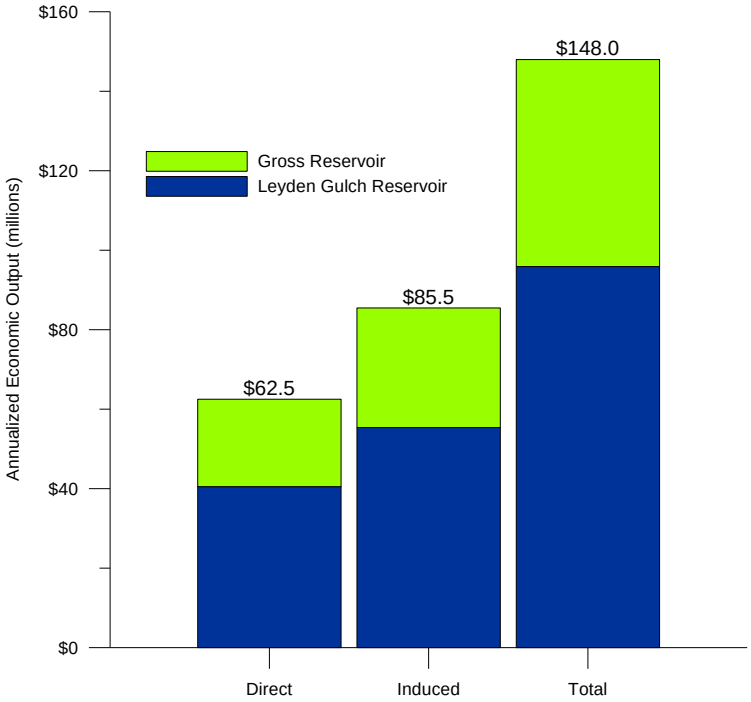
Direct construction costs associated with Alternative 1c would total about $231.3 million over the construction period, or about $62.5 million per year, including labor and non-labor costs.[23] Induced sales of goods and services result from these direct construction expenditures as described for the Proposed Action. Total annual average sales of goods and services would amount to about $148 million per year over the construction period.

Figure 5.19-6 shows the annual direct spending by Denver Water for construction activities, the annual induced spending and the total annual economic output generated by the construction activities in Alternative 1c.

[22] Compared to 2011 data, $39.9 million amounts to about 0.05% of total compensation for construction workers in the Denver/Boulder Metropolitan areas.

[23] Direct construction costs presented here do not include mobilization costs. Mobilization costs include bonds and insurance. Total construction costs include direct construction costs as well as engineering and environmental costs.

Figure 5.19-6
Annual Economic Output Generated from Construction Activities in Alternative 1c



Source: MWH, 2006; Denver Water, 2007e; Harvey Economics, 2007.
Notes:
Construction activities would occur over a 3.5-year period for Alternative 1c.
Due to rounding, figures may not add up to total shown.

Total sales for Denver Metropolitan area businesses in 2011 exceeded $157 billion. Total annual economic output created under Alternative 1c would account for less than a tenth of 1% of total sales in the Denver Metropolitan area. The economic output created as a result of Alternative 1c would have a negligible but positive and temporary impact on the Denver Metropolitan area.

Operational Phase Employment and Business Activity

Employment and business activity during operations would be similar to that described for the Proposed Action for the Gross Reservoir component. The current staff at the Ralston Reservoir Facility would also operate the proposed Leyden Gulch Reservoir and associated facilities.

Employment and Business Activity – Grand County

Employment and business impacts to Grand County for Alternative 1c would be the same as described for the Proposed Action.

5.19.2.2 Demographic Conditions

Gross Reservoir PIA

Impacts to the population and other demographic characteristics of the Gross Reservoir PIA would be the same as described under the Proposed Action. Construction phase impacts experienced by PIA residents would be similar in nature, but slightly less in magnitude, to those described for the Proposed Action (Alternative 1a) due to the shorter construction timeframe 3.5 years vs. more than 4.0 years and the smaller reservoir enlargement.

Leyden Gulch Reservoir PIA

The Leyden Gulch Reservoir site PIA is mainly rural and sparsely populated, although it does contain small portions of Arvada and Golden as described in Section 3.17.1.2. The majority of the acreage required to construct the proposed Leyden Gulch Reservoir under Alternative 1c is currently owned by Denver Water. That area is undeveloped and closed to the public, but some grazing does occur on the site.

Six additional private properties and partial interest in 900 acres of mineral rights land to the east and to the south of the reservoir site would need to be purchased in order to complete construction of the reservoir and dam. Homes exist on three of these parcels; the residents of these houses would relocate. The remaining parcels are vacant land.

As with Gross Reservoir, construction workers would commute to the Leyden Gulch Reservoir site each day and would probably not relocate to the PIA. Once completed, Leyden Gulch Reservoir and immediate surrounding area would continue to be closed to the public. Other than those inundated properties, the reservoir would not likely cause people to move into or out of the Leyden Gulch Reservoir site PIA. Given the small number of people that would be required to relocate compared to the overall PIA population, the population of the Leyden Gulch Reservoir PIA would remain essentially unchanged as a result of Alternative 1c. The demographic characteristics of this PIA population would also remain unchanged under Alternative 1c.

Boulder County and Denver Metropolitan Area Counties

Impacts to the population and other demographic characteristics of Boulder County and Denver Metropolitan area counties resulting from Alternative 1c would be similar to those described for the Proposed Action.

Grand County

Impacts to the Grand County population and the demographic characteristics of that population resulting from Alternative 1c would be similar to those described for the Proposed Action.

Table 5.19-5 describes the impacts of Alternative 1c on the demographic conditions of affected areas.

Table 5.19-5
Changes to Demographic Conditions from Alternative 1c

	Gross Reservoir PIA	Leyden Gulch Reservoir Site PIA	Boulder County	Denver Metropolitan Area	Grand County
Population	No impact	No impact	No impact	No impact	No impact
Migration Patterns	No impact	No impact	No impact	No impact	No impact
Ethnicity	No impact	No impact	No impact	No impact	No impact
Age Distribution	No impact	No impact	No impact	No impact	No impact
Commuting Patterns	Minor to moderate, temporary	No impact	Negligible, temporary	Negligible, temporary	No impact

Source: Harvey Economics, 2007.
Note:
PIA = Primary Impact Area

5.19.2.3 Environmental Justice

No specific ethnic or otherwise classified groups of PIA, Boulder County, or Denver Metropolitan area residents would be disproportionately impacted by construction or operational activities in Alternative 1c. No environmental justice issues would arise as a result of this alternative.

5.19.2.4 Housing Conditions

Housing Units

Impacts to the number of existing housing units in the Gross Reservoir PIA, Boulder County, the Denver Metropolitan area, and Grand County would be similar to those described for the Proposed Action. Three homes in the Leyden Gulch Reservoir site PIA would be unusable for private use as a result of construction activity in this alternative. The loss of three homes in this PIA would be negligible given the number of available housing units in the area. No population growth would be expected in the PIA and therefore, no additional homes would be required to meet housing demand.

Vacancy Rates

Impacts to vacancy rates in the Gross Reservoir PIA, Boulder County, the Denver Metropolitan area, and Grand County would be the same as those described for the Proposed Action. Vacancy rates in the Leyden Gulch Reservoir site PIA would be almost entirely unaffected by Alternative 1c. The population of the PIA would not change, therefore, the number of housing units in the PIA would not be expected to change.

Home Values

Impacts to home values in the Gross Reservoir PIA, Boulder County, and the Denver Metropolitan area would be the same as those described for the Proposed Action. Home values in the Leyden Gulch Reservoir site PIA would also be largely unaffected by Alternative 1c. The reservoir would be closed to the public and would not result in lakeside property, although some properties might marginally benefit from a distant view of the

reservoir. Because the population would remain unchanged, demand for homes in the PIA would not increase or decrease due to activities in Alternative 1c. Additionally, the minimal decrease in the number of homes available in the Leyden Gulch Reservoir site PIA would not be enough to affect home prices. In Grand County, properties surrounding Grand Lake would realize a total loss of value of about $223,000 due to changes in water quality and clarity (see Sections 4.6.2 and 4.6.19, for more detail).

Table 5.19-6 presents the impacts of Alternative 1c on the housing characteristics of affected areas.

Table 5.19-6
Changes to Housing Conditions from Alternative 1c

	Gross Reservoir PIA	Leyden Gulch Reservoir PIA	Boulder County	Denver Metropolitan Area	Grand County
Housing Units	No impact	Negligible, permanent	No impact	No impact	No impact
Vacancy Rates	No impact	No impact	No impact	No impact	No impact
Home Values	Minor to moderate, temporary impacts for a small number of homes along Gross Dam Road	Negligible, permanent	No impact	No impact	Minor impact to homes directly surrounding Grand Lake

Source: Harvey Economics, 2007.
Note:
PIA = Primary Impact Area

5.19.2.5 Fiscal Conditions of Public Entities Other than Denver Water

Operating Revenues

Local jurisdiction revenues and Denver Water tax responsibilities would be the same as described in the Proposed Action. Fiscal impacts due to the Gross Reservoir expansion would also be the same as described in the Proposed Action.

Denver Water currently owns most of the property required for the construction of Leyden Gulch Reservoir, but would need to purchase some additional land as detailed in Section 5.19.2.2, approximately 327 acres. As described in the Proposed Action, Denver Water does not pay property taxes. Therefore, as a result of this land purchase, public entities in Jefferson County would experience the following annual property tax losses:[24]

- Jefferson County: $1,895
- Jefferson County R-1 School District: $3,815[25]
- Jefferson County Sheriff's Office: $249
- Fairmount Fire Protection District: $617

[24]This does not include approximately 900 acres of mineral rights to be purchased or land purchased from BFI Waste Services. Property taxes are not paid on mineral rights and thus there would be no losses associated with this purchase.

[25]The State of Colorado guarantees a certain amount of funding per student to each school district and would make up losses to districts up to that guaranteed amount.

- Arvada Fire Protection District: $2
- Urban Drainage and Flood Control District: $47

These effects are considered negligible compared with the size of the budgets for these entities.

Operating Expenditures

Potential expenditures for local public entities would be related to road and bridge maintenance and would be negligible as a result of the Gross Reservoir expansion as described in the Proposed Action, except the number of construction and construction worker peak-hour vehicle trips would change. The average number of haul and concrete trucks per day would be reduced from 22 to 21 and the average number of peak-day commuter trips would increase from 101 to 319, including construction traffic to the Leyden Gulch Reservoir site.

For Leyden Gulch Reservoir construction, expenditures from local public entities would be for road and bridge maintenance, similar to the Proposed Action expenditures. Expenditures by CDOT for maintenance of State highways are also described in the Proposed Action. SH 93, leading to the Leyden Gulch Reservoir site, is located in Jefferson County. The Road and Bridge Division is responsible for maintenance of Jefferson County roads. Their annual budget for 2007 was in excess of $25 million. Any additional expenses for maintenance due to construction of Leyden Gulch Reservoir would be temporary and negligible to minor.

Construction-related traffic for the Leyden Gulch Reservoir site would primarily be for construction workers who would likely come from the Denver Metropolitan area. Commuting construction workers would likely utilize major traffic arteries, which would eventually be funneling onto SH 93. Unlike the Gross Reservoir expansion, borrow material would not be needed, reducing expected truck traffic. Average daily traffic on SH 93 is in excess of 20,000 vehicle trips per day. The addition of a maximum of peak-hour vehicle trips due to Leyden Gulch Reservoir construction would be about 200. This would present a negligible impact on traffic and road and bridge maintenance.

Capital Outlays

Net capital outlay expenditures for local public entities would not be impacted by Alternative 1c. Denver Water would be financially responsible for the SH 93 road re-location, either reimbursing CDOT for those costs or performing the re-location through its own contractors. No WTP, WWTP, or other facilities would be required by these entities as a result of the reservoir expansion or the construction of Leyden Gulch Reservoir.

5.19.2.6 Public Facilities and Services

Impacts resulting from the expansion of Gross Reservoir are discussed in Section 5.19.1.6 for the Proposed Action and are included in Table 5.19-7.

The populations of the PIAs, Boulder County, Denver Metropolitan area counties, and Grand County would not change as a result of Alternative 1c. The agencies that provide

public services to residents in these areas would not experience added pressure to serve any additional people as a result of Alternative 1c.

Table 5.19-7
Summary of the Impacts of Alternative 1c on Public Facilities and Services

Public Facilities and Services	Gross Reservoir PIA	Leyden Gulch Reservoir Site PIA	Boulder County	Jefferson County	Other Denver Metropolitan Area Counties	Grand County
Police Departments	No impact	No impact	Minor, temporary	Minor, temporary	No impact	No impact
Fire Departments	Minor, temporary	Minor, temporary	Negligible, temporary	Negligible, temporary	No impact	No impact
Health Services	No impact	No impact	No impact	No impact	No impact	No impact
Libraries	No impact	No impact	No impact	Negligible impact	No impact	No impact
Water Providers	No impact	Positive or No impact	Positive or No impact	Positive or No impact	Positive or No impact	Negligible
Wastewater Treatment	No impact	No impact	No impact	No impact	No impact or negligible	No impact
Solid Waste Disposal	No impact	No impact	No impact	No impact	No impact	No impact
Education	No impact	No impact	No impact	No impact	No impact	No impact

Source: Harvey Economics, 2007.
Notes:
Denver Water and water providers that are Denver Water customers would experience positive impacts from Alternative 1c, while other water providers would be unaffected.
Jefferson County is shown separately from the Denver Metropolitan area in this table because of the impacts to specific services resulting from the construction of Leyden Gulch Reservoir, located in Jefferson County.
PIA = Primary Impact Area

Service Specific Impacts

Impacts to public service providers resulting from Alternative 1c are discussed below and summarized in Table 5.19-7.

As for other Alternatives, water and wastewater treatment providers in Grand County have been discussed separately from other water and wastewater treatment providers because of river diversions that originate in Grand County.

Police Departments

Impacts to police departments in the Gross Reservoir PIA and Boulder County would be the same as described for the Proposed Action.

The Jefferson County Sheriff's Office would experience a loss of funding of about $250 per year as a result of Alternative 1c.[26] This would be due to the loss of property tax collected on the acreage that Denver Water would purchase in Jefferson County for the Leyden Gulch Reservoir. This funding change would result in a negligible impact to the Sheriff's Office budget.

Construction of Leyden Gulch Reservoir would result in increased traffic volume from truck traffic and commuting construction workers in Jefferson County. This might induce

[26]Based on 2006 assessed property values and 2006 mill levy rates in Jefferson County.

increased enforcement in the area, and the Jefferson County Sheriff's Department would need to respond to any additional traffic accidents resulting from the increased traffic. The effects should be temporary and minor and the Sheriff's Department should be able to accommodate these increases.

Fire Departments

Impacts to police departments in the Gross Reservoir PIA and Boulder County would be the same as described for the Proposed Action.

Demands on the Fairmount and Arvada fire protection districts would potentially increase by a small amount during the construction phase of Alternative 1c, stemming from emergencies at the site or along commuting routes. These fire protection agencies should be able to adequately respond to potential emergencies. The Fairmount Fire Protection District in Jefferson County would experience a loss of about $617 per year as a result of Alternative 1c.[27] This funding change would be a negligible impact to the District's budget. Funding of the Arvada Fire District would be reduced by about $2 per year, a negligible loss. These funding changes would be due to the loss of property tax collected on the acreage that Denver Water would purchase in Jefferson County for the proposed Leyden Gulch Reservoir.

No other fire departments in Boulder County, Denver Metropolitan area counties, or Grand County would experience any impacts related to changes in funding.

Health Services

Hospitals and health providers located near Gross Reservoir in Boulder County and near the proposed Leyden Gulch Reservoir in Jefferson County and in other Denver Metropolitan area counties would have the capacity and ability to provide services to any injured construction workers or other workers associated with the reservoir expansion without detriment to their current operations or patients. Any construction worker in need of medical attention would carry medical insurance or have workers compensation insurance to pay for the required services.

Libraries

No libraries in the Denver Metropolitan area, with the exception of those in Jefferson County, would experience any impacts as a result of Alternative 1c. Libraries in Jefferson County are funded through the county mill levy. Property taxes paid to the county would be reduced by $1,895 per year under Alternative 1c due to Denver Water's purchase of property for Leyden Gulch Reservoir.[28] A small portion of this loss may be allocated to the county's library system, resulting in a negligible impact to the libraries. Libraries in Grand County would not experience any funding changes or other impacts as a result of Alternative 1c.

[27]Based on 2006 assessed property values and 2006 mill levy rates in Jefferson County.

[28]Based on 2006 assessed property values and 2006 mill levy rates in Jefferson County.

Education

The Jefferson County Public School District would experience a reduction in revenue of about $3,815 due to lost property tax revenue. However, the State would likely make up that amount in guaranteed funding, eliminating any fiscal impacts to the District.[29] No other Denver Metropolitan area or Grand County school district would be impacted by Alternative 1c.

Denver Metropolitan Area and Boulder County Water Providers

Impacts within the Gross Reservoir PIA would be the same as described for the Proposed Action. Residents within the Leyden Gulch Reservoir site PIA obtain their water from a variety of sources, including wells and municipal water providers. Water availability in this PIA would not be impacted under Alternative 1c. South Boulder Creek flows would change as described for the Gross Reservoir PIA under the Proposed Action. Municipal providers within the Leyden Gulch Reservoir site PIA that get at least a portion of their water from Denver Water, such as Arvada, would benefit from this alternative. Other water providers in the PIA would be unaffected by Alternative 1c.

Impacts to Denver Water and its customers would be the same as described in the Proposed Action. Other water providers in Boulder County and Denver Metropolitan area counties would also be impacted as described for the Proposed Action. Changes to water rates for Denver Water's customers as a result of Alternative 1c are described in Section 5.19.2.7.

Grand County Water Providers

Impacts to Grand County water providers under Alternative 1c would be similar to those described for the Proposed Action. Overall, effects would be considered negligible.

Denver Metropolitan Area and Boulder County Wastewater Treatment

WWTPs that serve Boulder County, Jefferson County, and other Denver Metropolitan area residents would continue to provide treatment at the same level of service as before the reservoir expansion and additional river diversions. The river diversions that would occur as part of Alternative 1c would not cause dilution problems for WWTPs in Boulder County or the Denver Metropolitan area. Several WWTPs discharge effluent into rivers that would be unaffected by Denver Water's diversions. A number of other Denver Metropolitan area municipalities and sanitation districts send their wastewater to Denver's Metro WWTP for treatment. The portion of the South Platte River into which the Metro WWTP discharges its effluent would experience minimal changes in flows from Alternative 1c. Between October and April, flows in the South Platte River at the Denver gage would not change or would increase by up to 7% as compared to the baseline scenario; between May and September flows at the Denver gage would decrease by 1 to 3% as compared to the baseline scenario. This small decrease in flow would not impact wastewater treatment capabilities for the Metro WWTP. Overall, the effects from these flow changes would be considered negligible.

[29] The State of Colorado guarantees a certain amount of funding per student to each school district and would only be obligated to make up losses to districts up to that guaranteed amount. Districts that collect revenues in excess of the guaranteed funding amount would only be eligible for state reimbursement of losses if the loss caused total funding to dip below guaranteed levels.

Grand County Wastewater Treatment

Impacts to Grand County wastewater providers under Alternative 1c would be the same as those described for the Proposed Action.

Solid Waste Disposal

During the construction period, some construction associated waste may be disposed of at Denver Metropolitan area or Boulder County landfills. Denver Water would be responsible for any applicable fees for waste disposal and no landfills would be adversely impacted by the construction activities of Alternative 1c. No additional waste would be generated or disposed of at any landfills during operations.

Table 5.19-7 provides a summary of the impacts of Alternative 1c on public facilities and services in affected areas.

5.19.2.7 Financial Impacts to Denver Water Customers

Denver Water would be responsible for total construction costs of an estimated $294 million and annual O&M costs of about $612,000 under Alternative 1c. Construction and O&M costs would be paid for with Denver Water revenues, including those collected from water sales, new connection fees, bond proceeds, and other sources. Capital and O&M expenditures undertaken by Denver Water as a part of Alternative 1c would result in increases in water rates and new connection fees for Denver Water customers as described below.

Water Rates

Under Alternative 1c, the average cost per 1,000 gallons of water would increase by about 66% through 2017, from a 2008 rate of $2.38 to $3.94 in 2017. This compares with a 52% increase under the No Action Alternative. Water rates would increase by between 3% and 8% annually through 2017. Annual increases would be higher than annual increases under the No Action Alternative. These impacts on Denver Water and its customers are considered minor.

New Connection Charges

Under Alternative 1c, SDCs would increase by about 8.4% compared to 2008 rates. The ¾-inch SDC equivalent price would be $8,045 under Alternative 1c. This compares with $7,424 under the No Action Alternative. These impacts on Denver Water and its new customers are considered minor to moderate.

Outstanding Debt

Denver Water's outstanding debt balance would increase by about 59% by 2017 under Alternative 1c, compared to the current 2008 balance. More importantly, Denver Water's projected debt to net fixed asset ratio would be about 23% by 2017 under Alternative 1c. In fact, Denver Water might employ other financing strategies to stretch out the debt and otherwise manage its debt more effectively. This effect is considered to be a minor to moderate impact, since this additional debt might impinge on Denver Water's future capital investment program for a limited period of time.

5.19.2.8 Summary of Socioeconomic Impacts of Alternative 1c

As described for the individual topics above, some of the socioeconomic impacts of Alternative 1c would be temporary and tied to the construction phase and other impacts would be long term and permanent. A summary of impacts as a result of Alternative 1c is presented in Table 5.19-8.

Table 5.19-8
Summary of Socioeconomic Impacts of Alternative 1c

Socioeconomic Consideration	Gross Reservoir PIA	Leyden Gulch Reservoir Site PIA	Boulder County	Jefferson County	Other Denver Metropolitan Area Counties	Grand County
Demographic Conditions	Minor, temporary	Negligible, permanent	No impact	No impact	No impact	No impact
Housing Conditions	Negligible, temporary	Negligible, permanent	No impact	No impact	No impact	Negligible, permanent
Economic Conditions	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	No impact
Fiscal Conditions	Negligible	Negligible	Negligible	Negligible	Negligible	No impact
Water Providers	No impact	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Negligible, permanent
Other Public Facilities and Services	Minor or No impact	Minor or No impact	No impact, negligible or minor	No impact, negligible or minor	Negligible or No impact	No impact
Water Rates and Tap Fees	No impact	No impact	No impact	Permanent, minor to moderate, negative	Permanent, minor to moderate, negative	No impact

Source: Harvey Economics, 2007.
Notes:
Jefferson County has been shown separately from the Denver Metropolitan area in this table due to the potential for site-specific impacts related to the construction and operation of a proposed Leyden Gulch Reservoir.
PIA = Primary Impact Area

Temporary impacts would be similar to those of the Proposed Action and would include the following:

- An average of about 690 new jobs would be created during the construction period, which would result in about $40 million in annual employment related income.
- Denver Water would spend about $127 million on non-labor costs, much of which would be for materials and supplies, during the construction period. It is expected that many of the expenditures would occur in the Denver Metropolitan area and surrounding counties.

- Purchases made by Denver Water on labor and materials plus spending by persons employed as a result of this alternative would amount to economic output of $148 million per year during the construction period.
- The positive impacts to revenues of public entities from increased sales tax collections could not be quantified, but would be negligible and temporary.
- Impacts to expenditures of public entities would be related to road and bridge maintenance and would be negligible.
- Several public service providers would experience negligible or minor increases in demands during the construction period.

Long-term and permanent socioeconomic impacts of Alternative 1c would include:

- Benefits to Denver Water customers from a more reliable water supply.
- A water rate increase of about $1.60 per 1,000 gallons by 2017 and an increase of about $620 in tap fees for Denver Water customers. These impacts are considered minor.
- A $60 loss of annual funding to Boulder County, a $1,895 loss of annual funding to Jefferson County, a $21 loss of annual funding to the Coal Creek Canyon Fire Department, a $617 loss of annual funding to the Fairmount Fire Protection District, a $2 loss of annual funding to the Arvada Fire District, and a $249 loss in annual funding to local law enforcement agencies. Funding losses for these agencies are negligible, given their respective annual budgets.

5.19.3 Alternative 8a

5.19.3.1 Economic Conditions

Employment and Business Activity – PIAs and the Denver Metropolitan Area

The majority of impacts on employment and business activity would occur within the Denver Metropolitan area, as explained for the Proposed Action. The South Platte River Facilities PIA covers a relatively developed area and includes many businesses. Therefore, a larger amount of money may be spent in that PIA as compared to the Gross Reservoir PIA, which is mainly rural. The PIA for Conduit O occurs within the roadway itself, where no houses or businesses are presumed to exist. The magnitude and value of impacts to employment, income, and sales under Alternative 8a are unique compared to the Proposed Action and are described below.

Construction-Related Employment and Business Activity

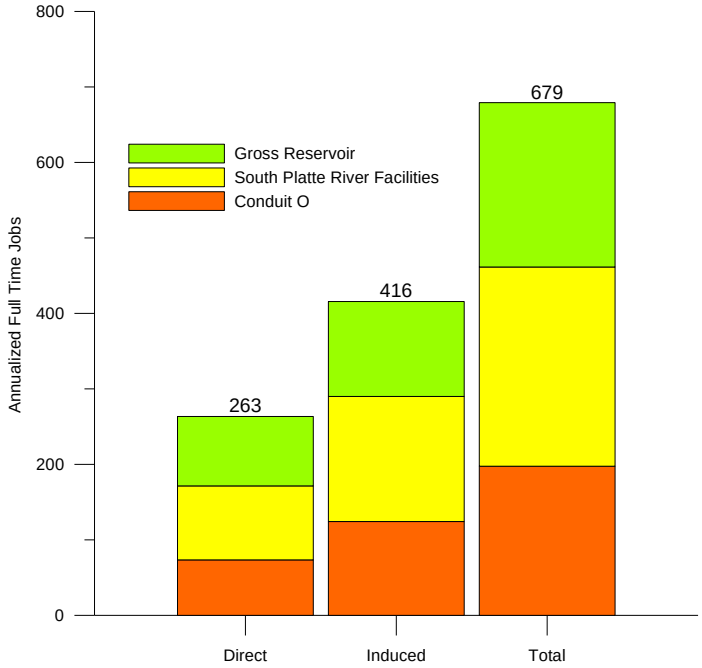
Denver Water would spend about $192 million on non-labor costs, most of which would be for materials and supplies to support the construction activities in Alternative 8a (Harvey Economics 2008).[30] This figure includes the purchase of the gravel pits.

[30]Spending on materials and supplies is reported in 2006 dollars.

During the approximately 3.2-year construction phase of Alternative 8a, an average of 263 construction workers would be employed each year. Employment would peak at 451, or less than 1% of all construction workers in Boulder County and the Denver Metropolitan area.[31] The types of workers employed would be similar to those employed under the Proposed Action. The induced employment created as a result of construction activities would provide about 416 additional jobs per year within a number of different industries in the Denver Metropolitan area.[32] Construction jobs and induced jobs would be temporary, as described for the Proposed Action.

Figure 5.19-7 shows the average annual direct construction employment and the average annual induced employment created as a result of construction activity in Alternative 8a.

Figure 5.19-7
Annual Employment Generated from Construction Activities in Alternative 8a



Source: MWH, 2006; Denver Water, 2007e; Boyle, 2008b; Harvey Economics, 2008.
Notes:
Construction activities would occur over a 3.2-year period for Alternative 8a.
Due to rounding, figures may not add up to total shown.

Personal Income

Total wages for construction workers would average about $18.2 million per year over the approximately 3.2-year construction period (MWH 2006; Harvey Economics 2008).[33] Average hourly wages for different types of construction workers would be the same as described for the Proposed Action. Wages of induced employees would vary considerably

[31]The 451 workers amount to 0.72% of total 2011 construction employment in Boulder County and the Denver Metropolitan area. If employment in the construction industry in the area grows, the number of workers directly employed to work on Alternative 8a will account for an even smaller percentage of the total.

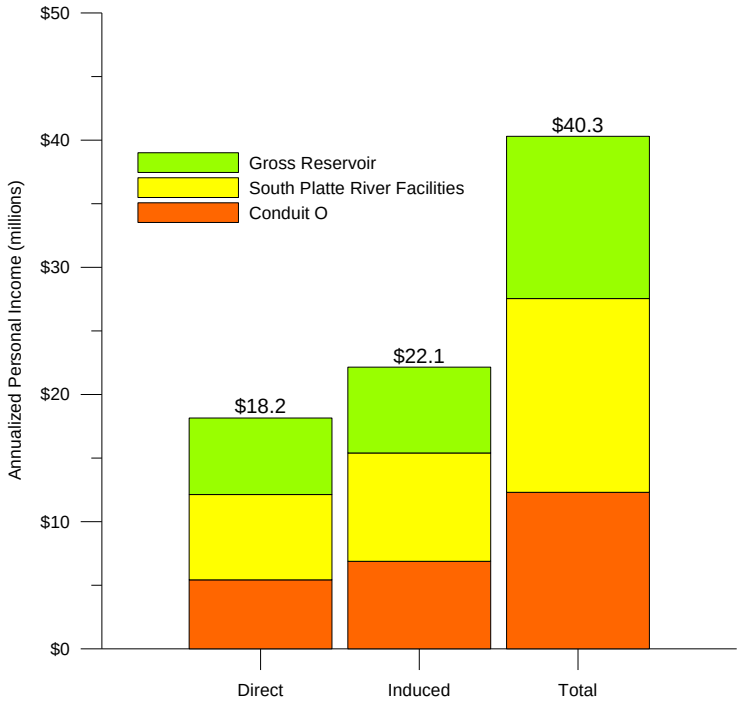
[32]Based on economic multipliers for the construction industry and the water, sewage and related systems industry obtained from the Colorado Department of Local Affairs (2006).

[33]Average annual wages are reported in constant 2006 dollars.

depending on the type of job created or the industry, but are estimated to total about $22.1 million per year.[34]

Figure 5.19-8 shows the average annual direct income and the average annual induced income created as a result of construction activities in Alternative 8a.

Figure 5.19-8
Annual Income Generated from Construction Activities in Alternative 8a



Source: MWH, 2006; Denver Water, 2007e; Boyle, 2008b; Harvey Economics, 2008.
Notes:
Construction activities would occur over a 3.2-year period for Alternative 8a.
Due to rounding, figures may not add up to total shown.

The annual total personal income created under Alternative 8a would account for less than one tenth of 1% of total compensation paid to all working persons in the Denver Metropolitan area (BEA 2008).[35] Therefore, the personal income created as a result of Alternative 8a would have a negligible positive impact on the Denver Metropolitan area.

Total Economic Output

Direct construction costs associated with Alternative 8a would total about $285 million over the construction period, or about $84 million per year, including labor and non-labor costs.[36] In addition to direct spending on goods and services (including labor), induced sales of goods and services would result from construction worker spending and spending

[34]Based on economic multipliers for the construction industry and the water, sewage and related systems industry obtained from the Colorado Department of Local Affairs (2006). The estimated wages for induced employees are reported in constant 2006 dollars.

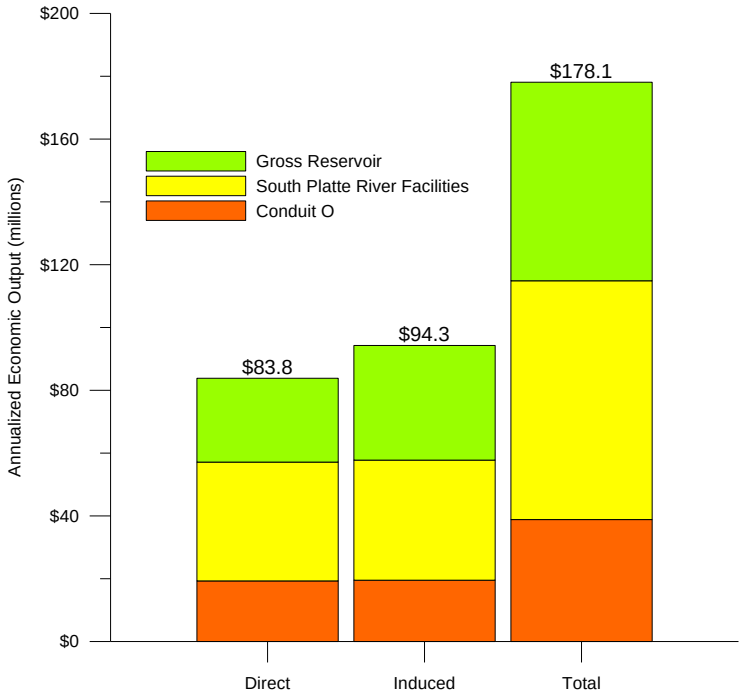
[35]Compared to 2011 data, $40.3 million amounts to about 0.06% of total compensation for construction workers in the Denver/Boulder Metropolitan areas.

[36]Direct construction costs presented here do not include mobilization costs. Mobilization costs include bonds and insurance. Total construction costs include direct construction costs as well as engineering and environmental costs.

of induced employees. Total sales of goods and services would amount to about $178 million per year over the construction period.

Figure 5.19-9 shows the annual direct spending by Denver Water for construction activities, the annual induced spending for goods and services and the total annual economic output generated by the construction activities in Alternative 8a.

Figure 5.19-9
Annual Economic Output Generated from Construction Activities in Alternative 8a



Source: MWH, 2006; Denver Water, 2007e; Boyle, 2008b; Harvey Economics, 2008.
Notes:
Construction activities would occur over a 3.2-year period for Alternative 8a.
Due to rounding, figures may not add up to total shown.

Total sales exceeded $157 billion for Denver Metropolitan area businesses in 2011. Total annual economic output created under Alternative 8a would account for about one tenth of 1% of total sales in the Denver Metropolitan area. The economic output created as a result of Alternative 8a would have a negligible but positive and temporary impact on the Denver Metropolitan area.

Operational Phase Employment and Business Activity

Employment and business activity during operations would be similar to that described for the Proposed Action, with the following additional information: the gravel pit storage facilities, Advanced Water Treatment Plant (AWTP), Conduit O and associated infrastructure would only operate during dry years or during emergencies. Workers required to operate those facilities would be existing Denver Water employees. No new

employees would be hired to operate any of the facilities and only a small amount of additional materials would be required for operation once construction has been completed.

Employment and Business Activity – Grand County

Impacts to employment and business activity in Grand County for Alternative 8c would be similar to that described in the Proposed Action.

5.19.3.2 Demographic Conditions

Gross Reservoir PIA

Impacts to demographic conditions in the Gross Reservoir PIA would be the same as described for the Proposed Action. Construction phase impacts experienced by PIA residents would be similar in nature, but slightly less in magnitude, to those described for the Proposed Action (Alternative 1a) due to the shorter construction timeframe of about 3.2 years and the smaller reservoir enlargement.

South Platte River Facilities and Conduit O PIAs

Demographic conditions in the South Platte River Facilities PIA would be unaffected under Alternative 8a. The gravel pits Denver Water would purchase for storage would be located in areas known for gravel mining; several different mining operations are currently active in the area where the representative gravel pits are located. The gravel pits that Denver Water would purchase are currently either fully mined or would soon be fully mined. Denver Water's purchase of the gravel pits would not positively or negatively impact the desirability of living in the PIA. Construction workers from Boulder County and the Denver Metropolitan area would commute to the site each day for creation of the river diversions and construction of the AWTP. As discussed above, no new permanent jobs would be created for operation of these facilities. For these reasons the population of the South Platte River Facilities PIA would be unaffected by activities in Alternative 8a. Therefore, other demographic characteristics of the PIA would also be unchanged as a result of Alternative 8a.

Boulder County and Denver Metropolitan Area Counties

The population and other demographic characteristics of the Denver Metropolitan area would not change due to construction activity, the operation of Gross Reservoir, or the operation of the gravel pit storage facilities and associated conduit in Alternative 8a. Demographic characteristics of Denver Metropolitan area counties would be the same as described for the Proposed Action, with the exception that construction workers would also commute to the gravel pits and AWTP site near Brighton, in Adams County, and to the area of Conduit O construction, in Adams or Jefferson County.

Grand County

Impacts to the population and other demographic characteristics in Grand County would be the same as those described for the Proposed Action.

Table 5.19-9 provides a summary of the impacts on demographic conditions in areas affected by Alternative 8a.

Table 5.19-9
Changes to Demographic Conditions from Alternative 8a

Demographic Considerations	Gross Reservoir PIA	South Platte River Facilities PIA	Boulder County	Denver Metropolitan Area	Grand County
Population	No impact	No impact	No impact	No impact	No impact
Migration Patterns	No impact	No impact	No impact	No impact	No impact
Ethnicity	No impact	No impact	No impact	No impact	No impact
Age Distribution	No impact	No impact	No impact	No impact	No impact
Commuting Patterns	Minor to moderate, temporary	No impact	Negligible, temporary	Negligible, temporary	No impact

Source: Harvey Economics, 2007.
Notes:
The Conduit O PIA is limited to the roadways affected by pipeline construction and therefore is not included in this Exhibit.
The Denver Metropolitan area includes Boulder County (location of Gross Reservoir), Adams County (location of the gravel pits, Advanced Water Treatment Plant, and a portion of the conduit), and Jefferson County (location of a portion of the conduit) in addition to other Denver Metropolitan area counties.
PIA = Primary Impact Area

5.19.3.3 Environmental Justice

No specific ethnic or otherwise classified groups of PIA, Boulder County, or Denver Metropolitan area residents would be disproportionately impacted by construction or operational activities in Alternative 8a. No environmental justice issues would arise as a result of this alternative.

5.19.3.4 Housing Conditions

Housing Units

Impacts to housing units under Alternative 8a would be similar to those described for the Proposed Action. No additional housing units would be built and no housing units would be demolished within the South Platte River Facilities PIA under Alternative 8a. The Conduit O PIA would not be impacted as the PIA only includes certain roadways and contains no housing units.

Vacancy Rates

Impacts to vacancy rates would be similar to those described for the Proposed Action, with the following addition: the population and number of housing units in the South Platte River Facilities PIA would be unchanged and, therefore, the vacancy rate in that PIA would also remain unchanged by Alternative 8a.

Home Values

Impacts to housing values would be the similar to those described for the Proposed Action, with the addition that home values in the South Platte River Facilities PIA would also be unaffected under Alternative 8a. In Grand County, properties surrounding Grand Lake

would realize a total loss of value of about $223,000 due to changes in water quality and clarity (see Section 4.6.2 for more detail).

Table 5.19-10 provides a summary of the impacts on housing conditions in areas affected by Alternative 8a.

Table 5.19-10
Changes to Housing Conditions from Alternative 8a

Housing Considerations	Gross Reservoir PIA	South Platte River Facilities PIA	Boulder County	Denver Metropolitan Area	Grand County
Housing Units	No impact	No impact	No impact	No impact	No impact
Vacancy Rates	No impact	No impact	No impact	No impact	No impact
Home Values	Minor to moderate, temporary impacts for a small number of homes along Gross Dam Road	No impact	No impact	No impact	Minor impact to homes directly surrounding Grand Lake

Source: Harvey Economics, 2007.
Notes:
The Conduit O PIA is limited to the roadways affected by pipeline construction and therefore, is not included in this Exhibit.
The Denver Metropolitan area includes Boulder County (location of Gross Reservoir), Adams County (location of the gravel pits, Advanced Water Treatment Plant, and a portion of the conduit), and Jefferson County (location of a portion of the conduit) in addition to other Denver Metropolitan area counties.
PIA = Primary Impact Area

5.19.3.5 Fiscal Impacts of Public Entities Other than Denver Water

Operating Revenues

Local jurisdiction revenues and Denver Water tax responsibilities are the same as described in the Proposed Action. Fiscal impacts due to the Gross Reservoir expansion are also the same as described in the Proposed Action.

Denver Water would purchase gravel pit properties for water storage and for the construction of the AWTP facility, but they would not pay property taxes on these properties. The majority of tax revenue on gravel mining operations comes from taxes on machinery and recovered resources. These pits would be completely mined and no gravel resources would be left behind. Denver Water would also purchase additional property for the solar evaporation ponds and solids drying beds for the AWTP. The specific location of these facilities is unknown at this time, but is assumed to be located in close proximity to the AWTP and within the same taxing districts.

The total projected annual loss of property tax revenues related to the gravel pit properties, AWTP and plant discharge facilities is estimated to be less than $1,000. Impacts to specific entities would be as follows:

- Adams County: $280
- Brighton 27-J School District: $472
- Brighton Fire Protection District: $122
- Rangeview Library District: $38

These losses would be very small relative to the entities total budgets and would be negligible.

Conduit O would be routed along roadways and utility corridors. No property would be purchased by Denver Water for the Conduit; therefore, there would be no impacts to any entity's operating revenues.

Operating Expenditures

Activities occurring under Alternative 8a would only be expected to impact operating expenditures related to road and bridge maintenance. CDOT's maintenance budget is described in the Proposed Action. Expenditures relating to the expansion of Gross Reservoir are also described in the Proposed Action, with the only difference being a modest reduction under Alternative 8a in the number of truck trips and vehicle trips for construction workers. All traffic impacts would be temporary and related to construction.

Traffic associated with construction of the AWTP would primarily consist of commuting construction workers, averaging 140 peak-hour vehicle trips per day. There would be 2 peak-hour trips for construction equipment during mobilization and demobilization of the Project. US 85 and local roads in the Brighton area of Adams County would experience the greatest impact as a result of AWTP construction. The Adams County 2007 budget provided $17.2 million for regular maintenance and road improvements.

Construction of Conduit O would also create additional traffic from commuting workers, averaging 138 peak-hour vehicle trips per day. In addition, 2 peak-hour trips for construction equipment are assumed. Construction would take place in Jefferson and Adams Counties at locations along the route. The Road and Bridge Division is responsible for maintenance of Jefferson County roads. Their annual budget for 2007 was in excess of $25 million.

The number of haul trucks and commuter vehicles required under Alternative 8a would have a negligible impact on traffic volume and additional road maintenance expenditures due to the additional worker and construction equipment traffic would be negligible.

Capital Outlays

Capital outlay expenditures for local public entities would not be impacted by the Alternative 8a. No new roads or other facilities would be required by these entities as a result of this alternative.

5.19.3.6 Public Facilities and Services

Impacts resulting from the expansion of Gross Reservoir are discussed in Section 5.19.1.6 for the Proposed Action and are included in Table 5.19-11.

The populations of the PIAs, Boulder County, Denver Metropolitan area counties and Grand County would not change as a result of Alternative 8a. The agencies that provide public services to residents in these areas would not experience added pressure to serve any additional people as a result of Alternative 8a.

Table 5.19-11
Summary of the Impacts of Alternative 8a on Public Facilities and Services

Facilities and Services	Gross Reservoir PIA	South Platte River Facilities PIA	Boulder County	Adams County	Other Denver Metropolitan Counties	Grand County
Police Departments	No impact	Negligible impact	Minor, temporary	Minor, temporary	No impact	No impact
Fire Departments	Minor, temporary	Negligible impact	Negligible impact	Minor, temporary	No impact	No impact
Health Services	No impact	No impact	No impact	No impact	No impact	No impact
Libraries	No impact	Negligible impact	No impact	Negligible impact	No impact	No impact
Water Providers	No impact	Positive to No impact	Positive to No impact	Positive to No impact	Positive to No impact	Negligible impact
Wastewater Treatment	No impact	No impact	No impact	No impact or negligible	No impact or negligible	No impact
Solid Waste Disposal	No impact	No impact	No impact	No impact	No impact	No impact
Education	No impact	No impact	No impact	No impact	No impact	No impact

Source: Harvey Economics, 2007.
Notes:
Denver Water and water providers that are Denver Water customers would experience positive impacts from Alternative 8a, while other water providers would be unaffected.
Adams County is shown separately in this table because of the specific impacts related to the construction and operation of the Advanced Water Treatment Plant and associated facilities in Adams County.
PIA = Primary Impact Area

Several public facilities and services in Adams County would be affected by funding changes resulting from Alternative 8a. Denver Water would not pay any property taxes on the gravel pits or other properties that would be purchased, which would result in decreased property tax revenues to several Adams County services. Fiscal impacts resulting from the purchase of these properties would be minimal for several reasons:

- The pits purchased by Denver Water would be fully mined for gravel and other materials prior to sale. No commercially viable aggregate resources or equipment would be left at the site. Therefore, there would be no loss of profit to the mining companies or loss of gravel related revenues to Adams County or other entities as a result of these land purchases.
- The acreage of the gravel pit properties would be assessed as agricultural land for any private buyer once mining was completed.
- The additional properties purchased for the processing of the AWTP discharge would likely be assessed as agricultural land.

Service Specific Impacts

Impacts resulting from Alternative 8a are discussed below and shown in Table 5.19-11.

As with the previous alternatives, water and wastewater treatment providers in Grand County have been discussed separately from other water and wastewater treatment providers because of river diversions that originate in Grand County.

Police Departments

Impacts to police departments in the Gross Reservoir PIA and Boulder County would be the same as described for the Proposed Action.

The Adams County Sheriff's Office may experience a minimal loss of funding as a result of Alternative 8a. This law enforcement agency is funded through property taxes to the county. Adams County would receive about $280 less in property taxes each year as a result of Denver Water's purchase of the gravel pits and other properties (Adams County 2007b). A portion of that loss may be allocated to the Sheriff's Office. This funding change would result in a negligible impact to the Sheriff's Office budget. In addition, the Sheriff might experience a minor, temporary increase in demand due to increased traffic and related incidents during AWTP construction.

Fire Departments

Impacts to fire departments in the Gross Reservoir PIA and Boulder County would be the same as described for the Proposed Action.

Demands on the Brighton Fire Protection District in Adams County would potentially increase by a small amount during the construction phase of Alternative 8a, stemming from emergencies at construction sites or along commuting routes. The District should be able to adequately respond to potential emergencies. The Brighton Fire Protection District would experience a loss of about $122 per year as a result of Alternative 8a (Adams County 2007b). This funding change would be due to the loss of property tax collected on the gravel pits and other properties that Denver Water would purchase in Adams County. This funding change would have a negligible impact on the District's budget.

No other fire departments in the Denver Metropolitan area or Grand County would experience impacts related to changes in funding.

Health Services

Hospitals and health providers located near Gross Reservoir in Boulder County, the gravel pits and AWTP in Adams County and in other Denver Metropolitan area counties would have the capacity and ability to provide services to any injured construction workers or other workers associated with the reservoir expansion, without detriment to their current operations or patients. Any construction worker or other person in need of medical attention would carry medical insurance or workers compensation insurance to pay for the required services.

Libraries

No libraries in the Denver Metropolitan area, with the exception of the Rangeview Library District in Adams County, would experience any impacts as a result of Alternative 8a. Libraries in the Rangeview Library District are funded through a special district mill levy. Property taxes to the District would be reduced by about $38 per year under Alternative 8a due to Denver Water's purchase of the gravel pit and other properties (Adams County 2007b). Libraries in Grand County would not experience any funding changes or other impacts as a result of Alternative 8a.

Education

School districts serving Boulder County, Adams County, other Denver Metropolitan area counties or Grand County would not be affected by Alternative 8a. Adams County property taxes include a mill levy specifically for school districts. Due to Denver Water's purchase of the gravel pits and other property in Adams County, property taxes for school district funding would be reduced by about $472 per year (Adams County 2007b). However, the State would make up that amount with guaranteed funding.[37] The Adams County school district would not be negatively impacted from Alternative 8a.

Boulder County and Denver Metropolitan Area Water Providers

Impacts within the Gross Reservoir PIA under Alternative 8a would be similar to those described for the Proposed Action.

Impacts to Denver Water and its customers would be similar to those described for the Proposed Action; these entities would benefit from the reliability and availability of the developed water rights. In general, average monthly flows in the South Platte River at Henderson gage would increase slightly less under Alternative 8a than under the Proposed Action. Since these changes under Alternative 8a would be similar to those for the Proposed Action, other water providers in Denver Metropolitan area counties would also be impacted as described for the Proposed Action. Changes to water rates for Denver Water's customers as a result of Alternative 8a are described in Section 5.19.3.6.

Grand County Water Providers

Impacts to Grand County water providers under Alternative 8a would be similar to those described for the Proposed Action.

Boulder County and Denver Metropolitan Area Wastewater Treatment

In general, average monthly flows in the South Platte River at Henderson gage would increase slightly less under Alternative 8a than under the Proposed Action. Since these changes under Alternative 8a would be similar to those for the Proposed Action, impacts to WWTPs that serve residents of Boulder County, Adams County, Jefferson County, and other Denver Metropolitan area counties would be similar to those described for the Proposed Action. Denver Water would have additional treatment capacity as a result of the new AWTP. This would decrease some of the current vulnerabilities and risk described in Chapters 1 and 2.

Grand County Wastewater Treatment

Impacts to Grand County wastewater treatment facilities under Alternative 8a would be similar to those described for the Proposed Action.

[37] The State of Colorado guarantees a certain amount of funding per student to each school district and would only be obligated to make up losses to districts up to that guaranteed amount. Districts that collect revenues in excess of the guaranteed funding amount would only be eligible for state reimbursement of losses if the loss caused total funding to dip below guaranteed levels.

Solid Waste Disposal

During the construction period, some construction associated waste may be disposed of at Boulder County or Denver Metropolitan area landfills. Denver Water would be responsible for any applicable fees for waste disposal and no landfills would be adversely impacted by the construction activities of Alternative 8a.

Alternative 8a contains a reverse osmosis WTP with zero liquid discharge, as described in Chapter 2. During operation, the solid waste from the plant would be compacted and disposed of at local landfills. Denver Water would be responsible for paying any fees related to this solid waste disposal. No landfills would be adversely impacted by operational activities in Alternative 8a.

Table 5.19-11 provides a summary of the impacts of Alternative 8a on public facilities and services in affected areas.

5.19.3.7 Financial Impacts to Denver Water Customers

Denver Water would be responsible for total construction costs of approximately $362 million and annual O&M costs of an estimated $4.9 million under Alternative 8a. Construction and O&M costs would be paid for with Denver Water revenues, including those collected from water sales, new connection fees, bond proceeds and other sources. Capital and O&M expenditures undertaken by Denver Water as a part of Alternative 8a would result in increases in water rates and new connection fees (known as SDC) for Denver Water customers as described below.

Water Rates

Under Alternative 8a, the average cost per 1,000 gallons of water would increase by about 77% through 2017, from a 2008 rate of $2.38 to $4.20 in 2017. This compares with a 52% increase under the No Action Alternative. Water rates would increase between 3% and 9% annually through 2017. These impacts on Denver Water and its customers are considered moderate.

New Connection Charges

Under Alternative 8a, SDCs would increase by about 10.4% compared to 2008 SDC amounts (same as the No Action Alternative). The ¾-inch SDC equivalent price would be $8,195 under Alternative 8a. This compares with $7,424 under the No Action Alternative. SDC impacts on Denver Water and its new customers are considered moderate.

Outstanding Debt

In addition, Denver Water's outstanding debt balance would increase by about 74% by 2017 under Alternative 8a, compared to the 2008 balance. However, Denver Water's projected debt to net fixed asset ratio would be about 24% by 2017 under Alternative 8a. Denver Water might employ other financing strategies to stretch out the debt and otherwise manage its debt more effectively. This effect is considered to be a moderate impact, since this additional debt might impinge on Denver Water's future capital investment program.

5.19.3.8 Summary of Socioeconomic Impacts of Alternative 8a

As described for the individual topics above, some of the socioeconomic impacts of Alternative 8a would be temporary and tied to the construction phase and other impacts would be long term and permanent. A summary of impacts associated with Alternative 8a is presented in Table 5.19-12.

Table 5.19-12
Summary of Socioeconomic Impacts of Alternative 8a

Socioeconomic Consideration	Gross Reservoir PIA	South Platte River Facilities PIA	Boulder County	Adams County	Denver Metropolitan Area	Grand County
Demographic Conditions	Minor, temporary	No impact	No impact	No impact	No impact	No impact
Housing Conditions	Negligible, temporary	No impact	No impact	No impact	No impact	Negligible, permanent
Economic Conditions	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	No impact
Fiscal Conditions	Negligible impact	Negligible, negative, permanent	Negligible impact	Negligible, negative, permanent	No impact	No impact
Water Providers	No impact	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Negligible impact, permanent
Other Public Facilities and Services	Minor or No impact	Negligible and permanent or No impact	Minor, negligible or No impact	Negligible and permanent or No impact	No impact	No impact
Water Rates and Tap Fees	No impact	No impact	No impact	Permanent, moderate, negative	Permanent, moderate, negative	No impact

Source: Harvey Economics, 2007.
Notes:
Adams County is shown separately from the Denver Metropolitan area in this table due to the potential for site-specific impacts related to the AWTP and associated facilities.
PIA = Primary Impact Area

Temporary impacts would be similar to those of the Proposed Action and would include the following:

Temporary impacts of Alternative 8a include the following:

- An average of 683 new jobs would be created during the construction period, which would result in over $40.3 million in annual employment related income.
- Denver Water would spend over $192 million for non-employment costs, most of which would be for materials and supplies during the construction period. It is expected that the majority of these expenditures would be made in the Denver Metropolitan area and surrounding counties.

- Purchases made by Denver Water for labor and materials plus spending by persons employed as a result of this alternative would amount to an increase in economic output of about $178 million per year during the construction period.
- The positive impacts to revenues of public entities from increased sales tax collections could not be quantified, but would be negligible.

Permanent impacts of Alternative 8a would include:

- Benefits to Denver Water customers from a more reliable water supply.
- A water rate increase of about $1.80 per 1,000 gallons by 2017 and an increase of about $770 in tap fees for Denver Water customers. These impacts are considered moderate.
- A $60 loss in annual funding to Boulder County, a $280 loss in annual funding to Adams County, a $21 loss in annual funding to the Coal Creek Canyon Fire Department, $38 loss of annual funding to the Rangeview Library District, and a $122 loss in annual funding to the Greater Brighton Fire Protections District in Adams County. These are considered negligible, given the size of the respective budgets.

5.19.4 Alternative 10a

5.19.4.1 Economic Conditions

Employment and Business Activity – Gross Reservoir, Denver Basin Aquifer Facilities PIA, and Conduit M PIAs

The activities included in Alternative 10a would generally impact employment and business activity in the Denver Metropolitan area as described for the Proposed Action. The Denver Basin Aquifer Facilities PIA, which is comprised of the Deep Aquifer AWTP PIA and the aquifer storage and recovery (ASR) system PIA, contains more businesses and therefore more money may be spent by construction workers in those PIAs compared to the Gross Reservoir PIA. The AWTP is located just north of the Denver County-Adams County line and the ASR system PIA covers all of Denver County. Therefore, Denver County may see a larger proportion of related business activity than other Denver Metropolitan area counties. The PIA for Conduit M occurs within a roadway itself, where no houses or businesses exist.

Construction-Related Employment and Business Activity

Denver Water would spend almost $201 million on non-employment related expenses. The bulk of these expenditures would likely be for materials and supplies to support the construction activity in Alternative 10a (Harvey Economics 2008).[38] Spending on materials and supplies would follow the patterns described for the Proposed Action.

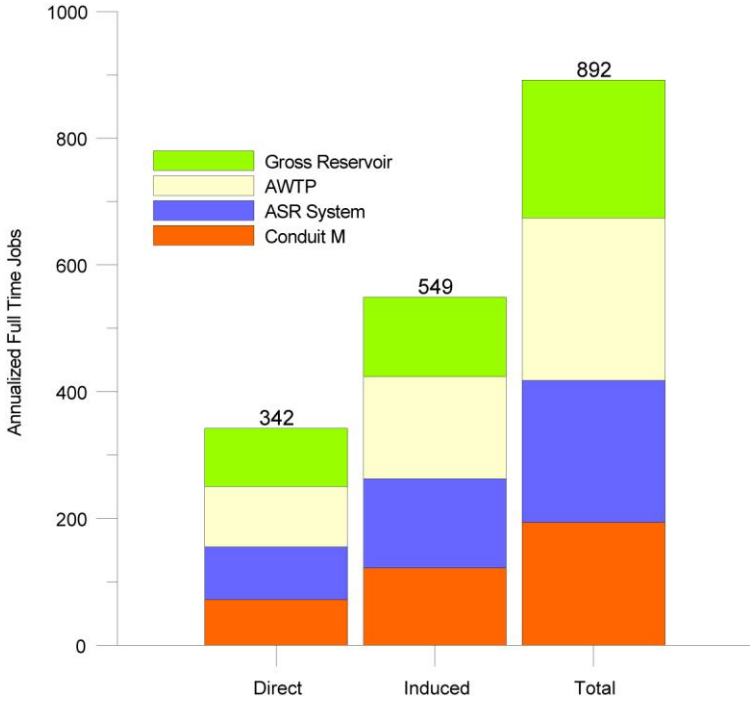
During the approximately 3.2-year construction phase of Alternative 10a, an average of 342 construction workers would be employed each year. In Year Two, employment would peak at about 573 workers, or less than 1% of all construction employment in the Denver-Boulder Metropolitan areas. The types of workers employed would be similar to those

[38]Spending on materials and supplies is reported in 2006 dollars.

employed under the Proposed Action. The induced employment created as a result of the construction operation would provide about 549 additional jobs per year within a number of different industries in the Denver Metropolitan area.[39] Construction employment and induced employment would be largely temporary, as described for the Proposed Action.

Figure 5.19-10 shows the average annual direct construction employment and the average annual induced employment created as a result of construction activity in Alternative 10a.

Figure 5.19-10
Annual Employment Generated from Construction Activities in Alternative 10a



Source: MWH, 2006; Denver Water, 2007e; Boyle, 2008b; Harvey Economics, 2008.
Notes:
Construction activities would occur over a 3.2-year period for Alternative 10a.
Due to rounding, figures may not add up to total shown.
ASR = aquifer storage and recovery
AWTP = Advanced Water Treatment Plant

Personal Income

Total wages for construction workers would average about $22.8 million per year over the approximately 3.2-year construction period (MWH 2006; Harvey Economics 2008).[40] Average hourly wages for different types of construction workers would be the same as described for the Proposed Action. Wages of induced employees would range considerably

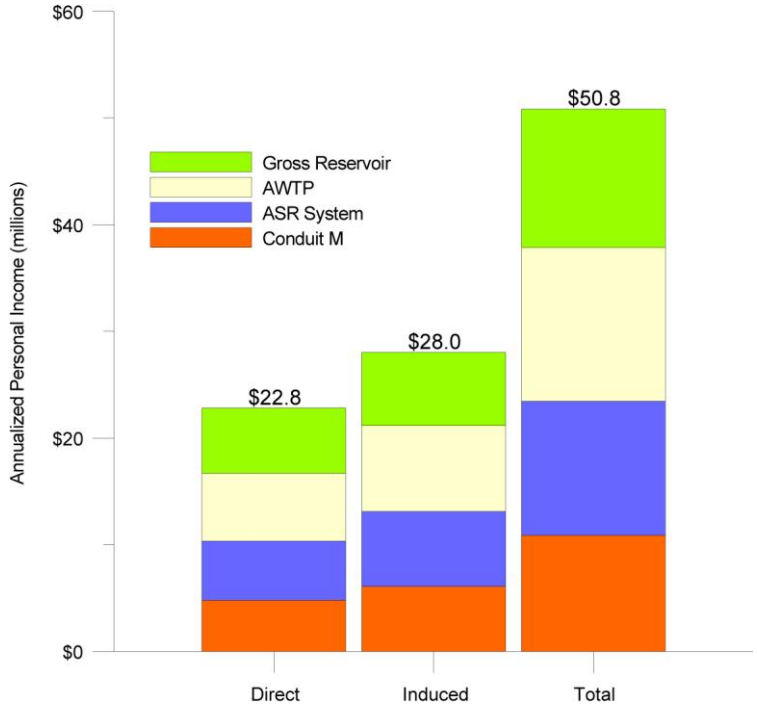
[39]Based on economic multipliers for the construction industry and the water, sewage and related systems industry obtained from the Colorado Department of Local Affairs (2006).

[40]Average annual wages are reported in constant 2006 dollars.

depending on the type of job created or the industry, but are estimated to average about $28.0 million per year.[41]

Figure 5.19-11 shows the average annual direct income and the average annual induced income generated by construction activities in Alternative 10a.

Figure 5.19-11
Annual Income Generated from Construction Activities in Alternative 10a



Source: MWH, 2006; Denver Water, 2007e; Boyle, 2008b; Harvey Economics, 2008.
Notes:
Construction activities would occur over a 3.2-year period for Alternative 10a.
Due to rounding, figures may not add up to total shown.
ASR = aquifer storage and recovery
AWTP = Advanced Water Treatment Plant

The annual total personal income created under Alternative 10a would account for less than one tenth of 1% of total compensation paid to all working persons in the Denver Metropolitan area (BEA 2008). Therefore, the personal income created as a result of Alternative 10a would have a negligible, positive impact on the Denver Metropolitan area.

Total Economic Output

Direct construction costs associated with Alternative 10a would total almost $317 million over the construction period, or about $93 million per year, including labor and non-labor costs.[42] In addition to direct spending on goods and services (including labor), induced

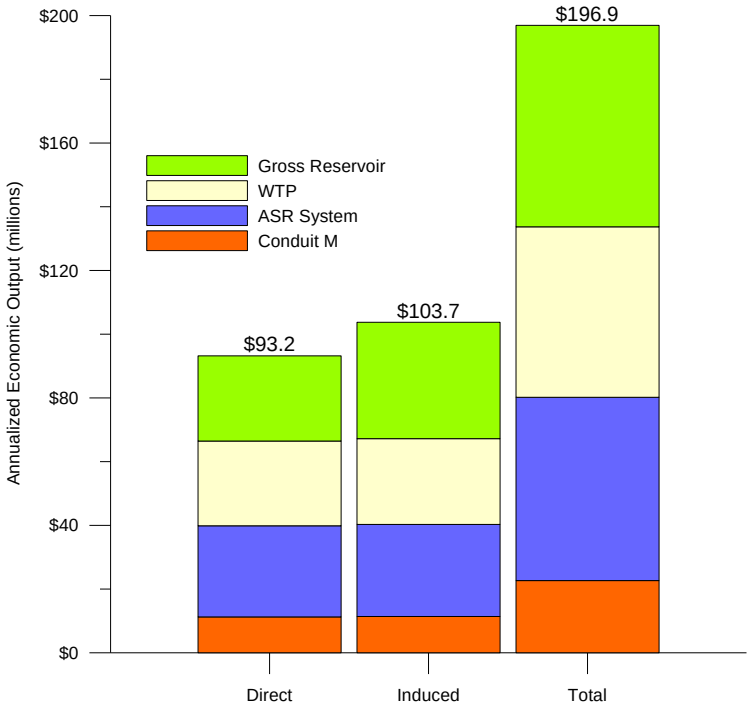
[41]Based on economic multipliers for the construction industry and the water, sewage and related systems industry obtained from the Colorado Department of Local Affairs (2006). The estimated wages for induced employees are reported in constant 2006 dollars.

[42]Direct construction costs presented here do not include mobilization costs. Mobilization costs include bonds and insurance. Total construction costs include direct construction costs as well as engineering and environmental costs.

sales of goods and services would result from construction spending and spending of induced employees. Total sales of goods and services would amount to about $196.9 million per year over the construction period.

Figure 5.19-12 shows the annual direct spending by Denver Water for construction activities, the annual spending of induced workers and the total annual economic output generated by the construction activities in Alternative 10a.

Figure 5.19-12
Annual Economic Output Generated from Construction Activities in Alternative 10a



Source: MWH, 2006; Denver Water, 2007e; Boyle, 2008b; Harvey Economics, 2008.
Notes:
Construction activities would occur over a 3.2-year period for Alternative 10a.
Due to rounding, figures may not add up to total shown.
ASR = aquifer storage and recovery
WTP = Water Treatment Plant

Total sales exceeded $157 billion for Denver Metropolitan area businesses in 2011. Total annual economic output created under Alternative 10a would account for about one tenth of 1% of total sales in the Denver Metropolitan area.[43] The economic output created as a result of Alternative 10a would have a negligible but positive and temporary impact on the Denver Metropolitan area.

Operational Phase Employment and Business Activity

Employment and business activity during operations would be similar to that described for the Proposed Action, with the following additional information: the Deep Aquifer AWTP,

[43]Based on economic multipliers for the construction industry and the water, sewage and related systems industry obtained from the Colorado Department of Local Affairs (2006).

ASR system, Conduit M, and associated infrastructure would only operate during dry years or during emergencies. Workers required to operate those facilities during specified periods would be existing Denver Water employees. New employees would not be hired to operate any of these facilities and no additional materials would be required for operation once construction has been completed.

Employment and Business Activity – Grand County

Employment and business related impacts to Grand County for Alternative 10a would be similar to that described in the Proposed Action.

5.19.4.2 Demographic Conditions

Changes in population, other demographic characteristics or housing characteristics generally occur as a result of the types of economic impacts described above as well as other site-specific or alternative specific characteristics, such as changes in recreational opportunities, land use, or visual appeal.

Gross Reservoir PIA

Impacts to the population and other demographic characteristics of the Gross Reservoir PIA would be similar to that identified under the Proposed Action. Construction phase impacts experienced by PIA residents would be similar in nature, but slightly less in magnitude, to those described for the Proposed Action (Alternative 1a) due to the shorter construction timeframe of about 3.2 years and the smaller reservoir enlargement.

Deep Aquifer AWTP, ASR System, and Conduit M PIAs

The AWTP would be located on a 6.5-acre site in an area already impacted by industrial development. The pipelines of the ASR system would be buried in city streets and utility corridors and the well fields would be located on public property. The conduit would be located within existing roadways. No housing units would be affected and no residents of these PIAs would be relocated as a result of Alternative 10a. No loss of population is expected from construction activities. The ASR system PIA includes all of Denver County and commuting patterns in the county would be temporarily altered due to temporary road closures and movement of construction workers. No changes to other demographic characteristics of these PIAs would occur under Alternative 10a.

Boulder County and Denver Metropolitan Area Counties

Impacts to the population and other demographic characteristics of Boulder County and Denver Metropolitan area counties resulting from Alternative 10a would be similar to those described for the Proposed Action. Other than at Gross Reservoir, all construction activities would occur within the Denver Metropolitan area. Construction workers would travel to all sites from their homes each day and would not relocate.

Grand County

Impacts to the Grand County population and the demographic characteristics of that population resulting from Alternative 10a would be similar to those described for the

Proposed Action. Table 5.19-13 describes the impacts of Alternative 10a on the demographic conditions of affected areas.

Table 5.19-13
Changes to Demographic Conditions from Alternative 10a

Demographic Considerations	Gross Reservoir PIA	Deep Aquifer Advanced Water Treatment Plant PIA	ASR System PIA/Denver County	Boulder County	Denver Metropolitan Area	Grand County
Population	No impact	No impact	No impact	No impact	No impact	No impact
Migration Patterns	No impact	No impact	No impact	No impact	No impact	No impact
Ethnicity	No impact	No impact	No impact	No impact	No impact	No impact
Age Distribution	No impact	No impact	No impact	No impact	No impact	No impact
Commuting Patterns	Minor to moderate, temporary	No impact	Negligible, temporary	Negligible, temporary	Negligible, temporary	No impact

Source: Harvey Economics, 2007.
Notes:
The Conduit M PIA is limited to the roadways affected by pipeline construction and therefore is not included in this table.
The Denver Metropolitan area includes Boulder County (location of Gross Reservoir), Adams County (location of the Advanced Water Treatment Plant and a portion of Conduit M), Jefferson County (location of a portion of Conduit M), and Denver County (location of the aquifer storage and recovery system) in addition to other Denver Metropolitan area counties.
PIA = Primary Impact Area

5.19.4.3 Environmental Justice

No specific ethnic or otherwise classified groups of PIA or Denver Metropolitan area residents would be disproportionately impacted by construction or operational activities in Alternative 10a. No environmental justice issues would arise as a result of this alternative.

5.19.4.4 Housing Conditions

Housing Units

Impacts to the number of existing housing units in the Gross Reservoir PIA, Boulder County, the Denver Metropolitan area, and Grand County would be similar to those described for the Proposed Action. No housing units in the Deep Aquifer AWTP PIA or the ASR PIA would be affected and no additional homes would be built in those PIAs as a result of Alternative 10a. No impacts would occur to the Conduit M PIA as no homes exist within the PIA.

Vacancy Rates

Impacts to vacancy rates in the Gross Reservoir PIA, Boulder County, the Denver Metropolitan area, and Grand County would be similar to those described for the Proposed Action. Vacancy rates in the Deep Aquifer AWTP PIA and the ASR PIA would be unaffected by Alternative 10a. The population of those PIAs would not change nor would the number of housing units in the PIAs.

Home Values

Impacts to home values in the Gross Reservoir PIA, Boulder County and the Denver Metropolitan area would be the same as those described for the Proposed Action. The populations of the Deep Aquifer AWTP PIA and the ASR PIA would remain unchanged and demand for homes in these PIAs would not increase or decrease; therefore, home values in these PIAs would also be unaffected by Alternative 10a. In Grand County, properties surrounding Grand Lake would realize a total loss of value of about $223,000 due to changes in water quality and clarity (see Section 4.6.2 for more detail).

Table 5.19-14 presents the impacts of Alternative 10a on the housing characteristics of affected areas.

Table 5.19-14
Changes to Housing Conditions from Alternative 10a

Housing Considerations	Gross Reservoir PIA	Deep Aquifer Advanced Water Treatment Plant PIA	ASR System PIA/Denver County	Boulder County	Denver Metropolitan Area	Grand County
Housing Units	No impact	No impact	No impact	No impact	No impact	No impact
Vacancy Rates	No impact	No impact	No impact	No impact	No impact	No impact
Home Values	Minor to moderate, temporary impacts for a small number of homes along Gross Dam Road	No impact	No impact	No impact	No impact	Minor impact to homes directly surrounding Grand Lake

Source: Harvey Economics, 2007.
Notes:
The Conduit M PIA is limited to the roadways affected by pipeline construction and therefore is not included in this table.
The Denver Metropolitan area includes Boulder County (location of Gross Reservoir), Adams County (location of the AWTP and a portion of Conduit M), Jefferson County (location of a portion of Conduit M), and Denver County (location of the ASR system) in addition to other Denver Metropolitan area counties.
PIA = Primary Impact Area

5.19.4.5 Fiscal Impacts of Public Entities Other than Denver Water

Operating Revenues

Local jurisdiction revenues and Denver Water tax responsibilities are the same as described in the Proposed Action. Fiscal impacts due to the Gross Reservoir expansion are also similar to those described in the Proposed Action. Denver Water would not purchase any property for the ASR system or the conduit and there would be no operating revenue impacts as a result of these components. Denver Water would purchase 7 acres of industrial of land in Adams County for the new AWTP and would purchase additional property for the solar evaporation ponds and solids drying beds required for processing the

waste associated with the plant, which would mean an annual property tax loss to the following entities:[44]

- Adams County: $505
- Adams County School District #14: $889
- South Adams Fire District #4: $82
- Commerce City: $61
- Rangeview Library District: $68

These losses would be very small relative to the entities total budgets and would be negligible.

Operating Expenditures

Activities occurring under Alternative 10a would only be expected to impact operating expenditures related to road and bridge maintenance. CDOT's maintenance budget is described in the Proposed Action. Expenditures relating to the expansion of Gross Reservoir are also described in the Proposed Action, with the only difference being a modest reduction in the number of truck trips. All traffic impacts would be temporary and related to construction.

Impacts related to the construction of the AWTP are provided in Alternative 8a. Construction of Conduit M would occur in Jefferson and Adams counties and would be generally the same as those described for Conduit O, Alternative 8a.

The Denver Basin Aquifer Facilities would all be located within Denver County. Construction workers would likely commute from the greater Denver Metropolitan area. The average number of peak-hour commuter vehicle trips per day would be 111. There would also be a total of four peak-hour construction equipment trips. These effects are considered negligible.

Capital Outlays

Capital outlay expenditures for local public entities would not be impacted by Alternative 10a. No new roads, WTPs, WWTPs, or other facilities would be required by these entities as a result of the reservoir expansion and the other facility development.

5.19.4.6 Public Facilities and Services

Impacts resulting from the expansion of Gross Reservoir are discussed in Section 5.19.1.6 for the Proposed Action and are included as part of the Alternative 10a impacts in Table 5.19-15.

The populations of the PIAs, Boulder County, Denver Metropolitan area counties, and Grand County would not change as a result of Alternative 10a. The agencies that provide

[44]The location of the additional property purchased by Denver Water for AWTP waste processing is unknown. The socioeconomic analysis assumes that it would be located in close proximity to the AWTP and would be part of the same taxing jurisdictions.

public services to residents in these areas would not experience added pressure to serve any additional people as a result of Alternative 10a.

Table 5.19-15
Summary of the Impacts of Alternative 10a on Public Facilities and Services

Public Facilities and Services	Gross Reservoir PIA	Deep Aquifer Advanced Water Treatment Plant PIA	ASR System PIA/Denver County	Boulder County	Adams County	Other Denver Metropolitan Counties	Grand County
Police Departments	No impact	Negligible	No impact	Minor, temporary	Minor, temporary	No impact	No impact
Fire Departments	Minor, temporary	Negligible	No impact	Negligible	Minor, temporary	No impact	No impact
Health Services	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Libraries	No impact	Negligible	No impact	No impact	Negligible	No impact	No impact
Water Providers	No impact	Positive to No impact	Positive to No impact	Positive to No impact	Positive to No impact	Positive to No impact	Negligible
Wastewater Treatment	No impact	No impact	No impact	No impact	Negligible or No impact	Negligible or No impact	No impact
Solid Waste Disposal	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Education	No impact	No impact	No impact	No impact	No impact	No impact	No impact

Source: Harvey Economics, 2007.
Notes:
Denver Water and water providers that are Denver Water customers would experience positive impacts from Alternative 10a, while other water providers will be unaffected.
PIA = Primary Impact Area

Service Specific Impacts

The impact of Alternative 10a on each type of service provider is discussed in detail below and summarized in Table 5.19-15. As with the previous alternatives, water and wastewater treatment providers in Grand County have been discussed separately from other water and wastewater treatment providers because of river diversions that originate in Grand County.

Police Departments

Impacts to police departments in the Gross Reservoir PIA and Boulder County would be the same as described for the Proposed Action.

The Adams County Sheriff's Office may experience a minimal loss of funding as a result of Alternative 10a. This law enforcement agency is funded through Adams County property taxes which would decline by about $505 annually as a result of Denver Water's purchase of property for the AWTP and associated facilities (Adams County 2007b). A portion of that loss may be allocated to the Sheriff's Office. This funding change would result in a negligible impact to the Sheriff's Office budget. A potential but temporary increase in demands might occur during the AWTP construction due to increased traffic or related incidents.

The Commerce City Police Department may also experience a minimal loss of funding as a result of the property purchases. Property taxes paid to Commerce City would be reduced by about a total of $61 per year and funding to the Police Department may be affected by a portion of that. This potential change in funding is not likely to have any impact on Police Department operations.

Fire Departments

Impacts to fire departments in the Gross Reservoir PIA and Boulder County would be the same as described for the Proposed Action.

Demands on the South Adams Fire District #4 would potentially increase by a small amount during the construction phase of Alternative 10a, stemming from emergencies at construction sites or along commuting routes. The District should be able to adequately respond to potential emergencies. The District would also experience a loss of about $82 per year as a result of Alternative 10a (Adams County 2007b). This funding change would be due to the loss of property tax collected on the property that Denver Water would purchase related to the AWTP. This funding change would have a negligible impact on the District's budget.

No other fire departments in Boulder County, Denver Metropolitan area counties, or Grand County would experience any impacts related to changes in funding.

Health Services

Impacts to hospitals and other health care providers in Boulder County and Denver Metropolitan area counties under Alternative 10a would be similar to those described for the Proposed Action.

Libraries

Libraries in Boulder County or the Denver Metropolitan area, with the exception of those in the Rangeview Library District in Adams County, would not experience any impacts as a result of Alternative 10a. The Rangeview Library District is funded through a unique mill levy. Property taxes paid to the District would be reduced by $68 per year under Alternative 10a due to Denver Water's land purchases (Adams County 2007b). Libraries in Grand County would not experience any funding changes or other impacts as a result of Alternative 10a.

Education

Due to Denver Water's purchase of property in Adams County for the AWTP and associated facilities, property taxes for Adams County School District #14 would be reduced by about $889 per year. However, the State of Colorado guarantees a certain amount of funding per student and therefore, the school district would not be at a

disadvantage from Alternative 10a.[45] No other school districts in Boulder County, the Denver Metropolitan area, or Grand County would be impacted by Alternative 10a.

Boulder County and Denver Metropolitan Area Water Providers

Impacts within the Gross Reservoir PIA would be similar to those described for the Proposed Action.

Impacts to Denver Water and its customers would be similar to those described for the Proposed Action; these entities would benefit from the reliability and availability of the developed water rights. Impacts to other water providers in Boulder County and Denver Metropolitan area counties would be similar to those described for Alternative 8a. These providers would continue to be able to serve their customers with the same level of water service as they do currently. Changes to water rates for Denver Water's customers as a result of Alternative 10a are described in a separate section of the socioeconomic analysis for Alternative 10a.

Grand County Water Providers

Impacts to Grand County water providers under Alternative 10a would be similar to those described for the Proposed Action.

Boulder County and Denver Metropolitan Area Wastewater Treatment

WWTPs that serve Boulder County and Denver Metropolitan area residents would continue to provide treatment at the same level of service under Alternative 10a as under Current Conditions (2006). Impacts to these plants would be similar to those described for Alternative 8a.

Denver Water would have additional treatment capacity as a result of the new AWTP. This would decrease some of the current vulnerabilities and risk described in Chapters 1 and 2.

Grand County Wastewater Treatment

Impacts to Grand County wastewater providers under Alternative 10a would be similar to those described for the Proposed Action.

Solid Waste Disposal

During the construction period, some construction associated waste may be disposed of at Denver Metropolitan area landfills. Denver Water would be responsible for any applicable fees for waste disposal and no landfills would be adversely impacted by the construction activities of Alternative 10a.

The WTP in this alternative would be a reverse osmosis plant with zero liquid discharge, as described in Section 2.6.2.2. During operation, the solid waste from the plant would be compacted and disposed of at local landfills. Denver Water would be responsible for paying any fees related to this solid waste disposal. No landfills would be adversely impacted by operational activities in Alternative 10a.

[45] The State of Colorado guarantees a certain amount of funding per student to each school district and would only be obligated to make up losses to districts up to that guaranteed amount. Districts that collect revenues in excess of the guaranteed funding amount would only be eligible for state reimbursement of losses if the loss caused total funding to dip below guaranteed levels.

Table 5.19-15 provides a summary of the impacts of Alternative 10a on public facilities and services in affected areas.

5.19.4.7 Financial Impacts to Denver Water Customers

Denver Water would be responsible for total construction costs of an estimated $393 million and annual O&M costs of about $6 million under Alternative 10a. Capital and O&M expenditures undertaken by Denver Water as a part of Alternative 10a would result in increases in water rates and new connection fees for Denver Water customers as described below.

Water Rates

Under Alternative 10a, the average cost per 1,000 gallons of water would increase by about 80% through 2017, from a 2008 rate of $2.38 to $4.28 in 2017. This compares with a 52% increase under the No Action Alternative. Water rates would increase by between 3 and 9% annually through 2017. These impacts on Denver Water and its customers are considered moderate.

New Connection Charges

Under Alternative 10a, new connection charges would increase by about 11.3% compared to current 2008 rates. The ¾-inch SDC equivalent price would be $8,260 under Alternative 10a. This compares with $7,424 under the No Action Alternative. These impacts on Denver Water and its new customers are considered moderate.

Outstanding Debt

In addition, Denver Water's outstanding debt balance would increase by about 81% by 2017 under Alternative 10a, compared to the current 2008 balance. Denver Water's projected debt to net fixed asset ratio would be about 24% by 2017 under Alternative 10a. In fact, Denver Water might employ other financing strategies to stretch out the debt and otherwise manage its debt more effectively. This effect is considered to be a moderate to major impact, since this additional debt can be expected to impinge on Denver Water's future capital investment program.

5.19.4.8 Summary of Socioeconomic Impacts of Alternative 10a

As described for the individual topics above, some of the socioeconomic impacts of Alternative 10a would be temporary and tied to the construction phase and other impacts would be long term and permanent. A summary of impacts associated with Alternative 10a is shown in Table 5.19-16.

Table 5.19-16
Summary of Socioeconomic Impacts of Alternative 10a

Socioeconomic Consideration	Gross Reservoir PIA	Deep Aquifer Advanced Water Treatment Plant PIA	ASR System PIA/Denver County	Boulder County	Adams County	Denver Metropolitan Area	Grand County
Demographic Conditions	Minor, temporary	No impact	No impact	No impact	No impact	No impact	No impact
Housing Conditions	Negligible, temporary	No impact	No impact	No impact	No impact	No impact	Negligible, permanent
Economic Conditions	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, positive, temporary	No impact
Fiscal Conditions	Negligible impact	Negligible, negative, permanent	Negligible, Negative, permanent	Negligible impact	Negligible, negative, permanent	No impact	No impact
Water Providers	No impact	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Negligible impact, permanent
Other Public Facilities and Services	Minor or No impact	Negligible or No impact	No impact	Minor, negligible or No impact	Negligible or No impact	No impact	No impact
Water Rates and Tap Fees	No impact	No impact	Permanent, moderate to major, negative	No impact	Permanent, moderate to major, negative	Permanent, moderate to major, negative	No impact

Source: Harvey Economics, 2007.
Note:
PIA = Primary Impact Area

Temporary impacts would be similar to those of the Proposed Action and would include the following:

- An average of about 900 new jobs would be created during the construction period, which would result in about $51 million in annual employment-related income.
- Denver Water would spend about $201 million on non-labor costs, much of which would be for materials and supplies during the construction period. It is expected that many of the expenditures would occur in the Denver Metropolitan area and surrounding counties.
- Purchases made by Denver Water on labor and materials plus spending by persons employed as a result of this Alternative would amount to an increase in economic output of about $197 million per year during the construction period.
- The positive impacts to revenues of public entities from increased sales tax collections could not be quantified, but would be negligible.
- Impacts to expenditures of public entities would be related to road and bridge maintenance and would be negligible.

- Several public service providers would experience negligible or minor increases in demands during the construction period.

Long-term and permanent socioeconomic impacts of Alternative 10a would include:

- Benefits to Denver Water customers from a more reliable water supply.
- An increase of $1.90 per 1,000 gallons by 2017 and an increase of about $840 in tap fees for Denver Water customers.
- A $60 loss in annual funding to Boulder County, a $21 loss in annual funding to the Coal Creek Canyon Fire Department, a $505 loss of annual funding to Adams County (a portion of which could be passed on to the Adams County Sheriff's Office), a loss of $61 to Commerce City (a portion of which could be passed on to the Police Department), a loss of $68 to the Rangeview Library District, and a loss of $82 to the South Adams Fire District #4. Funding losses for these agencies are negligible.

5.19.5 Alternative 13a

5.19.5.1 Economic Conditions

Employment and Business Activity – PIAs, Boulder County, and the Denver Metropolitan Area

The majority of impacts on employment and business activity would occur within Boulder County and in Denver Metropolitan area counties as described for the Proposed Action. However, the magnitude and value of impacts to employment, income and sales under Alternative 13a are unique and are described below.

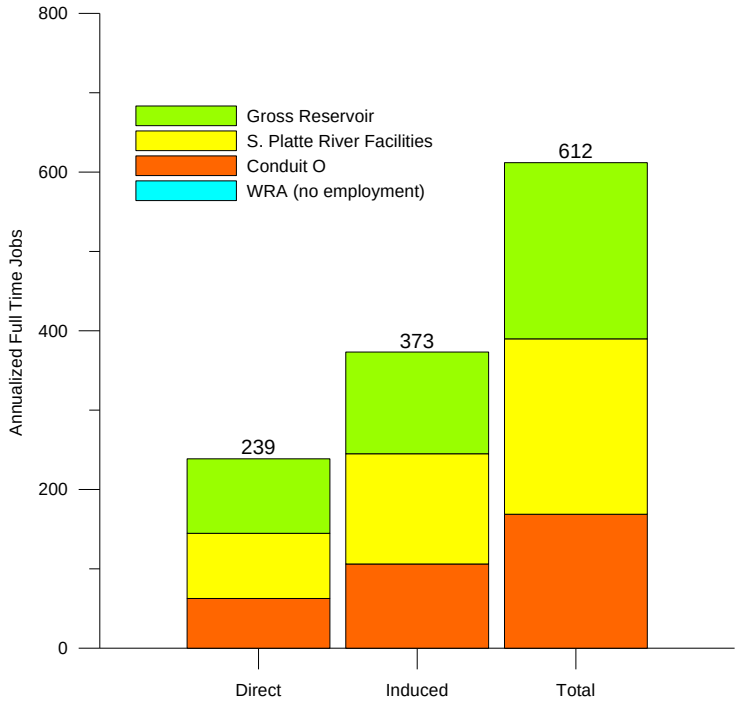
Construction-Related Employment and Business Activity

Denver Water would spend about $249 million for non-labor costs, most of which would be for materials and supplies in Alternative 13a (Harvey Economics 2008). This amount includes the purchase of the gravel pits and the agricultural water rights in addition to materials and supplies required for construction of facilities in Alternative 13a. Spending on materials and supplies would occur as described for the Proposed Action.

During the approximately 3.6-year construction phase of Alternative 13a, an average of 239 construction workers would be employed each year. The types of workers employed would be similar to those employed under the Proposed Action. The induced employment created as a result of construction activities would provide about 373 additional jobs per year within a number of different industries in the Denver Metropolitan area. Construction jobs and induced jobs would be temporary, as described for the Proposed Action.

Figure 5.19-13 shows the average annual direct construction employment and the average annual induced employment created as a result of construction activity in Alternative 13a.

Figure 5.19-13
Annual Employment Generated from Construction Activities in Alternative 13a



Source: MWH, 2006; Denver Water, 2007e; Boyle, 2008b; Harvey Economics, 2008.
Notes:
Construction activities would occur over a 3.6-year period for Alternative 13a.
Due to rounding, figures may not add up to total shown.
WRAA = water rights acquisition area

Personal Income

Total wages for construction workers would average about $14.9 million per year over the approximately 3.6-year construction period (MWH 2006; Harvey Economics 2008).[46] Average hourly wages for different types of construction workers would be the same as described for the Proposed Action. Wages of induced employees would range considerably, depending on the type of job created or the industry, but are estimated to total about $18 million per year.[47]

Figure 5.19-14 shows the average annual direct income and the average annual induced income created as a result of construction activities in Alternative 13a.

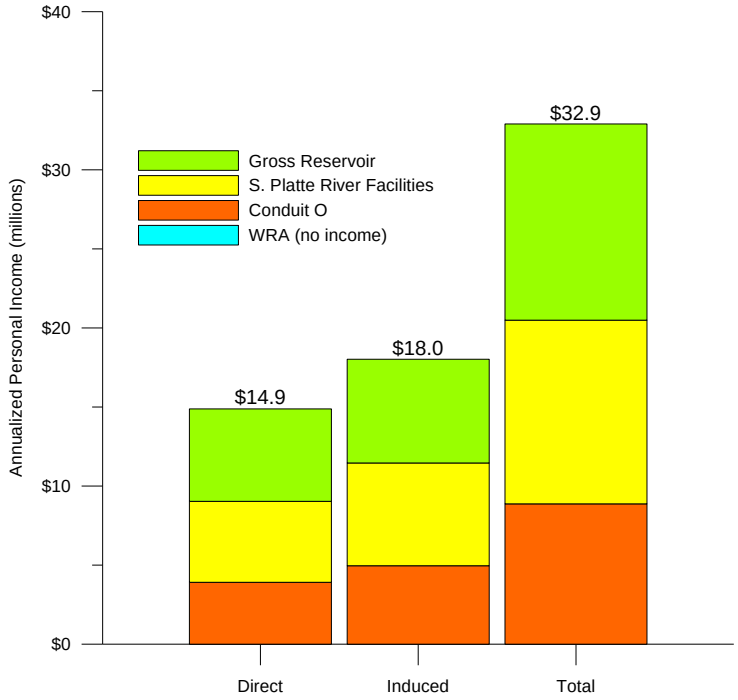
The annual total personal income created under Alternative 13a would account for less than one tenth of 1% of total compensation paid to all working persons in the Denver Metropolitan area.[48] The personal income created as a result of Alternative 13a would have a negligible positive impact on the Denver Metropolitan area.

[46]Average annual wages are reported in constant 2006 dollars.

[47]Economic multipliers for the construction industry were obtained from the Colorado Department of Local Affairs (2006) and applied by Harvey Economics (2007). The estimated wages for induced employees are reported in constant 2006 dollars.

[48]Direct construction costs presented here do not include mobilization costs. Mobilization costs include bonds and insurance. Total construction costs include direct construction costs as well as engineering and environmental costs.

Figure 5.19-14
Annual Income Generated from Construction Activities in Alternative 13a



Source: MWH, 2006; Denver Water, 2007e; Boyle, 2008b; Harvey Economics, 2008.
Notes:
Construction activities would occur over a 3.6-year period for Alternative 13a.
Due to rounding, figures may not add up to total shown.
WRAA = water rights acquisition area

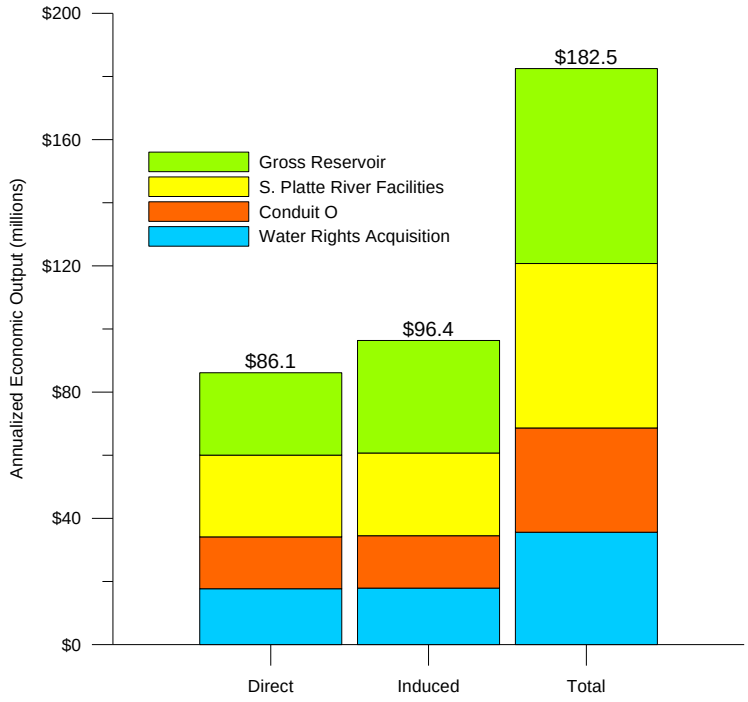
Total Economic Output

Direct construction costs associated with Alternative 13a would total about $336 million over the construction period, or about $86 million per year, including labor and non-labor costs. Induced sales of goods and services would result from construction worker spending and spending of induced employees as described for the Proposed Action. Total sales of goods and services would amount to about $182.5 million per year over the construction period.

Figure 5.19-15 shows the annual direct spending by Denver Water for construction activities, the annual spending of induced workers and the total annual economic output generated by the construction activities in Alternative 13a.

Total sales exceeded $157 billion for Denver Metropolitan area businesses in 2011. Total annual economic output created under Alternative 13a would account for less than a tenth of 1% of total sales in the Denver Metropolitan area. The economic output created as a result of Alternative 13a would have a negligible but positive and temporary impact on the Denver Metropolitan area.

Figure 5.19-15
Annual Economic Output Generated from Construction Activities in Alternative 13a



Source: MWH, 2006; Denver Water, 2007e; Boyle, 2008b; Harvey Economics, 2008.
Notes:
Construction activities would occur over a 3.6-year period for Alternative 13a.
Due to rounding, figures may not add up to total shown.

Agriculture Related Employment and Business Activity

Changes in economic activity related to agriculture would come from the purchase of agricultural water rights in the water rights acquisition area (WRAA) PIA. See Section 3.17.3.2 for a geographical description of the WRAA PIA. Representative ditches within this PIA would provide 3,000 AF/yr of firm yield needed under Alternative 13a. The water rights purchased would be from lands in the vicinity of these ditches, but specific parcels and their locations are unknown. The future use of the land is also unknown, but it is possible that it could be put into a rotating fallowing scheme, the purchase could be for a dry year lease (allowing irrigation in some years), or the irrigated acres could be converted to dryland crops. The conversion to dryland farming would be the worst case impact scenario, and as such has been used for this analysis in order to determine maximum potential economic impacts of this alternative. The EIS does not include an analysis of whether or not the land that would be dried up would be urbanized because the location of the acres would be needed to make that determination. However, if urbanized, the negative economic impacts would be less than the dryland farming scenario. While the WRAA PIA includes portions of Weld and Adams counties, this analysis uses Weld County data (where most of the representative ditch systems are located) as representative of the impacts that would occur under this alternative.

Direct Effects of Water Transfer

The amount of land dried up depends on the specific shares acquired. That is, because the acreage associated with a given share varies and the shares to be acquired are unknown, the amount of land dried up can only be estimated. As a result, minimum, maximum, and average scenarios were developed.

For purposes of this EIS analysis, water previously used for irrigated cropland would come from four representative ditches. The estimated minimum, maximum, and average number of acres taken out of irrigated production are shown in Table 5.19-17.

Table 5.19-17
Potential Irrigated Acreage Losses Under Alternative 13a

Potential Estimate	Ditch #1 (acres)	Ditch #2 (acres)	Ditch #3 (acres)	Ditch #4 (acres)	Total Irrigated Acres Impacted
Estimated Minimum	700	1,100	400	200	**2,400**
Estimated Maximum	2,800	1,100	500	1,000	**5,400**
Estimated Average	1,750	1,100	450	600	**3,900**

Source: Boyle, 2006c.
Note:
Estimated average calculated by Harvey Economics.

As shown in Table 5.19-18, under the maximum scenario, less than 2% of all the irrigated acres in Weld County would be converted to dry land farming.

Table 5.19-18
Percentage Loss in Weld County Irrigated Acreage Under Alternative 13a

County	2007			Estimated Acres Impacted			
	Total Cropland (acres)	Harvested Cropland (acres)	Irrigated Land (acres)	Maximum Scenario	Minimum Scenario	Average Scenario	% of Irrigated Acres (Max. Scenario)
Weld County	987,892	487,855	327,836	5,400	2,400	3,900	1.6%

Source: USDA, 2007; Harvey Economics, 2012.

The value of irrigated crops is roughly 7 times that of dry land crops in this region, based on the Census of Agriculture. In order to estimate losses from the dry up of these acres, the average value of 1 acre of dry land crops was subtracted from the average value of an acre of irrigated crops. This results in an estimated loss per acre of $426 or a total of $2.3 million per year. This loss would be about 1.5% of the total value of crops harvested in Weld County. The economic losses from conversion of irrigated lands are considered minor.

Operational Phase Employment and Business Activity

Employment and business activity during operations would be the same as described for Alternative 8a with some additional information.

Indirect and induced losses from reduced agricultural income caused by the change from irrigated agriculture to dry land farming include reduced sales to agricultural business, job losses, and reduced spending due to lower income.

A 2007 economic impact analysis of irrigated acres in four Colorado River basins estimated that the loss of one irrigated acre in the east South Platte River Basin resulted in a total economic loss of $690 per acre, including direct and induced effects (Thorvaldson 2007). This would indicate that an additional $1.4 million in economic losses would be incurred in the WRAA PIA, for a total economic loss of $3.7 million. This amount is considered negligible from the standpoint of the Weld County economy as a whole.

Estimation of jobs lost due to the conversion to dryland farming began with the number of agricultural workers per irrigated acre of farmland in Weld County. This number was applied to the maximum impacted acres, resulting in an estimated loss of 74 workers and annual income of about $1.5 million (BEA 2008; USDA 2002; Harvey Economics 2008).

In addition to the direct employment losses, induced jobs that were a result of spending by those 74 workers would cause a reduction of approximately 44 jobs and $1.5 million in wages.[49] As a result of the conversion of 5,400 irrigated acres to dryland farming, total job losses would be 118, and lost wages $3.1 million.

About 1.3% of Weld County agricultural jobs would be lost and less than one tenth of 1% of total Weld County jobs would lost. As a result, these impacts are considered to be negligible.

Employment and Business Activity – Grand County

Impacts to business and employment activity in Grand County for Alternative 13a would be similar to those described in the Proposed Action.

5.19.5.2 Demographic Conditions

Gross Reservoir PIA

Impacts to the population and other demographic characteristics of the Gross Reservoir PIA would be similar to that discussed under the Proposed Action. Construction phase impacts experienced by PIA residents would be similar in nature, but slightly less in magnitude, to those described for the Proposed Action (Alternative 1a) due to the shorter construction timeframe of about 3.6 years and the smaller reservoir enlargement.

South Platte River Facilities and Conduit O PIAs

Impacts to demographic conditions in these PIAs would be similar to those described for Alternative 8a.

Water Rights Acquisition Area PIA

The WRAA PIA encompasses the South Platte River Facilities PIA and additional areas in Adams County and Weld County in the vicinity of affected ditches. Impacts to demographic

[49]The average wage for Weld County agriculture employees is about $20,600; the average wage for all Weld County workers, as applied to indirect and induced employees, is about $35,000.

conditions in the South Platte River Facilities PIA would be similar to those described for Alternative 8a. The acquisition of water rights in Adams and Weld Counties is assumed to result in irrigated crops being replaced with dryland crops, as described above. This change in type of crop production on private land should have no effects on the demographics of the PIA. The population would likely remain unchanged and there would be no changes in the characteristics of the population.

Boulder County and Denver Metropolitan Area Counties

Impacts to demographic conditions in Boulder County and the Denver Metropolitan area would be similar to those described for Alternative 8a.

Weld County

Alternative 13a is the only alternative that would directly affect Weld County. Weld County is not included in the Denver Metropolitan area and is therefore discussed separately throughout the socioeconomic analysis of Alternative 13a. Part of southern Weld County, including Fort Lupton and Platteville, are part of the WRAA PIA. This area is in the vicinity of the ditches that would provide the purchased water rights to Denver Water. Weld County would likely experience no demographic changes as a result of the Water Transfer.

Grand County

Impacts to the Grand County population and the demographic characteristics of that population resulting from Alternative 13a would be similar to those described for the Proposed Action.

Table 5.19-19 describes the impacts of Alternative 1c on the demographic conditions of affected areas.

Table 5.19-19
Changes to Demographic Conditions from Alternative 13a

Demographic Considerations	Gross Reservoir PIA	South Platte River Facilities PIA	WRAA PIA	Boulder County	Weld County	Denver Metropolitan Area	Grand County
Population	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Migration Patterns	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Ethnicity	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Age Distribution	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Commuting Patterns	Minor to moderate, temporary	No impact	No impact	Negligible, temporary	No impact	Negligible, temporary	No impact

Source: Harvey Economics, 2007.
Notes:
The Denver Metropolitan area includes Adams County (location of the gravel pits, Advanced Water Treatment Plant, and a portion of the conduit) and Jefferson County (location of a portion of the conduit), and other Denver Metropolitan area counties.
PIA = Primary Impact Area

5.19.5.3 Environmental Justice

No specific ethnic or otherwise classified groups of PIA, Boulder County, Denver Metropolitan area, or Weld County residents would be disproportionately impacted by construction or operational activities in Alternative 13a. No environmental justice issues would arise as a result of this alternative.

5.19.5.4 Housing Conditions

Housing Units

Impacts to housing units under Alternative 13a would be similar to those described for Alternative 8a, with some additional information. No additional housing units would be built and no housing units would be affected in the WRAA PIA or Weld County under Alternative 13a. Alternative 13a would not change the population or the demographic make-up of the WRAA PIA or Weld County and therefore no change in number of housing units is expected. The conversion to dryland crops would have no affect on the number or type of housing units.

Vacancy Rates

Impacts to vacancy rates would be similar to those described for Alternative 8a, with the following addition: the population and number of housing units in the WRAA PIA and Weld County would be unchanged and, therefore, the vacancy rate in that PIA would also remain unchanged by Alternative 13a.

Home Values

Impacts to housing values would be similar to those described for Alternative 8a, with the following addition: within the WRAA PIA, lands dried up by the sale of water rights would likely experience a decline in value as dryland crops produce less income than irrigated crops. Rents for dry land were about 20% of that for irrigated cropland. It is likely this may adversely effect the value of the homes on the property. However, the number of homes affected would be so small it is unlikely there would be an impact on PIA home values in general, resulting in negligible impacts. In Grand County, properties surrounding Grand Lake would realize a total loss of value of about $223,000 due to changes in water quality and clarity (see Section 4.6.2, for more detail).

Table 5.19-20 presents the impacts of Alternative 13a on the housing characteristics of affected areas.

Table 5.19-20
Changes to Housing Conditions from Alternative 13a

Housing Considerations	Gross Reservoir PIA	South Platte River Facilities PIA	WRAA PIA	Boulder County	Weld County	Denver Metropolitan Area	Grand County
Housing Units	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Housing Units	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Home Values	Minor to moderate, temporary impacts for a small number of homes along Gross Dam Road	No impact	Negligible impact	No impact	No impact	No impact	Minor impact to homes directly surrounding Grand Lake

Source: Harvey Economics, 2007.
Note:
PIA = Primary Impact Area

5.19.5.5 Fiscal Impacts of Public Entities Other than Denver Water

Operating Revenues

Local jurisdiction revenues and Denver Water tax responsibilities are the same as described in the Proposed Action. Fiscal impacts due to the Gross Reservoir expansion are also similar to those described in the Proposed Action. Changes to operating revenue as a result of the purchase of the gravel pits and properties for the AWTP and associated facilities are as follows:

- Adams County: $319
- Brighton 27-J School District: $538
- Brighton Fire Protection District: $139
- Rangeview Library District: $43

Conduit O would be routed along roadways and utility corridors. No property would be purchased by Denver Water for the Conduit; therefore, there would be no impacts to any entities operating revenues.

Under the assumptions used for this analysis, that all land that would be dried up in the WRAA PIA in Weld County, the county would experience losses as a result of the change from irrigated to dryland. Property taxes are based on the net income of the property. Since dryland crops are less valuable than irrigated crops, a reduction in property tax revenue would occur. Annual losses for countywide levies would be:

- Weld County: $9,500
- AIMS Junior College: $3,600

- High Plains Library District: $1,800 (formerly the Weld Library District)

Other losses would accrue to fire, school, and water districts, but mill levies vary among these and since the location of the property is unknown, dollar amounts cannot be determined. In addition, there are 2,210 taxing areas in Weld County and it is likely that the lands would be in more than one area. However, if all of the acres were located in one taxing area, an example of losses would be: School District RE, $5,200; Platteville-Gilchrest Fire District, $2,100; and CCW Water, $565. These losses are small relative to total budgets and would have a negligible, negative impact.

Operating Expenditures

Activities related to Gross Reservoir expansion are similar to those described in the Proposed Action except that the average number of haul and concrete trucks per day would be reduced from 22 to 21. For the other components, impacts would be related to additional traffic resulting from construction activities. CDOT budget and maintenance expenditures are discussed in the Proposed Action. Traffic related impacts from the South Platte River Facilities and Conduit O are discussed in Alternative 8a. There would be no traffic related impacts as a result of the water rights acquisition.

Capital Outlays

Capital outlay expenditures for Alternative 13a would be similar to those described in the Proposed Action.

5.19.5.6 Public Facilities and Services

Impacts resulting from the expansion of Gross Reservoir are discussed in Section 5.19.1.6 for the Proposed Action and are included in Table 5.19-21.

The populations of the PIAs, Denver Metropolitan area counties, and Grand County would not change as a result of Alternative 13a. The agencies that provide public services to residents in these areas would not experience added pressure to serve any additional people as a result of Alternative 13a.

Several public facilities and services in Adams County would be affected by funding changes resulting from Alternative 13a. Impacts to Adams County would be similar to those describe in Alternative 8a, but would be somewhat larger. Impacts to Weld County as a result of water rights acquisition and reduced property taxes are detailed below.

Table 5.19-21
Summary of the Impacts of Alternative 13a on Public Facilities and Services

Public Facilities and Services	Gross Reservoir PIA	South Platte River Facilities PIA	WRAA PIA	Boulder County	Adams County	Weld County	Other Denver Metropolitan Counties	Grand County
Police Departments	No impact	Negligible impact	No impact	Minor, temporary	Minor, temporary	No impact	No impact	No impact
Fire Departments	Minor, temporary	Negligible impact	No impact	Negligible impact	Minor, temporary	No impact	No impact	No impact
Health Services	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Libraries	No impact	Negligible impact	Negligible impact	No impact	Negligible impact	Negligible impact	No impact	No impact

Table 5.19-21 (continued)
Summary of the Impacts of Alternative 13a on Public Facilities and Services

Public Facilities and Services	Gross Reservoir PIA	South Platte River Facilities PIA	WRAA PIA	Boulder County	Adams County	Weld County	Other Denver Metropolitan Counties	Grand County
Water Providers	No impact	Positive impact to Denver Water customers; No impact to others	No impact	Positive impact to Denver Water customers; No impact to others	Positive impact to Denver Water customers; No impact to others	No impact	Positive impact to Denver Water customers; No impact to others	Negligible impact. permanent
Wastewater Treatment	No impact	No impact	No impact	No impact	Negligible or No impact	No impact	Negligible or No impact	No impact
Solid Waste Disposal	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Education	No impact	No impact	No impact	No impact	No impact	Negligible	No impact	No impact

Source: Harvey Economics, 2007.
Notes:
Adams County is shown separately from the Denver Metropolitan area due to the potential for site specific impacts related to the construction and operation of the Advanced Water Treatment Plant and associated facilities.
PIA = Primary Impact Area

Service Specific Impacts

The impact of Alternative 13a on each type of service provider is discussed below and summarized in Table 5.19-21. For specific services, impacts are described as being similar to Alternative 8a, as opposed to the Proposed Action since Alternatives 8a and 13a include similar components in the same geographic area.

As with the previous alternatives, water and wastewater treatment providers in Grand County have been discussed separately from other water and wastewater treatment providers because of river diversions that originate in Grand County.

Police Departments

Impacts to police departments in the Gross Reservoir PIA and Boulder County would be the same as described for the Proposed Action.

The Adams County Sheriff's Office may experience a minimal loss of funding as a result of Alternative 13a. Adams County would receive about $319 less in property taxes each year as a result of Denver Water's purchase of the gravel pits and other properties (Adams County 2007b). A portion of that loss may be allocated to the Sheriff's Office. This funding change would result in a negligible impact to the Sheriff's Office budget. In addition, the Sheriff might experience a minor, temporary increase in demand due to increased traffic and related incidents during AWTP construction.

Weld County would lose about $9,500 as a result of the water rights acquisition and associated property tax reduction. The Weld County Sheriff's Office is funded by the County and could experience a reduction in funds as a result of this loss. The loss would be negligible relative to their total budget.

Fire Departments

Impacts to fire departments in the Gross Reservoir PIA and Boulder County would be the same as described for the Proposed Action.

Demands on the Brighton Fire Protection District would potentially increase by a small amount during the construction phase of Alternative 13a, stemming from emergencies at construction sites or along commuting routes. The District should be able to adequately respond to potential emergencies. The District would experience a loss of funding of $139 each year, which is a negligible amount (Adams County 2007b).

Grassland fires from increased dryland agriculture could create a modest potential fire risk in Weld County. Additionally, it is unknown if a single fire department or multiple fire departments in Weld County would lose property tax revenue as a result of the water rights acquisition. It is likely that the loss would be in more than one district, and the impacts would be negligible.

No other fire departments in Adams County, Boulder County, Denver Metropolitan area counties, or Grand County would experience any impacts related to changes in funding.

Health Services

Health Service impacts would be similar to those described in Alternative 8a with this additional information; no additional services would be need as a result of water rights acquisition.

Libraries

Impacts to libraries in Boulder County and the Denver Metropolitan area would be similar to those described in Alternative 8a, with the following exception: the Rangeview Library District would experience a loss of $43 in annual funding. Additionally, the Weld County Library, which is funded by a mill levy, would experience a reduction in property tax income of about $1,800 due to the water rights acquisition (Adams County 2007b).

Education

School districts serving Boulder County, Adams County, other Denver Metropolitan area counties, or Grand County would not be affected by Alternative 13a. Adams County property taxes include a mill levy specifically for school districts. Due to Denver Water's purchase of the gravel pits and other properties in Adams County, property taxes for school district funding would be reduced by about $538 per year (Adams County 2007b). However, the State would make up that amount with guaranteed funding.[50]

AIMS Junior College in Weld County would lose about $3,600 in property revenue each year and one or more schools districts in Weld County would also experience a reduction in funding as a result of the water rights acquisition. However, the State would make up that amount with guaranteed funding and therefore, no Weld County school district would be at a disadvantage from Alternative 13a.

[50] The State of Colorado guarantees a certain amount of funding per student to each school district and would only be obligated to make up losses to districts up to that guaranteed amount. Districts that collect revenues in excess of the guaranteed funding amount would only be eligible for State reimbursement of losses if the loss caused total funding to dip below guaranteed levels.

Boulder County and Denver Metropolitan Area Water Providers

Impacts within the Gross Reservoir PIA would be similar to those described for the Proposed Action.

Impacts to water providers in the South Platte River Facilities PIA, Boulder County, and Denver Metropolitan area counties would be similar to those described for Alternative 8a.

Water providers in the WRAA PIA and in Weld County would see flow changes in the South Platte River at the Henderson gage as described in Section 5.1. However, no water providers in these areas would experience any reduction of supply or loss of water rights under Alternative 13a.

Grand County Water Providers

Impacts to Grand County water providers under Alternative 13a would be similar to those described for the Proposed Action.

Boulder County and Denver Metropolitan Area Wastewater Treatment

Impacts to WWTPs that serve Boulder County and Denver Metropolitan area residents would be similar to those described for Alternative 8a.

Denver Water would have additional treatment capacity as a result of the new AWTP. This would decrease some of the current vulnerabilities and risk described in Chapters 1 and 2.

Grand County Wastewater Treatment

Impacts to Grand County wastewater providers under Alternative 13a would be similar to those described for the Proposed Action.

Solid Waste Disposal

During the construction period, some construction associated waste may be disposed of at Boulder County or Denver Metropolitan area landfills. Denver Water would be responsible for any applicable fees for waste disposal and no landfills would be adversely impacted by the construction activities of Alternative 13a.

Table 5.19-21 provides a summary of the impacts of Alternative 13a on public facilities and services in affected areas.

5.19.5.7 Financial Impacts to Denver Water Customers

Denver Water would be responsible for total construction costs of about $427 million and annual O&M costs of about $3.9 million under Alternative 13a. Capital and O&M expenditures undertaken by Denver Water as a part of Alternative 13a would result in increases in water rates and new connection fees for Denver Water customers as described below.

Water Rates

Under Alternative 13a, the average cost per 1,000 gallons of water would increase by about 85% through 2017, from a 2008 rate of $2.38 to $4.40 in 2017. This compares with a 52%

increase under the No Action Alternative. Water rates would increase by between 4% and 9% annually through 2017. These impacts on Denver Water and its customers are considered moderate to major.

New Connection Charges

Under Alternative 13a, new connection charges would increase by about 12% compared to 2008 rates (same as the No Action Alternative). The ¾-inch SDC equivalent price would be $8,324 under Alternative 13a. This compares with $7,424 under the No Action Alternative. These impacts on Denver Water and its new customers are considered moderate.

Outstanding Debt

In addition, Denver Water's outstanding debt balance would increase by about 88% by 2017 under Alternative 13a, compared to the current 2008 balance. Denver Water's projected debt to net fixed asset ratio would be about 25% by 2017 under Alternative 13a. In fact, Denver Water might employ other financing strategies to stretch out the debt and otherwise manage its debt more effectively. This effect is considered to be a moderate to major impact, since this additional debt is expected to have an important effect on Denver Water's future capital investment program.

5.19.5.8 Summary of Socioeconomic Impacts of Alternative 13a

As described for the individual topics above, some of the socioeconomic impacts of Alternative 13a would be temporary and tied to the construction phase and other impacts would be long term and permanent. A summary of impacts associated with Alternative 13a is presented in Table 5.19-22.

Table 5.19-22
Summary of Socioeconomic Impacts of Alternative 13a

Demographic Considerations	Gross Reservoir PIA	South Platte River Facilities PIA	WRAA PIA	Weld County	Denver Metropolitan Area	Grand County
Demographic Conditions	Minor, temporary	No impact	No impact	No impact	No impact	No impact
Housing Conditions	Negligible, temporary	No impact	No impact	No impact	No impact	Negligible, permanent
Economic Conditions	Negligible, positive, temporary	Negligible, positive, temporary	Negligible, impact, negative, permanent	Negligible to minor, negative, permanent	Minor, positive, temporary	No impact
Fiscal Conditions	Negligible	Negligible	Negligible	Negligible	No impact	No impact

Table 5.19-22 (continued)
Summary of Socioeconomic Impacts of Alternative 13a

Demographic Considerations	Gross Reservoir PIA	South Platte River Facilities PIA	WRAA PIA	Weld County	Denver Metropolitan Area	Grand County
Water Providers	No impact	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Positive, permanent for Denver Water customers; No impact for others	Negligible impact, permanent
Other Public Facilities and Services	No impact or minor	No impact, negligible or minor	Negligible or No impact	Negligible impact	Negligible impact	No impact
Water Rates and Tap Fees	No impact	No impact	No impact	No impact	Permanent, moderate to major, negative	No impact

Source: Harvey Economics, 2007.
Note:
PIA = Primary Impact Area

Temporary impacts would be similar to those of the Proposed Action and would include the following:

- An average of about 616 new jobs would be created during the construction period, which would result in about $33 million in annual employment-related income.
- Denver Water would spend about $249 million on non-labor costs, much of which would be for materials and supplies during the construction period. It is expected that many of the expenditures would occur in the Denver Metropolitan area and surrounding counties.
- Purchases made by Denver Water on labor and materials plus spending by persons employed as a result of this Alternative would amount to an increase in economic output of $182.5 million per year during the construction period.
- The positive impacts to revenues of public entities from increased sales tax collections was not be quantified, but would be negligible.
- Impacts to expenditures of public entities would be related to road and bridge maintenance and would be negligible.
- Several public service providers would experience negligible or minor increases in demands during the construction period.

Long-term and permanent socioeconomic impacts of Alternative 13a would include:

- Benefits to Denver Water customers from a more reliable water supply.
- A water rate increase of about $2.00 per 1,000 gallons and an increase of $900 in tap fees for Denver Water customers.
- A $60 loss in annual funding to Boulder County, a $319 loss in annual funding to Adams County, a $21 loss in annual funding to the Coal Creek Canyon Fire

Department, $43 loss of annual funding to the Rangeview Library District, and a $139 loss in annual funding to the Greater Brighton Fire Protection District in Adams County.

- A $9,500 annual loss of property tax revenue to Weld County, $1,800 loss to the High Plains Library District, and $3,600 loss to AIMS Junior College. Limited additional losses to fire protection and water districts are likely, but the specific districts potentially affected are unknown, as detailed in Section 5.19.5.5.

5.19.6 No Action Alternative

The socioeconomic impacts for the No Action Alternative are driven by Denver Water's attempt to fulfill its mission of meeting treated water and raw water demands of its customers. Without additional supplies in the Moffat Collection System, as identified in Sections 1.3 and 1.4, Denver Water would deplete water reserves and impose various levels of restrictions during drought periods. The level of depletion and intensity of restrictions would depend on specific circumstances in any given year, but would result in socioeconomic impacts both to the utility and to Denver Water's treated and raw water customers.

Socioeconomic impacts would occur as a result of:

1. The vulnerability and risks to which Denver Water would be exposed.
2. Periodic shortages of deliveries to raw water customers.
3. Periodic shortages of deliveries to treated water customers.
4. More frequent and severe drawdown of Gross Reservoir.

The section describes the socioeconomic effects which would result from each of these situations.

Due to the uncertainty of future conditions, such as the length and severity of future drought periods, and the specifics of Denver Water's response, the socioeconomic impact analysis for the No Action Alternative is largely qualitative. The types of impacts described below can be expected to occur, but the severity of the impacts is dependent on specific circumstances.

5.19.6.1 Vulnerability and Risk

The sources of increased vulnerability and risk to Denver Water were described in detail in Sections 1.4.4 and 2.10. System reliability is diminished because the North System and the Moffat AWTP would face periodic shortages in the future. A particularly critical issue would be the seasonal shutdown of the Moffat AWTP, leaving only two AWTPs to serve Denver Water's Combined Service Area (CSA), increasing the chances that Denver Water would not be able to fulfill its mission. Additionally, a North System with inadequate supplies means that the South System must not ever go down, and can never experience a man-made or natural disaster. Clearly, the No Action Alternative increases the vulnerability of the Denver Water system and raises the probability, however small, of system failure.

Denver Water would also lose the flexibility in the future of shifting the resource requirements between the North and South systems in normal times to optimize system efficiency. Denver Water would experience an opportunity cost without future flexibility.

Socioeconomic Impacts of Increased Vulnerability and Risk

Decreased system reliability, decreased operational flexibility and increased system vulnerability under the No Action Alternative would result in the likelihood of periodic interrupted service or water shortage to Denver Water customers. Additionally, restrictions on water use would impact customers. The resulting socioeconomic impacts to Denver Water's contractors (i.e., read/bill utilities within the CSA), residential and commercial customers resulting from unmet water demands and Denver Water's operations under the No Action Alternative are described in Sections 5.19.6.2 and 5.19.6.3. Beyond minor system failures and shortages, the impacts of a major system failure are also addressed.

However remote the possibility, major system failure represents dire consequences for Denver Water as an institution and has major social impacts for the CSA. In the event of a major system failure, the faith which the City of Denver and the other Denver Metropolitan institutions place in Denver Water to meet its commitment of water delivery would be breached. This perception of institutional instability may lead to new management, new oversight responsibilities, and control by other levels of government. Similarly, water customers would lose confidence in the certainty of Denver Water's service delivery, and they would seek backup supplies or other redundancies to make sure they receive critical supplies. These redundancies themselves would create additional environmental as well as financial impacts. Friction between the utility and its customers, including lawsuits, would likely follow.

Recognizing the seriousness of these consequences, Denver Water would need to consider and plan for this eventuality. The costs of responding to a major system failure are likely to be major, and even planning for them would be an expense. In the end, there would likely be a substantial loss in operational efficiency.

A reduction in system flexibility is likely under the No Action Alternative since the North System would not be expanded. Increased flexibility allows Denver Water to take advantage of efficiencies and hold down cost increases, perhaps even reducing costs. This increased flexibility thus offers an opportunity to limit water rate increases. The No Action Alternative would result in a loss of this opportunity. Decreased water use resulting from water restrictions or surcharges could result in decreased revenue for Denver Water. This would put an additional burden on the utility in terms of funding routine maintenance, meeting customer demands, providing high water quality or acquiring additional supplies.

5.19.6.2 Raw Water Shortages

Section 2.10.4.2 discusses the raw water shortages that could occur under the No Action Alternative. During drought periods, when Gross and Ralston reservoirs are drawn down to minimum storage capacities, Denver Water would be unable to meet its contractual commitments to raw water customers served by the North System. Many of these customers treat the raw water supplied by Denver Water for delivery to their residential and commercial customers. The City of Arvada, City of Westminster, and North Table

Mountain would be especially vulnerable since they cannot take delivery of water from Denver Water's other raw water sources. According to PACSM results, maximum annual shortages in deliveries to raw water customers using the North System could be as much as the following under the No Action Alternative:[51]

- City of Arvada: 2,050 AF of historical deliveries, plus 3,000 AF in future deliveries
- City of Westminster: 671 AF
- North Table Mountain: 928 AF
- Other North System contracts[52]: 430 AF

The maximum shortages would occur in about 1 out of 45 years; however, smaller shortages are likely to occur in additional years. The majority of the shortages would occur between December and March, with smaller amounts of shortage occurring in April and May.

Socioeconomic Impacts of Raw Water Shortages

In general, utilities experiencing water shortages in drought years under the No Action Alternative would likely respond in one or both of the following ways:

- Enact restrictions on water use to reduce their customers' water demand. Restrictions would vary from voluntary to mandatory and range in intensity depending on the severity of dry weather and potential amount of water shortage. This could include increases in the cost of water to customers, such as surcharges.
- Attempt to acquire additional water supplies, most likely temporary supplies to meet demands during the drought periods when shortages would occur.

Shortages are projected to occur in only a few dry years. The limited time frame of potential shortage would somewhat limit economic impacts. However, shortages could occur at any time and in concurrent years. The uncertainty of when a shortage might occur and the amount of potential shortage would make it difficult for utilities to plan for these events.

Socioeconomic Impacts of Water Restrictions

Effects of restrictions on residential and commercial customers would include the following:

- Residential customers would consume less water, potentially at the expense of lawns and landscaping or water use for recreational activities, such as backyard swimming pools or other water-based recreation. Some of the reductions in water use might be achieved by greater efficiency at no measurable sacrifice of the benefits of that use, but some of the reductions might also come from a loss of the benefits of that use. These customers may feel they experience a reduced quality of life under these restrictions. Surcharges or other fees would place a financial burden on some customers.

[51]The raw water shortages assume Arvada's demand increases by 3,000 AF per year under the No Action Alternative.

[52]These include the Arvada Parks Department, Department of Energy, Gilpin County Road and Bridge, Jefferson County Road and Bridge, and the Asphalt Paving Company.

Residential customers expending more money for their water or the restrictions might become frustrated with their water utilities as a result.

- Commercial customers would be required to reduce water use, experience increased costs from higher utility rates or both. Unmet demands and increased costs would reduce production and businesses would experience decreases in profit from reduced sales. There would likely be some loss of employment for businesses affected by restrictions and depending on the utility response, some companies might close down altogether. Water-based businesses and recreational facilities which cannot easily reduce water use (golf courses, parks, the landscaping industry, and agricultural users) would be especially impacted. Denver Metropolitan area businesses would experience reduced production and sales resulting in lower profits. Municipal entities would collect less sales tax revenue as a result of the decreased economic activity.
- The socioeconomic impacts of water restrictions, reduced discretionary income, reduced quality of life, lower levels of economic activity, reduced employment, and reduced income might be considered moderate in intensity, but temporary in nature. Given their temporary nature, the affected parties would typically attempt to engage in substitute efforts to lessen the effects. However, the duration and magnitude of these shortages are unknown.

Socioeconomic Impacts of Acquisition of Temporary Water Supplies

Raw water customers may attempt to acquire temporary water supplies in periods of shortage. However, during drought periods these supplies may be unavailable or difficult to find as other utilities may also be in the market for additional supplies to meet demands. Available supplies would likely be expensive in drought situations, potentially causing utilities to increase rates in the short term. The increased cost of water would reduce economic activity in general and place extra burdens on businesses that require water for production.

Additionally, the temporary supplies available in drought periods may not be in locations where utilities or other entities can easily access them. Additional infrastructure costs may be prohibitive in acquiring new supplies or may result in increased water rates to customers.

City of Arvada

Arvada has a firm yield of about 24,500 AF, which meets current demands, but is not believed to be sufficient to meet future demands (City of Arvada). The City is heavily reliant on Denver Water, which supplies about 75 to 80% of Arvada's water (City of Arvada 2006; Denver Water 2008c). In addition to the raw water shortage described above, under the No Action Alternative Arvada would be unable to add 3,000 AF of water supply that would have been contributed by Denver Water as part of the action alternatives. Although the City has the financial ability to purchase additional water in the current market, acquiring water in drought periods may be more difficult and more expensive.

City of Westminster and North Table Mountain Water and Sanitation District

These entities also rely on supplies from Denver Water to meet the demands of their customers. Westminster and North Table Mountain include Denver Water supplies when

making planning decisions for meeting current and future demands. Higher water costs leading to higher rates would have an impact on these entities and their customers.

About 12% of Westminster's total water supply comes from contracts with Denver Water (Denver Water 2008c). The City relied heavily on this source of supply in the recent drought of 2002-2004 and it is likely that they would rely on Denver Water supplies again in future dry periods. If other sources of water are unavailable to Westminster and the Denver Water supplies are short, the City may be forced to purchase expensive alternative supplies, enforce more severe restrictions, or both.

All of North Table Mountain's water supply is obtained through its contract with Denver Water, making the District especially vulnerable to shortage (Denver Water). If North Table Mountain does not have the infrastructure in place to obtain water from other sources, the purchase of temporary supplies would be unlikely due to the cost and other logistics involved. The District would be forced to enforce stringent restrictions on its customers.

Raw water shortages and the resulting measures taken by raw water customers would have negative minor to major impacts depending on the frequency and amount of the shortages. Several of Denver Water's raw water customers rely heavily on Denver Water supplies and adjusting to any shortage may be difficult. Restrictions and surcharges place financial and other burdens on customers, as well as create friction between customers and utilities.

5.19.6.3 Treated Water Shortages

According to PACSM results, Denver Water's treated water customers would have a maximum shortage of about 554 AF in drought periods. This is a modest amount compared to available supplies, even in a drought situation. However, treated water shortages coupled with raw water shortages and the depletion of the Strategic Water Reserve would likely cause Denver Water to impose more frequent and mandatory water restrictions. For instance, Denver Water might impose the same restrictions as those applied to raw water customers to enforce reductions. It is likely that these restrictions would be of longer duration and would be more severe than under the action alternatives and would be applied to all customers. The level and duration of restrictions in any given year would be dependent on specific circumstances at that time, but could include any measures covered under Stage 1 through Stage 4 drought restrictions, as described in Section 2.10.2.2. Additionally, South System customers may also be required to reduce water use as a result of North System shortages.[53]

Denver Water enforced Stage 1 and Stage 2 restrictions between 2002 and 2005, resulting in varying amounts of water demand reductions depending on the time of year.[54] Both voluntary and mandatory restrictions resulted in decreased water demand. Under the No Action Alternative, Stage 2 and Stage 3 restrictions may become more frequent and would have socioeconomic impacts as described below. Stage 1 restrictions would generally not produce the reduction in demand required under the No Action Alternative since it is

[53]Because of the water supplies and reservoir storage available in the South System, there would technically be no raw water shortages to customers using the South System. However, Denver Water has historically required all treated water and raw water customers to reduce water use during droughts, regardless of water source.

[54]The level of restrictions and resulting reduction in water demands by month are shown in Tables 2-21 and 2-22.

unlikely that all customers would conserve water under voluntary restrictions. It is also possible that Stage 4 restrictions might be needed. Denver Water's anticipated conservation programs under all alternatives would reduce demand and make it more difficult to produce additional water savings from voluntary restrictions under the No Action scenario.[55]

Residential and commercial customers may be willing and able to adapt to certain watering restrictions when necessary. Historically, Denver Water's voluntary restrictions have resulted in water savings, indicating that customers are interested in conserving when asked. However, stricter restrictions that are enforced on a more frequent basis may be seen as an imposition and customers may become frustrated and less cooperative. Impacts of restrictions for treated water customers would be similar to the impacts of restrictions for raw water customers discussed above. If strict restrictions continue to be enforced for lengthy periods of time, the perception of the Denver area as an attractive place to live or run a business may be negatively impacted, potentially causing a decrease in in-migration, property values, and business activity.

As with raw water shortages, treated water shortages are projected to occur in only a few dry years and mainly over the winter months; however, they could occur at any time and in concurrent years. The modest amount of potential shortage would dampen economic impacts, as would the potentially limited time frame of shortage. However, both residential and commercial customers would likely become frustrated if shortages continued to occur. The uncertainty of when a shortage would occur and the amount of shortage would make it difficult for businesses to plan for future production and frequent shortages would become an increasing burden.

Limiting outdoor watering to certain days of the week and to specific times of day or under Stage 3, curtailing outdoor use, would have a negative visual impact on private properties, public spaces, and the overall visual quality of the Denver Metropolitan area. Restrictions, in combination with the financial burden of a surcharge, may result in a more rapid conversion to xeriscape or in some homeowners allowing lawns to turn brown. Certain recreational activities may be reduced. Restrictions on industry water use would lead to efforts to replace that water or to curtailment of production and business activity for targeted commercial customers. Businesses that rely on water as an input would be forced to seek replacement supplies or decrease production, resulting in decreased profits, or would be required to pay additional charges for water to remain at current levels of production. Surcharges would result in increased costs of production and smaller profit margins. Passing fees on to the customer would likely decrease demand, exerting additional pressure on business profit. Surcharges and restrictions would place a financial burden on businesses in the Denver Metropolitan area and reduce economic activity in general.

Customers of all types would likely experience a reduced quality of life. Some businesses could be forced to reduce production and reduce their workforce, others may have to shut down.

[55]Conservation projects and goals are discussed in the 2002 IRP (Denver Water 2002a) and in Section 2.10.1.

The socioeconomic impacts of Stage 3 drought restrictions would include an increase periodically in the number of dry, brown lawns, both on private properties and public places, such as parks. Parks would likely have fewer residents and visitors participating in recreational activities due to the reduced visual appeal of the area. These restrictions would place burdens on residential and commercial customers, might result in negative perception of the Denver area in general, possibly decreasing property values, and might have an adverse impact on business activity.

Customers of all types would increasingly experience a reduced quality of life and become frustrated with conditions under these restrictions. A larger number of businesses would likely reduce production and their workforce than under Stage 2 restrictions. Additional companies may have to shut down production.

Impacts to Denver Water's treated water customers would range from minor to moderate, depending on the frequency and intensity of restrictions. These impacts would be negative and would occur intermittently during dry periods or other times when watering restrictions are applied to customers.

5.19.6.4 Drawdown of Gross Reservoir

Under the No Action Alternative, Denver Water would rely more heavily on supplies in Gross Reservoir to meet demand. Gross Reservoir would be drawn down to the minimum operating level once every 5 years, compared to once every 25 to 30 years for the Proposed Action. In many of these years, the reservoir would remain at the minimum operating level for at least 6 months. According to PACSM analysis, the elevation of Gross Reservoir would decrease by a maximum monthly average of 7 feet in an average year and 9 feet in dry years and wet years under the No Action Alternative. The surface area of the reservoir would decrease by a maximum monthly average of 15 acres in an average year (a 6% decrease), 22 acres in dry years (a 7% decrease), and 20 acres in wet years (a 7% decrease). The decrease in elevation and surface area would result in decreased shoreline.

The drawdown of Gross Reservoir would impact recreational visitors and residents of the Gross Reservoir PIA, particularly residents of the communities in close proximity and in sight of the reservoir.

Socioeconomic Impacts of Changes in Recreational Visitation

As discussed in Section 5.1, lower water levels, decreased surface area, and the resulting decrease in shoreline would reduce the number of visitors to the reservoir. Certain recreational activities would be limited by the more difficult access to the water and the overall visitor experience would be reduced due to the decrease in aesthetics resulting from the reservoir drawdown.

Prospective visitors would likely recreate at other sites in or near the Denver Metropolitan area instead of going to Gross Reservoir, especially during years of maximum drawdown. Visitation may be decreased in average years if there is a perception that the reservoir does not have enough water for recreation or to meet visual expectations of visitors. Boaters, anglers, campers, hikers, and other recreational users would continue enjoying the same activities at other locations. Therefore, the net socioeconomic loss would be the additional travel costs and, potentially, the reduced visitor experience of driving to an alternate lake or

reservoir. For instance, the roughly 37% of visitors from Boulder County may drive longer distances for lake recreation. Visitors to Gross Reservoir are likely to make purchases related to recreational activities close to home or work as there are a limited number of businesses in the PIA; therefore, visitors would not likely change their spending patterns related to those activities and retail sales and sales tax revenue in the Denver Metropolitan area would not change under the No Action Alternative. The dispersal of Gross Reservoir visitors to other areas would not be enough to make other sites feel noticeably more crowded. Denver Water does not charge any fees for using the facilities at the reservoir and would not experience any reduction in revenues resulting from reduced visitation.

The drawdown of Gross Reservoir under the No Action Alternative would result in minor socioeconomic impacts to visitors. Visitors have alternatives to enjoy boating, fishing and other recreational activities at other reservoirs and facilities in and near the Denver Metropolitan area. Impacts to businesses reliant upon recreation would be negligible assuming people continue to recreate. There would be no impacts to Denver Water resulting from a decrease in visitation to the reservoir.

Socioeconomic Impacts to Residents of the PIA

The Gross Reservoir PIA is a rural area that is home to several unincorporated communities. Homeowners in the PIA enjoy proximity to the reservoir and the benefits that are associated with that location. The 2010 Census indicated that many of the homes in the PIA were for seasonal use, which may be related to the existence of the reservoir and the recreational activities available, especially during the spring and summer months. Year-round residents also benefit from the existence of the reservoir, for recreation and other purposes. The frequent drawdown of Gross Reservoir under the No Action Alternative compared to the action alternatives would likely reduce the desirability of the PIA as a place to purchase a seasonal or year-round home due to reduced recreational opportunities and the negative visual impact of lowered water levels. Marketability and property values in the PIA might decrease if there is a perception that the reservoir is frequently low and unattractive. However, residents with homes located at the edge of the reservoir would enjoy the reduction in non-resident visitors and related traffic.

Residents of the Gross Reservoir PIA would experience moderate adverse impacts resulting from the drawdown of the reservoir under the No Action Alternative. Residents at the edge of the reservoir would feel the most impact due to the decrease in attractiveness of the reservoir. Impacts related to reduced recreational options would be temporary and would occur during dry periods. Impacts related to decreased desirability of the area and decreased property values would be permanent.

5.19.6.5 Financial Impacts to Denver Water Customers

Denver Water would incur no additional capital costs or operating expenses directly as a result of the No Action Alternative. Denver Water would continue to be responsible for routine maintenance and operations costs of their facilities and would increase water rates and other sources of revenue as needed to cover expenses. It is expected that SDCs would remain at the 2008 level under the No Action Alternative.

Water rates would increase between 3 and 7% annually through 2017 for an overall increase of about 52% during that period. The increase in water rates through 2017 amounts to about $1.25 per 1,000 gallons. This increase can be characterized as a negligible impact to Denver Water customers. Denver Water's outstanding debt balance would decrease by about 6% between 2008 and 2017, also considered negligible.

5.19.6.6 Summary of Socioeconomic Impacts of the No Action Alternative

The socioeconomic impacts resulting from the No Action Alternative, described for individual topics in the previous sections, would be long term and permanent. These impacts (summarized in Table 5.19-23) would include:

- Increased chances of a major system failure through the treated water or raw water systems. Loss of trust in Denver Water on the part of individual water customers and Denver Metropolitan area institutions in the event of a major system failure. This could result in a change in Denver Water's management structure and responsibilities.
- Increased expenditures for Denver Water related to planning for and responding to system failures.
- Periodic raw water and treated water shortages to customers in dry years. The cities of Arvada and Westminster and the North Table Mountain Water and Sanitation District would be especially vulnerable to raw water shortages.
- Raw water customers would attempt to acquire temporary supplies when shortages are likely to occur. These supplies may not be readily available or may be more expensive during dry periods.
- More severe and frequent mandatory watering restrictions, including surcharges, may result in a reduced quality of life and place financial burdens on customers. Though still infrequent, Stages 2 and 3 restrictions would likely reduce production, employment, and other business activity in the Denver Metropolitan area. Agricultural users and certain types of recreational facilities would be especially impacted. Customer relations with utilities would be strained.
- A minor water rate increase of about $1.25 per 1,000 gallons for a single-family residential customer by 2017. Even with these increased water rates, Denver Water would collect less in total revenue as a result of reduced sales during periods of watering restrictions.
- Reduced recreational economic benefits from Gross Reservoir due to more frequent drawdown, likely resulting in decreased visitation. The reduced desirability of the Gross Reservoir PIA as a place to live or own a home would reduce marketability and property values in the Gross Reservoir PIA.

Table 5.19-23
Summary of Socioeconomic Impacts of the No Action Alternative

Socioeconomic Considerations	Gross Reservoir PIA	Denver Metropolitan Area, including Boulder County
Residential Treated Water Customers-Quality of Life	No impact	Minor to moderate, negative, periodic
Residential Treated Water Customers-Economic Conditions	No impact	Minor to moderate, negative, periodic
Commercial Treated Water Customers-Business Activity	No impact	Minor to moderate, negative, periodic
Raw Water Customers	No impact	Minor to moderate, negative, periodic
Water Utilities-Customer Relations	No impact	Negligible to major, negative, permanent
Housing Values	Minor to moderate, negative, permanent	No impact
Recreational Economic Benefits	Moderate to major, negative, periodic to permanent impact to PIA residents	Minor, negative, periodic to permanent
Water Rates	No impact	Negligible to minor, permanent for Denver Water customers
Denver Water as an Institution	No impact	Moderate, negative, permanent

Source: Harvey Economics, 2008.
Note:
PIA = Primary Impact Area

5.19.7 Comparison of Major Aspects of the Socioeconomic Analysis

Table 5.19-24 provides a summary comparison of socioeconomic impacts for the Proposed Action and Alternatives 1c, 8a, 10a, and 13a. The detailed analysis for each alternative can be found in Sections 5.19.1 through 5.19.5. The approach taken for socioeconomic analysis of the No Action Alternative does not lend itself to easy comparison with the Proposed Action or other action alternatives. A summary of the socioeconomic impacts of the No Action Alternative can be found in Section 5.19.6 and Table 5.19-23.

Table 5.19-24
Comparison of Socioeconomic Impacts of the Proposed Action and Alternatives 1c, 8a, 10a, and 13a

Socioeconomic Considerations	Proposed Action	Alternative 1c	Alternative 8a	Alternative 10a	Alternative 13a
Total Annual Employment (Full time jobs)	213	686	683	895	616
Total Annual Income (Millions of $)	$12.6	$39.9	$40.3	$50.9	$33.0
Total Annual Economic Output (Millions of $)	$62.1	$148.0	$178.1	$196.9	$183.0
Demographic Conditions	No impact	No impact	No impact	No impact	No impact

Table 5.19-24 (continued)
Comparison of Socioeconomic Impacts of the Proposed Action and Alternatives 1c, 8a, 10a, and 13a

Socioeconomic Considerations	Proposed Action	Alternative 1c	Alternative 8a	Alternative 10a	Alternative 13a
Housing Conditions	No impact	No impact to negligible impact	No impact	No impact	No impact
Fiscal Conditions	No impact to negligible impact	No impact to negligible impact	No impact to negligible impact	No impact to negligible impact	No impact to negligible impact
Water Providers	Negligible, No impact or Positive impact	Negligible, No impact or Positive impact	Negligible, No impact or Positive impact	Negligible, No impact or Positive impact	Negligible, No impact or Positive impact
Other Public Facilities and Services	No impact to Minor impact	No impact to Minor impact	No impact to Minor impact	No impact to Minor impact	No impact to Minor impact
Water Rates and Tap Fees	Minor impact for Denver Water customers; No impact for others	Minor to moderate impact for Denver Water customers; No impact for others	Moderate impact for Denver Water customers; No impact for others	Moderate to major impact for Denver Water customers; No impact for others	Moderate to major impact for Denver Water customers; No impact for others

Source: Harvey Economics, 2008.
Notes:
Annual employment, annual income, and annual economic output measures include both direct and induced components. These impacts would be temporary, generally occurring within the construction period.
The construction periods differ for each alternative.

5.20 HAZARDOUS MATERIALS

This section describes the direct and indirect impacts from hazardous materials expected to occur as a result of implementing a Moffat Collection System Project (Moffat Project or Project) alternative. Concerns were raised during scoping regarding radioactive contamination at the Rocky Flats site located north of the Leyden Gulch Reservoir site. This issue is addressed in Section 5.20.1.2. Also, as described in Section 3.20.1.2, soil and groundwater at Rocky Flats have been extensively analyzed for radioactive isotopes and other contaminants. Extensive remediation has also been conducted at Rocky Flats with site closure completed in 2006.

The presence of hazardous material may be due to current or historic land uses and/or releases of hazardous substances (pesticides, volatile and semi-volatile organic compounds, heavy metals) or petroleum products (gasoline, diesel fuel, lubricants, etc.). Direct impacts may result from construction-related activities in areas where contaminated soil or groundwater occur. An example of an indirect impact from a hazardous material site would be reduced landfill capacity due to disposal of large volumes of contaminated soil.

As summarized in Tables 3.20-2 through 3.20-4, several hazardous material sites were identified within or immediately adjacent to the Project area. The presence of these sites could result in Project delays and increased costs, particularly if they are not identified prior to construction. Construction work on sites where hazardous materials are present must be controlled to avoid release of contaminants to the environment. The following concerns would apply for proposed construction areas where soil and/or groundwater contamination has been identified:

- Health and safety of workers encountering contaminated material.
- Special handling and disposal requirements for contaminated material and a corresponding cost increase.
- Inability to reuse contaminated soil as fill in other areas of the Project.
- Requirements for special permits.

As previously stated in Section 3.20, the Denver Basin Aquifer Facilities and Conduits M and O are expected to have a high number of hazardous waste sites associated with the urban location of large portions of these components. If Alternative 8a, 10a, or 13a is selected and permitted by the U.S. Army Corps of Engineers (Corps), any hazardous waste sites would be dealt with in accordance with Federal, State, and local regulations.

5.20.1 Proposed Action (Alternative 1a)

5.20.1.1 Gross Reservoir

No direct or indirect impacts associated with hazardous material sites were identified within the Gross Reservoir study area. Two hazardous materials sites are located approximately 2,000 feet downgradient of the reservoir. The fuels are contained in double galvanized steel tanks and no leaks or releases have been reported.

5.20.2 Alternative 1c

5.20.2.1 Gross Reservoir

The potential impacts from hazardous materials under Alternative 1c are the same as those described for the Proposed Action.

5.20.2.2 Leyden Gulch Reservoir Site

No recognized hazardous material sites were identified from the database search within the Leyden Gulch Reservoir site. The Rocky Flats site north of Leyden Gulch and two landfills on the eastern border of the site, however, were generated from the database search. Two underground storage tanks (USTs), two aboveground storage tanks (ASTs), abandoned utility lines, and a concrete slab were documented during a site visit as potential hazardous materials sites. Poles located in the proposed reservoir inundation area would be removed along with any stained soil prior to construction activities. Table 5.20-1 summarizes hazardous materials sites adjacent to and within the Leyden Gulch Reservoir site. Impacts associated with these sites are anticipated to be minor during construction.

Table 5.20-1
Potential for Environmental Release from Hazardous Material Sites Identified Adjacent to and within the Leyden Gulch Reservoir Site

Hazardous Material Sites	Location		Potential for Environmental Release	Rationale
	Within Site	Adjacent to Site		
Utility Poles	X		Low	Potential for localized creosote contamination in soil around poles.
Concrete Slab	X		Unknown	Historic use of area unknown. Located near expected construction disturbance at south tunnel portal.
Rocky Flats		X	Unknown	Possible soil contamination from radioactive isotopes. Inadequate data available to determine impacts on proposed reservoir.
Foothills Landfill		X	Low	Landfill is hydraulically downgradient from proposed reservoir site with little hydraulic connection.
Jefferson County Landfill		X	Low	Landfill is hydraulically downgradient from proposed reservoir with little hydraulic connection.

Table 5.20-1 (continued)
Potential for Environmental Release from Hazardous Material Sites Identified Adjacent to and within the Leyden Gulch Reservoir Site

Hazardous Material Sites	Location		Potential for Environmental Release	Rationale
	Within Site	Adjacent to Site		
Former UST Sites at Maintenance Facility		X	Low	Former UST sites (two tanks removed) are located more than 2,000 feet away from the Leyden Gulch Reservoir site and is hydraulically unrelated to proposed reservoir. The two USTs were removed in the 1990s and no documented releases of contaminants were observed or reported after tank removal.
AST Sites at Maintenance Facility		X	Low	Two AST sites located more than 2,000 feet away from the Leyden Gulch Reservoir site and are hydraulically unrelated to proposed reservoir.

Notes:
AST = aboveground storage tank
UST = underground storage tank

5.20.3 Alternative 8a

5.20.3.1 Gross Reservoir

The potential impacts from hazardous materials under Alternative 8a are the same as those described for the Proposed Action.

5.20.3.2 South Platte River Facilities

Eight sites with a high potential for an environmental release if disturbed during construction were identified within and adjacent to Worthing and South Tower gravel pits (Table 5.20-2). Multiple dumpsites for construction and inert debris were documented although the precise locations of the sites were not available. No impacts associated with hazardous material sites were identified near the North Tower gravel pit. Impacts associated with these sites are anticipated to be minor during construction.

Table 5.20-2
Potential for Environmental Release from Hazardous Material Sites Identified Adjacent to and within the Worthing and South Tower Gravel Pits

Hazardous Material Sites	Location		Potential for Environmental Release	Rationale
	Within Site	Adjacent to Site		
Albert Frei & Sons 13205 Brighton Boulevard	X		High	Possible buried materials and unknown impacts associated with soil and groundwater contamination.
Bromley Dump 130th and Old Brighton Road		X	High	Possible buried organic material and associated soil and groundwater contamination from undocumented disposal. Exact location unknown.

Table 5.20-2 (continued)
Potential for Environmental Release from Hazardous Material Sites Identified Adjacent to and within the Worthing and South Tower Gravel Pits

Hazardous Material Sites	Location		Potential for Environmental Release	Rationale
	Within Site	Adjacent to Site		
Unnamed Dump 144th Avenue and Riverdale Road		X	High	Possible methane emissions from historic dumping.
Adams County Landfill		X	High	Possible sludge landfill and associated soil and groundwater contamination from undocumented disposal. Exact location unknown.
Brighton Sanitary Landfill (Riverdale) NW		X	High	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		X	High	Location is approximately 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.
Oil and Gas Production Wells		X	High	Oil and gas production from deep formations dot the landscape in the vicinity of the proposed water storage sites. Pumping units and associated facilities identified near the site.
Sand and Gravel Operations		X	High	Sand and gravel operations with on-site tanks, production buildings, and heavy equipment operation with a potential for an environmental release were documented in the site visit.

Notes:
CDPHE = Colorado Department of Public Health and Environment
TCHD = Tri-County Health Department
US = U.S. Highway
UST = underground storage tank

Potential impacts to hazardous materials were not evaluated for Conduit O due to the expected high number of hazardous waste sites associated with the urban location of these components. If this alternative were selected and permitted by the Corps, a detailed analysis of this component would be conducted prior to construction activity.

5.20.4 Alternative 10a

5.20.4.1 Gross Reservoir

The potential impacts from hazardous materials under Alternative 10a are the same as those described for the Proposed Action.

5.20.4.2 Denver Basin Aquifer Facilities

Potential impacts to hazardous materials were not evaluated for the Denver Basin Aquifer Facilities and Conduit M due to the expected high number of hazardous waste sites associated with the urban location of these components. If this alternative were selected and permitted by the Corps, a detailed analysis of this component would be conducted prior to construction activity.

5.20.5 Alternative 13a

5.20.5.1 Gross Reservoir

The potential for environmental release from hazardous materials under Alternative 13a are the same as those described for the Proposed Action.

5.20.5.2 South Platte River Facilities

The potential for environmental release associated with the Worthing and South Tower gravel pits are the same as those described for Alternative 8a. Potential hazardous material sites associated with the Challenger gravel pit are described below and summarized in Table 5.20-3.

Table 5.20-3
Hazardous Material Sites Identified Near
Challenger Gravel Pit Storage Area

Hazardous Material Site	Location		Potential for Environmental Release	Rationale
	Within Site	Adjacent to Site		
Bestway Concrete Company 11723 Weld County Road #2 Brighton, CO 80601		X	Moderate	Site is located due north of Challenger gravel pit. Site contains two ASTs 12,000-gallon diesel tanks. No violations noted. Site remains open with the OPS.

Notes:
AST = aboveground storage tank
OPS = Colorado Office of Public Safety

One site was identified with a moderate potential for environmental release to the Challenger Pit. The site is located due north of the pit and contains two 12,000-gallon diesel ASTs. No reports of any release or violations have been documented at the Office of Public Safety. Impacts associated with these sites are anticipated to be minor during construction.

Potential impacts to hazardous materials were not evaluated for Conduit O due to the expected high number of hazardous waste sites associated with the urban location of these components. If this alternative were selected and permitted by the Corps, a detailed analysis of this component would be conducted prior to construction activity.

5.20.6 No Action Alternative

No ground disturbing would result from the No Action Alternative. Therefore, no hazardous material impacts are anticipated.

5.20.7 Mitigation and Monitoring

A wide variety of environmental settings with diverse hazardous material impacts are associated with the action alternatives. Contaminated soil and groundwater may affect the Project in terms of cost and schedule. Acquisition of contaminated properties is a liability concern and can result in long-term efforts associated with remediation.

Mitigation of impacts from hazardous materials would consist of modifying construction activities to avoid conflict with subsurface contamination. If any property is to be acquired, a site-specific investigation of that property should be performed. The investigation may consist of a preliminary type assessment, a Phase I investigation or a more complex Phase II investigation. The type of investigation selected would depend on site-specific conditions and the availability and quality of existing soil and groundwater data. A Phase II investigation that includes laboratory sampling and analysis should be undertaken at sites where existing soil and groundwater contamination may affect the Project design. Areas adjacent to hazardous material sites where construction activities, excavation, and property acquisition would occur should also be evaluated for possible migration of existing contamination. For Moderate ranked sites, additional information from landowners should be obtained to further evaluate the potential for impact.

A Materials Handling Plan would be developed to properly handle and dispose of contaminated materials generated during the Project. For example, contractors would store fuel and other hazardous materials associated with construction activities away from water bodies and take appropriate precautions to avoid spilling hazardous materials or fuels during construction. A Material Abatement Plan would be developed for asbestos and lead-based paint if any structures are identified for removal or acquired.

5.20.7.1 Avoidance, Minimization and Mitigation Measures by Alternative

Proposed Action (Alternative 1a)

No hazardous material sites were identified within or adjacent to the Gross Reservoir study area, thus, it is unlikely that mitigation measures beyond what is contained in the Materials Handling Plan would need to be implemented. If contaminated soils or groundwater are identified during construction activities, however, they would be segregated and managed in accordance with appropriate regulations.

Alternative 1c

The mitigation measures at Gross Reservoir under Alternative 1c are the same as those described for the Proposed Action. Table 5.20-4 summarizes possible mitigation measures for potential impacts at the Leyden Gulch Reservoir site.

Table 5.20-4
Possible Mitigation for the Leyden Gulch Reservoir Site

Potential Impact	Type of Contamination	Possible Mitigation			
		Avoidance	Sampling	Research	Removal Action
Abandoned utility poles that traverse the proposed Leyden Gulch Reservoir area	Polyaromatic hydrocarbon in soil		X		X
Concrete Slab	Unknown	X	X		X
Rocky Flats	Radionuclides in soil	X	X	X	X*

Note:
*If research warrants.

Alternative 8a

The mitigation measures at Gross Reservoir under Alternative 8a are the same as those described for the Proposed Action. Table 5.20-5 summarizes possible mitigation measures for the Worthing and South Tower pits.

Table 5.20-5
Possible Mitigation Near the Worthing and South Tower Pits

Potential Impact	Type of Contamination	Possible Mitigation			
		Avoidance	Sampling	Research	Removal Action
Albert Frei & Sons	Landfill	X	X		
Bromley Dump	Landfill	X			
Adams County Landfill	Landfill	X			
Brighton SL (Riverdale) NW	Landfill	X			
Oil and Gas Production Wells	Petroleum products from operation	X	X	X	
Sand and Gravel Operations	Chemicals from operation	X	X	X	

No hazardous material sites were identified within or adjacent to the North Tower pit. Thus, it is unlikely that mitigation measures beyond what is contained in the Materials Handling Plan would need to be implemented at this site. However, if contaminated soils or groundwater are identified during construction activities, they would be segregated and managed in accordance with appropriate regulations.

If Alternative 8a is selected, mitigation measures would be developed prior to construction activity for the potential hazardous sites that would be encountered in the urban corridor associated with Conduit O.

Alternative 10a

The mitigation measures at Gross Reservoir under Alternative 10a are the same as those described for the Proposed Action. If Alternative 10a is selected, mitigation measures would be developed prior to construction activity for the potential hazardous sites that would be encountered in the urban corridors associated with the Denver Basin Aquifer Facilities and Conduit M.

Alternative 13a

The mitigation measures at Gross Reservoir under Alternative 13a are the same as those described for the Proposed Action. Also, possible mitigation measures for the Worthing and South Tower pits are the same as described for Alternative 8a. Possible mitigation measures for the Challenger pit are presented in Table 5.20-6.

Table 5.20-6
Possible Mitigation Near the Challenger Pit

Potential Impact	Type of Contamination	Possible Mitigation			
		Avoidance	Sampling	Research	Removal Action
Bestway Concrete Company	Aboveground storage tank (No release has been reported)	X	X		

If Alternative 13a is selected, mitigation measures would be developed prior to construction activity for the potential hazardous sites that would be encountered in the urban corridor associated with Conduit O.

5.20.8 Unavoidable and Adverse Impacts

There are no unavoidable and adverse impacts associated with hazardous materials which cannot be mitigated for.

5.21 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

The development and operation of the Moffat Collection System Project (Moffat Project or Project) would involve irreversible and irretrievable commitment of various resources that are either consumed, committed, or lost during the life of the Project. Irreversible commitment of resources would occur if processes related to the Project could not be stopped, and the resource or its productivity or utility is forever consumed or committed. Irretrievable commitment of resources would result from resources used, consumed, destroyed, or degraded during construction, operation, and abandonment of the Project and could not ever be retrieved or replaced.

The irreversible and irretrievable commitment of resources of the Moffat Project includes the following:

- **Geology** – Loss of geologic resources (i.e., bedrock and sand and gravel deposits); rock cut associated with the State Highway (SH) 93 realignment
- **Soils** – Loss of soil due to accelerated erosion from construction activities; loss of soil profile development and soil productivity due to reservoir inundation; loss of soil due to construction of Advanced Water Treatment Plants, pump stations, and other permanent Project facilities; loss of soil from the SH 93 realignment
- **Surface Water** – Loss of water to evaporation from the reservoirs; diversion and consumptive use of water would reduce flows and availability of water for other uses
- **Vegetation** – Loss of natural vegetation that currently exists within the dam and reservoir sites or lost from construction of permanent Project facilities
- **Wetlands and other waters of the U.S., and Riparian Areas** – Loss of wetlands, other waters of the U.S., and riparian areas located within the footprint of reservoirs, and other permanent facilities
- **Wildlife** – Loss of wildlife habitat that currently exists within the dam and reservoir site and other permanent Project facilities
- **Cultural and Paleontological Resources** – Loss of cultural and paleontological resources due to accidental disturbance during construction activities
- **Visual** – Degradation of natural scenic quality due to potential permanent changes in topography and vegetation patterns at the reservoir sites
- **Construction Materials** – Use of aggregate, water, steel, concrete, and fossil fuels for construction of the Project facilities

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5.22 COMPARISON OF ALTERNATIVES

The Board of Water Commissioners (Denver Water) developed an Integrated Resources Plan in 1997, with an update in 2002, to evaluate future water supplies in relation to projected customer demand (Denver Water 1997, 2002a). Additionally, Denver Water analyzed potential savings from system refinements, non-potable reuse, natural replacement, and cooperative projects with other water providers. It was determined that beginning in 2022, and by 2032, an annual shortfall of 34,000 acre-feet (AF) in water supplies would occur. Of this 34,000 acre-feet per year (AF/yr) shortfall, Denver Water is relying on 16,000 AF/yr from the implementation of conservation efforts. Development of new firm yield is necessary to meet the remaining 18,000 AF/yr of shortfall. Based on the current system imbalance, creating 18,000 AF/yr of firm yield in the North System would increase reliability, and decrease vulnerability and limited operation flexibility in Denver Water's Collection System.

Implementing the Proposed Action with the Environmental Pool for mitigation or one of the other action alternatives would allow Denver Water to meet the projected 18,000 AF/yr shortfall. All action alternatives contain an enlarged Gross Reservoir component. Thus, potential land-based impacts associated with Gross Reservoir are similar between alternatives, but vary in accordance with the expansion sizes. For example, the Proposed Action would permanently disturb 465 acres of soils in association with a 77,000 AF expansion whereas Alternative 1c (40,700 AF expansion) would permanently disturb 302 acres of soils at Gross Reservoir.

All action alternatives are comprised of an enlarged Gross Reservoir component coupled with various other storage components (i.e., new reservoir, gravel pits, deep aquifer storage), conveyance systems, and water treatment systems. Additionally, Alternative 13a would utilize transferred agricultural water to meet a portion of the 18,000 AF/yr need. These other components create distinguishing land-based impacts between the alternatives. For example, Alternative 1c is the only alternative that would impact black-tailed prairie dog colonies due to the construction of a new Leyden Gulch Reservoir. Similarly, Alternative 13a is the only alternative that would indirectly impact approximately 82 acres of wetlands as a result of the transfer of agricultural water rights.

Like potential land-based impacts, water-related impacts are similar between alternatives because each action alternative contains an enlarged Gross Reservoir component. For instance, Gross Reservoir would be expanded to approximately twice the volume under each alternative, resulting in larger annual fluctuations and greater evaporative loss. Additionally, the initial filling of an enlarged Gross Reservoir may increase organic matter and an increased volume would likely affect reservoir turnover rates and thermal stratification under each alternative. For all alternatives, stream flow changes are greatest in average and wet years; no stream flow changes would occur in dry years. Stream flow changes would be greatest in the Fraser and Williams Fork river basins and least in the South Platte River and South Boulder Creek basins for all alternatives. Alternatives with reusable effluent components (i.e., Alternatives 8a and 10a) would divert less water from the West Slope. Stream flow changes, however, would still be similar to the Proposed

Action since reusable supplies would infrequently be pumped back to the Moffat Collection System to supplement supplies during a drought. Table 5.22-1 presents a summary of these and other potential land- and water-based impacts for each alternative. Table 5.22-2 presents a more detailed summary of potential impacts to the river segments in the Moffat Collection System Project (Moffat Project or Project) area for each alternative.

If a Section 404 Permit is not obtained for the Moffat Project (i.e., No Action Alternative), Denver Water would continue to develop and implement its conservation, non-potable recycling, system refinements and cooperative action projects as described in the 2002 Integrated Resource Plan (Denver Water 1997, 2002a). Assuming these activities are fully implemented, projected demand on Denver Water's system would still exceed supply beginning in 2022. The No Action Alternative would require Denver Water to use a combination of strategies to meet the need for additional supply, including a portion of the Strategic Water Reserve and imposing more frequent and mandatory restrictions during drought periods. These strategies, however, do not resolve the issues of system vulnerability, flexibility, or reliability. The No Action Alternative does not include any ground-disturbing activities, thus, land-based resources would not be impacted. System operations may, however, impact water-based resources. For example, under the No Action Alternative, Gross Reservoir would be frequently drawn down to the minimum operating pool. Potential impacts associated with the No Action Alternative are described in each resource section in Chapter 5.

Table 5.22-1
Summary of Impacts by Alternative

SURFACE WATER
TYPE OF POTENTIAL IMPACT Surface water flows.[1]
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Denver Water would divert additional water in average and wet years during the runoff months. • Changes in stream flow would be greatest in the Fraser and Williams Fork river basins, and least in the South Platte River Basin. • Changes in stream flow would be greatest in average and wet years. • There would be no change in stream flows in a dry year.
Alternative 1c
Gross Reservoir Expansion • Timing, relative amount, and location of changes in stream flows would be similar to Proposed Action.
Leyden Gulch Reservoir • Timing, relative amount, and location of changes in stream flows would be similar to Proposed Action.
Alternative 8a
Gross Reservoir Expansion • Timing, relative amount, and location of changes in stream flows would be similar to Proposed Action.
South Platte River Facilities • Reusable effluent would be diverted from the South Platte River and stored in gravel pit storage adjacent to the South Platte River. • Denver Water's Moffat System diversions would be slightly lower on average under this alternative compared to the Proposed Action. • Changes in stream flows throughout the Project area would still be similar to Proposed Action.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Timing, relative amount, and location of changes in stream flows would be similar to Proposed Action.
Denver Basin Aquifer Facilities • Reusable effluent would be stored in the Denver Basin aquifer via injection wells. • Denver Water's Moffat System diversions would be slightly lower on average under this alternative compared to the Proposed Action. • Changes in stream flows throughout the Project area would still be similar to Proposed Action.
Conduit M • N/A.
Alternative 13a
Gross Reservoir Expansion • Timing, relative amount, and location of changes in stream flows would be similar to Proposed Action.
South Platte River Facilities • Gravel pit storage adjacent to the South Platte River would be used to store transferred agricultural water rights diverted from the South Platte River. • Denver Water's Moffat System diversions would be slightly lower on average under this alternative compared to the Proposed Action. • Changes in stream flows throughout the Project area would still be similar to Proposed Action.
Conduit O • N/A.
Agricultural Water Transfer • For the reach downstream of the Metro Wastewater Reclamation District Plant, average annual flows are 1,400 AF to 3,000 AF higher than the other action alternatives. • The firm yield generated from transferred agricultural rights would be 3,000 AF/yr versus 5,000 AF/yr from reusable supplies under Alternatives 8a and 10a.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SURFACE WATER (continued)
TYPE OF POTENTIAL IMPACT Effects on other surface water users.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Additional Denver Water diversions in average and wet years would decrease flows available to other surface water users on the West Slope. • On the East Slope, additional return flows attributable to Denver Water's indoor and outdoor water usage would increase flows downstream of the Henderson gage. These flows could be available to other water users if Denver Water is unable to reuse these supplies.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Same as Proposed Action.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as the Proposed Action on the West Slope. • Diversion of reusable return flows from the South Platte River would decrease flows available to other surface water users.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Same as the Proposed Action on the West Slope. • Diversion of reusable return flow from the South Platte River would decrease flows available to other surface water users.
Conduit M • N/A.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Denver Water diversions of transferred agricultural rights should have little to no impact on other surface water users on the South Platte River since historical return flows would need to be replaced in accordance with the change decree.
Conduit O • N/A.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SURFACE WATER (continued)
TYPE OF POTENTIAL IMPACT Reservoir volume and fluctuation.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Gross Reservoir's volume would be 118,811 AF. • Normal high water level would increase by 124 feet. • The annual pattern of fluctuation in level and content would be similar to existing conditions; however, fluctuations would be greater.
Alternative 1c
Gross Reservoir Expansion • Gross Reservoir's volume would be 82,511 AF. • Normal high water level would increase by 75 feet. • The annual pattern of fluctuation in level and content would be similar to existing conditions; however, fluctuations would be greater.
Leyden Gulch Reservoir • Leyden Gulch Reservoir would generally be maintained at capacity except in an extended drought. • Generally, Leyden Gulch Reservoir contents would be approximately 28,000 AF to 31,000 AF.
Alternative 8a
Gross Reservoir Expansion • Gross Reservoir's volume would be 93,811 AF. • Normal high water level would increase by 92 feet. • The annual pattern of fluctuation in level and content would be similar to existing conditions; however, fluctuations would be greater.
South Platte River Facilities • Includes approximately 5,000 AF of gravel pit storage adjacent to the South Platte River. • Maximum end-of-month contents would be 4,000 AF in average years, 4,600 AF in dry years, and 3,800 AF in wet years. • The change in average end-of-month surface elevation throughout the year would be 14 feet.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Gross Reservoir's volume would be 93,811 AF. • Normal high water level would increase by 92 feet. • The annual pattern of fluctuation in level and content would be similar to existing conditions; however, fluctuations would be greater.
Denver Basin Aquifer Facilities • N/A.
Conduit M • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SURFACE WATER (continued)
Alternative 13a
Gross Reservoir Expansion • Gross Reservoir's volume would be 101,811 AF. • Normal high water level would increase by 103 feet. • The annual pattern of fluctuation in level and content would be similar to existing conditions; however, fluctuations would be greater.
South Platte River Facilities • Includes approximately 3,625 AF of gravel pit storage adjacent to the South Platte River. • Maximum end-of-month contents would be 2,700 AF in average years, and 3,000 AF in dry and wet years. • The change in average end-of-month surface elevation throughout the year would be 3 feet.
Conduit O • N/A.
Agricultural Water Transfer • N/A.
TYPE OF POTENTIAL IMPACT Reservoir evaporation (average annual evaporative loss).
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • 991 AF (compared to 477 AF under existing conditions).
Alternative 1c
Gross Reservoir Expansion • 769 AF.
Leyden Gulch Reservoir • 623 AF.
Alternative 8a
Gross Reservoir Expansion • 858 AF.
South Platte River Facilities • 886 AF.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • N/A.
Conduit M • N/A.
Alternative 13a
Gross Reservoir Expansion • 912 AF.
South Platte River Facilities • 656 AF.
Conduit O • N/A.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WATER QUALITY
TYPE OF POTENTIAL IMPACT Surface water quality.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • In the Fraser River, the number of days near or above the temperature stream standard is not expected to increase. There are no projected impacts on Moffat Tunnel permitted discharges and impacts on nutrient levels are expected to be negligible. Effects on estimated acute and chronic low flows would result from Full Use of the Existing System conditions, but no additional impact is expected due to the Proposed Action. • Minor to negligible nutrient concentration increases due to the Project are anticipated in the Fraser River. These anticipated changes are small relative to changes anticipated due to population growth, increased WWTP flows, and anticipated changes in WWTP treatment efficiency. • Water quality impacts in the Williams Fork River are expected to be negligible to minimal. • Water quality changes in the Blue River system are not expected, including effects on the Joint Sewer Authority WWTP discharge permit, and effects from changes in tributary flows and water quality due to changes in Dillon or Green Mountain reservoir operations or releases. • An increase in the percentage of treated wastewater in the Blue River could occur in October of wet years. • A change in contribution to total stream flow by Dillon Reservoir and Boulder Creek could occur in October of wet years. • Water quality in the North Fork South Platte River is anticipated to change due to concentration increases in copper, iron, and nickel in periods of reduced Roberts Tunnel deliveries, and changes are also expected in periods of increased deliveries. • No water quality impacts are anticipated in South Boulder Creek upstream of Gross Reservoir. Downstream of Gross Reservoir, short-term impacts related to water quality in Gross Reservoir are anticipated. • Downstream of Gross Reservoir, summer water temperatures would be cooler due to enlargement of the reservoir. • Water quality impacts on the South Platte River would be limited to impacts from the changes in the North Fork South Platte River and are anticipated to be negligible.
Alternative 1c
Gross Reservoir Expansion • Similar to the Proposed Action.
Alternative 8a
Gross Reservoir Expansion • Similar to the Proposed Action.
South Platte River Facilities • Water quality changes are not expected.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Similar to the Proposed Action.
Denver Basin Aquifer Facilities • N/A.
Conduit M • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WATER QUALITY (continued)
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • N/A.
Agricultural Water Transfer • N/A.
TYPE OF POTENTIAL IMPACT Reservoir water quality.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Water quality changes not anticipated in Dillon, Williams Fork, Wolford Mountain, or the South Platte reservoirs. • For Gross Reservoir, initial filling operations may increase organic matter, resulting in a minor to moderate decrease in water quality in the short term. • Within Gross Reservoir, short-term impacts associated with inundation of new areas for reservoir expansion are anticipated. These short-term impacts include increased concentrations of mercury in fish tissue. • No long-term adverse impacts to water quality are anticipated within Gross Reservoir. • None to negligible impacts to the Three Lakes. • Chatfield Reservoir would experience seasonal changes in phosphorus loading; annual loading would remain similar to current levels.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action for Dillon, Williams Fork, Wolford Mountain, and the South Platte reservoirs. • Similar impacts as Proposed Action for Gross Reservoir, but slightly less due to smaller reservoir size.
Leyden Gulch Reservoir • Water quality impacts would be minor compared to existing water quality in Gross Reservoir. • Source water quality would be similar to, though slightly lower than, that of Gross Reservoir during periods of initial filling. • Leyden Gulch Reservoir water quality would be slightly lower than Gross Reservoir quality, though the impact would be minor.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action for Dillon, Williams Fork, Wolford Mountain, and the South Platte reservoirs. • Similar impacts as Proposed Action for Gross Reservoir, but slightly less due to smaller reservoir size.
South Platte River Facilities • AWTP facilities would control potential for increased nutrient loading in Ralston Reservoir.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action for Dillon, Williams Fork, Wolford Mountain, and the South Platte reservoirs. • Similar impacts as Proposed Action for Gross Reservoir, but slightly less due to smaller reservoir size.
Denver Basin Aquifer Facilities • CDPHE permit conditions would disallow degradation of the aquifer.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WATER QUALITY (continued)
Conduit M • N/A.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action for Dillon, Williams Fork, Wolford Mountain, and the South Platte reservoirs. • Similar impacts as Proposed Action for Gross Reservoir, but slightly less due to smaller reservoir size.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • N/A.
Agricultural Water Transfer • N/A.
CHANNEL MORPHOLOGY
TYPE OF POTENTIAL IMPACT Stream morphology and sedimentation.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Localized sediment deposition is anticipated along affected West Slope river segments. Deposition is predicted to be limited in extent and magnitude. Larger flow events such as those required for Phase 2 transport as well as peak floods are expected to occur at similar frequencies; therefore, changes to long-term channel morphology are not anticipated. • Continued vegetative encroachment and sediment accumulation is likely below diversions with no bypass flows as the frequency of larger flow events are expected to be reduced. • Localized bed and bank erosion are anticipated along affected East Slope river segments as a result of increased flows. Flow regulation of Gross Reservoir would reduce peak flows downstream of the reservoir; therefore, additional erosion would be less likely at these locations.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Same as Proposed Action.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • N/A.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • N/A.
Conduit M • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

CHANNEL MORPHOLOGY (continued)
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • N/A.
Conduit O • N/A.
Agricultural Water Transfer • N/A.
GROUNDWATER
TYPE OF POTENTIAL IMPACT Seepage and groundwater mounding.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Increased groundwater levels due to increased seepage from the enlarged reservoir. • Decrease in hydraulic gradients upstream of the reservoir.
Alternative 1c
Gross Reservoir Expansion • Similar but smaller effects than the Proposed Action on the surrounding groundwater system.
Leyden Gulch Reservoir • Seepage and groundwater impacts at the proposed Leyden Gulch Reservoir would be similar to those described for Gross Reservoir.
Alternative 8a
Gross Reservoir Expansion • Similar but smaller effects than the Proposed Action on the surrounding groundwater system.
South Platte River Facilities • Design of gravel pits would restrict seepage to the groundwater system.
Conduit O • Conduit O would be designed as a closed pipeline to prevent impacts to groundwater.
Alternative 10a
Gross Reservoir Expansion • Similar but smaller effects than the Proposed Action on the surrounding groundwater system.
Denver Basin Aquifer Facilities • No impacts.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Similar but smaller effects than the Proposed Action on the surrounding groundwater system.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • Conversion of agricultural water rights to municipal or other non-irrigation uses would result in less groundwater recharge in localized areas that are no longer irrigated.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

GROUNDWATER (continued)
TYPE OF POTENTIAL IMPACT Groundwater quality.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • No impacts.
Alternative 1c
Gross Reservoir Expansion • No impacts.
Leyden Gulch Reservoir • Unknown contaminants from Rocky Flats could, if present on site, be remobilized from soil to groundwater during construction. However, seepage of good quality water out of the reservoir would provide natural attenuation by dilution.
Alternative 8a
Gross Reservoir Expansion • No impacts.
South Platte River Facilities • The gravel pit slurry walls would restrict seepage out of the gravel pit storage areas.
Conduit O • Conduit O would be designed as a closed pipeline to prevent impacts to groundwater.
Alternative 10a
Gross Reservoir Expansion • No impacts.
Denver Basin Aquifer Facilities • Injected water would not degrade the existing groundwater quality. The reusable water would be treated to meet all water quality standards prior to injection into the Denver Basin Aquifers.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • No impacts.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

GROUNDWATER (continued)
TYPE OF POTENTIAL IMPACT Effects on other groundwater users.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • No impact.
Alternative 1c
Gross Reservoir Expansion • No impact.
Leyden Gulch Reservoir • No impact.
Alternative 8a
Gross Reservoir Expansion • No impact.
South Platte River Facilities • N/A.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • No impact.
Denver Basin Aquifer Facilities • There would be no net long-term effect on groundwater levels caused by the Denver Water wells. • Groundwater in wells within the vicinity of the Denver Water wells may fluctuate in response to injection and withdrawal pumping.
Conduit M • N/A.
Alternative 13a
Gross Reservoir Expansion (60,000 AF) • No impact.
South Platte River Facilities (3,625 AF) • N/A.
Conduit O • N/A.
Agricultural Water Transfer • N/A.
GEOLOGY
TYPE OF POTENTIAL IMPACT Structural instability of dam, reservoir, and associated facilities due to seismic activity and blasting during construction.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Low probability, located in Seismic Zone 1. • Dam raise and expansion may slightly increase the potential for reservoir-induced seismicity. • Blasting during construction would be monitored to avoid impacts to dam.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

GEOLOGY (continued)
Alternative 1c
Gross Reservoir Expansion • Similar to Proposed Action, but less ground-disturbing activity for the smaller expansion.
Leyden Gulch Reservoir • Same as Proposed Action.
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action, but less ground-disturbing activity for the smaller expansion.
South Platte River Facilities • Gravel pits would be reclaimed for use as a water storage facility. No impacts anticipated.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a, Gross Reservoir.
Denver Basin Aquifer Facilities • N/A.
Conduit M • N/A.
Alternative 13a
Gross Reservoir Expansion • Similar to Proposed Action, but less ground-disturbing activity for the smaller expansion.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • N/A.
Agricultural Water Transfer • Same as Alternative 8a, Gravel Pits.
TYPE OF POTENTIAL IMPACT Effects to unique geologic features.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • N/A.
Alternative 1c
Gross Reservoir Expansion • N/A.
Leyden Gulch Reservoir • The hogback east of the proposed dam contains clay mine workings that contribute to the instability of this geologic feature. The SH 93 relocation design should include methods to stabilize workings.
Alternative 8a
Gross Reservoir Expansion • N/A.
South Platte River Facilities • N/A.
Conduit O • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

GEOLOGY (continued)
Alternative 10a
Gross Reservoir Expansion • N/A.
Denver Basin Aquifer Facilities • N/A.
Conduit M • N/A.
Alternative 13a
Gross Reservoir Expansion • N/A.
South Platte River Facilities • N/A.
Conduit O • N/A.
Agricultural Water Transfer • N/A.
TYPE OF POTENTIAL IMPACT Dam safety.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Dam safety analysis would be conducted during final design. • Design reviews would be conducted by Federal and State agencies. • Emergency Preparedness Plan would be updated.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir) • Same as Proposed Action.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Proposed Action.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Same as Proposed Action.
Conduit M • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

GEOLOGY (continued)
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Proposed Action.
Conduit O • N/A.
Agricultural Water Transfer • N/A.
TYPE OF POTENTIAL IMPACT Slope failure, potentially unstable slopes and reservoir rim instability as a result of ongoing natural process of erosion and seepage.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Reservoir rim may erode through wave action resulting in slope instability. • Fluctuations in water level may increase reservoir rim instability.
Alternative 1c
Gross Reservoir Expansion • Similar to Proposed Action, but less ground-disturbing activity for the smaller expansion.
Leyden Gulch Reservoir • Seepage under the reservoir and dam site may create reservoir rim instability and erosion. • Periodic drawdown of the reservoir may initiate formation of landslides.
Alternative 8a
Gross Reservoir Expansion • Similar to the Proposed Action, but less ground-disturbing activity for the smaller expansion.
South Platte River Facilities • Gravel pits would be reclaimed for use as a water storage facility. No impacts anticipated.
Conduit O • Temporary excavation instability during construction.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • N/A.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Similar to Proposed Action, but less ground-disturbing activity due to smaller expansion.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOILS
TYPE OF POTENTIAL IMPACT Permanent soil disturbance from excavation, covering, or inundation; indirect impacts to soils.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • 465 acres of permanent soil loss as a result of reservoir expansion. Inundated soils would have altered chemical and biological processes.
Alternative 1c
Gross Reservoir Expansion • Similar to Proposed Action, except permanent soil loss would be 302 acres.
Leyden Gulch Reservoir • 389 additional acres of permanent soil loss as a result of construction. Similar impacts to Proposed Action.
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action, except permanent soil loss would be 363 acres.
South Platte River Facilities • Six acres of permanent soil loss associated with construction of an AWTP and ancillary facilities. • Construction of pipelines within existing roadways would result in minimal impacts.
Conduit O • 1.6 acres of permanent soil loss resulting from construction of the pump stations. • Construction of pipeline and associated facilities would occur within roadways.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • Nineteen acres of permanent soil loss associated with construction of Denver Basin Aquifer Facilities.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Similar to Proposed Action, except permanent soil loss would be 413 acres.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • An estimated 3,900 acres of agricultural lands would be taken out of irrigation, causing indirect impacts to soils. • Hydric soils supported by discontinued irrigation water would change characteristics.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOILS (continued)
TYPE OF POTENTIAL IMPACT Temporary soil disturbance from construction activities.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • 89 acres. • Soil disturbance may result in temporary minor erosion and sedimentation.
Alternative 1c
Gross Reservoir Expansion • 105 acres. • Soil disturbance may result in temporary minor erosion and sedimentation.
Leyden Gulch Reservoir • 176 acres. • Soil disturbance may result in temporary minor erosion and sedimentation.
Alternative 8a
Gross Reservoir Expansion • 98 acres. • Soil disturbance may result in temporary minor erosion and sedimentation.
South Platte River Facilities • 11 acres. • Soil disturbance may result in temporary minor erosion and sedimentation.
Conduit O • Construction of pipeline and associated facilities would occur within roadways; however, approximately 7 acres of soils would be temporarily disturbed at crossings over US 36, I-25, and the South Platte River. • Soil disturbance may result in temporary minor erosion and sedimentation.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • Twenty five acres of soil temporarily disturbed through earth-moving activities and construction equipment traffic, which includes nearly 3 acres of temporary impacts associated with the Denver Basin distribution pipeline stream crossings. • Soil disturbance may result in temporary minor erosion and sedimentation.
Conduit M • Construction of pipeline and associated facilities would occur within roadways; however, approximately 4 acres of soils would be temporarily disturbed at crossings over the South Platte River. • Soil disturbance may result in temporary minor erosion and sedimentation.
Alternative 13a
Gross Reservoir Expansion • 93 acres. • Soil disturbance may result in temporary minor erosion and sedimentation.
South Platte River Facilities • 12 acres. • Soil disturbance may result in temporary minor erosion and sedimentation.
Conduit O • Same as Alternative 8a.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOILS (continued)
Agricultural Water Transfer • N/A.
TYPE OF POTENTIAL IMPACT Shoreline character.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Fluctuating water levels would be similar to Full Use of the Existing System and could create stresses and erosion in shoreline slopes.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Type of potential impacts similar to Proposed Action.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Fluctuating water levels from seasonal changes and return flow obligations.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • N/A.
Conduit M • N/A.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Fluctuating water levels from seasonal changes and return flow obligations.
Conduit O • N/A.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOILS (continued)
TYPE OF POTENTIAL IMPACT Expansive (shrink-swell) soils.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • No expansive soils identified in the Gross Reservoir study area. No impacts anticipated.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Moderate to highly expansive soils would be considered in Project design, mitigating potential for adverse impacts.
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action.
South Platte River Facilities • Gravel pits would be reclaimed for use as a water storage facility. No impacts anticipated.
Conduit O • No impacts.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Expansive soils would be addressed in the design stage of the facilities.
Conduit M • No impacts.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOILS (continued)
TYPE OF POTENTIAL IMPACT Reclamation potential of areas of temporary disturbance.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Limitations include steep slopes and shallow depth to bedrock.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Limitations include moderate to severe water and wind erosion potential, shrink-swell clays, shallow depth to bedrock, and occasional flooding.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Gravel pits would be reclaimed for use as a water storage facility. No impacts anticipated.
Conduit O • Soils temporarily disturbed by construction would be revegetated; no major soil limitations.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Soils temporarily disturbed by construction would be revegetated.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

VEGETATION
TYPE OF POTENTIAL IMPACT Loss of vegetation.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • 456 acres of permanent loss and 52 acres of temporary loss, mostly ponderosa pine and Douglas-fir forest.
Alternative 1c
Gross Reservoir Expansion • 293 acres of permanent loss and 67 acres of temporary loss, mostly ponderosa pine and Douglas-fir forest.
Leyden Gulch Reservoir • 383 acres of permanent loss and 172 acres of temporary loss, mostly grassland.
Alternative 8a
Gross Reservoir Expansion • 354 acres of permanent loss and 61 acres of temporary loss, mostly ponderosa pine and Douglas-fir forest.
South Platte River Facilities • Six acres of permanent loss and 11 acres of temporary loss, mostly disturbed vegetation.
Conduit O • Two acres of permanent loss and 9 acres of temporary loss, mostly disturbed vegetation.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • Eighteen acres of permanent loss and 21 acres of temporary loss, mostly urban parks.
Conduit M • Two acres of permanent loss and 5 acres of temporary loss, mostly disturbed vegetation.
Alternative 13a
Gross Reservoir Expansion • 404 acres of permanent loss and 56 acres of temporary loss, mostly ponderosa pine and Douglas-fir forest.
South Platte River Facilities • Six acres of permanent loss and 12 acres of temporary loss, mostly disturbed vegetation.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • Transfer of agricultural water rights would primarily affect irrigated croplands used for growing alfalfa, corn, hay, pasture, sugar beets, and other crops.
TYPE OF POTENTIAL IMPACT Establishment of shoreline vegetation.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Drawdown area likely to be relatively barren because of large annual fluctuations in water level.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Vegetation, including wetlands and riparian, is likely to establish along shoreline.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

VEGETATION (continued)
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • A narrow ring of wetland and riparian vegetation is likely to establish along reservoir shorelines.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • N/A.
Conduit M • N/A.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • A narrow ring of wetland and riparian vegetation is likely to establish along reservoir shorelines.
Conduit O • N/A.
Agricultural Water Transfer • N/A.
TYPE OF POTENTIAL IMPACT Spread of noxious weeds.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Several species may invade drawdown area and temporary disturbance areas.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Similar to Proposed Action, but area already has abundant weeds.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Similar to Proposed Action, but affected areas are disturbed and already have abundant weeds.
Conduit O • Construction could spread several noxious weeds.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

VEGETATION (continued)
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Noxious weeds could invade disturbed areas at crossings or spread into less infested areas.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • Changes in agricultural land use have the potential to substantially increase the distribution and cover of noxious weeds.
TYPE OF POTENTIAL IMPACT Mountain pine beetle and wildfire.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Not likely to increase spread of mountain pine beetle or increase risk of forest wildfire.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • N/A (not forested).
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • N/A (not forested).
Conduit O • N/A (not forested).
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • N/A (not forested).
Conduit M • N/A (not forested).

Table 5.22-1 (continued)
Summary of Impacts by Alternative

VEGETATION (continued)
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • N/A (not forested).
Conduit O • N/A (not forested).
Agricultural Water Transfer • N/A (not forested).
TYPE OF POTENTIAL IMPACT Loss of rare vegetation communities.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • 4.9 acres of river birch/mesic forb and thinleaf alder/mesic forb.
Alternative 1c
Gross Reservoir Expansion • 3.8 acres of river birch/mesic forb and thinleaf alder/mesic forb.
Leyden Gulch Reservoir • No impacts.
Alternative 8a
Gross Reservoir Expansion • 4.3 acres of river birch/mesic forb and thinleaf alder/mesic forb.
South Platte River Facilities • No impacts.
Conduit O • No impacts.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • No impacts.
Conduit M • No impacts.
Alternative 13a
Gross Reservoir Expansion • 4.6 acres of river birch/mesic forb and thinleaf alder/mesic forb.
South Platte River Facilities • No impacts.
Conduit O • No impacts.
Agricultural Water Transfer • No impacts.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

RIPARIAN AND WETLAND AREAS
TYPE OF POTENTIAL IMPACT Direct impacts to wetlands.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • 1.95 acres of permanent impacts and 0.12 acre of temporary impact.
Alternative 1c
Gross Reservoir Expansion • 1.60 acres of permanent impacts and 0.12 acre of temporary impact.
Leyden Gulch Reservoir • 4.55 acres of permanent impacts and 13.18 acres of temporary impacts.
Alternative 8a
Gross Reservoir Expansion • 1.75 acres of permanent impacts and 0.12 acre of temporary impact.
South Platte River Facilities • <0.1 acre of permanent impact and 0.22 acre of temporary impact.
Conduit O • <0.1 acre of temporary impact.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a, Gross Reservoir.
Denver Basin Aquifer Facilities • <0.1 acre of temporary impact.
Conduit M • <0.1 acre of temporary impact.
Alternative 13a
Gross Reservoir Expansion • 1.83 acres of permanent impacts and 0.12 acre of temporary impact.
South Platte River Facilities • <0.1 acre of permanent impact and 0.24 acre of temporary impact.
Conduit O • <0.1 acre of temporary impact.
Agricultural Water Transfer • Transfer of agricultural water rights on about 3,900 acres of land would adversely affect wetlands and other water features in ditches, ponds and wetlands sustained by leakage, overflows, and/or return water flows.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

RIPARIAN AND WETLAND AREAS (continued)
TYPE OF POTENTIAL IMPACT Direct impacts to other waters of the U.S.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • 3.53 acres of permanent impacts and 0.49 acre of temporary impact.
Alternative 1c
Gross Reservoir Expansion • 2.82 acres of permanent impacts and 0.49 acre of temporary impact.
Leyden Gulch Reservoir • 0.31 acre of permanent impact and 1.55 acres of temporary impacts.
Alternative 8a
Gross Reservoir Expansion • 3.16 acres of permanent impacts and 0.49 acre of temporary impact.
South Platte River Facilities • <0.1 acre of permanent impact and 0.36 acre of temporary impact.
Conduit O • 0.33 acre of temporary impact.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a, Gross Reservoir.
Denver Basin Aquifer Facilities • 1.18 acres of temporary impacts.
Conduit M • 0.52 acre of temporary impact.
Alternative 13a
Gross Reservoir Expansion • 3.36 acres of permanent impacts and 0.49 acre of temporary impact.
South Platte River Facilities • <0.1 acre of permanent impact and 0.90 acre of temporary impact.
Conduit O • Same as Alternative 8a, Conduit O.
Agricultural Water Transfer • Transfer of agricultural water rights on about 3,900 acres of land would adversely affect wetlands and other water features in ditches, ponds and wetlands sustained by leakage, overflows, and/or return water flows.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

RIPARIAN AND WETLAND AREAS (continued)
TYPE OF POTENTIAL IMPACT Direct impacts to riparian habitats.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • 4.08 acres of permanent impacts and <0.1 acre of temporary impact.
Alternative 1c
Gross Reservoir Expansion • 3.24 acres of permanent impacts and <0.1 acre of temporary impact.
Leyden Gulch Reservoir • 0.21 acre of permanent impact and 1.32 acres of temporary impacts.
Alternative 8a
Gross Reservoir Expansion • 3.62 acres of permanent impacts and <0.1 acre of temporary impact.
South Platte River Facilities • <0.01 acre of permanent impact and <0.1 acre of temporary impact.
Conduit O • <0.1 acre of temporary impact.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a, Gross Reservoir.
Denver Basin Aquifer Facilities • 0.30 acre of temporary impact.
Conduit M • 0.25 acre of temporary impact.
Alternative 13a
Gross Reservoir Expansion • 3.88 acres of permanent impacts and <0.1 acre of temporary impact.
South Platte River Facilities • <0.01 acre of permanent impact and <0.1 acre of temporary impact.
Conduit O • Same as Alternative 8a, Conduit O.
Agricultural Water Transfer • Riparian areas along streams are not likely to be affected by agricultural transfers.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WILDLIFE
TYPE OF POTENTIAL IMPACT Effects on elk crucial seasonal habitats.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Permanent loss of 465 acres of elk severe winter range and migration corridor; 269 acres of winter concentration area. Not likely to adversely affect overall population. Temporary displacement during construction, especially on east side of reservoir. Displacement is not likely to affect winter use of Winiger Ridge. Permanent loss of portions of the migration corridor is likely to change elk migration patterns.
Alternative 1c
Gross Reservoir Expansion • Similar to Proposed Action, but smaller area of habitat affected. Permanent loss of 302 acres of elk severe winter range and migration corridor; 168 acres of winter concentration area.
Leyden Gulch Reservoir • No crucial habitats would be affected; loss of general winter range. Also, temporary displacement during construction.
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action, but smaller area of habitat affected. Permanent loss of 363 acres of elk severe winter range and migration corridor; 203 acres of winter concentration area.
South Platte River Facilities • No impacts.
Conduit O • Temporary disturbance during construction in western portion near Rocky Flats.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a, Gross Reservoir.
Denver Basin Aquifer Facilities • No impacts.
Conduit M • Temporary disturbance during construction in western portion near Rocky Flats.
Alternative 13a
Gross Reservoir Expansion • Similar to Proposed Action, but smaller area of habitat affected. Permanent loss of 413 acres of elk severe winter range and migration corridor; 236 acres of winter concentration area.
South Platte River Facilities • No impacts.
Conduit O • Same as Alternative 8a, Conduit O.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WILDLIFE (continued)
TYPE OF POTENTIAL IMPACT Effects on other big game species.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Loss of non-crucial habitat for mule deer, black bears, and mountain lions. Potential mule deer collisions along haul roads. Temporary displacement during construction.
Alternative 1c
Gross Reservoir Expansion • Similar to Proposed Action, but smaller area would be affected.
Leyden Gulch Reservoir • Loss of non-crucial habitat for mule deer, black bears, and mountain lions. Temporary displacement during construction.
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action, but smaller area would be affected.
South Platte River Facilities • Small loss of non-crucial habitat for mule deer and white-tailed deer. Temporary displacement during construction.
Conduit O • Temporary displacement of mule deer and white-tailed deer during construction at western end of conduit and at South Platte River.
Alternative 10a
Gross Reservoir Expansion • Similar to Proposed Action, but smaller area would be affected.
Denver Basin Aquifer Facilities • No impacts.
Conduit M • Temporary displacement of mule deer and white-tailed deer during construction at western end of conduit, Clear Creek, and at South Platte River.
Alternative 13a
Gross Reservoir Expansion • Similar to Proposed Action, but smaller area would be affected.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • Approximately 80 acres of wetlands and riparian areas would be lost from agricultural diversions, creating a negligible to minor impact to habitat.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WILDLIFE (continued)
TYPE OF POTENTIAL IMPACT Impacts to prairie dog colonies.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • No impacts.
Alternative 1c
Gross Reservoir Expansion • No impacts.
Leyden Gulch Reservoir • Loss of 7.2 acres of black-tailed prairie dog colonies.
Alternative 8a
Gross Reservoir Expansion • No impacts.
South Platte River Facilities • No impacts.
Conduit O • No impacts.
Alternative 10a
Gross Reservoir Expansion • No impacts.
Denver Basin Aquifer Facilities • No impacts.
Conduit M • No impacts.
Alternative 13a
Gross Reservoir Expansion • No impacts.
South Platte River Facilities • No impacts.
Conduit O • No impacts.
Agricultural Water Transfer • The area of upland grasslands is likely to increase; therefore, prairie dog towns are likely to expand.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WILDLIFE (continued)
TYPE OF POTENTIAL IMPACT Habitat fragmentation.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Inundation of 2,495 feet of South Boulder Creek and 2,160 feet of Winiger Gulch above the reservoir would affect animal movement, including elk migration. Effects would be reduced in the spring when the reservoir is lower.
Alternative 1c
Gross Reservoir Expansion • Similar to Proposed Action, but fewer impacts. Inundation of 2,100 feet of South Boulder Creek and 1,370 feet of Winiger Gulch.
Leyden Gulch Reservoir • Reservoir would block east-west movement, but not in an important migration corridor.
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action, but fewer impacts. Inundation of 2,140 feet of South Boulder Creek and 1,780 feet of Winiger Gulch.
South Platte River Facilities • No impacts.
Conduit O • No impacts.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a, Gross Reservoir.
Denver Basin Aquifer Facilities • No impacts.
Conduit M • No impacts.
Alternative 13a
Gross Reservoir Expansion • Similar to Proposed Action, but fewer impacts. Inundation of 2,320 feet of South Boulder Creek and 2,045 feet of Winiger Gulch.
South Platte River Facilities • No impacts.
Conduit O • No impacts.
Agricultural Water Transfer • Loss of about 82 acres of wetlands and 8 acres of surface water in ditches and ponds. Most of the affected area is likely to have low to moderate value for wildlife.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WILDLIFE (continued)
TYPE OF POTENTIAL IMPACT Raptors and other migratory birds.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • No known active raptor nests in Project area. Construction may affect nesting birds. Long-term loss of habitat for forest birds. Osprey platforms would not be affected. • Operation of the reservoir would provide loafing and foraging habitat for waterfowl.
Alternative 1c
Gross Reservoir Expansion • Similar to Proposed Action, but less loss of forest habitat.
Leyden Gulch Reservoir • One known red-tailed hawk nest in disturbance area and one nearby. Construction may affect nesting birds, but there are few trees or shrubs in the Project area except at Ralston Creek. • Operation of the reservoir would be beneficial to water birds.
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action, but less loss of forest habitat.
South Platte River Facilities • One known raptor nest near Project area. Construction may affect nesting birds. Small loss of habitat for riparian birds. • Operation of the reservoir would be beneficial to water birds.
Conduit O • No known raptor nests in vicinity. Construction may affect nesting birds in areas where pipeline is located outside existing road. Small temporary loss of habitat.
Alternative 10a
Gross Reservoir Expansion • Similar to Proposed Action, but less loss of forest habitat.
Denver Basin Aquifer Facilities • No known raptor nests in vicinity of facilities. Small temporary loss of habitat.
Conduit M • No known raptor nests in vicinity. Construction may affect nesting birds in areas where pipeline is located outside existing road. Small temporary loss of habitat.
Alternative 13a
Gross Reservoir Expansion • Similar to Proposed Action, but less loss of forest habitat.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • Minor loss of habitat for breeding birds. The lower vegetation productivity of non-irrigated land may result in a reduction of prey base for raptors, but increases in prairie dogs would be beneficial.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WILDLIFE (continued)
TYPE OF POTENTIAL IMPACT USFS wildlife habitats.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Permanent loss of 197 acres of effective habitat, 224 acres of forested corridors, 4 acres of open corridors, 17 acres of interior forest, 1 acre of existing old growth, 195 acres of old growth development area.
Alternative 1c
Gross Reservoir Expansion • Permanent loss of 124 acres of effective habitat, 134 acres of forested corridors, 1 acre of open corridors, 6 acres of interior forest, <1 acre of existing old growth, 133 acres of old growth development area.
Leyden Gulch Reservoir • N/A (no USFS lands).
Alternative 8a
Gross Reservoir Expansion • Permanent loss of 153 acres of effective habitat, 167 acres of forested corridors, 2 acres of open corridors, 9 acres of interior forest, <1 acre of existing old growth, 159 acres of old growth development area.
South Platte River Facilities • N/A (no USFS lands).
Conduit O • N/A (no USFS lands).
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • N/A (no USFS lands).
Conduit M • N/A (no USFS lands).
Alternative 13a
Gross Reservoir Expansion • Permanent loss of 175 acres of effective habitat, 192 acres of forested corridors, 3 acres of open corridors, 12 acres of interior forest, <1 acre of existing old growth, 176 acres of old growth development area.
South Platte River Facilities • N/A (no USFS lands).
Conduit O • N/A (no USFS lands).
Agricultural Water Transfer • N/A (no USFS lands).

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WILDLIFE (continued)
TYPE OF POTENTIAL IMPACT USFS Management Indicator Species.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Construction and operation would have minor effects to pygmy nuthatch, hairy woodpecker, and mountain bluebird, and negligible effects to golden-crowned kinglet, warbling vireo, and Wilson's warbler. It would also have minor impacts to elk and mule deer habitat; however, the elk migration corridor near Gross Reservoir may be moderately affected.
Alternative 1c
Gross Reservoir Expansion • Similar to Proposed Action, but less loss of habitat.
Leyden Gulch Reservoir • N/A (no USFS lands).
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action, but less loss of habitat.
South Platte River Facilities • N/A (no USFS lands).
Conduit O • N/A (no USFS lands).
Alternative 10a
Gross Reservoir Expansion • Similar to Proposed Action, but less loss of habitat.
Denver Basin Aquifer Facilities • N/A (no USFS lands).
Conduit M • N/A (no USFS lands).
Alternative 13a
Gross Reservoir Expansion • Similar to Proposed Action, but less loss of habitat.
South Platte River Facilities • N/A (no USFS lands).
Conduit O • N/A (no USFS lands).
Agricultural Water Transfer • N/A (no USFS lands).

Table 5.22-1 (continued)
Summary of Impacts by Alternative

WILDLIFE (continued)
TYPE OF POTENTIAL IMPACT Loss of sensitive habitats.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Loss of 4% of Winiger Gulch PCA and 7% of Winiger Ridge ECA.
Alternative 1c
Gross Reservoir Expansion • Loss of 2% of Winiger Gulch PCA and 4% of Winiger Ridge ECA.
Leyden Gulch Reservoir • Temporary disturbance of <1% of Rocky Flats PCA for construction staging and spoil storage.
Alternative 8a
Gross Reservoir Expansion • Loss of 3% of Winiger Gulch PCA and 5% of Winiger Ridge ECA.
South Platte River Facilities • Facilities would be located in South Platte River PCA and Greenway, but no adverse effects.
Conduit O • Temporary disturbance of South Platte River PCA and Greenway, no adverse effects.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • Temporary disturbance of South Platte River PCA and Greenway, no adverse effects.
Conduit M • Temporary disturbance of South Platte River PCA and Greenway, no adverse effects.
Alternative 13a
Gross Reservoir Expansion • Loss of 4% of Winiger Gulch PCA and 6% of Winiger Ridge ECA.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • No impacts.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SPECIAL STATUS SPECIES
TYPE OF POTENTIAL IMPACT Effects to Federal and State listed species from construction and reservoir filling.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Not likely to adversely affect greenback cutthroat trout. No effect to other species.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Construction could impact nesting burrowing owls. Not likely to adversely affect Preble's meadow jumping mouse, or Ute ladies'-tresses orchid. No effect on Colorado butterfly plant.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Construction could impact nesting burrowing owls. Unlikely to affect interior least tern, piping plover, Ute ladies'-tresses orchid, or Colorado butterfly plant.
Conduit O • Temporary disturbance of burrowing owl. • Unlikely to affect interior least tern, piping plover, Ute ladies'-tresses orchid, or Colorado butterfly plant.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • No impacts.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Similar to Alternative 8a, but less area of open water created.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • Transfer of agricultural water rights would not affect any Federally listed threatened or endangered species.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SPECIAL STATUS SPECIES (continued)
TYPE OF POTENTIAL IMPACT Effects to other special status animal species from construction and reservoir filling.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Loss of habitat for, and temporary displacement of, USFS Region 2 sensitive species including northern goshawk, flammulated owl, and several other bird and bat species. Not likely to affect viability of these species on the Arapaho & Roosevelt National Forests.
Alternative 1c
Gross Reservoir Expansion • Similar to Proposed Action, but reduced loss of habitat because smaller reservoir.
Leyden Gulch Reservoir (31,300 AF) • 7.2 acres of black-tailed prairie dog towns would be destroyed. • Loss of habitat for ferruginous hawk and sensitive butterflies. Loss of habitat for, and mortality to, northern leopard frog.
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action, but reduced loss of habitat because smaller reservoir.
South Platte River Facilities • Temporary displacement of, and mortality to, northern leopard frog, common garter snake, and black-tailed prairie dog along pipeline. • Temporary disturbance of bald eagle, snowy egret and white-faced ibis. • Beneficial impacts to several species from creation of new open water and shoreline habitat.
Conduit O • Temporary displacement of, and mortality to, common garter snake at stream and riparian crossings. • Temporary disturbance of bald eagle, several other species.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • Temporary displacement of, and mortality to, common garter snake and northern leopard frog at stream and riparian crossings.
Conduit M • Temporary displacement of several species.
Alternative 13a
Gross Reservoir Expansion • Similar to Proposed Action, but reduced loss of habitat because smaller reservoir.
South Platte River Facilities • Similar to Alternative 8a, but less area of open water created.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • Loss of potential habitat for some special status species, such as common garter snake and northern leopard frog, in ditches, ponds, and wetlands. Black-tailed prairie dog populations are likely to increase, providing more habitat for burrowing owls and foraging ferruginous hawks through the creation of new prairie dog colonies.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SPECIAL STATUS SPECIES (continued)
TYPE OF POTENTIAL IMPACT Effects to other special status plant species from construction and reservoir filling.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Loss of occupied habitat and reduction of local populations of several species of Arapaho & Roosevelt National Forests' plant species of local concern. The Project may affect the viability of four Arapaho & Roosevelt National Forests' species (i.e., Dewey sedge, Sprengel's sedge, tall blue lettuce, and false melic), and the viability of local populations of other species.
Alternative 1c
Gross Reservoir Expansion • Similar to Proposed Action, but fewer impacts. The Project may affect the viability of two Arapaho & Roosevelt National Forests' species (i.e., tall blue lettuce and false melic), and the viability of local populations of wild sarsaparilla and enchantress's nightshade.
Leyden Gulch Reservoir • No impacts.
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action but fewer impacts. The Project may affect the viability of three Arapaho & Roosevelt National Forests' species (i.e., Sprengel's sedge, tall blue lettuce, and false melic), and the viability of local populations of wild sarsaparilla, Dewey sedge, and enchantress's nightshade.
South Platte River Facilities • No impacts.
Conduit O • No impacts.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • No impacts.
Conduit M • No impacts.
Alternative 13a
Gross Reservoir Expansion • The Project may affect the viability of three Arapaho & Roosevelt National Forests' species (i.e., Sprengel's sedge, tall blue lettuce, and false melic), and the viability of local populations of wild sarsaparilla, Dewey sedge, and enchantress's nightshade.
South Platte River Facilities • No impacts.
Conduit O • No impacts.
Agricultural Water Transfer • No impacts.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

AQUATIC BIOLOGICAL RESOURCES
TYPE OF POTENTIAL IMPACT Temporary construction impacts of reservoir enlargement and pipeline construction.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Disruption of normal reservoir operations during construction would have a temporary adverse impact on fish and invertebrates.
Alternative 1c
Gross Reservoir Expansion • Similar but smaller impacts than the Proposed Action.
Leyden Gulch Reservoir • No impact.
Alternative 8a
Gross Reservoir Expansion • Similar but smaller impacts than the Proposed Action.
South Platte River Facilities • Pipeline construction would have a temporary, direct adverse impact on aquatic resources of the South Platte River.
Conduit O • Pipeline construction would have a temporary, direct adverse impact on aquatic resources at stream crossings.
Alternative 10a
Gross Reservoir Expansion • Similar but smaller impacts than the Proposed Action.
Denver Basin Aquifer Facilities) • Pipeline construction would have a temporary, direct adverse impact on aquatic resources at stream crossings.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Similar but smaller impacts than the Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

AQUATIC BIOLOGICAL RESOURCES (continued)
TYPE OF POTENTIAL IMPACT Impacts of reservoir enlargement/creation.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Additional available habitat (from an enlarged Gross Reservoir) would be beneficial to fish and invertebrates.
Alternative 1c
Gross Reservoir Expansion • Similar but smaller beneficial impacts than the Proposed Action.
Leyden Gulch Reservoir • Additional available habitat would be beneficial to fish and invertebrates. • Inundation of a small spring pool would represent an adverse impact.
Alternative 8a
Gross Reservoir Expansion • Similar but smaller beneficial impacts than the Proposed Action.
South Platte River Facilities • Additional available habitat would be beneficial to fish and invertebrates.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Similar but smaller beneficial impacts than the Proposed Action.
Denver Basin Aquifer Facilities • N/A.
Conduit M • N/A.
Alternative 13a
Gross Reservoir Expansion • Similar but smaller beneficial impacts than the Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • N/A.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

TRANSPORTATION
TYPE OF POTENTIAL IMPACT Effects from temporary construction traffic.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Traffic in the area would increase due to construction activities over the 4.1-year period. • Workforce, equipment, and supply delivery trips would result in 107 peak vehicles and 214 peak-hour vehicle trips. • Heavy equipment and haul trucks could cause rutting in the unpaved road segments of the Gross Dam Road (CR 77S).
Alternative 1c
Gross Reservoir Expansion • Traffic in the area would increase due to construction activities over the 3.1-year period. • Peak-hour vehicle trips and peak vehicles would be similar to, but slightly less than, that of the Proposed Action. • Similar construction-related impacts as Proposed Action.
Leyden Gulch Reservoir • Traffic in the area would increase due to construction activities over the 3.5-year period. • Workforce and equipment trips would result in 242 peak vehicles and 484 peak-hour vehicle trips. • Approximately 4,000 feet of SH 93 would be permanently relocated; the existing SH 93 would remain in service while the realignment was constructed.
Alternative 8a
Gross Reservoir Expansion • Traffic in the area would increase due to construction activities over the 3.2-year period. • Peak-hour vehicle trips and peak vehicles would be similar to, but slightly less than, that of the Proposed Action. • Similar construction-related impacts as Proposed Action.
South Platte River Facilities • Traffic in the area would increase due to construction activities over the 2.5-year period. • Workforce and equipment trips would result in 131 peak vehicles and 262 peak-hour vehicle trips. • Passenger vehicle delays and higher-than-average volumes of commuter traffic during peak construction would affect US 85 and local roads in the Brighton area.
Conduit O • New pipeline construction anticipated to occur within a 2.5-year period. • Workforce and equipment trips would result in 82 peak vehicles and 164 peak-hour vehicle trips. • Pipeline construction activities would cross major transportation corridors, including three railroad grades, two highways, and seven major arterials. • A particular stretch of roadway would typically be impacted for less than one week; crossings of railroads and major roads are anticipated to be completed within approximately 20 working days.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a, Gross Reservoir.
Denver Basin Aquifer Facilities • Construction of ASR system and related facilities are anticipated to occur within a 2.5-year period. • Workforce and equipment trips would result in in 222 peak vehicles and 444 peak-hour vehicle trips. • Construction of distribution pipeline would average approximately 25 to 35 days per mile for in-street construction. • Construction time of each well house would range from 30 to 60 days.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

TRANSPORTATION (continued)
Conduit M • New pipeline construction anticipated to occur within a 2.5-year period. • Workforce and equipment trips would result in 73 peak vehicles and 146 peak-hour vehicle trips. • Pipeline construction activities would cross major transportation corridors, including two highways and six arterials.
Alternative 13a
Gross Reservoir Expansion • Traffic in the area would increase due to construction activities over the 3.6-year period. • Peak-hour vehicle trips and peak vehicles would be similar to, but slightly less than, that of the Proposed Action. • Similar construction-related impacts as Proposed Action.
South Platte River Facilities • Same as Alternative 8a, South Platte River Facilities.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer N/A.
TYPE OF POTENTIAL IMPACT Effects from maintenance and operations traffic.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • No change in current traffic volumes or travel patterns.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
Leyden Gulch Reservoir • Current staff at the Ralston Reservoir facility would operate and maintain the new Leyden Gulch Reservoir using existing roads or Denver Water access roads between the two reservoirs. Minimal to no impacts are anticipated.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
South Platte River Facilities • These facilities would operate only during dry years or emergencies. Workforce would come from existing Denver Water facilities when needed. Minimal to no impacts are anticipated.
Conduit O • Same as Alternative 8a, South Platte River Facilities.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
Denver Basin Aquifer Facilities • Same as Alternative 8a, South Platte River Facilities.
Conduit M • Same as Alternative 8a, Conduit O.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

TRANSPORTATION (continued)
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
South Platte River Facilities • Same as Alternative 8a, South Platte River Facilities.
Conduit O • Same as Alternative 8a, Conduit O.
Agricultural Water Transfer • N/A.
TYPE OF POTENTIAL IMPACT Effects from recreation traffic.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Public access to Gross Reservoir via the existing north and south access points would remain unchanged. • The parking lot located east of the existing spillway would be covered by the dam raise buttress and relocated. • During construction, recreational access would be limited in the area around the dam. • During operation, a minor increase in visitation to the reservoir is possible. • Emergency access to Gross Reservoir would be maintained during construction.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
Leyden Gulch Reservoir • No recreational facilities or public access would be provided.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
South Platte River Facilities • No recreational facilities or public access would be provided.
Conduit O • N/A.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
Denver Basin Aquifer Facilities • No recreational facilities or public access would be provided. • Access to public parks would not be changed. Temporary delays during construction due to an increased volume of construction-related traffic are anticipated.
Conduit M • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

TRANSPORTATION (continued)
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
South Platte River Facilities • No recreational facilities or public access would be provided.
Conduit O • N/A.
Agricultural Water Transfer • N/A.
AIR QUALITY
TYPE OF POTENTIAL IMPACT Temporary effects from emissions during construction. (Emissions of the gases noted in this table would exceed conformity *de minimis* levels of 100 tons per year; therefore, the Project must undergo a general conformity analysis to ensure compliance with NAAQS prior to construction.)
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • CO and NO_x. • Project would result in emissions of dust and combustion products. • Greenhouse gas emissions would be minor impact.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
Leyden Gulch Reservoir • CO, NO_x, and PM_{10}. • Project would result in emissions of dust and combustion products.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
South Platte River Facilities • CO, NO_x, and PM_{10}. • Project would result in emissions of dust and combustion products.
Conduit O • CO, NO_x, and PM_{10}. • Project would result in emissions of dust and combustion products.
Alternative 10a
Gross Reservoir Expansion • Same as Alternative 8a.
Denver Basin Aquifer Facilities • CO, NO_x, and PM_{10}. • Project would result in emissions of dust and combustion products.
Conduit M • CO, NO_x, and PM_{10}. • Project would result in emissions of dust and combustion products.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

AIR QUALITY (continued)
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action, Gross Reservoir.
South Platte River Facilities • CO, NO_x, and PM_{10}. • Project would result in emissions of dust and combustion products.
Conduit O • CO, NO_x, and PM_{10}. • Project would result in emissions of dust and combustion products.
Agricultural Water Transfer • N/A.
TYPE OF POTENTIAL IMPACT Operational/cumulative emissions from maintenance and/or visitor vehicles.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Insignificant emissions.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Insignificant emissions.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Insignificant emissions.
Conduit O • Insignificant emissions.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Insignificant emissions.
Conduit M • Insignificant emissions.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Insignificant emissions.
Conduit O • Insignificant emissions.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

NOISE
TYPE OF POTENTIAL IMPACT Short-term exposure to noise during daytime hours from construction activities (on-site and off-site).
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • On-site construction noise impacts would be temporary and moderate. • On-site construction noise may periodically exceed the EPA noise threshold of 70 dBA for public exposure but not on a continuous basis. • Temporary and minor off-site noise impacts related to construction traffic.
Alternative 1c
Gross Reservoir Expansion • Same as those described for Proposed Action, but the construction period would be shorter.
Leyden Gulch Reservoir • On-site construction noise impacts would be temporary and moderate. • Temporary and minor off-site noise impacts related to construction traffic.
Alternative 8a
Gross Reservoir Expansion • Same as those described for Proposed Action, but the construction period would be shorter.
South Platte River Facilities • Minor noise-related impacts would result from construction of the gravel pits.
Conduit O • Intermittent noise impacts. Noise associated with construction activities occurring within the urban portions of Conduit O would be negligible in the context of the Denver Metropolitan area. The rural portions of Conduit O are likely to be more affected by temporary construction noise than the more developed areas.
Alternative 10a
Gross Reservoir Expansion • Same as those described for Proposed Action, but the construction period would be shorter.
Denver Basin Aquifer Facilities • Short term and negligible in the urban context of Denver.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Same as those described for Proposed Action, but the construction period would be shorter.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a, Conduit O.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

NOISE (continued)
TYPE OF POTENTIAL IMPACT Long-term contribution to background noise from operation of the dam, reservoir, and associated facilities.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • No long-term noise impacts anticipated.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • No long-term noise impacts anticipated.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • No long-term noise impacts anticipated. The AWTP would be equipped with sound mitigation features to comply with applicable local noise ordinances.
Conduit O • No long-term noise impacts anticipated. Conduit O would only operate during dry years or emergencies.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Short-term and minor construction impacts in the urban context of Denver. • Noise from submersible pumps in the wells would be negligible.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

RECREATION
TYPE OF POTENTIAL IMPACT Direct and indirect impacts to recreational resources.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Expansion of the reservoir would result in the inundation of six developed recreation areas which would need to be relocated. During construction, access to some areas of shoreline and on-water access may also be restricted. There would also be impacts to the recreation experience from visual and sound disturbances. Increased surface area and shoreline may create new recreation opportunities.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Impacts to existing recreation from the construction of a reservoir at Leyden Gulch would be minimal. There would be some disturbance to bicyclists on SH 93 due to road re-alignment. There would be no public access to the reservoir. Therefore, no new recreation opportunities would be created.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Impacts to recreation at South Platte River Facilities would include removal of the Worthing Pit as a recreation resource. Portions of the South Platte River Heritage Trail would need to be re-routed. There would be a temporary disturbance to bicyclists on Brighton Road during construction.
Conduit O • No permanent impacts. There would be temporary disturbances to bicycling along the Adams County Trail and kayaking along the South Platte River during construction.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Well sites would permanently remove 0.5 acre and temporarily remove 0.9 acre during construction from City and County of Denver parks. May be an impact to visitor experience due to presence of well houses.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

LAND USE
TYPE OF POTENTIAL IMPACT Conflicts with existing land uses.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Minor short-term impacts as a result of construction activities. • No facility development on the West Slope. Existing water rights would be protected under Colorado water law. Project would have little to no additional impact to irrigation structures or practices.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Minor short-term impacts to residential areas in proximity to Leyden Gulch as a result of construction activities. Conflicts with two Trails 2000 segments planned by Arvada.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • The construction of gravel pits would result in minimal impacts to existing land uses; structure design criteria would ensure that the advanced water treatment facility would not result in adverse impacts to future land uses.
Conduit O • Reduced or modified access due to traffic detours may temporarily affect retail and commercial land uses along the conduit alignment.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Injection/recovery wells: minor, adverse, long-term impacts to city properties. See also Visual and Recreation impact summaries. • The AWTP would be compatible with surrounding industrial areas and would not create impacts beyond temporary construction activities.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • Some of the lands that could no longer be irrigated due to the removal of water rights might remain in dryland cultivation or some other agricultural use. However, these uses are less productive than irrigated farmland. Due to the anticipated reduced productivity of these lands, as well as urban development pressures, conversion of these lands to non-agricultural uses is likely.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

VISUAL RESOURCES
TYPE OF POTENTIAL IMPACT Temporary effects from construction activities.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Construction activities would create temporary, direct effects to visual resources.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Temporary construction activities would result in a major short-term impact.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • The diversion, pipeline, AWTP, and dechlorination facility would create a temporary visual contrast during construction.
Conduit O • Temporary visual effects due to construction activities and soil disturbance.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Temporary, adverse effects from well clusters would vary based on their placement within each park, as well as the size and type of park. • Architecture of the AWTP would be consistent with other industrial buildings in the area and would not create impacts beyond temporary construction activities.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

VISUAL RESOURCES (continued)
TYPE OF POTENTIAL IMPACT Post-construction effects.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Short-term effects in construction staging, quarry and stockpile areas, and other disturbed areas until reclamation efforts lessen visual contrasts; major, permanent impacts from the auxiliary spillway.
Alternative 1c
Gross Reservoir Expansion) • Similar to Proposed Action.
Leyden Gulch Reservoir • The visual character and scenic attributes of Leyden Gulch would unavoidably change due to a new water storage feature.
Alternative 8a
Gross Reservoir Expansion • Similar to Proposed Action.
South Platte River Facilities • The diversion would create a moderate long-term visual contrast. • Utilizing available water storage capacity in previously-constructed gravel pits would improve the scenic quality of the study area.
Conduit O • Minor or negligible effects from small aboveground facilities.
Alternative 10a
Gross Reservoir Expansion • Similar to Proposed Action.
Denver Basin Aquifer Facilities • Minor or negligible effects from small aboveground facilities.
Conduit M • Same as Alternative 8a, Conduit O.
Alternative 13a
Gross Reservoir Expansion • Similar to Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • Generally, the types of visual impacts would be expected to include conversion of irrigated cropland to dryland cropland and pasture grasslands, along with a probable increase in noxious weed infestations. Some emergent wetlands would also convert to grassland when water sources are removed.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

CULTURAL/HISTORICAL/PALEONTOLOGICAL RESOURCES
TYPE OF POTENTIAL IMPACT Effects on cultural resources.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Expansion of the dam, reservoir, and related facilities would permanently affect the dam, reservoir, and a portion of the Resumption Flume. These impacts are considered to be an adverse effect, and treatment of this effect would be required before construction begins. • A Programmatic Agreement between Denver Water, American Indian Tribes, and several State and Federal agencies has been prepared that stipulates protection measures.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Eighteen significant sites are located within the APE for the construction of the proposed Leyden Gulch Reservoir. Alternative 1c would have temporary impacts to 3 significant cultural resources and permanent impacts to 6 significant cultural resources. The remaining 9 sites would not be impacted.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • No significant cultural resources are known to exist within the APE that would be impacted by the South Platte River Facilities.
Conduit O • Five significant sites are located within the APE for the construction of Conduit O. This alternative would have temporary impacts to 3 significant cultural resources and permanent impacts to 2 significant cultural resources.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Sixteen significant sites are located within the APE for the construction of the Denver Basin Aquifer Facilities. Construction of the facilities would have permanent impacts to all 16 of the sites.
Conduit M • Four significant sites are located within the APE for the construction of Conduit M. This conduit would have temporary impacts to 1 significant cultural resource and permanent impacts to 3 significant cultural resources.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

CULTURAL/HISTORICAL/PALEONTOLOGICAL RESOURCES (continued)
TYPE OF POTENTIAL IMPACT Effects on paleontological resources.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Enlargement of Gross Reservoir would have no impact on paleontological resources, nor would there be any impact to cultural or archaeological resources from inundation.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Although no paleontological resources have been identified within the APE, the area is underlain by the Pierre Shale, which is characterized as Class I for paleontological resources. Therefore, awareness training of construction personnel and paleontological monitoring are recommended as mitigation measures.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • No significant paleontological resources are known to exist within the APE that would be impacted by the South Platte River Facilities.
Conduit O • Conduit O would have no impact on paleontological resources.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Construction of the well sites is unlikely to have impacts on paleontological resources.
Conduit M • Conduit M would have no impact on paleontological resources.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • No significant paleontological resources are known to exist within the APE that would be impacted by the South Platte River Facilities.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOCIOECONOMICS
TYPE OF POTENTIAL IMPACT Total annual employment.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • 213 FTE/construction year.
Alternative 1c
Gross Reservoir Expansion • 187 FTE/construction year.
Leyden Gulch Reservoir • 499 FTE/construction year.
Alternative 8a
Gross Reservoir Expansion • 218 FTE/construction year.
South Platte River Facilities • 264 FTE/construction year.
Conduit O • 198 FTE/construction year.
Alternative 10a
Gross Reservoir Expansion • 218 FTE/construction year.
Denver Basin Aquifer Facilities • 481 FTE/construction year.
Conduit M • 194 FTE/construction year.
Alternative 13a
Gross Reservoir Expansion • 222 FTE/construction year.
South Platte River Facilities • 221 FTE/construction year.
Conduit O • 169 FTE/construction year.
Agricultural Water Transfer • 0 FTE/construction year.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOCIOECONOMICS (continued)
TYPE OF POTENTIAL IMPACT Total annual income.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • $12.6 million.
Alternative 1c
Gross Reservoir Expansion • $10.9 million.
Leyden Gulch Reservoir • $29.0 million.
Alternative 8a
Gross Reservoir Expansion • $13.0 million.
South Platte River Facilities • $15.2 million.
Conduit O • $12.1 million.
Alternative 10a
Gross Reservoir Expansion • $13.0 million.
Denver Basin Aquifer Facilities • $27.0 million.
Conduit M • $10.9 million.
Alternative 13a
Gross Reservoir Expansion • $12.4 million.
South Platte River Facilities • $11.6 million.
Conduit O • $8.9 million.
Agricultural Water Transfer • $0.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOCIOECONOMICS (continued)
TYPE OF POTENTIAL IMPACT Total annual economic output.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • $62.1 million.
Alternative 1c
Gross Reservoir Expansion • $52.1 million.
Leyden Gulch Reservoir • $95.9 million.
Alternative 8a
Gross Reservoir Expansion • $63.2 million.
South Platte River Facilities • $76.0 million.
Conduit O • $38.8 million.
Alternative 10a
Gross Reservoir Expansion • $63.2 million.
Denver Basin Aquifer Facilities • $111.0 million.
Conduit M • $22.7 million.
Alternative 13a
Gross Reservoir Expansion • $61.8 million.
South Platte River Facilities • $52.1 million.
Conduit O • $33.0 million.
Agricultural Water Transfer • $35.6 million.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOCIOECONOMICS (continued)
TYPE OF POTENTIAL IMPACT Demographic conditions.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • No impact on demographic conditions, except for negligible, temporary impacts to commuting patterns in Boulder County and the Denver Metropolitan area, and minor to moderate, temporary impacts to commuting patterns in the Gross Reservoir PIA during construction.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • No impact on demographic conditions, except negligible, temporary impacts to commuting patterns in the Denver Metropolitan area during construction.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • No impact on demographic conditions, except negligible and temporary impacts to commuting patterns in the Denver Metropolitan area during construction.
Conduit O • No impact on demographic conditions, except negligible and temporary impacts to commuting patterns in the Denver Metropolitan area during construction.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • No impact on demographic conditions, except negligible and temporary impacts to commuting patterns in the Denver Metropolitan area during construction.
Conduit M • No impact on demographic conditions, except negligible and temporary impacts to commuting patterns in the Denver Metropolitan area during construction.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • No impact on demographic conditions.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOCIOECONOMICS (continued)
TYPE OF POTENTIAL IMPACT Housing conditions.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • No impact on housing units, home values or other housing conditions, except for minor to moderate, temporary impacts to the values of a small number of homes along Gross Dam Road during construction.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • No impact on housing units, home values, or other housing conditions.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • No impact on housing units, home values, or other housing conditions.
Conduit O • No impact on housing units, home values, or other housing conditions.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • No impact on housing units, home values, or other housing conditions.
Conduit M • No impact on housing units, home values, or other housing conditions.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • No impact on housing units, home values, or other housing conditions.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOCIOECONOMICS (continued)
TYPE OF POTENTIAL IMPACT Fiscal conditions.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Negligible, permanent impacts to revenues of Boulder County, the RE-2 school district, and the Coal Creek Canyon Fire District.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Negligible, permanent impacts to revenues of Jefferson County, the R-1 School District, Jefferson County Sheriff's Office, the Fairmount and Arvada Fire Protection Districts, and the Urban Drainage and Flood Control District.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Negligible, permanent impacts to revenues of Adams County, the Brighton 27-J School District, Brighton Fire Protection District, and the Rangeview Library District.
Conduit O • No impacts on fiscal conditions of public entities.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Negligible, permanent impacts to revenues of Adams County, Adams County School District #14, South Adams Fire District #4, Commerce City, and the Rangeview Library District.
Conduit M • No impacts on fiscal conditions of public entities.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • Negligible, permanent impacts to the revenues of Weld County, AIMS Junior College, and the High Plains Library District.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOCIOECONOMICS (continued)
TYPE OF POTENTIAL IMPACT Water providers.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Negligible impact to one Grand County water provider. Denver Water and its customers would experience permanent, positive impacts. Other water providers not impacted. The City of Arvada will experience a particularly positive effect from the additional supply.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Same as Proposed Action.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Proposed Action.
Conduit O • Same as Proposed Action.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Same as Proposed Action.
Conduit M • Same as Proposed Action.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Proposed Action.
Conduit O • Same as Proposed Action.
Agricultural Water Transfer • Same as Proposed Action.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOCIOECONOMICS (continued)
TYPE OF POTENTIAL IMPACT Other public facilities and services.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Minor, temporary impacts to fire departments in the Gross Reservoir PIA and police departments in Boulder County. Negligible, permanent reductions in Boulder County revenue. Other service providers would not be impacted.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Minor, temporary impacts to fire departments in the Leyden Gulch Reservoir PIA, police departments in Jefferson County. Negligible, permanent reductions in Jefferson County revenue. Other service providers would not be impacted.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Minor temporary impacts to fire departments and police departments in the South Platte River Facilities PIA and Adams County. Negligible, permanent reductions in Adams County revenue. Rangeview Library District would experience a negligible decrease in annual revenue. Other service providers would not be impacted.
Conduit O • Public Services would not be impacted by Conduit O.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Negligible to minor temporary impacts to fire departments and police departments in the Denver Basin Aquifer Facilities PIA and Adams County. Negligible, permanent reductions in revenue to Adams County. Rangeview Library District would experience a negligible, permanent decrease in annual revenue. Other service providers would not be impacted.
Conduit M • Public Services would not be impacted by Conduit O.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Alternative 8a.
Conduit O • Same as Alternative 8a.
Agricultural Water Transfer • AIMS Junior College and the High Plains Library District in Weld County would experience negligible, permanent reductions in revenue. Other service providers would not be impacted.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

SOCIOECONOMICS (continued)
TYPE OF POTENTIAL IMPACT Water rates and tap fees.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Minor rate and tap fee increases for Denver Water customers.
Alternative 1c
Gross Reservoir Expansion • Minor rate increases and minor to moderate tap fee increases for Denver Water customers.
Leyden Gulch Reservoir • Same as Alternative 1c, Gross Reservoir.
Alternative 8a
Gross Reservoir Expansion • Moderate rate and tap fee increases for Denver Water customers.
South Platte River Facilities • Same as Alternative 8a, Gross Reservoir.
Conduit O • Same as Alternative 8a, Gross Reservoir.
Alternative 10a
Gross Reservoir Expansion • Moderate rate and tap fee increases for Denver Water customers.
Denver Basin Aquifer Facilities • Same as Alternative 10a, Gross Reservoir.
Conduit M • Same as Alternative 10a, Gross Reservoir.
Alternative 13a
Gross Reservoir Expansion • Moderate to major rate increases and moderate tap fee increases for Denver Water customers.
South Platte River Facilities • Same as Alternative 13a, Gross Reservoir.
Conduit O • Same as Alternative 13a, Gross Reservoir.
Agricultural Water Transfer • Same as Alternative 13a, Gross Reservoir.
HAZARDOUS MATERIALS
TYPE OF POTENTIAL IMPACT Effect of construction work on sites where hazardous materials may be present.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Two hazardous materials sites are located approximately 2,000 feet downgradient of the reservoir; however, these sites are properly contained and no releases have been reported. No impacts anticipated.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Seven hazardous material sites were identified adjacent to and within the Leyden Gulch Reservoir site. The sites have a low or unknown potential for an environmental release.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

HAZARDOUS MATERIALS (continued)
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Eight sites with a high potential for an environmental release were identified within and adjacent to the Worthing and South Tower gravel pits. • No impacts associated with hazardous material sites were identified near the North Tower Gravel pit.
Conduit O • Not evaluated because of the expected high number of hazardous waste sites associated with the urban location of this component. • If this alternative were selected and permitted by the Corps, a detailed analysis of this component would be conducted.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Not evaluated because of the expected high number of hazardous waste sites associated with the urban location of this component. • If this alternative were selected and permitted by the Corps, a detailed analysis of this component would be conducted.
Conduit M • Not evaluated because of the expected high number of hazardous waste sites associated with the urban location of this component. • If this alternative were selected and permitted by the Corps, a detailed analysis of this component would be conducted.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • The potential impacts associated with the Worthing and South Tower gravel pits are the same as those described for Alternative 8a. • One site with a moderate potential for impact to the Challenger Gravel Pit was identified. No report of any release or violations has been documented.
Conduit O • Not evaluated because of the expected high number of hazardous waste sites associated with the urban location of this component. • If this alternative were selected and permitted by the Corps, a detailed analysis of this component would be conducted.
Agricultural Water Transfer • N/A.

Table 5.22-1 (continued)
Summary of Impacts by Alternative

HAZARDOUS MATERIALS (continued)
TYPE OF POTENTIAL IMPACT Use, storage, and disposal of hazardous materials.
Proposed Action (Alternative 1a)
Gross Reservoir Expansion[2] • Compliance with State and Federal regulations would result in low potential for adverse impacts.
Alternative 1c
Gross Reservoir Expansion • Same as Proposed Action.
Leyden Gulch Reservoir • Same as Proposed Action.
Alternative 8a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Proposed Action.
Conduit O • Same as Proposed Action.
Alternative 10a
Gross Reservoir Expansion • Same as Proposed Action.
Denver Basin Aquifer Facilities • Same as Proposed Action.
Conduit M • Same as Proposed Action.
Alternative 13a
Gross Reservoir Expansion • Same as Proposed Action.
South Platte River Facilities • Same as Proposed Action.
Conduit O • Same as Proposed Action.
Agricultural Water Transfer • N/A.

Notes:
[1] Changes in stream flow by river segment are described in Table 5.22-2.
[2] The acres assume disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).

AF = acre-feet
AF/yr = acre-feet per year
APE = Area of Potential Effects
AWTP = Advanced Water Treatment Plant
CDPHE = Colorado Department of Public Health and Environment
CO = carbon monoxide
Corps = U.S. Army Corps of Engineers
dBA = A-weighted decibel scale
ECA = Environmental Conservation Area
EPA = U.S. Environmental Protection Agency
FTE = full-time employee
NAAQS = National Ambient Air Quality Standards
NO_x = oxides of nitrogen
PCA = Potential Conservation Area
PIA = Primary Impact Area
PM_{10} = particulate matter less than 10 microns in diameter
WTP = Water Treatment Plant
WWTP = Wastewater Treatment Plant

Table 5.22-2
Summary of Impacts to River Segments

SURFACE WATER
PROPOSED ACTION (ALTERNATIVE 1A)[1]
Affected River Segments
Fraser River • Additional Denver Water diversions would occur in average and wet years, would be highly concentrated during the runoff months primarily in May, June, and July, and typically would be greatest in wet years following dry year sequences. • Annual peak flows would generally be the same or lower under the Proposed Action, implying the same or reduced areas of inundation for the flood of a given return interval. Lower frequency flood events (return intervals greater than 2 to 5 years) are likely to be the same, while higher frequency events are likely to be reduced.
Williams Fork River • Additional Denver Water diversions would occur in average and wet years, would be highly concentrated during the runoff months primarily in May, June, and July, and typically would be greatest in wet years following dry year sequences. • Annual peak flows would be generally the same or lower under the Proposed Action, implying the same or reduced areas of inundation for the flood of a given return interval. Lower frequency flood events (return intervals greater than 2 to 5 years) are likely to be the same, while higher frequency events are likely to be reduced.
Colorado River • Flows along the Colorado River mainstem would decrease in average and wet years during the runoff months due to changes in surface water flows in the Fraser, Williams Fork, and Blue river basins which would be translated downstream and into the Colorado River. • Annual peak flows would be generally the same or lower under the Proposed Action, implying the same or reduced areas of inundation for the flood of a given return interval. Lower frequency events (return intervals greater than 2 to 5 years) are likely to be the same, while higher frequency events are likely to be reduced.
Blue River • Flows in the Blue River Basin would decrease in average and wet years during summer months and increase slightly during winter months due to differences in Roberts Tunnel diversions and spills at Dillon Reservoir. Flow changes in the Blue River Basin would be driven primarily by the seasonal shift in WTP operations. There would be a reduction in winter operations of Foothills and Marston WTP because the Moffat WTP would operate at a minimum level during the winter. • On the Blue River below Dillon Reservoir, annual peaks for recurrence intervals greater than 5 years increase, by less than 5%.
South Boulder Creek • Flows in South Boulder Creek upstream of Gross Reservoir would increase in average and wet years during the runoff months due to Denver Water's additional diversions through the Moffat Tunnel. From Gross Reservoir to the South Boulder diversion structure, changes in flow reflect Gross Reservoir operations. In general, flows would be higher during winter months as water would be moved out of Gross Reservoir and into Ralston Reservoir in response to the WTP load shift. Increases in outflow from Gross Reservoir would generally be greatest in dry years because Denver Water would typically draw more water from their North System storage as a drought begins. Flows during the summer would be lower on average because Foothills and Marston WTPs would meet a greater portion of the overall demand during these months so Gross Reservoir releases would decrease. Downstream of the South Boulder Diversion Canal, flows would generally decrease on average because Denver Water would divert more native South Boulder Creek water. • On South Boulder Creek above Gross Reservoir, floodplain areas would be unaffected. Below Gross Reservoir, annual peaks for recurrence intervals of 2 or more years would typically drop by 10%.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

SURFACE WATER (continued)
North Fork South Platte River • Flows in the North Fork South Platte River would decrease on average during winter months and increase during summer months. Flow changes in the North Fork South Platte River would be driven primarily by the seasonal shift in WTP operations. Diversions through the Roberts Tunnel during winter months would be lower on average, which results in equivalent lower flows in the North Fork South Platte River in these months. Summer diversions through Roberts Tunnel would generally be higher, and consequently flows would be higher on average from May through September. • Annual peak flows are virtually the same for all flood flows with an estimated recurrence interval of 2 years or more.
South Platte River • Flows changes along the South Platte River would vary depending on the location. Flow changes upstream of the Waterton gage would be relatively minor. South Platte River flows at the Waterton gage would decrease on average in summer months due to Denver Water's additional direct diversions and exchanges to Strontia Springs Reservoir and Conduit 20. There would be little change in flows at the Waterton gage in most winter months. Between the South Platte River at Waterton gage and South Platte River at Henderson gage, flows would increase on average during winter months due primarily to additional effluent returns at the Littleton-Englewood (Bi-City) WWTP and the Metro Wastewater Reclamation District Plant (Metro WWTP) and return flows accruing to the river due to Denver Water's outdoor water usage. • Annual peak flows would generally be at the same or smaller along the South Platte River mainstem, for all recurrence intervals greater than or equal to 2 years.
ALTERNATIVE 1C
Affected River Segments
Fraser River • The water sources for Alternative 1c are the same as the Proposed Action. Thus, impacts to surface water resources due to increased diversions of surface water are similar to those described for the Proposed Action.
Williams Fork River • Same as Fraser River summary.
Colorado River • Same as Fraser River summary.
Blue River • Same as Fraser River summary.
South Boulder Creek • The water sources for Alternative 1c are the same as the Proposed Action. Thus, impacts on surface water resources due to increased diversions of surface water are similar to those described for the Proposed Action. However, from Gross Reservoir to the South Boulder diversion structure, differences in flow changes between Alternative 1c and the Proposed Action are greater because of the timing and quantity of water that would be released from Gross Reservoir to Leyden Gulch Reservoir. In general, flows during summer months would be higher as more water would be released to Leyden Gulch Reservoir. During the winter, flows would be less compared to the Proposed Action. • The reductions in annual floods on South Boulder Creek below Gross Reservoir are not as pronounced, because of the smaller reservoir size.
North Fork South Platte River • Same as Fraser River summary.
South Platte River • Same as Fraser River summary.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

SURFACE WATER (continued)
ALTERNATIVES 8A AND 10
Affected River Segments
Fraser River • The water sources for Alternatives 8a and 10a are similar to the Proposed Action; however, this alternative includes reusable water on the East Slope for a portion of the new supply. As a result, West Slope diversions would be slightly lower while diversions of reusable water from the South Platte River would be higher on average compared to the Proposed Action. Impacts to surface water resources in the Fraser and Williams Fork river basins would be slightly less than those described for the Proposed Action.
Williams Fork River • Same as Fraser River summary.
Colorado River • Same as Fraser River summary.
Blue River • Same as Fraser River summary.
South Boulder Creek • Same as Fraser River summary. • The reductions in annual floods on South Boulder Creek below Gross Reservoir are not as pronounced, because of the smaller reservoir size.
North Fork South Platte River • Same as Fraser River summary.
South Platte River • The water sources for Alternatives 8a and 10a are similar to the Proposed Action; however, this alternative includes reusable water on the East Slope for a portion of the new supply. As a result, diversions of reusable water from the South Platte River would be higher on average compared to the Proposed Action. For the reach downstream of the Metro WWTP, average annual flows would be slightly lower than the Proposed Action.
ALTERNATIVE 13A
Affected River Segments
Fraser River • The water sources for Alternative 13a are similar to the Proposed Action; however, this alternative includes transferred agricultural water on the East Slope for a portion of the new supply. As a result, West Slope diversions would be slightly lower on average compared to the Proposed Action. Impacts to surface water resources in the Fraser and Williams Fork river basins would be slightly less than those described for the Proposed Action.
Williams Fork River • Same as Fraser River summary.
Colorado River • Same as Fraser River summary.
Blue River • Same as Fraser River summary.
South Boulder Creek • Same as Fraser River summary. • The reductions in annual floods on South Boulder Creek below Gross Reservoir are not as pronounced, because of the smaller reservoir size.
North Fork South Platte River • Same as Fraser River summary.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

SURFACE WATER (continued)
South Platte River
• The water sources for Alternative 13a are similar to the Proposed Action; however, this alternative includes transferred agricultural water on the East Slope for a portion of the new supply. As a result, diversions from the Moffat Collection System would be slightly lower. Diversions of transferred agricultural water from the South Platte River would have little effect on flows since historic return flows would be maintained. Impacts to surface water resources in the South Platte River Basin would be similar to those described for the Proposed Action.
WATER QUALITY
PROPOSED ACTION (ALTERNATIVE 1A)[1]
Affected River Segments
Fraser River
• Available data does not support a direct statistical correlation between water temperature and flow. The number of days near or above stream temperature standards is not anticipated to increase. Segments of the Fraser River are 303(d) listed for temperature, and the additional impact due only to the Proposed Action is considered negligible to minor. • The Ranch Creek tributaries are not anticipated to experience an increase in the number of days of temperature near, at, or above the regulatory standard. • The impact of acute low flow decreases on WWTPs is unknown and will be dependent on future operations and facilities. • No impacts are expected from changes in tributary flows or water quality. • Negligible to minor nutrient concentration increases due to the Project are anticipated in the Fraser River. These Project-related anticipated changes are small relative to changes anticipated due to population growth, increased WWTP flows, and anticipated changes in WWTP treatment efficiency.
Williams Fork River
• Changes are anticipated to be negligible in the Williams Fork River and Williams Fork Reservoir.
Colorado River
• Available data does not support a direct statistical correlation between water temperature and flow. The number of days near or above stream temperature standard is not anticipated to increase. The Colorado River is 303(d) listed for stream temperature, but the additional impact due only to the Proposed Action is considered negligible. • No impacts are anticipated to WWTPs. Negligible impacts are expected in the Three Lakes area.
Blue River
• The Blue River may experience a greater percentage of treated wastewater as compared to releases from Dillon Reservoir during October of wet years. • Acute low flows are anticipated to increase; a benefit to the Joint Sewer Authority WWTP. • Other changes are not anticipated.
South Boulder Creek
• Water quality changes are not anticipated between the Moffat Tunnel discharge and Gross Reservoir. With the enlargement of Gross Reservoir, short-term minor changes in downstream water quality changes are anticipated due to inundation of new areas for reservoir expansion. • Due to the short-term changes in Gross Reservoir water quality, a short-term increase in Total Organic Compound in the influent to Moffat WTP is likely. • In South Boulder Creek, downstream of Gross Reservoir to the diversion to Ralston Reservoir, long-term decreases in summer water temperatures are anticipated, due to the enlargement of Gross Reservoir.
North Fork South Platte River
• Minor changes in the concentrations of copper, iron, and nickel are anticipated to be minor. The concentration of these parameters is anticipated to increase during periods of reduced deliveries from the Roberts Tunnel. Concentrations are anticipated to decrease during periods of increased deliveries through the Roberts Tunnel.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

WATER QUALITY (continued)
South Platte River • Water quality impacts are not anticipated except for minor changes in metals as noted on the North Fork South Platte River.
ALTERNATIVE 1C
Affected River Segments
Fraser River • Changes in water quality for Alternative 1c are anticipated to be similar to the Proposed Action.
Williams Fork River • Changes in water quality for Alternative 1c are anticipated to be similar to the Proposed Action.
Colorado River • Changes in water quality for Alternative 1c are anticipated to be similar to the Proposed Action.
Blue River • Changes in water quality for Alternative 1c are anticipated to be similar to the Proposed Action.
South Boulder Creek • Changes in water quality in Boulder Creek and Gross Reservoir are anticipated to be similar to the Proposed Action. • Water quality in Leyden Gulch Reservoir could potentially be lower than in Gross Reservoir under Current Conditions (2006).
North Fork South Platte River • Changes in water quality for Alternative 1c are anticipated to be similar to the Proposed Action.
South Platte River • Changes in water quality for Alternative 1c are anticipated to be similar to the Proposed Action.
ALTERNATIVES 8A AND 10A
Affected River Segments
Fraser River • Changes in water quality for Alternatives 8a and 10a are anticipated to be similar to the Proposed Action.
Williams Fork River • Changes in water quality for Alternatives 8a and 10a are anticipated to be similar to the Proposed Action.
Colorado River • Changes in water quality for Alternatives 8a and 10a are anticipated to be similar to the Proposed Action.
Blue River • Changes in water quality for Alternatives 8a and 10a are anticipated to be similar to the Proposed Action.
South Boulder Creek • Changes in water quality for Alternatives 8a and 10a are anticipated to be similar to the Proposed Action.
North Fork South Platte River • Changes in water quality for Alternatives 8a and 10a are anticipated to be similar to the Proposed Action.
South Platte River • Changes in water quality for Alternatives 8a and 10a are anticipated to be similar to the Proposed Action.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

WATER QUALITY (continued)
ALTERNATIVE 13A
Affected River Segments
Fraser River • Changes in water quality for Alternative 13a are anticipated to be similar to the Proposed Action.
Williams Fork River • Changes in water quality for Alternative 13a are anticipated to be similar to the Proposed Action.
Colorado River • Changes in water quality for Alternative 13a are anticipated to be similar to the Proposed Action.
Blue River • Changes in water quality for Alternative 13a are anticipated to be similar to the Proposed Action.
South Boulder Creek • Changes in water quality for Alternative 13a are anticipated to be similar to the Proposed Action.
North Fork South Platte River • Changes in water quality for Alternative 13a are anticipated to be similar to the Proposed Action.
South Platte River • Changes in water quality for Alternative 13a are anticipated to be similar to the Proposed Action.
CHANNEL MORPHOLOGY
PROPOSED ACTION (ALTERNATIVE 1A)[1]
Affected River Segments
Fraser River • For a majority of areas in the Fraser River Basin, decreases in flow would result in a decrease in sediment transport capacity and supply in the Fraser River Basin. Phase 2 sediment transport is predicted to continue at a similar frequency. Larger flood events like the 5- and 10-year event are expected to occur at somewhat reduced frequencies. Additional temporary localized sediment deposition is expected to occur; however, it should be limited in extent and magnitude. Given the relatively unchanged frequency of Phase 2 transport, no long-term changes in channel morphology are predicted. • Stream segments located directly downstream of diversions with no bypass flows are predicted to behave differently than other locations. In these locations, Phase 2 sediment transport is predicted to occur very rarely and large peak flows are predicted to occur somewhat less frequently, suggesting that existing aggradation and vegetative encroachment may be accelerated.
Williams Fork River • Decreases in flow would result in a decrease in sediment transport capacity and supply in the Williams Fork River Basin. Phase 2 sediment transport is predicted to continue to occur at a similar frequency. Larger flood events like the 5- and 10-year event are expected to occur with the same frequency. Additional temporary localized sediment deposition is expected to occur; however, it should be limited in extent and magnitude. Given the relatively unchanged frequency of Phase 2 transport no long-term changes in channel morphology are predicted.
Colorado River • Decreases in flow would result in a decrease in sediment transport capacity in the Colorado River. Localized sediment deposition is anticipated to continue, particularly upstream of the confluence with the Williams Fork due the low frequency of Phase 2 transport. **However,** the frequency of Phase 2 transport and larger flood events such as the 5- and 10-year floods are generally unchanged by the Proposed Action, leading to the conclusion that systematic shifts in channel morphology are not anticipated.
Blue River • Flow changes would result in a slight decrease in sediment transport capacity in the Blue River. Localized sediment deposition is anticipated to continue. The frequency of Phase 2 sediment transport and 5- and 10-year floods are predicted to remain generally unchanged; therefore, systematic shifts in channel morphology are not anticipated.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

CHANNEL MORPHOLOGY (continued)
South Boulder Creek • Increases in flow would result in an increase in sediment transport capacity along South Boulder Creek upstream of Gross Reservoir. Flows initiating Phase 2 transport would occur more frequently as a result of the Proposed Action. Increases in sediment transport capacity in South Boulder Creek could lead to additional localized bed and bank erosion and additional bank stabilization may be required. Systematic shifts in channel morphology are not anticipated. • Planned operations of Gross Reservoir would limit peak releases into South Boulder Creek downstream of the reservoir. Reductions in peak flows will reduce the frequency of larger flood events and Phase 2 sediment transport, however flow changes are not predicted to cause systematic shifts in channel morphology.
North Fork South Platte River • Increases in flow would result in an increase in sediment transport capacity along the North Fork South Platte River. Flows initiating Phase 2 transport would occur more frequently as a result of the Proposed Action. Increases in sediment transport capacity in the North Fork South Platte River could lead to additional localized bed and bank erosion and additional bank stabilization may be required. Systematic shifts in channel morphology are not anticipated.
South Platte River • Given the flow changes predicted along the South Platte River, impacts to channel morphology are not anticipated.
ALTERNATIVE 1C
Affected River Segments
Fraser River • The water sources for Alternative 1c are the same as the Proposed Action. Thus, impacts to channel morphology due to increased diversions of surface water are similar to those described for the Proposed Action.
Williams Fork River • Same as Fraser River summary.
Colorado River • Same as Fraser River summary.
Blue River • Same as Fraser River summary.
South Boulder Creek • Same as Fraser River summary.
North Fork South Platte River • Same as Fraser River summary.
South Platte River • Same as Fraser River summary.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

CHANNEL MORPHOLOGY (continued)
ALTERNATIVES 8A AND 10A
Affected River Segments
Fraser River • The water sources for Alternatives 8a and 10a are similar to the Proposed Action; however, this alternative includes reusable water on the East Slope for a portion of the new supply. As a result, West Slope diversions would be slightly lower while diversions of reusable water from the South Platte River would be higher on average compared to the Proposed Action. Impacts to channel morphology would be similar to those described for the Proposed Action.
Williams Fork River • Same as Fraser River summary.
Colorado River • Same as Fraser River summary.
Blue River • Same as Fraser River summary.
South Boulder Creek • Same as Fraser River summary.
North Fork South Platte River • Same as Fraser River summary.
South Platte River • Same as Fraser River summary.
ALTERNATIVE 13A
Affected River Segments
Fraser River • The water sources for Alternative 13a are similar to the Proposed Action; however, this alternative includes transferred agricultural water on the East Slope for a portion of the new supply. As a result, West Slope diversions would be slightly lower on average compared to the Proposed Action. Impacts to channel morphology would be similar to those described for the Proposed Action.
Williams Fork River • Same as Fraser River summary.
Colorado River • Same as Fraser River summary.
Blue River • Same as Fraser River summary.
South Boulder Creek • Same as Fraser River summary.
North Fork South Platte River • Same as Fraser River summary.
South Platte River • Same as Fraser River summary.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

GROUNDWATER
PROPOSED ACTION (ALTERNATIVE 1A)[1]
Affected River Segments
Fraser River • Decreases in stream flows in an average year would occur below Denver Water diversion points during seasonal runoff. Changes in the level of the river would cause indirect, localized short-term impacts to groundwater levels near the stream, but the magnitude of these changes would be small, similar to the changes in stream levels. A WWTP in the upper reach of the Fraser River Basin discharges effluent into the river. If the quality of the stream water downstream of the WWTP effluent discharge point is degraded, this may adversely impact groundwater quality if there are any localized reaches where the stream level is substantially higher than the adjacent groundwater level. Data indicate the overall hydrologic pattern is that the groundwater levels are higher than the adjacent stream level. Thus a groundwater quality impact is not expected. Natural attenuation of undesirable constituents (e.g., nutrients) in the stream water, and along the streambed-groundwater interface, would further minimize the effects on groundwater quality.
Williams Fork River • The indirect impacts to groundwater level elevations would be similar to, but less than, those for the Fraser River.
Colorado River • Decreases in flows for an average year would occur downstream of the Windy Gap gage and the Kremmling gage. These decreases in surface water flow would result in lower river water levels, a slightly narrower width of the river, and the potential for indirect impacts on the groundwater levels in the vicinity of the river.
Blue River • The indirect impacts to groundwater levels would be similar to, but less than, those for the Fraser River. • There are several WWTPs in the upper reaches of the Blue River Basin that may create similar impacts as those described for the Fraser River. Natural attenuation of undesirable constituents in the Blue River and along the riverbed-groundwater interface would minimize the effects to groundwater quality.
South Boulder Creek • Above Gross Reservoir, flows would increase in the summer months and remain relatively unchanged during winter months of an average year. Below Gross Reservoir, flows would increase during winter months and would remain approximately the same during the summer months. The slight changes in groundwater levels would be limited to the area immediately adjacent to the stream.
North Fork South Platte River • Below the Geneva Creek gage, flows would decrease in winter and increase in summer in an average year. The groundwater level changes caused by the small changes in stream flow would be limited to the areas near the river.
South Platte River • Below Chatfield Reservoir and at the Denver gage, flows would increase in the winter and decrease in late summer in an average year. The groundwater level changes caused by the small changes in stream flow would be limited to the areas near the river.
ALTERNATIVE 1C
Affected River Segments
Fraser River • The water sources for Alternative 1c are the same as the Proposed Action. Thus, impacts to groundwater resources due to increased diversions of surface water on the West Slope are similar to those described for the Proposed Action.
Williams Fork River • Same as Fraser River summary.
Colorado River • Same as Fraser River summary.
Blue River • Same as Fraser River summary.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

GROUNDWATER (continued)
South Boulder Creek • Same as Fraser River summary.
North Fork South Platte River • Same as Fraser River summary.
South Platte River • Same as Fraser River summary.
ALTERNATIVES 8A AND 10A
Affected River Segments
Fraser River • The water sources for Alternatives 8a and 10a are the same as the Proposed Action; however, this alternative includes reusable water on the East Slope for a portion of the new supply. Impacts to groundwater resources would be similar, but less than those described for the Proposed Action due to reusable water component.
Williams Fork River • Same as Fraser River summary.
Colorado River • Same as Fraser River summary.
Blue River • Same as Fraser River summary.
South Boulder Creek • Same as Fraser River summary.
North Fork South Platte River • Same as Fraser River summary.
South Platte River • Same as Fraser River summary.
ALTERNATIVE 13A
Affected River Segments
Fraser River • The water sources for Alternative 13a are the same as the Proposed Action; however, this alternative includes transferred agricultural water on the East Slope for a portion of the new supply. Impacts to groundwater resources would be similar, but less than those described for the Proposed Action due to the agricultural water component.
Williams Fork River • Same as Fraser River summary.
Colorado River • Same as Fraser River summary.
Blue River • Same as Fraser River summary.
South Boulder Creek • Same as Fraser River summary.
North Fork South Platte River • Same as Fraser River summary.
South Platte River • Same as Fraser River summary.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

RIPARIAN AND WETLAND AREAS
PROPOSED ACTION (ALTERNATIVE 1A)[1]
Affected River Segments
Fraser River • Changes in the amount and timing of diversions would result in minor changes to wetland and riparian habitat along the Fraser River and its tributaries, including changes in composition to more mesic vegetation in relatively small areas adjacent to the stream. • Changes in flow would have negligible or no effects to fens that occur along the Fraser River and its tributaries.
Williams Fork River • Changes in flows would have negligible or no effect on riparian and wetland areas along the upper Williams Fork, and negligible to minor effects along diverted tributaries. • Changes in flow would have negligible or no effects to fens that occur along the upper Williams Fork and its tributaries.
Colorado River • Changes in flows would result in negligible changes to wetland and riparian habitat.
Blue River • Changes in flows would result in minor changes to wetland and riparian habitat including changes in composition to more mesic vegetation in relatively small areas adjacent to the stream.
South Boulder Creek • Changes in flows would result in negligible to minor changes to wetland and riparian habitat including changes in composition to more mesic vegetation in relatively small areas adjacent to the stream.
North Fork South Platte River • Changes in flows would result in negligible changes to wetland and riparian habitat.
South Platte River • Changes in flows would result in negligible changes to wetland and riparian habitat.
ALTERNATIVES 1C, 8A, 10A, AND 13A
Affected River Segments
Fraser River • Same as Proposed Action.
Williams Fork River • Same as Proposed Action.
Colorado River • Same as Proposed Action.
Blue River • Same as Proposed Action.
South Boulder Creek • Same as Proposed Action.
North Fork South Platte River • Same as Proposed Action.
South Platte River • Same as Proposed Action.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

WILDLIFE
PROPOSED ACTION (ALTERNATIVE 1A)[1]
Affected River Segments
Fraser River • Minimal or no effect on wildlife habitat or species, including waterfowl, raptors and other migratory birds; moose and elk; small mammals and amphibians. Elk migration corridors, however, may be moderately affected. • Not likely to adversely affect USFS Management Indicator Species for riparian and wetland areas - Wilson's warbler and boreal toad. • Negligible or no effect on sensitive areas (Potential Conservation Area [PCA]) downstream of diversions.
Williams Fork River • Same as Fraser River summary.
Colorado River • Minimal or no effect on wildlife habitat or species, including waterfowl, raptors and other migratory birds; moose and elk; small mammals and amphibians. • Negligible or no effect on sensitive areas (State wildlife areas) downstream of diversions.
Blue River • Minimal or no effect on wildlife habitat or species, including waterfowl, raptors and other migratory birds; moose and elk; small mammals and amphibians. • Negligible or no effect on sensitive areas (PCA and State wildlife areas) downstream of diversions.
South Boulder Creek • Minimal or no effect on wildlife habitat or species, including waterfowl, raptors and other migratory birds; moose and elk; small mammals and amphibians. • Negligible or no effect on sensitive areas (PCA) downstream of diversions.
North Fork South Platte River • Minimal or no effect on wildlife habitat or species, including waterfowl, raptors and other migratory birds; moose and elk; small mammals and amphibians. • Negligible or no effect on sensitive areas (PCA) downstream of diversions.
South Platte River • Minimal or no effect on wildlife habitat or species, including waterfowl, raptors and other migratory birds; moose and elk; small mammals and amphibians. • Negligible or no effect on sensitive areas (PCA) downstream of diversions.
ALTERNATIVES 1C, 8A, 10A, AND 13A
Affected River Segments
Fraser River • Same as Proposed Action.
Williams Fork River • Same as Proposed Action.
Colorado River • Same as Proposed Action.
Blue River • Same as Proposed Action.
South Boulder Creek • Same as Proposed Action.
North Fork South Platte River • Same as Proposed Action.
South Platte River • Same as Proposed Action.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

SPECIAL STATUS SPECIES
PROPOSED ACTION (ALTERNATIVE 1A)[1]
Affected River Segments
Fraser River • Flow changes are likely to adversely affect Colorado River system endangered fish species (Colorado pikeminnow, bonytail chub, humpback chub, and razorback sucker). • Section 7 consultation would be required; mitigation would be done through payment of a one-time fee to support the recovery program. • Likely to adversely affect Greenback and Colorado River cutthroat trout through entrainment, but would not directly affect the conservation populations above the diversions. • No effect to Canada lynx. Negligible effects to river otter and boreal toad; no effects to other special status species.
Williams Fork River • Same as Fraser River summary.
Colorado River • Flow changes are likely to adversely affect Colorado River system endangered fish species (Colorado pikeminnow, bonytail chub, humpback chub, and razorback sucker). Section 7 consultation would be required; mitigation would be done through payment of a one-time fee to support the recovery program. • Negligible effects to river otter; no effect to other special status species.
Blue River • Flow changes are likely to adversely affect Colorado River system endangered fish species (Colorado pikeminnow, bonytail chub, humpback chub, and razorback sucker). Section 7 consultation would be required; mitigation would be done through payment of a one-time fee to support the recovery program. • Negligible effects to river otter; no effect to other special status species. • No effect to Canada lynx.
South Boulder Creek • Flow changes are likely to adversely affect Platte River system threatened and endangered species in Nebraska (whooping crane, piping plover, least tern, and pallid sturgeon). Section 7 consultation would be required. Depletions would be addressed under the SPWRAP. • Not likely to adversely affect Preble's meadow jumping mouse and habitat and Ute ladies'-tresses and their habitat downstream of South Boulder Diversion Canal diversion point. • No effect to other special status species. • No effect to Canada lynx.
North Fork South Platte River • Flow changes are likely to adversely affect Platte River system threatened and endangered species in Nebraska (whooping crane, piping plover, least tern, and pallid sturgeon). Section 7 consultation would be required. Depletions would be addressed under the SPWRAP. • Not likely to adversely affect Preble's meadow jumping mouse and critical habitat along the North Fork South Platte River. • Minimal or no effects to bald eagle. No effects to other special status species.
South Platte River • Flow changes are likely to adversely affect Platte River system threatened and endangered species in Nebraska (whooping crane, piping plover, least tern, and pallid sturgeon). Section 7 consultation would be required. Depletions would be addressed under the SPWRAP. • Not likely to adversely affect Preble's meadow jumping mouse and critical habitat between Waterton Canyon and Chatfield Reservoir, and habitat along the South Platte River between Cheesman Reservoir and Chatfield Reservoir. • Minimal or no effects to bald eagle. No effect to other special status species.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

SPECIAL STATUS SPECIES (continued)
ALTERNATIVES 1C, 8A, 10A, AND 13A
Affected River Segments
Fraser River • Same as Proposed Action.
Williams Fork River • Same as Proposed Action.
Colorado River • Same as Proposed Action.
Blue River • Same as Proposed Action.
South Boulder Creek • Same as Proposed Action.
North Fork South Platte River • Same as Proposed Action.
AQUATIC BIOLOGICAL RESOURCES
PROPOSED ACTION (ALTERNATIVE 1A)[1]
Affected River Segments
Fraser River • The Proposed Action would have adverse impacts to beneficial impacts on the macroinvertebrate and fish communities in the different segments of the Fraser River. • Reductions in runoff flows would tend to have an adverse impact in the upper Fraser River and a negligible to beneficial impact to the benthic macroinvertebrate and fish communities in the lower Fraser River. • In most of the Fraser River tributary streams, the reductions in runoff flows with the Proposed Action would result in a minor adverse impact compared to existing conditions. • In lower St. Louis Creek, the reductions in flow for much of the year would have negligible impacts on fish and macroinvertebrates. In the streams in the Englewood Ranch Gravity System, the minor changes in flow would result in negligible impacts.
Williams Fork River • The reductions in runoff flows would have a negligible impact on the macroinvertebrate and fish communities. • The reductions in flow for much of the year would have minor adverse effects on the fish and macroinvertebrates in McQueary, Jones, Bobtail, and Steelman creeks.
Colorado River • Negligible impacts on macroinvertebrate and fish communities.
Blue River • Negligible impacts on macroinvertebrate and fish communities.
South Boulder Creek • Increases in runoff flows would have minor adverse impacts to fish and macroinvertebrates in South Boulder Creek upstream of Gross Reservoir. • Downstream of Gross Reservoir, the increases in winter flow, reductions in runoff flows, and changes in water temperature would have a minor beneficial impact to fish and macroinvertebrates.
North Fork South Platte River • Increases in runoff flows and higher concentrations of copper would have a minor adverse impact to fish and macroinvertebrates.
South Platte River • Upstream of Chatfield Reservoir, there would be negligible impacts to fish and macroinvertebrates. More favorable winter flows would have a minor beneficial impact to fish and macroinvertebrates in the section of the South Platte River between Chatfield Reservoir and Bear Creek.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

AQUATIC BIOLOGICAL RESOURCES (continued)
ALTERNATIVES 1C, 8A, 10A, AND 13A
Affected River Segments
Fraser River • Same as Proposed Action.
Williams Fork River • Same as Proposed Action.
Colorado River • Same as Proposed Action.
Blue River • Same as Proposed Action.
South Boulder Creek • Same as Proposed Action.
North Fork South Platte River • Same as Proposed Action.
South Platte River • Same as Proposed Action.
RECREATION
PROPOSED ACTION (ALTERNATIVE 1A)[1]
Affected River Segments
Fraser River • During average and wet years, implementation would result in a long-term effect on boating. This would include a reduction in the average number of days boating could occur and an overall reduction in high flows. There would be no impact to boating in dry years. No negative impacts to fishing would occur, although possibly some improvements to the quality of fishing. • In some tributaries, flow reductions would result in negligible to minor effects on fishing.
Williams Fork River • There is no boating on the Williams Fork. No negative impacts to fishing are anticipated.
Colorado River • There would be negligible impacts on the boating experience in average and wet years and no effect in dry years. There would be no impact to fishing.
Blue River • There would be a reduction in the number of days available for boating and an overall reduction in high flows. No impact to fishing is expected.
South Boulder Creek • The overall impact on boating resulting from increased flows in upper South Boulder Creek would be beneficial (minor to moderate). Inundation of the Right In My Backyard rapid would be a major impact on whitewater boating. There may be a minor impact on the quality of fishing on upper South Boulder Creek due to a potential reduction in fish habitat. There would be a negligible effect on boating on lower South Boulder Creek. There would be a minor beneficial effect on fishing on lower South Boulder Creek due to reduced flows.
North Fork South Platte River • Increased flows would result in a moderate to major positive effect on boating. Minor shift in fishing season due to early increased flows.
South Platte River • Minor effects on boating due to flow reduction. Minor beneficial effects on fishing due to more favorable winter flows.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

RECREATION (continued)
ALTERNATIVES 1C, 8A, 10A, AND 13A
Affected River Segments
Fraser River • Same as Proposed Action.
Williams Fork River • Same as Proposed Action.
Colorado River • Same as Proposed Action.
Blue River • Same as Proposed Action.
South Boulder Creek • Same as Proposed Action.
North Fork South Platte River • Same as Proposed Action.
South Platte River • Same as Proposed Action.
VISUAL RESOURCES
PROPOSED ACTION (ALTERNATIVE 1A)[1]
Affected River Segments
Fraser River • Flow reductions above Crooked Creek would be approximately 30% for May, June, and July in average and wet years. Although the stream flows would not drop to the level of dry year flows, the difference would be noticeable and adverse. In the upper reaches, impacts would be adverse and moderate; however, flow changes would not fundamentally alter the character of the stream. Downstream of Crooked Creek, adverse impacts would be negligible to minor and would be noticeable only to highly skilled observers. In all other months, flow changes would be imperceptible to the casual observer. These visual impacts may also present an indirect, minor impact to recreation as a result of a temporary diminishment to the overall recreation experience during times of flow reductions.
Williams Fork River • Flow changes are not likely to be noticed by most observers. An exception to this statement would occur near the Steelman gage where flows would drop by over 30% in May during an average year, dropping from 9 cfs to 6 cfs with implementation of all Project alternatives. However, this would occur during a period when snow cover is usually present and therefore the flow changes may not be seen by many observers.
Colorado River • No impacts to visual resources or aesthetics on this river segment.
Blue River • Impacts to visual resources on the Blue River above Green Mountain Reservoir would be negligible. Below Green Mountain Reservoir, the flow changes would be imperceptible.
South Boulder Creek • Overall, visual impacts to South Boulder Creek above Gross Reservoir would be minor and beneficial. • Below Gross Reservoir, winter flows would increase noticeably, resulting in a beneficial impact. • Further downstream (near Eldorado Springs gage), the Proposed Action would result in no perceptible impacts to stream appearance or other visual resources and aesthetics.
North Fork South Platte River • Minor to moderate adverse visual impacts, including impacts to stream appearance and characteristics, are expected in all winter months of all years as a result of flow reductions on the North Fork South Platte River. • Flow increases in spring and summer months (i.e., naturally higher flow periods) would have no noticeable impacts on stream appearances.

Table 5.22-2 (continued)
Summary of Impacts to River Segments

VISUAL RESOURCES (continued)
South Platte River • Flow changes on the South Platte River, with the exception of immediately below Chatfield Reservoir, would be imperceptible to the casual observer.
ALTERNATIVES 1C, 8A, 10A, AND 13A
Affected River Segments
Fraser River • Same as Proposed Action.
Williams Fork River • Same as Proposed Action.
Colorado River • Same as Proposed Action.
Blue River • Same as Proposed Action.
South Boulder Creek • Same as Proposed Action.
North Fork South Platte River • Same as Proposed Action.
South Platte River • Same as Proposed Action.

Notes:
[1]The acres assume disturbance between the current reservoir pool elevation (7,282 feet) and elevation 7,410 feet. This includes disturbance associated with the expanded reservoir of the Environmental Pool for mitigation (elevation 7,406 feet).

cfs = cubic feet per second
N/A = not applicable
PCA = Potential Conservation Area
WTP = Water Treatment Plant
WWTP = Wastewater Treatment Plant

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