FINAL
BEAR CREEK RESERVOIR, CO
RECONNAISSANCE STUDY
SECTION 905(b) (WRDA 86) ANALYSIS
May 7, 2015

RECONNAISSANCE STUDY
SECTION 905(b) (WRDA 86) ANALYSIS
Bear Creek Reservoir, CO

1 PROJECT AND STUDY AUTHORITY

The Bear Creek Dam and Reservoir in the South Platte River Basin in Colorado was authorized by the Flood Control Act of 1968 Public Law 90-483. The authorized purposes are flood control, recreation, and fish and wildlife enhancement. Municipal or industrial water supply is authorized by the Water Supply Act of 1958. Authorizing language for construction of the project reads:

"The project for the Bear Creek Dam and Reservoir, South Platte River, Colorado, is hereby authorized substantially in accordance with the recommendations of the Chief of Engineers in Senate Document Numbered 87, Ninetieth Congress, at an estimated cost of $32,314,000."

The Energy and Water Development Appropriations Act of 1998 authorized study of Chatfield, Cherry Creek and Bear Creek for water supply reallocation. Legislative language reads:

"Chatfield, Cherry Creek, and Bear Creek Reservoirs, Colorado.—The Bill included an initial $100,000 for the Corps of Engineers to initiate a study of the potential for reallocation of storage at Chatfield, Cherry Creek, and Bear Creek Reservoirs from flood control to water supply."

In 1998, funding was provided to develop the Expedited Reconnaissance Study for Chatfield, Cherry Creek and Bear Creek, Colorado with the focus on Chatfield Reservoir. The Chatfield Reservoir Storage Reallocation Final Integrated Feasibility Report and Environmental Impact Statement (FR/EIS) was completed in September 26, 2013. The ASA(CW) approved the FR/EIS on May 29, 2014 and simultaneously issued a Record of Decision. A water storage agreement was executed between Colorado Department of Natural Resources (CDNR) and the U.S. Corps of Engineers (USACE or Corps) on October 9, 2014. Following the successful completion of the Chatfield study, interest has shifted to assessing the potential for reallocation at Bear Creek. Funds in the amount of $50,000 were appropriated in Fiscal Year 2014 to conduct the reconnaissance phase on Bear Creek.

2 STUDY PURPOSE

The purpose of this reconnaissance study is to determine if there is a federal interest by the Corps and a non-federal sponsor to pursue the investigation of water storage reallocation for Bear

Creek Dam and Reservoir Project through the completion of a Generation Investigation (GI) Study. A preliminary assessment of water supply and demand, engineering feasibility, and other technical issues regarding potential water storage reallocation at the Bear Creek Reservoir are presented in this report.

3 LOCATION OF STUDY, NON-FEDERAL SPONSOR AND CONGRESSIONAL DISTRICTS

3.1 Tri-Lakes Location

Bear Creek Reservoir, in conjunction with Chatfield and Cherry Creek Reservoirs (i.e., Tri-Lakes), were constructed by the Corps. The Tri-Lakes dams are systemically managed to protect the Denver Metro area from catastrophic floods that devastated the area periodically for more than 100 years. Construction of Cherry Creek Dam began in 1946 and was completed in 1950. Chatfield Dam was the second dam to be built; construction began in 1967 and was completed in 1975. Bear Creek Dam construction began in 1973 and was completed in 1977. Figure 1 shows the Tri-Lakes project locations within the greater Denver region.

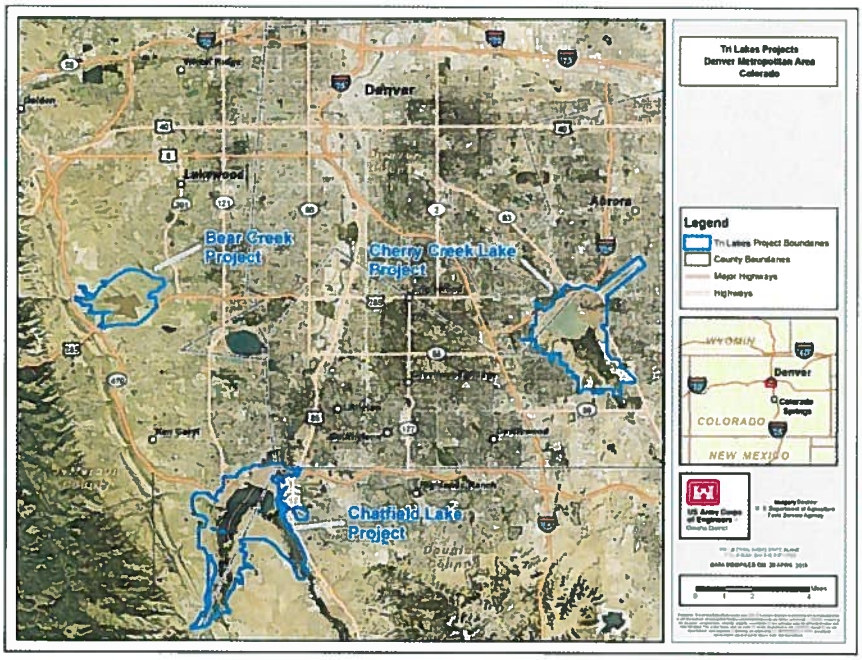

Figure 1: Tri-Lakes Project Locations within Greater Denver Region

3.2 Bear Creek Location

Bear Creek Dam and Reservoir is located in the Bear Creek Watershed and the South Platte River Basin. The Bear Creek Watershed is 236 square miles and extends from the Mount Evans Wilderness Area on the western end to the town of Morrison, Colorado on the eastern end. The

watershed includes all tributary water flows, including the two major tributaries (Bear Creek and Turkey Creek), that discharge into Bear Creek Reservoir. The South Platte River Basin has a drainage area of approximately 24,300 miles and is located in parts of Colorado, Wyoming and Nebraska.

The Bear Creek Dam and Reservoir Project is located on Bear Creek immediately below its confluence with Turkey Creek and downstream of Evergreen Lake and Dam, approximately 10 miles southwest of Denver, Colorado in Jefferson County. Figure 2 depicts the location of Bear Creek Lake Project in relation to Bear Creek, Turkey Creek, the South Platte River and Chatfield Lake Project.

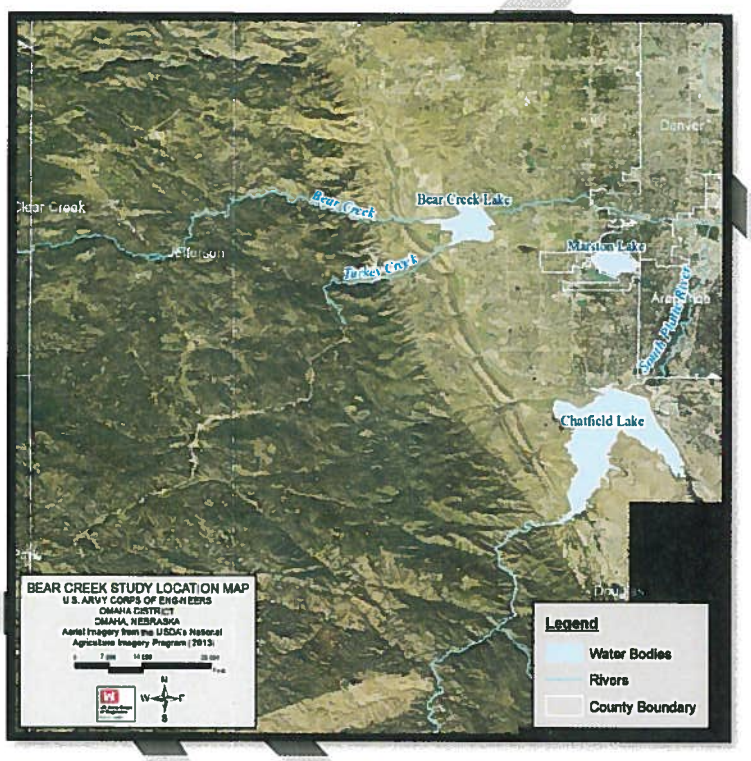

Figure 2: Bear Creek Study Location Map

3.3 Study Sponsor

The CDNR has expressed interest in a Bear Creek Reallocation Study based in part on findings from the "2010 Statewide Water Supply Initiative" developed by the Colorado Water Conservation Board, a division of CDNR. This report concludes the state's population is expected to double by the year 2050 with the majority of people living in the South Platte River and Arkansas River Basins, further increasing demand for water supply.

3.4 Congressional District Representation

The study area lies within the jurisdiction of Colorado's 7th Congressional District, represented by Ed Perlmutter. Colorado Senators are Michael Bennet and Cory Gardner.

4 PRIOR REPORTS AND EXISTING PROJECTS

4.1 House Document No. 669, 80th Congress, 2nd Session, 1948

This congressional document contained the Chief of Engineer's Report for the Bear Creek Project which provided an evaluation of the flood and related water problems of the South Platte River Basin based on levels of economic growth existing in 1945. The report included a plan for flood control on Bear Creek by means of a dam and reservoir, but the plan was not economically justified at that time (USACE, 1977). By the mid-1960s, development of housing and businesses along Bear Creek below the current dam site resulted in a favorable economic justification for construction of the Bear Creek Dam and Lake Project.

4.2 Design Memorandum (DM) No. PB-2, Preliminary Development and Site Selection, Bear Creek Dam and Lake, South Platte River, Colorado, October 1970

This DM submits the results of preliminary cost analyses and subsurface investigations in sufficient detail to indicate the most appropriate location for the dam axis and the major project structures. Included within this DM is documentation of the field review conference held in September 1970 regarding site selection for the Bear Creek Dam project that included members of the Omaha District, Missouri River Division and OCE offices of USACE.

4.3 Design Memorandum No. PB-6, General Design Memorandum, Bear Creek Dam and Lake, South Platte River, Colorado, March 1972

This DM submits a summary of the overall preliminary design of Bear Creek Dam and includes (1) the basic project plan, (2) major features of the project, and (3) a reliable cost estimate. This DM covers the analyses and coordination of all aspects of the project in order to (1) provide the basis for preparation of feature design memoranda, (2) determine all project purposes, (3) establish the scope of the project, based on current criteria and develop the most economical plan, in total cost, of the acceptable alternative plans studied, (4) establish operating requirements and determine that the project will meet such requirements, (5) coordinate the project plan with views of other governmental agencies and local interests, (6) provide the basis for a reliable, up-to-date estimate of project cost, (7) establish the current economic aspects of the project, and (8) facilitate the orderly scheduling and programming of funds for detailed design and construction of the project.

4.4 Design Memorandum No. PB-7, Embankment and Spillway, Bear Creek Dam and Lake, South Platte River, Colorado, July 1974

This DM presents the results of final studies, analyses, and laboratory testing pertaining specifically to the main and south embankments and the spillway. It covers the design of the main embankment, the supplemental earthfill dam (south embankment), and the spillway, and also presents a plan for handling drainage from Coyote Gulch.

4.5 Embankment Criteria and Performance Report, Bear Creek Dam and Lake, South Platte River, Colorado, June 1980

This report provides in one volume the significant information needed by engineers to (1) familiarize themselves with the project, (2) re-evaluate the embankment in the event unsatisfactory performance occurs, and (3) provide guidance for designing comparable future projects. The scope includes a summary record of significant design data, design assumptions, design computations, specification requirements, construction equipment, construction procedures, construction experience, field control test data, and an assessment of project performance.

4.6 Construction Foundation Report, Bear Creek Dam and Lake, South Platte River, Colorado, February 1983

This report documents the construction procedures and foundation conditions encountered during the design and construction of Bear Creek Dam. This information is useful for future work on the embankments, or for planning purposes on projects with similar design requirements.

4.7 Memorandum of Understanding (MOU), State of Colorado and the Corps, March 1988 regarding the regulation for Bear Creek Dam and Reservoir

This MOU allows for continuous gated release for water rights and/or water supply up to elevation 5559.0 feet. Releases below elevation 5559.0 feet are determined by the Colorado State Engineer's Office as needed to satisfy downstream water rights. Elevation 5559.0 feet is one foot into the flood storage zone and was selected to allow flexibility in targeting authorized pool levels. The Bear Creek Dam and Reservoir is to be regulated for flood control and multi-purpose usage by the state and Corps. In flood conditions, the Corps' Omaha District office retains authority to make all water release decisions.

4.8 Screening for Portfolio Risk Analysis (SPRA), Bear Creek Dam, 19 September 2009; [Revised February 2010 to reflect new information on the Probable Maximum Flood (PMF)]

A preliminary screening-level risk analysis was performed for Bear Creek Dam by an independent regional SPRA cadre in September 2009. The cadre conducted an evaluation and gave engineering ratings to potential failure modes for the major project features. All failure modes were evaluated for three hydrologic loading conditions (PMF, 300-year & 10-year) and two seismic loading conditions: Operating Basis Earthquake and Maximum Design Earthquake.

Life loss, economic damage, and loss of project benefit estimates were developed during the SPRA by the Omaha District.

The SPRA report is the official documentation of the initial Dam Safety Action Classification (DSAC) rating of 4 that was assigned to the main embankment of Bear Creek Dam by the Dam Safety Senior Oversight Group.

4.9 SPRA for Bear Creek Dam South Embankment, 3 November 2009

A preliminary screening-level risk analysis of the south embankment was performed for Bear Creek Dam by an independent regional SPRA cadre in November 2009. The SPRA report is the official documentation of the initial DSAC rating of 3 that was assigned to the south embankment structure by the Dam Safety Senior Oversight Group. This rating was primarily due to the high consequences resulting from potential failure of the embankment. Both the main and south embankments received an inadequate (I) engineering rating for the overtopping potential failure mode during an extreme event (for having less than the required freeboard).

4.10 Statewide Water Supply Initiative (SWSI), Colorado's Water Supply Future, 2010

The SWSI is a comprehensive study that was authorized by the Colorado Legislature in 2003. The CWCB is the lead agency for SWSI. Key analyses in this report are: water supply demands to 2050, non-consumptive needs in each basin, and water availability in the Colorado River Basin. Other elements are representative costs for water supply strategies and implementation associated with identified projects, water conservation agricultural transfers, and development of new water supplies.

4.11 A 2050 Vision for Colorado's Water Supply Future, 2010

Colorado's population is expected to nearly double within the next 40 years. Other pressures on Colorado's water supply include recurring drought conditions, the need to meet multiple water user needs (i.e., municipal, environmental, recreational) with limited water resources, and impacts to agriculture due to water shortages, urbanization, and transfers to new users. The CWCB has undertaken a visioning process to explore solutions to these future water supply challenges by engaging stakeholders across Colorado's multiple river basins. The *2050 Vision for Colorado's Water Supply Future* report recommends various portfolios depending on basin circumstances combining methods such as conservation, local water projects, new Colorado River development, and agricultural transfers.

4.12 Bear Creek Watershed Association (BCWA). 2011a. 2010 Annual Report for the Water Quality Control Commission

The BCWA is a local water quality management agency and watershed association for the Bear Creek Watershed, Colorado. The Association implements the *State of Colorado Bear Creek Reservoir Control Regulation* (Regulation #74). The control regulation assures watershed point

and nonpoint source water quality compliance consistent with adopted Colorado stream standards and classifications.

4.13 Bear Creek Dam Consequence Assessment Report, October 2011

The Consequence Assessment Report summarizes modeling efforts and consequence assessments conducted by the Modeling Mapping and Consequence Estimation (MMC) Production Center for Bear Creek Dam using a range of real world flood scenarios under normal and extreme hydrological conditions. The consequence report provides a basis for the loss of life estimates used in future semi-quantitative risk assessments.

4.14 Design Memorandum No. PB-10, Final Master Plan, Bear Creek Dam and Lake Project, South Platte River, Colorado, 2012

This master plan for the Bear Creek Dam and Lake Project updates the original 1980 Bear Creek Dam and Lake Master Plan and 1988 partial update. The Master Plan provides guidance for future development and maintenance of recreation opportunities, consistent with the project purposes of flood control, recreation, and fish and wildlife enhancement.

4.15 Chatfield Reservoir Storage Reallocation, Final Integrated Feasibility Report and Environmental Impact Statement, July 2013

The Chatfield Reservoir Storage Reallocation FR/EIS, approved May 29, 2014, evaluates the impacts of reallocation alternatives on the ecological, cultural, and aesthetic resources identified and investigated, and determined the financial feasibility and cost of water storage reallocation. The federally-owned Chatfield Reservoir provides an opportunity to reallocate 20,600 acre-feet of storage to help the state and water providers meet a growing demand for water in the Denver Metro area.

4.16 Engineering Regulation (ER) 1110-2-1156, "Safety of Dams – Policy and Procedures," 31 March 2014

This regulation prescribes the guiding principles, policy, organization, responsibilities, and procedures for implementation of risk-informed dam safety program activities and a dam safety portfolio risk management process within USACE. The purpose and intent of this regulation is to ensure that responsible officials at all levels within USACE implement and maintain a strong dam safety program in compliance with "Federal Guidelines for Dam Safety." The program ensures that all dams and appurtenant structures are designed, constructed, and operated safely and effectively under all conditions, based on the following dam safety and dam safety program purposes, as adopted by the Interagency Committee on Dam Safety (ICODS). Chapter 24 of ER 1110-2-1156 establishes policy and provides guidance on the impacts of dam safety deficiencies for storage allocation, reallocation, and related studies.

5 PROBLEMS AND OPPORTUNITIES

The primary water resource problem to be addressed is the inadequate supply of water to meet increasing water supply demand in the Denver Metro area over the next 50 years due to the combined effects of population growth, depletion of nonrenewable groundwater sources, and agricultural water providers' need for augmentation water for alluvial wells. Potential reallocation of storage space at Bear Creek Reservoir is just one of many opportunities that may help secure Colorado's water future.

5.1 Problem Statements

5.1.1 Population growth has resulted in increased Municipal and Industrial (M&I) water demands.

In the past, the Colorado water picture has been difficult to bring into focus given the multitude of individual water users and providers, the voluminous information available, and the complexity of developing water supply solutions. As a means to address the collective water communities' desire to understand their water supply situation, the CWCB undertook, at the direction of the Colorado General Assembly, the SWSI in 2003-2004 and 2009 to identify water supply needs now and in the future and inventory current and future projects and processes that local and regional entities are planning to fulfill the water supply needs.

In 2010, the state of Colorado's population was approximately 5.0 million. The CWCB SWSI estimates in 2050 the state's population will roughly double to between 8.6 and 10.3 million people. The majority of these people will live in the South Platte and Arkansas River basins. Figure 3 depicts population concentration in the South Platte River Basin with the most concentrated population density located along the Front Range urban corridor where the mountains meet the plains.

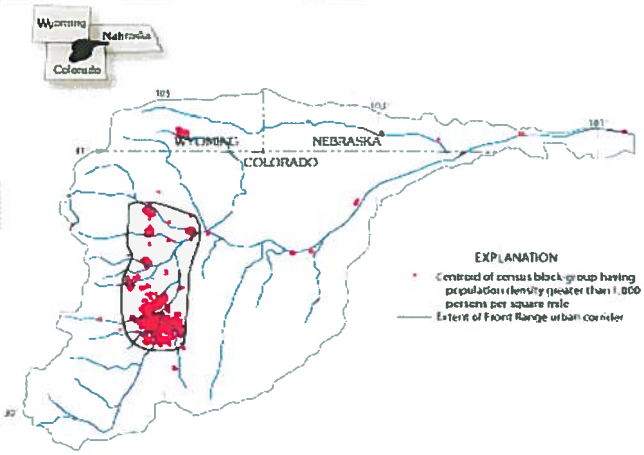

Figure 3: Population Concentration in the South Platte River Basin

Based upon the CWCB research, it is projected that 360,000 to 450,000 acre-feet of additional M&I water supply will be needed (known as the "gap") in the South Platte Basin including the

Denver Metro area. In addition to conservation and other measures, SWSI identified local plans for several "Identified Projects and Processes" (IPPs), in order to help meet the M&I needs and the needs of agricultural producers in northeast Colorado. Even with the IPPs and other measures, a significant water supply "gap" will still remain.

5.1.2 Water need has resulted in the reliance on non-renewable Denver Basin groundwater by some municipal and agricultural water providers.

Denver Basin groundwater for municipal water supplies has been determined to be an insufficient and unsustainable long-term source for water supply, a path of severely increasing costs and decreased water availability and reliability that will continue to worsen in the future (Black & Veatch et al., 2003). Additionally, ground water is not sustainable for agricultural water providers' need for augmentation water for alluvial wells. The water providers now using groundwater need to reduce dependency on this to preserve long-term availability of these sources during periods of drought. This water is legally reusable; however, the practical ability to reuse usually involves recapture (either downstream or upstream by exchange) and storage of effluent after discharge to a stream.

5.2 Opportunity Statements

5.2.1 There is an opportunity to potentially expand the use of an existing federal facility (Bear Creek Reservoir) to provide additional water supply storage.

To address the water shortages resulting from population growth, Colorado water providers have the options of either stretching existing supplies, developing new supplies, or, most likely, a combination of both. SWSI identifies several broad strategies for meeting the South Platte River Basin's future water needs including: development of additional storage, M&I reuse, agricultural water transfers, conjunctive use of surface and groundwater, and additional water conservation. Developing additional storage could include utilizing new storage projects or expanding the use of existing storage facilities, such as Bear Creek Reservoir. The major opportunity offered by the potential reallocation of storage space in Bear Creek Reservoir is that making storage space available in an existing structure may be lower cost and have less impact on the environment than constructing new storage facilities.

5.2.2 Ability to store augmentation water for future use exists.

The Bear Creek Reservoir storage reallocation project could potentially give agricultural water providers involved in the project the additional ability to store augmentation water for later release. Because Bear Creek flows into the South Platte River, some relief from the mandated well pumping curtailment situation may be provided.

5.2.3 Bear Creek Reservoir's on-channel location provides the opportunity to logistically and cost-effectively capture available flow.

The reservoir's location directly on Bear Creek and Turkey Creek, or "on-channel," allows the reservoir to immediately capture all available flows that can be legally stored. Bear Creek is a

tributary to the South Platte (see Figure 2). This is a significant advantage over off-channel reservoirs that are limited by the design capacity of diversion and delivery facilities. Additional storage in Bear Creek Reservoir could be operated in conjunction with existing off-channel storage facilities further downstream to allow certain water providers to maximize the capture of their junior water rights. The opportunity for recapture of reusable water for indirect reuse may also exist depending on water providers in the project.

5.2.4 Bear Creek Reservoir's location at a relatively high elevation within the basin provides opportunity to deliver water by gravity flow.

Bear Creek Reservoir's location and relatively high elevation within the watershed provides the opportunity to deliver water by gravity flow. The possibility exists for water providers who would potentially be involved in the project, to receive water deliveries directly from Bear Creek Reservoir releases. Because Bear Creek is a tributary to the South Platte, the need for constructing new conveyances (e.g., ditches, pump stations, and pipelines) is reduced.

5.2.5 Availability of storage potentially exists.

During the original site selection study for Bear Creek Dam, the crest elevation of the spillway was set to contain a predetermined surcharge storage above the flood pool. This increment of storage was recommended by the authorizing document to reduce the frequency of spillway operation and the magnitude of its discharges. During design, several spillway crest elevations were studied in combination with various spillway widths. It was concluded the optimum spillway (based on total earthwork costs for the project) was the current spillway configuration (crest at elevation 5667 and bottom width of 800 feet).

This resulted in a "perched" spillway with potential excess storage capacity in the reservoir between the flood control pool and the spillway crest. Flood control storage requirements for Bear Creek Dam were determined to be 26,290 acre-feet to control the Standard Project Flood. Because the spillway was constructed at elevation 5,667 feet Project Datum (PD), there was 55,290 acre-feet of storage at the crest of the spillway. Since 2,000 acre-feet of storage was required for sediment and 26,290 acre-feet of storage was required for flood control, the original design included approximately 27,000 acre-feet of storage capacity (surcharge) beyond requirements for the Standard Project Flood. The calculation is shown in Table 1.

Table 1: Potential Excess Storage Calculations

Reservoir Area	Acre-Feet
Spillway Crest Storage	55,290
Sediment Storage (minus)	-2,000
Flood Control Storage (minus)	-26,290
Potential Excess Storage Capacity	=27,000

It should be noted that the Standard Project Flood, which determines the flood control storage, is less severe than the Inflow Design Flood (IDF). Without structural modifications to the dam or

spillway, a significant portion or possibly all of the calculated excess storage in Table 1 is needed as surcharge storage to safely pass the IDF. Detailed analyses of the IDF and the availability of potential excess storage will be carried out during the feasibility study.

6 PLANNING GOALS AND OBJECTIVES

- Assess the potential to provide water supply from Bear Creek enabling water providers to meet the increasing demand of local users, mainly for municipal, industrial, and agricultural purposes.
- Maintain the primary flood control purpose in Bear Creek Reservoir. Avoid or minimize recreation and fish and wildlife impacts identified with a reallocation. Mitigate any recreation and environmental resources impacts which may result from a reallocation.

In addition to meeting the goals and objectives, the study will also assess impacts from water reallocation alternatives including: socio-economics, water rights, environmental laws and policies including the National Environmental Policy Act (NEPA), public concerns, downstream flow, and water quality.

7 PLANNING CONSTRAINTS AND CONSIDERATIONS

7.1 Constraints

7.1.1 Flood Risk Management Purpose

The Bear Creek, Cherry Creek and Chatfield Projects operate as a system providing critical flood protection to the Denver Metro area. Any reallocation at Bear Creek must not adversely impact the primary authorized purpose of flood risk management, operation of the reservoir, or operation of the Tri-Lakes system. If reallocation at Bear Creek is pursued, a Tri-Lakes system evacuation analysis would need to be performed to show how the reallocation at Bear Creek might impact the system. Figure 4 shows a similar analysis that was conducted for the Chatfield Reallocation.

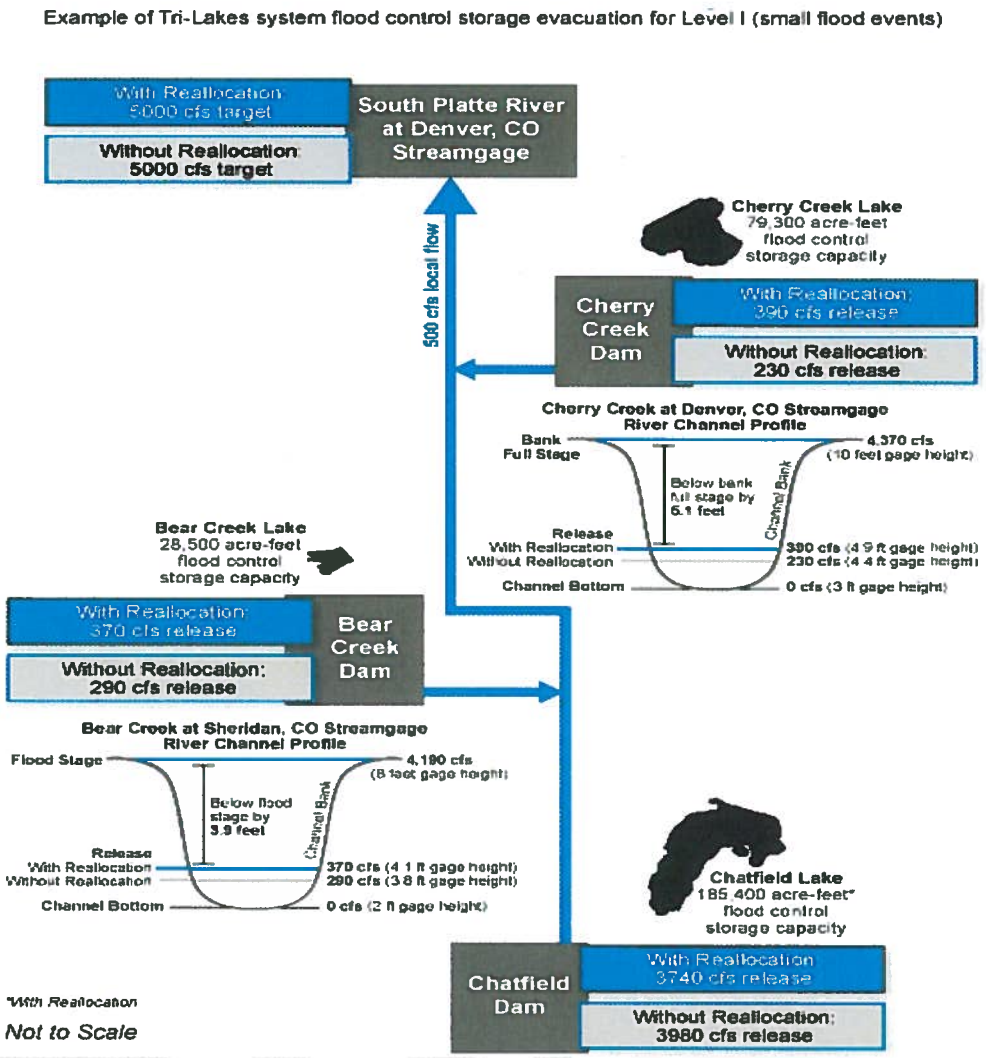

Figure 4: Tri-Lakes Flood Control Storage Evacuation for Small Flood Events (Level 1)
Prepared by the Omaha District Water Control and Water Quality Section for Chatfield Reallocation

Release decisions for the Tri-Lakes system are made by the Corps' Omaha District Office during flood events. Flood control storage evacuation for the system occurs when portions of two or more of the flood control storage zones of Cherry Creek, Chatfield and Bear Creek Reservoirs are occupied. An equal protective balance of remaining flood control storage should be maintained during the evacuation of these projects. This balance is based on establishing an equal risk in each project of filling the remaining flood control space from a similar subsequent flood.

The storage remaining should provide equal protection at each project against runoff from rainfall of standard project flood magnitude. System or coordinated regulation of the three projects in parallel will be necessary only after the cessation of flood inflows and during flood storage evacuation. All three of the projects release water contributing to the South Platte River at Denver, CO streamgage. The current Water Control Plan targets 5,000 cubic feet per second

(cfs), including incremental flow below the dams, at this stream gage. Table 2 shows the Bear Creek Reservoir flood control release rates based on pool elevation for individual operation.

Table 2: Bear Creek Reservoir Release Schedule

Elevation (ft)		Release Rate (cfs)
From	To	Streamflow up to
5558	5611.5	500
5611.5	5625	1000
5625	5635.5	1500
5635.5	5667	2000

Bear Creek flood control releases are controlled and regulated by two 3x6-foot slide service gates in the dome-type gated control structure buried under the embankment. The outlet works has discharge capacity of 2,160 cfs at elevation 5667.0 feet, which is the emergency spillway crest.

A gated outlet structure is located on the Harriman Canal in the south embankment. The invert elevation of the canal as it enters the south embankment is 5548.0 feet. In order to keep flood water stored in the reservoir from flowing into the Harriman Canal below the project, a gated control structure is located in this south embankment. This structure contains an 84x84-inch sluice gate. The conduit entering and leaving this structure is an 84 inch diameter reinforced concrete pipe and may require mitigation due to issues with long-term pressurization. This is explained in more detail in Section 8.3.1.6.

The historical record pool level of 5607.8 feet was set on September 21, 2013 after an estimated 5-6 inches, with a localized area of up to 8 inches, of rainfall occurred in the basin from September 9-16. The historical record daily inflow of 1,170 cfs also occurred during this event on September 17, 2013. Figure 5 depicts the reservoir elevation, inflow and release for this event.

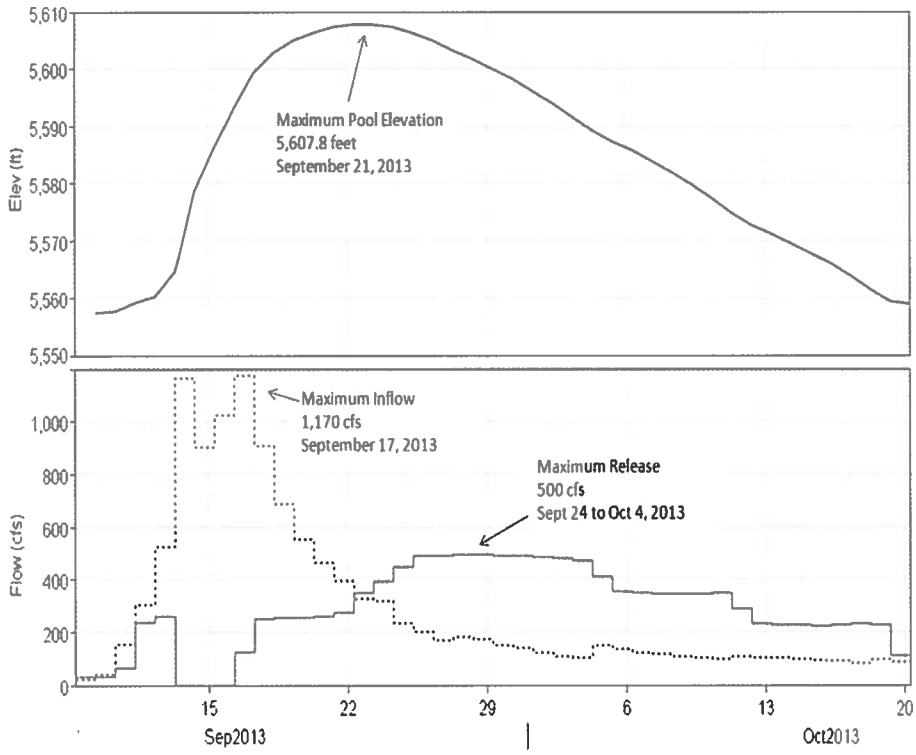

Figure 5: Bear Creek Reservoir Elevation, Inflow, and Release for the 2013 Rainfall Event

If this study proceeds to a feasibility study, an analysis of the impact of raising the top of the flood control pool on the IDF will be required. The original design of Bear Creek Dam had 5.0 feet of freeboard. A draft update of the IDF routings performed in 2012 using probable maximum precipitation data from Hydrometerological Report (HMR) 55A indicated that there is currently about 3.4 feet of freeboard. According to guidance in ER1110-8-2(FR), the minimum required freeboard at Bear Creek Dam is 3 feet since the reservoir level would be within three feet of maximum pool for less than 36 hours. The antecedent pool for the IDF routing was assumed to be the top of the flood control pool or elevation 5635.5 feet PD. If the top of the flood control pool is raised from elevation 5635.5 to 5659.6, this will have an impact on the maximum pool from the IDF routing. If the amount of freeboard is less than 3 feet, mitigation may be required to meet dam safety requirements. It is anticipated the IDF would be analyzed in greater detail during the feasibility study. A potential outcome would be a lower maximum pool occurring from the IDF routing which could allow for greater excess storage available for reallocation.

7.1.2 Impacts to Environmental Resources

Unavoidable impacts to environmental resources that are considered significant would need to be fully mitigated. This includes impacts to migratory bird habitat and wetlands. Costs of mitigation maintenance and monitoring costs, and any increase in Corps operation costs of a preferred alternative being implemented would be borne 100 percent by the non-federal sponsor in accordance with the 1958 Water Supply Act.

7.1.3 Environmental Compliance. The project must comply with the Clean Water Act and other applicable environmental laws and regulations. Other legal and policy constraints including compliance with county, state and federal permitting actions must be adhered to.

7.1.4 Dam Safety Compliance. The project must comply with all applicable USACE Dam Safety Policies and Guidance.

7.1.4.1 USACE Dam Safety Portfolio Risk Management, Dam Safety Action Classification and Storage Reallocation Study Policy.

Engineering Regulation (ER) 1110-2-1156, "Safety of Dams – Policy and Procedures" dated 31 March 2014, prescribes the guiding principles, policy, organization, responsibilities, and procedures for implementation of risk-informed dam safety program activities and a dam safety portfolio risk management process within USACE. USACE's dam safety portfolio risk management process is a series of hierarchical activities that are used to assess, classify, and manage the risks associated with the USACE inventory of dams. These activities include SPRA, development of Interim Risk Reduction Measure Plans (IRRMP), Issue Evaluation Studies (IES) and Dam Safety Modification Studies (DSMS).

USACE's DSAC System provides consistent and systematic guidelines for appropriate actions to address the dam safety issues and deficiencies of USACE dams. USACE dams are classified through a risk assessment process into five DSAC ratings which represent varying levels of urgency of action and incremental flood risk (ranging from DSAC 1 dams having the highest urgency for action and typically the highest risk level to DSAC 5 dams considered to have very low risk and that meet all essential USACE guidelines). DSAC considers event probability, probability of failure, and the incremental inundation consequences, given the physical properties of the dam.

Chapter 24 of ER 1110-2-1156 establishes policy and provides guidance on the impacts of dam safety deficiencies for storage allocation, reallocation, and related studies. Para. 24.4.1.1 states "a reallocation that would require raising the conservation pool is not permitted while a project is classified DSAC 1, 2, or 3." Para. 24.4.2 states that for DSAC 4 dams "recommendations for reallocations that would require raising the conservation pool will be considered by Headquarters USACE (USACE Dam Safety Officer [DSO] and Headquarters' Planning and Policy Division) on a case-by-case basis. Reallocation reports that recommend pool raises must include a review of the Potential Failure Mode Analysis for the dam and an analysis of the effect of a higher pool elevation on the probability of failure and consequences associated with the changed pool elevation. Para. 24.7.1 states "reallocation Studies are not allowed at projects where a DSAC 1, 2, or 3 is currently assigned to the dam, levees, dikes, or appurtenant structures, except when approved by the USACE DSO." Preliminary planning and the requests for exception must be coordinated among the District, MSC and HQ DSOs, District, Major Subordinate Command

(MSC), and Headquarters Planning Division Chiefs, and the Water Management and Reallocation Studies Planning Center of Expertise.

Requests for exceptions must address the following considerations: (1) a clear and consistent logic outlining why the project should be granted an exception, including the purpose and need for the proposed study or action; (2) the sponsor must be well-informed, including in writing, of the financial risks and acknowledge the information in a letter; (3) identification of all stakeholders or stakeholder groups, upstream and downstream, that must be informed and invited to participate in the study; (4) the study schedule and availability of necessary funding to complete all analyses, including the requirements of this chapter and other relevant guidance, policy, law, and regulations.

Paragraph 24.7.6 states "in all cases, prior to initiation of a reallocation study, the non-Federal entity must be informed, in writing, by the District Commander of the project's DSAC and the current status of the dam and reservoir; that dam safety risks are dynamic and future performance could require elevated monitoring and evaluation, IRRM or other remediation; the restrictions and conditions imposed by this ER; that water supply storage may be reduced by IRRM or other remediation; and that, upon, execution of a water storage or surplus water agreement, the non-Federal entity will be required to share in the costs of IRRM and other remediation consistent with current policy. The non-Federal entity must submit a Letter of Intent that includes their understanding of the costs typically associated with reallocation, including potential costs of modifications for Dam Safety related reasons."

7.1.4.2 Risk Assessment History and DSAC for Bear Creek Dam.
SPRA evaluations for the main embankment and the south embankment of Bear Creek Dam were conducted in September and November 2009, respectively. In January 2010, the main embankment was assigned a DSAC rating of 4 (low urgency of action) and the south embankment was assigned a DSAC rating of 3 (moderate urgency of action). The south embankment was given a DSAC 3 rating primarily due to the high consequences resulting from potential failure of the embankment. In addition, both the main and south embankments received an inadequate (I) engineering rating for the overtopping potential failure mode during an extreme event (for having less than the required freeboard). By virtue of its current individual rating of the south embankment, the entire Bear Creek Dam Project is currently rated as DSAC 3 (moderate urgency of action). As per ER1110-2-1156, all significant and high hazard potential dams operated and maintained by USACE must undergo a Periodic Assessment (PA) on a routine and systematic schedule not to exceed ten fiscal years. Periodic assessments consist of a site visit, typically in conjunction with a periodic inspection, a potential failure modes analysis, and a risk assessment based on existing data and estimated potential consequences. The next re-evaluation of the risk associated with the Bear Creek Dam is scheduled for FY16 when a PA is scheduled. The DSAC rating of the dam will be re-evaluated during the PA process.

Due to the current DSAC 3 rating for the Bear Creek Dam Project, a reallocation study is not allowed unless an exception is approved by the USACE Dam Safety Officer. This exception is required prior to the initiation of the study. The current DSAC rating for Bear Creek Dam should be considered a significant constraint for the proposed feasibility study and storage reallocation at Bear Creek Dam.

7.1.5 Land Development Guidance

Design, materials, and elevations of recreation modification structures need to comply with the provisions of the Northwest Division (NWD) Regulation 1110-2-5, Land Development Guidance at Corps Reservoir Projects, as coordinated with Corps, Omaha District staff.

7.2 Planning Considerations

In addition to the specific planning constraints, some additional considerations were identified that will need to be evaluated during any feasibility study.

7.2.1 Water Quality Purpose

Water quality (WQ) concerns regarding storage reallocation at Bear Creek Reservoir are due to the potential increase in reservoir hypolimnetic volume. Increased hypolimnetic oxygen depletion, internal nutrient loading, and liberation of sediment bound metals could result from an expansion of the hypolimnion. Hypoxic conditions have been monitored in the past during periods of thermal stratification; however, the reservoir aeration system has helped to address the problem. An expanded reservoir aeration system could potentially mitigate the increased hypolimnetic oxygen demand if storage reallocation was desired. A secondary WQ concern is the potential increase in E. coli/fecal coliform bacteria due to increased use by waterfowl.

7.2.2 Conveyance Infrastructure

Water providers desiring to install any infrastructure associated with on- or off-channel water storage or water distribution systems on Corps project lands must apply to the Corps for a land availability determination. If Corps project lands are determined to be available for any proposed infrastructure, the water providers must acquire the appropriate real estate easements and pay any Corps charges in accordance with Corps real estate regulations. See Figure 6 depicting existing infrastructure within the area leased to the city of Lakewood, Colorado.

Figure 6: Bear Creek Infrastructure within Bear Creek Park, Lakewood, Colorado

8 INVENTORY AND FORECAST

8.1 Water Rights in Bear Creek

Preliminary information indicates the state of Colorado holds water rights in Bear Creek Reservoir. Approximately one half of these rights are absolute meaning the permit has been issued, and the water is being put to beneficial use for environmental, recreational or piscatorial purposes, the latter which specifically involves fish or fishing. Denver Water also holds water rights in Bear Creek. The state submitted an application October, 2014 to increase the amount of water it holds in Bear Creek and to make all of its water rights in Bear Creek absolute. The CWCB has identified seven potential water providers who may be interested in storage in Bear Creek.

8.2 Bear Creek Reservoir Water Yield and Storage-Comparison Analysis

8.2.1 Water Yield

Historical daily flows for the Bear Creek at Morrison stream gage for the period of 1920-2014 were analyzed and used to estimate the demand that could be met (yield) with various amounts of storage in Bear Creek Reservoir allocated to water supply. The daily flows were converted to monthly flows and a sequential routing was performed using an Excel spreadsheet. Inflows were compared to a constant monthly demand and excess flows were stored in the water supply storage pool up to the maximum reallocated capacity. In months where inflows were not sufficient to meet demand, water was withdrawn from storage. If the demand could not be met

by inflows and water in storage, the demand was varied by trial and error until the demand could be met throughout the period of record. The end of month storage was converted to surface area using the 2009 elevation capacity curve and average net evaporation rates for each month were applied to the surface area and subtracted from the storage amounts. This was a preliminary analysis and did not consider water rights in order to estimate the maximum yield potential of storage in Bear Creek Reservoir. Consideration of existing water rights would have to be accounted for to estimate the water supply yield per acre/foot of storage. Future studies should include adjusting historical streamflows to present conditions and consideration of water rights to estimate the true yield of storage in Bear Creek. The critical drawdown period is the time from when the storage is full until it is empty and begins to refill. The critical drought period for the South Platte River Basin was in the early 2000's for smaller storage amounts and in the 1950's for storage of 20,000 acre-feet. An informal analysis indicated that the yield without any storage would be 2,100 acre-feet per year. This amount was subtracted from the yield with storage when computing the storage to yield ratio. The storage to yield ratio represents the amount of storage in acre-feet needed to provide a yield of 1 acre-foot per year. Results are summarized in Table 3 and Figure 7.

Table 3: Bear Creek Storage Analysis

Storage (acre-feet)	Critical Drawdown Period	Critical Drawdown Period (months)	Yield (ac-ft/yr)	Storage to Yield Ratio
0	-	-	2,100	-
2,000	Jun 2002-Feb 2003	9	8,500	0.31
5,000	Dec 2001-Feb 2003	15	11,200	0.55
10,000	Oct 2001-Feb 2003	17	14,900	0.78
20,000	Sep 1953-Mar 1957	43	19,300	1.16

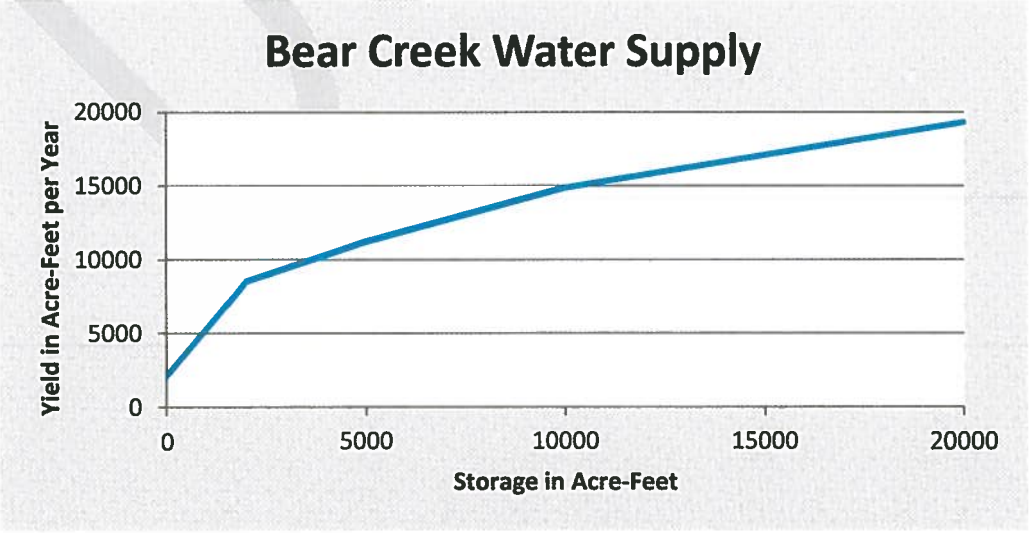

Figure 7: Bear Creek Water Supply Storage Yield Relationship

8.2.2 Storage-Zone Comparison

Results of a 2009 survey of Bear Creek Reservoir indicated that the multipurpose/sediment pool (elevation 5528-5558) had 1,824 acre-feet of storage; the flood control pool (elevation 5558-5635.5) had 30,338 acre-feet of storage (including the sediment pool); and the total storage below the spillway crest (elevation 5667) was 57,678 acre-feet. Therefore, the current potential excess storage between the top of the flood control pool and the spillway crest is 27,340 acre-feet, similar to the original design. Based on this calculation and recognizing that greater reallocated storage will influence the dam's ability to pass the IDF, reallocating 20,000 acre-feet of storage was assumed to be the upper value for consideration in this analysis. As presented in Table 4 and depicted in Figure 8, the water supply pool would exist between the multipurpose/sediment pool and the flood control pool. This level of storage would require a raise in the elevation of the top of the designated flood control pool from elevation 5635.5 to elevation 5659.6 (24.1 feet), which would remain about 7 feet below the spillway crest elevation.

Table 4: Bear Creek Storage Zone Capacities and Elevations

Pool	Original Design		Current Condition (2009 Survey)		With Additional 20,000 AF Storage for Water Supply (2009 Survey)	
	Elevation Project Datum	Cumulative Capacity (ac-ft)	Elevation (Project Datum)	Cumulative Capacity (ac-ft)	Elevation (Project Datum)	Cumulative Capacity (ac-ft)
Multipurpose Pool/Sediment	5558	2,000	5558	1,824	5558	1,824
Water Supply	NA	NA	NA	NA	5623	21,824
Flood Control	5635.5	28,290	5635.5	30,338	5659.6	50,338
Spillway Crest	5667	55,290	5667	57,678	5667	57,678
Maximum Pool	5684.5[1]	75,000	5685.6[2]	78,647	TBD[5]	TBD[5]
Top of Dam	5689.5	NA	5690.2[3]	84,000[4]	5690.2[3]	84,000[4]

(1) The original Inflow Design Flood (IDF) used HMR44 to develop the maximum pool elevation.

(2) The 2012 IDF used HRM55A to develop the maximum pool elevation.

(3) The current top of the dam elevation is based on a March 2010 surveyed profile along the dam centerline with a low point of 5690.2 feet.

(4) Capacity curve was extrapolated to obtain this value

(5) Maximum pool would be determined based on a study of the Inflow Design Flood.

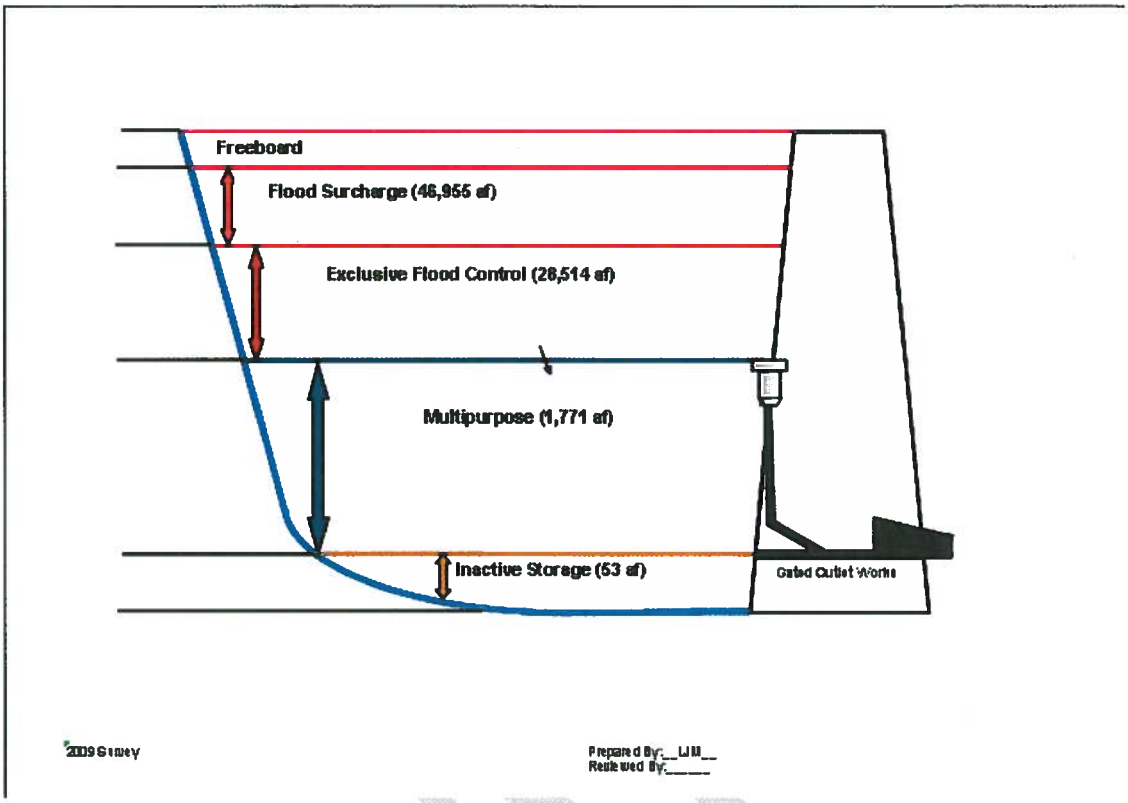

Figure 8: Cross Section of Bear Creek Reservoir

8.3 Dam Safety Considerations and Infrastructure

8.3.1 Original Dam Design/Potential Impacts if Multi-purpose Pool is Raised.

8.3.1.1 Embankment and Foundation Stability. Five cases were evaluated for the stability of the embankments and foundations of the main and south embankments during original design of the dam: (1) end of construction, (2) sudden drawdown, (3) partial pool, (4) steady seepage, and (5) earthquake. A re-evaluation of stability will be required as part of this study. The re-evaluation will consider the hydraulic loading conditions proposed in this study and will use the current state of the practice methodology. It is currently not anticipated that embankment and foundation stability will be a significant concern during this re-evaluation. Re-evaluation analysis of seismic loading conditions (and seismic stability) for the embankments will also be required.

8.3.1.2 Seepage Control Through the Dam Foundation. Seepage control through the foundations of the main and south embankments include an upstream impervious blanket and inspection/cutoff trenches to bedrock. These features were designed to control foundation underseepage considering the original hydraulic loading conditions for the dam. The adequacy of these existing features will need to be re-evaluated for the hydraulic loading conditions proposed in this study and using the current state of the practice methodology.

8.3.1.3 Seepage Control Through the Dam Embankment. Seepage control through the main and south embankments include central impervious cores, random fill shells upstream of the core and clay-shale fill shells downstream of the core. In addition, inclined and horizontal pervious drains exist downstream of the impervious core for both embankments. The adequacy of these existing features will need to be re-evaluated for the hydraulic loading conditions proposed in this study and using the current state of the practice methodology.

8.3.1.4 Riprap Slope Protection. Slope protection for the upstream face of the main embankment consists of riprap protection between elevations 5553.0 and 5572.0 and between elevation 5679.5 and the crest. A rock-raked zone, topsoiling and seeding exist between the two riprap sections. Slope protection for the upstream face of the south embankment consists of riprap protection between elevation 5679.5 and the crest. New riprap protection will be required for the main embankment (above elevation 5572) for any increase in the multipurpose pool. The need for additional slope protection for the south embankment will have to be further investigated as part of this study.

8.3.1.5 Operation and Maintenance (O&M) Access Road. Access to the upstream slope inspections during normal conditions will be affected by a normal pool raise. The service road on the upstream dam face is overtopped at its current elevation of 5572 feet PD. Installation of a new upstream road would be required for operational and surveillance reasons for normal pool levels above elevation 5572 PD.

8.3.1.6 Outlet Works (Intake Structure, Flood Conduit, Domed-Gate Structure). The outlet works are currently designed for normal pool levels and controlled releases through the dam up to elevation 5558 (the uncontrolled weir elevation of the intake structure). The intake structure, conduit and service gates were not designed for sustained pool levels above elevation 5558. Above this elevation water is released through the intake into the flood conduit either under gravity flow or pressurized flow depending on the service gate openings and the reservoir elevation. Increasing/raising the multi-purpose pool for long periods above elevation 5564.5 will impact access to the existing intake and the gate controls for the low level inlets. In addition, long-term pool levels above elevation 5558 will pressurize the portion of the conduit upstream of the domed gate structure. The existing intake structure will require modification or replacement as part of a proposed reallocation project. The potential long-term pressurization of the upstream conduit and whether or not there will be resulting joint or seepage issues will also have to be further investigated as part of this study.

8.3.2 Dam Performance and Dam Safety Surveillance (Inspections and Instrumentation)

8.3.2.1 Dam Performance. To date, there have been no significant operational or dam performance issues at the Bear Creek Dam project. The maximum pool of record (elevation 5607.8) at Bear Creek Dam occurred in September 2013. The flood event, which was 5-6 weeks in duration, occurred without any adverse or significant impacts to the project. There were

several areas on the dam that experienced relatively minor flood related damage/problems. These included a large amount of debris on the upstream slope, damage to the vegetation on upstream slope and abutments, damage to the upstream slope access road and damage to the low level intake valves.

The embankment and foundation as well as the appurtenant structures of Bear Creek Dam have not yet been tested above elevation 5607.8 (the current maximum pool of record). Below elevation 5607.8, the dam has only been tested for a limited period of time (the record pool was only above normal pool for approximately 5 weeks). Potential storage behind the dam for water supply with a normal pool up to elevation 5623 would likely occur for much longer than a few days or weeks. Increased surveillance of the dam (inspections and instrumentation) for a higher normal pool that is above elevation of 5558 for longer periods of time will need to be evaluated as part of this study.

8.3.2.2 Dam Surveillance (Inspections and Instrumentation). The dam safety surveillance program for Bear Creek Dam currently includes a routine inspection program consisting of monthly inspections, annual inspections, periodic inspections (PI), and periodic assessments (PA). The program also includes regular instrumentation data collection and evaluation.

If a reallocation is ultimately recommended, increases to the normal pool elevation will most likely require increases to the frequency and number of inspections conducted, the amount of instrumentation data collected and evaluation of the data. Continuing evaluation inspections of the embankments and appurtenant structures by the Tri-Lakes Project Office would need to be increased until the Corps' Engineering Division is confident the dam is performing as designed. Additional (or more frequent) Periodic (or 1st Filling) Inspections may need to be conducted depending on the amount of the normal pool raise. Existing instrumentation may need to be monitored more frequently. New instrumentation may need to be installed to monitor embankment and foundation movement and/or piezometric conditions.

8.4 Environmental Resources

8.4.1 Wetlands and Riparian Habitat

The most abundant wetland types in the potential inundation zone include forested and scrub-shrub wetlands dominated by narrowleaf cottonwood (*Populus angustifolia),* plains cottonwood (*Populus sargentii*), sandbar willow (*Salix exigua*) and peachleaf willow (*Salix amygdaloides*). This wetland type is currently found along the reservoir shoreline, alluvial fans at the mouths of both Bear and Turkey Creeks, and scattered throughout the floodplains of both creeks. The willow shrub and cottonwood forested wetland types intermix in varying proportions throughout both creek floodplains. Narrow bands of willow, narrowleaf cattail (*Typha angustifolia*), sedges, and rushes occur along two unnamed intermittent-flow drainages that enter the reservoir from the north. Corridor widths of this habitat type vary from 15 to 25 feet. Several small ponds within the Turkey Creek floodplain have shallow-water shoreline areas dominated by sedges and

rushes. Most of the wetland acreage is located in the Bear Creek floodplain, followed by the Turkey Creek floodplain, the Bear Creek Reservoir shoreline, and the two unnamed intermittent drainages. These wetlands provide varying degrees of wildlife habitat, sediment retention and stabilization, nutrient transformation, water quality, and production export.

The main areas of riparian habitat in the project area are associated with Bear and Turkey Creeks upstream of the existing reservoir. Plains cottonwood (*Populus deltoides occidentalis*), box elder (*Acer negundo*), and sandbar willow (*Salix exigua*) are the most abundant species within the Bear Creek, Turkey Creek, and Coyote Gulch riparian corridors (Harner & Associates, 1990). The riparian corridor understory is composed of chokeberry (*Prunus virginiana*), skunkbush sumac (*Rhus trilobata*), and snowberry (*Symphoricarpos albus*) (Harner & Associates, 1990).

8.4.2 Listed Species

No federally-listed endangered, threatened, or candidate species are known to exist in the potential project area (USACE, 2012) although there are listed species with a history of high profile review from the U.S. Fish and Wildlife Service (USFWS) in the region. Those species include the black footed ferret (*Mustela nigripes*, endangered) and preble's meadow jumping mouse (*Zapus hudsonius Preble*, threatened). In addition to these species, there are four federally-listed species on the Central Platte River in Nebraska subject to a 2006 Biological Opinion that are consistently a USFWS concern on any project with the potential to deplete flows to the Platte River. These additional species include the whooping crane (*Grus Americana),* the northern Great Plains population of the piping plover (*Charadrius melodus*), the interior least tern (*Sterna antillarum*), and the pallid sturgeon (*Scaphirhynchus albus*). Under a 2007 program established by the USFWS, project proponents can use a streamlined consultation process for Platte River species using the programmatic biological opinion of June 16, 2006.

8.4.3 Aquatic Habitat

The seasonality, frequency, rate, and degree of water level change could be either beneficial or detrimental to fish and the recreational fishery. Shallow shoreline habitats are important to aquatic species and increased storage could alter the structure, substrate, vegetation, and overall habitat of shoreline areas. Alternatives that cause inundation of trees and other vegetation near shorelines could be beneficial for spawning/reproductive success of some species, for example. Overall, stability of water levels would be better for fish spawning than rapidly changing levels. An abrupt fluctuation in water levels during spawning is anticipated to be the most problematic. The city of Lakewood installed a new complete aeration system in early fall of 2002 providing greater coverage throughout the lake and improved oxygen transfer potential (BCWA, 2003). In 2010, operational studies were conducted to evaluate the aeration system's efficacy in oxygen transfer during phased on-off cycling. Results of the testing indicate that the aeration system can increase the dissolved oxygen concentrations throughout the water column by about 2 mg/l within a two-week period (BCWA, 2011a), which provides needed oxygen to protect the existing fishery.

8.5 Recreation Assessment

The Bear Creek Reservoir project land is leased to the city of Lakewood for park and recreation purposes. The city is concerned about impacts to recreation facilities constructed at its expense. Unavoidable impacts to facilities would need to be fully mitigated.

The Bear Creek Lake Park is a very popular recreation area due to its proximity to the Denver Metropolitan area, as well as the popular Red Rocks Amphitheater (located within a 15-minute drive north west of the project). The Bear Creek Lake Park average annual visitation estimate from 2003 through 2011 is 424,150. Visitors come to the park for a variety of recreation activities including: hiking, picnicking, camping and other activities. During days of peak visitation (summer weekends), the campground and parking lots are typically full with many visitors walking or biking into the park. Recreation use of the reservoir is expected to continue at current or increasing levels with nearby Denver population growth. City of Lakewood park management staff considers recreational facilities at Bear Creek Lake Park to be complete for recreation amenities and operating at or near capacity. Figure 9 depicts the hatched area leased to the city of Lakewood for park and recreational purposes within the blue outlined project boundary.

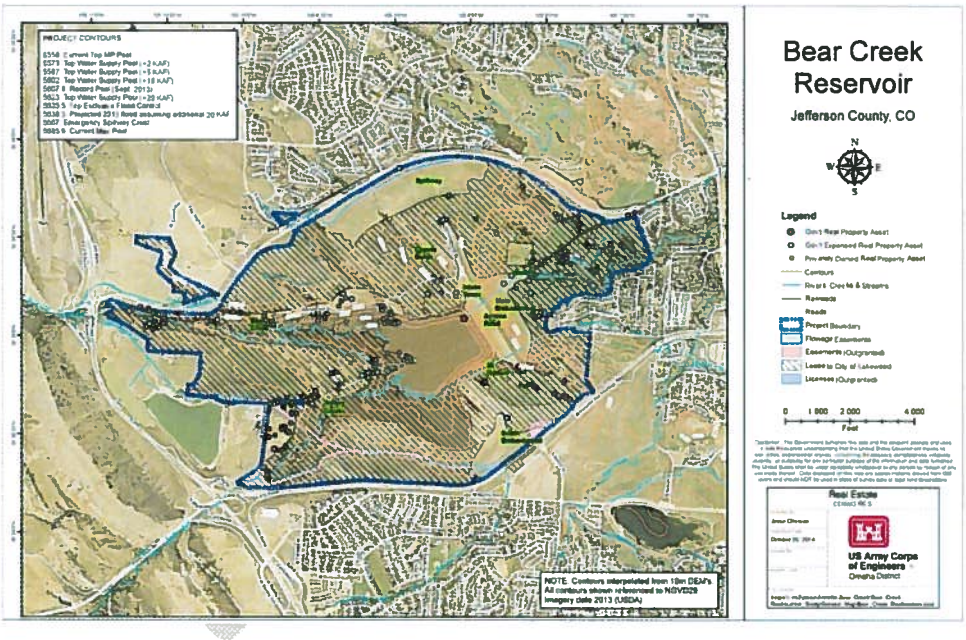

Figure 9: Area Leased to City of Lakewood for Park and Recreation Purposes

8.6 Preliminary Updated Cost of Storage Calculations

As described in the Corps' Water Supply Handbook, the updated cost of storage procedure begins with updating the original cost of reservoir construction to present day price levels and then assigning a percentage of the costs based on a 'use of facilities' cost allocation procedure. Costs are allocated to usable storage based upon the original reservoir storage capacity. As

shown in Table 5, total usable storage for Bear Creek Reservoir includes the exclusive flood control pool and the spillway crest; it does not include the permanent sediment pool.

Table 5: Bear Creek Usable Storage Calculations (acre-feet)

Zone	Acre- Feet*
Operating Pool	73,000
Multipurpose/Sediment	2,000
Total	75,000

*Original design storage capacity

For the reconnaissance study, 20,000 acre-feet or 27.4 percent of the usable storage pool is assumed to be available for reallocation, and thus is the basis of the updated cost of storage estimate. The 20,000 acre-feet value is a preliminary estimate of storage available for reallocation, and would likely change if this study proceeds to feasibility.

Construction costs are updated using the Corps of Engineers' Civil Works Construction Cost Index System (CWCCIS) as provided in EM 1110-2-1304 (revised 31 March 2014). The updated cost calculations are estimated based on the midpoint of construction as per the Water Supply Handbook (page 4-9). The mid-point of construction was identified as 1975, since construction began in 1973 and ended in 1977 (see Table 6). The state adjustment factor for Colorado is 0.98, as identified in EM 1110-2-1304, CWCCIS table A-3; this adjustment factor is also used in the calculation of the FY15 costs. The value of lands are updated based on the ratio of total FY15 updated costs to the total original costs (excluding lands) as directed by the Water Supply Handbook (page 4-10). This ratio is 4.16 and is based on ratio of $162,821,946 (cost in FY15 dollars excluding land) to $39,172,697 (cost in 1975 excluding land).

Table 6: Bear Creek Reservoir - Updated Cost of Construction 1975 - FY2015

Cost Category	1975 Cost	1975 CWCCIS	1st Quarter FY15 CWCCIS	FY15 Cost
Main Dam	$37,820,410	189.8	802.53	$156,717,457
Outlet Works	-	-	-	-
Reservoirs	$1,180,687	189.8	885.32	$5,397,155
Intake Structure	$171,600	189.8	798.32	$707,333
Fish & Wildlife	-	-	-	-
Levees & Floodwalls	-	-	-	-
Pumping Plant	-	-	-	-
Roads & Bridges	-	-	-	-
Buildings & Grounds	-	-	-	-
Perm Operating Equip	-	-	-	-
Relocations	-	-	-	-
Lands & Damages	$21,290,670	-	-	$88,495,012.78
Total	**$60,463,367**			**$251,316,958**

The proportion of storage considered for reallocation is 27.40 percent which equals $68,853,961 in FY15 dollars. This equals a cost per acre-foot of storage of $3,443.

The total annual cost of storage for the non-Federal sponsor would include both the annual payment for reallocation storage, plus the proportional annual operation and maintenance costs (O&M). Detailed O&M cost were not calculated since this is a reconnaissance level of analysis. Based on average annual O&M costs through 2009, however, it's estimated that O&M costs for water supply would be approximately $160,000 annually (this is the estimated proportion of total O&M allocated to water supply).

Annual payments are based on a 30-year payment schedule and the Water Supply Interest Rate from PL 85-500, which is the interest rate used for water supply storage space in projects completed or under construction prior to enactment of PL 99-662 (17 Nov 1986). The FY15 water supply interest rate is 3.5%. The annual cost for storage is estimated at $3,777,084, which equals $188.85/acre-foot of storage (included estimated O&M).

An evaluation of storage yield has not been completed for Bear Creek Reservoir as part of the reconnaissance study. A final estimate of cost/acre-foot of firm yield is unavailable at this time.

9 KEY UNCERTAINTIES

Currently, there are uncertainties related to impacts and effects of the topics listed below if a reallocation at Bear Creek would occur. As further analysis is completed and information is gathered, the following key uncertainties associated with a proposed study, will be addressed.

- Dam Safety – Bear Creek Dam currently has a DSAC rating of 3. As per ER-1110-2-1156, an exception approved by the USACE DSO would be required prior to initiation of a reallocation study. The current DSAC rating of the dam will be re-evaluated during the Periodic Assessment currently scheduled to be initiated in 2016 and completed in 2017.
- Inflow Design Flood – An analysis of the impact of raising the top of the flood control pool on the IDF would be required.
- Intake Structure – Ability to modify the structure cost effectively for higher water levels.
- Water Rights – Identification of providers' water rights involved in the project would be needed to assess impacts.
- Operations – Impacts to operations need to be identified at proposed pool elevations.
- Hydrology – Impacts and effects on non-tributary ground water, infrastructure, environment and facilities.
- Water Quality – The primary water quality concern is an increase in the hypolimnetic volume of Bear Creek Reservoir. The secondary concern is the potential increase in water eutrophication, phosphorous loads, metals, E. coli/fecal coliform bacteria, nutrients and algae.
- Aquatic Life and Fisheries – Extent of impacts resulting by creating/constructing new storage facilities, impacts and effects on existing reservoir aquatic life.
- Vegetation/Wetlands – Impacts to onsite wetlands, plants and trees.
- Wildlife – Effect on upland, terrestrial resident, migratory, riparian, wetland, water dependent, aquatic, semi-aquatic including any species of concern and sensitive communities.
- Recreation Impacts – Extent of impacts on facilities.
- Cultural Resources – Potential for and extent of impacts on cultural resources.

10 FORMULATING ALTERNATIVE PLANS

The process of building alternative plans will occur during plan formulation. Plan formulation begins with development of potential management measures that meet planning objectives and avoid planning constraints. Multiple measures will be identified to address the objectives of this project and combined into alternatives for evaluation. Initially, alternatives will be screened on broad concepts categorized as follows:

- Increased storage
- Importation of water
- Increased ground water use
- Increased water conservation

Details on potential alternative reallocations levels would be further developed during the feasibility phase.

10.1 Screening of Measures and Alternatives

Measures that pass screening will be combined into preliminary alternatives, based on initial data collection and professional judgment. These alternatives will again be screened using a wider range of planning criteria and more quantitative analysis based on measures identified below.

- Completeness of an alternative by itself vs. dependence on uncontrollable factors
- Effectiveness toward achieving the objectives partially or fully
- Efficiency, such as cost-benefit effectiveness, a low incremental cost
- Acceptablity/Feasibility, in technical, environmental, legal, and social terms
- Focus on the federal interest, significant federal resources

The results will be ranked in order of highest priority based on which objectives are met. Key uncertainties affecting selection of a tentatively selected plan will be identified and addressed.

11 RECOMMENDATION AND FINDINGS

It is recommended that a feasibility study be conducted, based on federal and sponsor interest in water supply reallocation. The initiation of the study would be subject to approval of an exception to proceed with conducting feasibility by the USACE DSO due to the current DSAC rating. Additional information on dam safety will be available following the PA scheduled to be initiated in 2016 and completed in 2017 and. Support for this recommendation is outlined in the report and include the following. CDNR has expressed support in pursuing a study. The 2010 State Water Supply Initiative Report projects the population of Colorado will double by 2050. The reallocation would help enable water providers to meet increasing water supply demand in the Denver Metro area over the next 50 years due to the combined effects of population growth, depletion of nonrenewable groundwater sources, and agricultural water providers' need for

augmentation water for alluvial wells. Potential exists for storage availablility in Bear Creek Reservoir. Finally, the state has reported that potential communities interested in obtaining water storage shares in Bear Creek have been identified. Following approval of this study, an exception requesting to proceed with a feasibility study examining the potential of reallocating existing storage for water supply in Bear Creek Reservoir will follow.

JOEL R. CROSS
Colonel, EN
Commanding