APPENDIX A

CHATFIELD REALLOCATION ADAPTIVE MANAGEMENT PLAN (ERO RESOURCES CORPORATION 2013)

Consultants in natural resources and the environment

Denver • Boise • Durango • Western Slope

CHATFIELD REALLOCATION PROJECT ADAPTIVE MANAGEMENT PLAN

Prepared for—

U.S. Army Corps of Engineers,
Omaha District
1616 Capitol Avenue
Omaha, Nebraska 68102

Prepared by—

ERO Resources Corporation
1842 Clarkson Street
Denver, Colorado 80218
(303) 830-1188

July 2013

ERO Project #4048

ERO

ERO Resources Corp.
1842 Clarkson Street
Denver, CO 80218
(303) 830-1188
Fax: (303) 830-1199
www.eroresources.com
ero@eroresources.com

CONTENTS

TABLES

FIGURES

CHATFIELD RESERVOIR REALLOCATION ADAPTIVE MANAGEMENT PLAN JULY 2013

Introduction

This adaptive management plan (AMP) provides a framework for how uncertainties regarding impacts and/or mitigation will be addressed for a variety of resources that may be affected by the Selected Plan (Alternative 3) for the proposed Chatfield Reallocation Project (project). Adaptive management was addressed in several sections of the draft Feasibility Report/Environmental Impact Statement (FR/EIS) and its Appendix K (Compensatory Mitigation Plan (CMP)). Comments on the draft FR/EIS requested that the final FR/EIS provide information on adaptive management in a more consolidated fashion and provide more information on how adaptive management will be used.

This AMP consolidates and adds to information previously provided in the draft FR/EIS. For the purposes of this AMP, "adaptive management" refers to actions taken as part of the project to:

- Reduce and/or address uncertainties associated with impact estimates and proposed mitigation;
- Provide contingent plans if needed for proposed mitigation and management;
- Serve as part of the feedback loop between mitigation monitoring and mitigation actions that will lead to appropriate adjustment; and
- Provide new and enhanced applications by learning through management and information from all sources as they become available.

The AMP addresses the following resources and management actions:

- Target environmental resources (Preble's meadow jumping mouse (Preble's), bird habitat, and wetlands);
- Tree clearing within the fluctuation zone;
- Weed control within the fluctuation zone;
- Water quality;
- Operations; and
- Fisheries and downstream aquatic habitat.

These resources and management actions have uncertainties, will be monitored, and are likely to require adjustments to their proposed management plans and actions. The impacts and mitigation associated with other resources (vegetation, wildlife, socioeconomics, and recreation) are unlikely to require iterative adjustments informed by monitoring, as is the case for the resources and management actions addressed by the AMP.

Framework

The following components for the AMP provide a framework that can be built upon as more information becomes available through monitoring of impacts, mitigation, and resource management.

1. Establish Core Objectives – Each resource or management action subject to adaptive management will have a defined core objective or set of core objectives. The core objectives are those objectives that are not proposed to be modified by adaptive management. The means of achieving the core objectives may be changed through the adaptive management process.
2. Identify Uncertainties – For each resource or management action, the potential uncertainties that are currently known and for which adaptive management may be needed will be identified.
3. Develop Contingencies – For each identified uncertainty, a corresponding potential adjustment to the currently identified action will be identified. The identified contingency or adjustment could be modified in the future, but given what is currently known, is the recommended course of action.

Each of the resources and management actions discussed in this AMP establish core objectives, identify uncertainties, and develop corresponding contingencies. As currently feasible, monitoring and success criteria are presented or incorporated by reference to the CMP.

This framework will provide the information needed for reviewers to know what uncertainties have been identified and the contingencies developed to address these uncertainties, and will also provide the flexibility to revise the AMP in the future as needed. The AMP helps to cement the relationship among future impact assessment and the implementation of mitigation and monitoring by identifying the potential uncertainties that could affect impact assessment and mitigation, and identifying contingencies and adjustments that can be explored to address these uncertainties. Monitoring of impacts and mitigation will provide important information and feedback for an iterative process of refining actions to minimize impacts and address uncertainties.

The AMP directly supports the CMP (Appendix K of the FR/EIS). The CMP provides detail on mitigation, monitoring, reporting, and associated costs.

Oversight

Implementation of the AMP will require oversight. The AMP will inform and guide adjustments and modifications to the mitigation and management that is currently proposed. These adjustments and modifications will require review and oversight to make sure they are needed, sound approaches are taken, and that they are aligned with achieving the core objectives. The FR/EIS established oversight responsibilities for mitigation and monitoring, and these responsibilities will also extend to adaptive management as discussed below.

The U.S. Army Corps of Engineers (Corps), the Colorado Department of Natural Resources (CDNR), and the water users (Chatfield Water Providers) will each have complementary responsibilities for ensuring the accomplishment of the reallocation, and of the CMP, the Recreation Modification Plan, and the AMP (the Plans).

The Corps and the CDNR will enter into a Water Storage Agreement (WSA) setting out their respective obligations for reallocating the designated water supply storage, and for accomplishing the Plans. The CDNR will then execute subagreements, identical in their terms and conditions, with each of the Chatfield Water Providers. The subagreements will set out the responsibilities of the Chatfield Water Providers to the CDNR for funding the reallocation of the water supply storage under the WSA, and for undertaking the CDNR's obligations to the U.S. Government under the WSA for implementing the Plans. The subagreements, however, will not affect the ultimate duty of the CDNR and the U.S. Government to fulfill their reciprocal obligations under the WSA, unless the WSA is suitably modified by mutual consent of the Corps and the CDNR. However, the Corps continues to have discussions with the State and the Chatfield Water Providers to further refine the legal relationship between the entities.

After execution of the WSA, the Chatfield Water Providers will place the funds then judged necessary to satisfy all of the nonfederal obligations under the WSA into an escrow account with funds necessary to implement the AMP including associated monitoring, reporting, and mitigation measures unless otherwise stated for a particular resource issue. The Chatfield Water Providers will supplement the escrow fund if the Project Coordination Team (PCT) determines that additional funding is necessary to meet all of the nonfederal obligations. The Chatfield Water Providers will also create a new nonprofit corporation called the Chatfield Reservoir Mitigation Company as a vehicle for facilitating the coordinated management of the process for implementing the Plans.

In accordance with the terms of the WSA, senior management oversight of the implementation of the Plans will reside in the PCT, consisting of senior management representation from the Corps, the CDNR, and the Chatfield Water Providers. The PCT shall consult on the progress of the nonfederal work being undertaken pursuant to the Plans, with a view toward anticipating and offering solutions to potential problems to the Plans' scheduled completion and make recommendations to the Omaha District Commander. The Corps has the final authority on acceptance or rejection of the PCT's recommendations.

The PCT can create advisory committees if it determines that the advice from such committees may be helpful. Such advisory committees would be created to provide review and comments upon the activities conducted to implement all of the mitigation obligations. Two such committees, the Technical Advisory Committee (TAC) and the Operations Advisory Committee, will be created to provide assistance with technical and operational issues including implementation of and any revisions to the AMP. The PCT will have discretion to accept or reject, in whole or in part, the recommendations from its advisory committees. The PCT will approve a charter governing membership and decision making for any advisory committees that it creates. The TAC will tentatively be comprised of representatives from the following:

- Environmental organizations;
- Chatfield Water Providers;
- Colorado Division of Parks and Wildlife (CPW);
- Chatfield State Park;
- Douglas County Land Trust or other land conservation organization;
- Colorado Water Conservation Board and/or CDNR;
- Denver Water;
- Corps;
- U.S. Environmental Protection Agency (EPA);

- U.S. Fish and Wildlife Service (USFWS); and
- Other "in-stream" interests, including governmental and nongovernmental downstream water interests.

The TAC will provide review and comments on technical components of the implementation process including the following:

- Suitability of private properties for lands protection and enhancement that occur outside the off-site target mitigation area;
- Management plans for off-site properties;
- Technical questions regarding proposed adjustments to mitigation resulting from the adaptive management process;
- An Annual Monitoring Report; and
- Other aspects of the project requested by the PCT.

The Operational Advisory Committee will provide review and comments on mitigation obligations related to operational issues. The principal goal of the committee is to facilitate efficient collective operations. The committee would tentatively be composed of the following:

- All of the Chatfield Water Providers;
- A Denver Water representative; and
- A Colorado State Engineers Office representative.

The AMP presents broad guidelines for conducting adaptive management for the Chatfield Reservoir reallocation project. By its very nature, the AMP will become more specific as mitigation and management plans become more specific. The AMP is a living plan that will be revised as needed to address new uncertainties and needed adjustments, and incorporate new information from monitoring and other sources.[1] Annual monitoring reports will include information on needed and proposed adjustments and uncertainties. Once the details of a resource mitigation plan are finalized, a corresponding detailed plan will be developed identifying uncertainties and detailed

[1] Unless addressed in specific management plans for mitigation properties, adaptive management will not be triggered by natural disasters that may impact mitigation once mitigation has been completed, nor for any additional impacts caused by the storage or release of water not associated with reallocation of storage that are not identified as significant impacts in the final FR/EIS and project decision documents (e.g., flood releases).

contingencies for each proposed mitigation action. All mitigation monitoring reports and revisions to the AMP will be submitted to the PCT and TAC for review and comment.

Schedule

The schedule for implementing adaptive management is variable. By their very nature, adaptive management actions are implemented on an "as needed" basis and as informed by monitoring. Table 1 provides a schedule of how adaptive management will likely be implemented.

Table 1. Schedule for adaptive management measures.

Resource/Issue	Monitoring	Adaptive Management Measures	Frequency
Target Environmental Resources (impacts and mitigation)	Annual	Implement contingencies	As needed
Tree Clearing within the Fluctuation Zone	Following inundation	Remove dead and severely stressed trees when they pose a significant risk to visitor, boater, or dam safety/operations and other contingencies	As needed
Weed Control within the Fluctuation Zone	Annual	Follow iterative process for weed control	Annual
Water Quality	Annual	Water quality monitoring and assessment Remove vegetation (see Tree Clearing within the Fluctuation Zone) Control weeds (see Weed Control within the Fluctuation Zone) Dynamic water quality modeling Altering inflow and outflow Structural measures	Annual As needed Annual Annual As needed As needed
Operations	First 3 years of operations	Conduct studies to determine the effects of operations and how operations might lessen Develop revised operations plan based on first 3 years of operations and studies	First 3 years of operations As feasible
Aquatic Life and Fisheries	Annual	Determine target seasonal schedule of releases and maximum flow rates Determine operations that could promote strategic releases Adjust operations to benefit aquatic life	First 3 years of operations First 3 years of operations As feasible

establishment of desirable vegetation include the swim beach or other portions of the fluctuation zone where vegetation may not be desirable.

Monitoring will inform the effectiveness of treatments, but it is likely that new weed treatments will be developed in the future, which will need to be tested. It is also possible that weeds not currently known to occur in the region could invade the fluctuation zone. It will be important for the Chatfield Reservoir Mitigation Company to contract with individuals and firms for monitoring and controlling weeds who are up to date on new weeds found in the region and new weed treatments. Section 6.1.1.2 and Appendix F of the CMP establishes success criteria for weed control.

Water Quality

Water quality concerns for the Chatfield Reservoir reallocation focus on potential change to water quality from expansion of the hypolimnion and inundation of shoreline areas within the reservoir with increased pool levels. Nutrient analysis and water quality modeling show uncertainty in the potential water quality impacts from increased internal nutrient (i.e., phosphorus) loading due to higher pool levels. There is uncertainty whether increased inundated vegetation and the expansion of the hypolimnion and anaerobic sediments will increase internal phosphorus loading to the extent that promulgated water quality standards and the identified Total Maximum Annual Load (TMAL) may be exceeded. Site-specific water quality standards have been promulgated for Chatfield Reservoir to manage phosphorus enrichment, and a TMAL for phosphorus is being implemented by the Chatfield Watershed Authority (CWA). The current phosphorus-associated water quality standards and Assessment Criteria for Chatfield Reservoir are:

Water Quality Standards:

Phosphorus (Total) = 0.030 mg/L

Chlorophyll = 10 μg/L

Measured through samples that are representative of the mixed layer from July through September, with an allowable exceedance frequency of 1 in 5 years.

Assessment Criteria (used when assessing whether the water body is in attainment of the specified standard):

Phosphorus (Total) = 0.035 mg/L

Chlorophyll = 11.2 μg/L

Summer averages, 1-in-5 year allowable exceedance frequency (CDPHE-WQCC 2013).

The current TMAL identified for Chatfield Reservoir for phosphorus, to attain the chlorophyll and phosphorus water quality standards, is 19,600 pounds per year (lbs/yr) under a median inflow of 100,860 acre-feet per year (AF/yr). Figures 1 and 2 display the current phosphorus-associated water quality standards and TMAL for Chatfield Reservoir related to historical Chatfield Reservoir data (CWA 2013). The monitoring of both chlorophyll and phosphorus is a focus because both have an established water quality standard and both relate to potential increased internal nutrient loading due to higher pool levels.

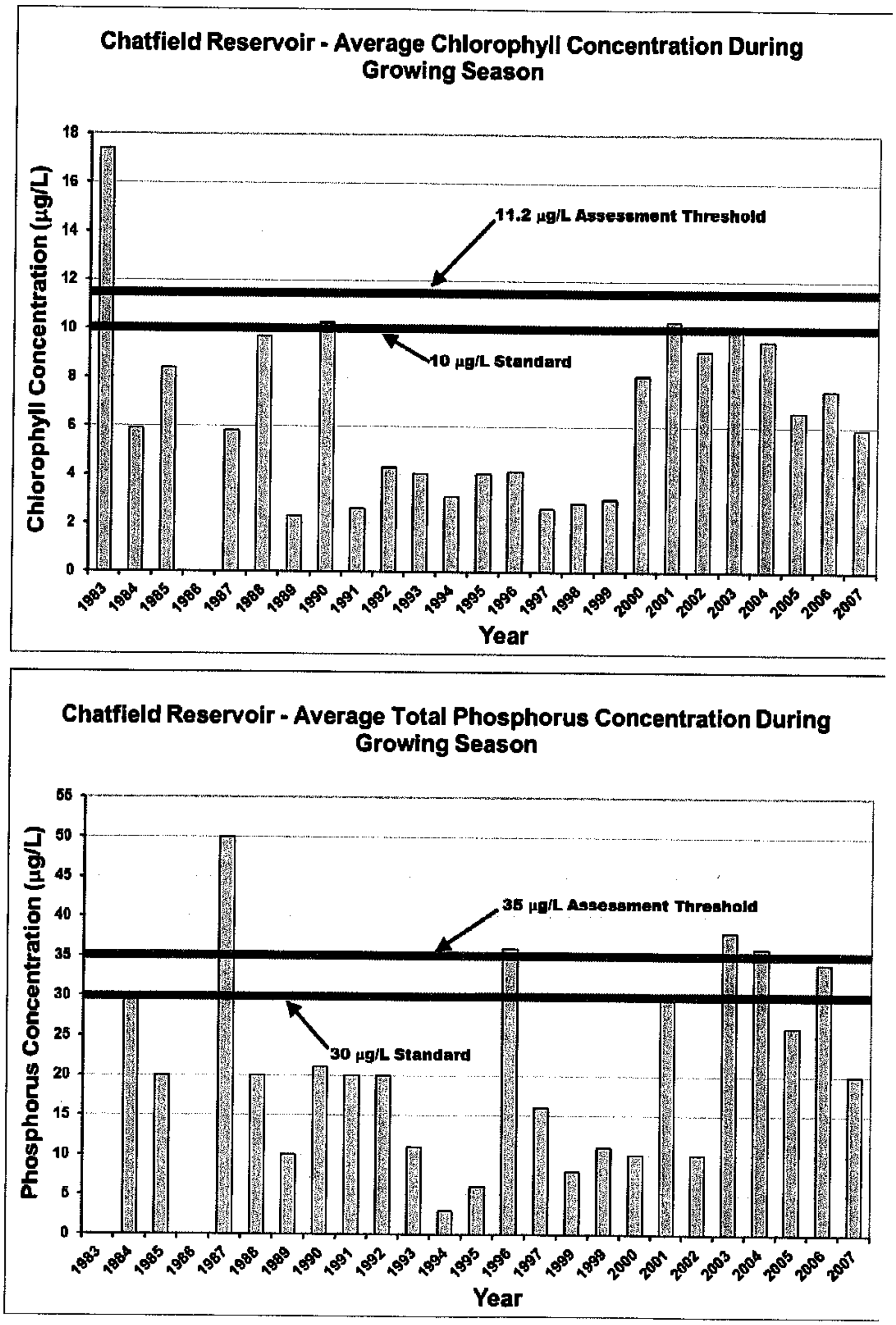
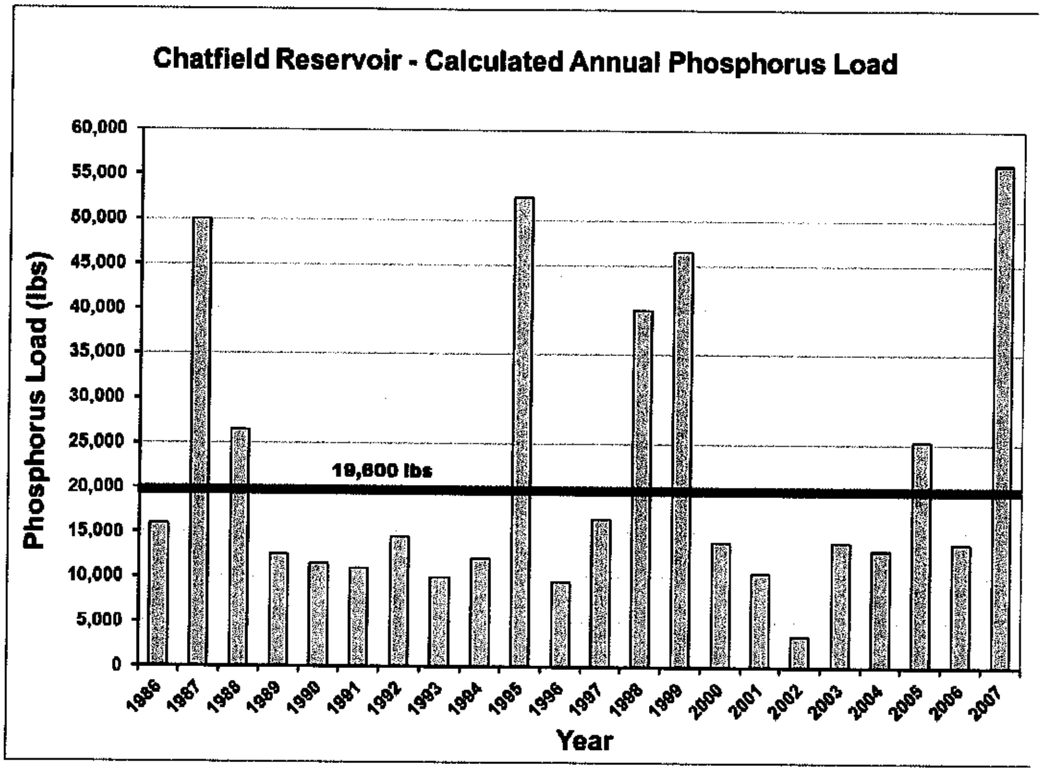


Figure 1. Current chlorophyll and total phosphorus water quality standards related to historical Chatfield Reservoir water quality conditions (from http://www.chatfieldwatershedauthority.org/regulations.html).



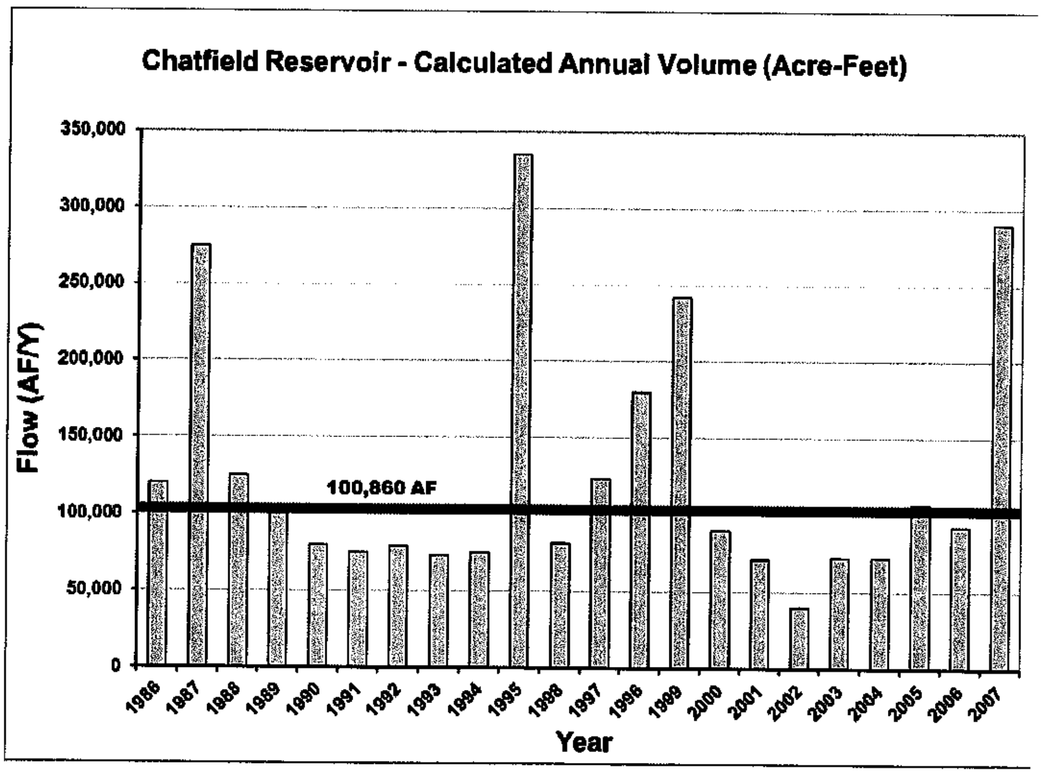


Figure 2. Identified phosphorus TMAL and median inflow conditions related to historical Chatfield Reservoir conditions (from http://www.chatfieldwatershedauthority.org/regulations.html).

The water quality uncertainty associated with the Chatfield Reservoir reallocation is partially a result of past water quality monitoring deficiencies. It was generally concluded, based on readily available water quality data, that Chatfield Reservoir did not experience extensive hypoxic conditions in the hypolimnion that established during the summer. However, recent water quality monitoring data and a more investigative assessment of historical water quality data indicate that is not the case, and in fact, the reservoir likely experiences regular hypoxic conditions in the hypolimnion throughout the summer. Water quality monitoring deficiencies regarding the Chatfield Reservoir reallocation will be identified and corrected with future water quality monitoring conducted at Chatfield Reservoir. The AMP recognizes that the Chatfield Water Providers are responsible for their portion of water quality monitoring only; not for correcting past deficiencies nor for the entire monitoring and modeling efforts needed to address all of the water quality issues in Chatfield Reservoir. To assess potential water quality impacts from the Chatfield Reservoir reallocation, ongoing water quality modeling will be implemented at Chatfield Reservoir to address water quality uncertainties, provide input to contingency planning, and facilitate feedback between mitigation monitoring and mitigation actions if necessary. One suggested approach is using a dynamic water quality model. One example of a dynamic water quality model is the CE-QUAL-W2 (W2) model. W2 is a water quality and hydrodynamic model in two dimensions (longitudinal and vertical) for rivers, estuaries, lakes, reservoirs, and river basin systems. In reservoir settings, W2 models basic physical, chemical, and biological processes such as temperature, nutrient, algae, dissolved oxygen, organic matter, and sediment relationships while accounting for flow dynamics within the reservoir. Water quality monitoring would be implemented to collect the information needed to facilitate the initial and ongoing application of a dynamic water quality model to Chatfield Reservoir. Application of the dynamic water quality model could facilitate addressing water quality uncertainties and contingency planning, and provide feedback for possible mitigation actions. The Chatfield Water Providers, through the Chatfield Reservoir Mitigation Company, will be responsible for funding their share of water quality monitoring and modeling costs and the mitigation actions related to their use of reallocated space as required by the Corps.

Core Objectives

The following are the core objectives for water quality:

1. Internal loading from "new" anoxic sediments attributed to reallocation pool level increases will not cause water quality standards for chlorophyll and total phosphorus or the total phosphorus TMAL to be exceeded.
2. Internal loading from "newly" inundated vegetation attributed to reallocation pool level increases will not cause water quality standards for chlorophyll and total phosphorus or the total phosphorus TMAL to be exceeded.
3. Expansion of hypoxic conditions and potential release of reduced contaminants from anaerobic sediments will not cause other water quality standards (i.e., other than chlorophyll and total phosphorus) to be exceeded.

Uncertainties

Adaptive management will be used to address the following uncertainties associated with reallocation regarding water quality at Chatfield Reservoir.

- Water quality analysis shows there may be uncertainty regarding internal nutrient (i.e., phosphorus) loading from increased hypoxic conditions and associated anaerobic sediments.
- Water quality could be adversely affected by shoreline erosion associated with increased water level fluctuations.
- The hypoxic area could expand and potentially increase the release of reduced contaminants from anaerobic sediments and increase methylation of mercury within the reservoir.
- Vegetation establishment within the fluctuation zone that would eventually be inundated could increase internal nutrient loading.

Contingencies

The following approach using a dynamic water quality model could be executed to adaptively manage water quality uncertainties regarding the Chatfield Reservoir reallocation.

Water Quality Monitoring and Assessment

Water quality monitoring would be implemented at Chatfield Reservoir to allow for the initial and ongoing application of a dynamic water quality model and assessment of reservoir water quality conditions for compliance with water quality standards. Dynamic water quality modeling would require the appropriate monitoring of reservoir, inflow, and outflow water quality conditions. Appropriate water quality data will be collected in Chatfield Reservoir to assess compliance with promulgated water quality standards criteria. This information will be used to help determine if mitigation actions need to be taken. The Chatfield Water Providers will be responsible for monitoring and modeling that are related to reallocation and are in addition to the efforts now being made by the CWA that do not already satisfy the following monitoring or modeling objectives. It is the intent of the AMP that the Chatfield Water Providers and CWA work together on Chatfield Reservoir water quality issues. The following monitoring and modeling actions should be planned and implemented in close coordination with the CWA to avoid duplication of efforts. The following identifies monitoring objectives and specific data needs for water quality monitoring and assessment regarding the Chatfield Reservoir reallocation.

Monitoring Objective 1 – Conduct Water Quality Monitoring to Characterize the Spatial and Temporal Occurrence of Water Quality Conditions in Chatfield Reservoir

The water quality in Chatfield Reservoir is subject to spatial and temporal variability. Water quality conditions in reservoirs are a reflection of their watersheds and can also vary widely over time in response to climatic and seasonal influences. A thorough understanding of the spatial and temporal variability of water quality conditions in Chatfield Reservoir is needed to model water quality and assess potential water quality impacts from reallocation.

Specific Data Needs

- Conduct monthly (April through October) depth-profile measurements (minimum 1-meter increment) at three locations in Chatfield Reservoir: 1) a deepwater location near the dam, 2) a mid-reservoir location characteristic of deepwater areas of the South Platte River arm, and 3) a mid-reservoir location characteristic of the Plum Creek arm of the reservoir. The following constituents should be measured as part of the depth-profile measurement: 1) temperature, 2) dissolved oxygen, 3) pH, 4) oxidation-reduction potential, and 5) chlorophyll *a*.
- Conduct monthly (April through October) analysis of near-surface and near-bottom water quality conditions to include: 1) phosphorus (total, dissolved, and reactive); 2) nitrogen (total Kjeldahl, ammonia, and nitrate-nitrite); 3) organic carbon (total and dissolved); 4) carbonaceous biological oxygen demand (CBOD); 5) alkalinity; 6) total dissolved solids; 7) total suspended solids; 8)

sulfate; 9) silica; 10) chlorophyll *a* (near-surface only); 11) phytoplankton; 12) zooplankton; and 13) Secchi depth.
- Conduct monthly (May, July, and September) analysis of near-surface and near-bottom water quality conditions for metals (total and dissolved metals scan).

Monitoring Objective 2 – Conduct Water Quality Monitoring to Determine if Reallocation has Impacted Water Quality Conditions in Chatfield Reservoir – Determine if Water Quality Standards have been Exceeded

Likely water quality constituents, with promulgated state water quality standards, that could be impacted by the Chatfield Reservoir reallocation include total phosphorus, chlorophyll *a*, ammonia, metals, and *E. coli* bacteria. These constituents will need to be monitored in Chatfield Reservoir to determine if the reallocation has caused water quality standards for these constituents to be exceeded. The water quality monitoring results and water quality standards attainment assessment will be included in an Annual Water Quality Monitoring Report that is presented to the TAC and PCT.

Specific Data Needs

- Conduct water quality monitoring to meet Monitoring Objective 1, which will provide the data needed to assess compliance for total phosphorus, chlorophyll *a*, ammonia, and metals.
- Conduct weekly (May through September) analysis of water samples collected at designated swimming beaches for *E. coli* bacteria.

Monitoring Objective 3 – Conduct Water Quality Monitoring to Facilitate Application of a Dynamic Water Quality Model to Chatfield Reservoir

A dynamic water quality model can predict water quality conditions in Chatfield Reservoir that cannot efficiently be empirically monitored. Water quality modeling also allows for evaluation of water quality impacts and facilitates scenario testing. Calibration of a water quality model with empirical information collected at Chatfield Reservoir is important to increase the accuracy of the model application to the reservoir. Derived model coefficients for Chatfield Reservoir can be used in lieu of default values to improve the results of the modeling application. Once the Chatfield Reservoir water quality model has been "validated," it can confidently be used to facilitate water quality management decisions regarding reallocation.

Specific Data Needs

- Conduct water quality monitoring to meet Monitoring Objective 1, which will provide the in-reservoir water quality data needed to apply a dynamic water quality model to Chatfield Reservoir.
- Maintain year-round flow gauging stations on the South Platte River and Plum Creek that are representative of the inflows to Chatfield Reservoir. Consider adding temperature logging to the gauging stations.
- Conduct biweekly (April through September), monthly (October through March), and storm event (April through September) water quality sampling of the South Platte River and Plum Creek inflows to Chatfield Reservoir. Sampled inflow constituents should include: 1) temperature; 2) dissolved oxygen; 3) pH; 4) specific conductance; 5) organic carbon (total and dissolved); 6) CBOD; 7) phosphorus (total, dissolved, and reactive); 8) nitrogen (total kjeldahl, ammonia, and nitrate-nitrite); 9) total dissolved solids; 10) total suspended solids; 11) silica; and 12) alkalinity.
- Conduct annual sampling of bottom sediments from deepwater areas of Chatfield Reservoir. Collected sediments should be analyzed for labile and refractory nutrients, labile and refractory organic matter, and metals. The sediments should also be tested to determine nutrient flux under anoxic conditions.

Monitoring Objective 4 – Conduct Water Quality Monitoring to Evaluate the Effectiveness of Implemented Mitigation Measures to Alleviate Water Quality Impacts Attributed to Reallocation

Implemented mitigation measures to address water quality impacts from the Chatfield Reservoir reallocation need to be monitored to evaluate their effectiveness. This will allow for ineffective measures to be identified and the pursuance of alternative measures. It will also allow for the identification of successful measures that can be documented for future application.

Specific Data Needs

- Conduct monitoring as needed and specific to the water quality impact being addressed.

Inundated Vegetation

The following actions will be taken to monitor inundated vegetation regarding the Chatfield Reservoir reallocation.

- Remove vegetation below 5,439 ft msl to minimize the introduction of nutrients associated with inundation, as discussed under Tree Management within the Fluctuation Zone of this AMP.
- Control weeds within the fluctuation zone that could increase nutrient levels when inundated.

- Monitor the establishment of vegetation within the fluctuation zone that could increase nutrient levels when inundated.

Dynamic Water Quality Modeling

An initial application of a dynamic water quality model could be attempted using historic water quality, meteorological, pool level, and flow data. Annual models would be developed where historical data allow. If sufficient historical data are lacking, an initial application of a dynamic water quality model would be based on newly collected data. Once initially developed, a dynamic water quality model would be applied annually on an ongoing basis. Water quality, meteorological, pool level, and flow data for the past year would be used to develop a specific model for the year. As the annual models are developed, they could be used to further assess water quality in Chatfield Reservoir and help determine if water quality has been adversely impacted by reallocation. If adverse impacts are identified, the model could be used to conduct scenario testing of possible water quality mitigation measures. If core objectives are threatened, a dynamic water quality model could be used to scope out the water quality concern, and, if appropriate, identify mitigation measures that could be implemented. Mitigation measures to manage water quality could include, but are not limited to:

- Altering inflow and outflow to better manage flushing flows and hydraulic residence time; and
- Implementing "structural" measures to reduce hypoxia (e.g., aeration, mixing, and bottom-withdrawal).

The following identifies objectives and decision points for water quality modeling regarding the Chatfield Reservoir reallocation.

Modeling Objective 1 – Annually Apply the Dynamic Water Quality Model to Chatfield Reservoir to Assess Water Quality Impacts from Reallocation and Report the Findings

- Water quality monitoring, modeling and results will be included in an Annual Water Quality Modeling Report completed by the Chatfield Water Providers, in cooperation with the CWA, that includes the results from data obtained from the monitoring and modeling, assesses the information, and identifies potential water quality impacts resulting from reallocation.
- The Annual Water Quality Modeling Report will be presented to the TAC by no later than March 1 of the year following the year the monitoring report addresses. The TAC will review the report and make recommendations to the PCT regarding

the water quality assessment findings, significant impacts, and potential mitigation measures if necessary.

- The PCT will consider the recommendations of the TAC and determine if the reallocation has had a significant adverse effect on the water quality of Chatfield Reservoir based on the model results, the Annual Water Quality Modeling Report, and recommendations from the TAC and agencies. The determination of the PCT will be forwarded to the Corps for concurrence or comment.

Modeling Objective 2 – If the PCT Concurs with the Recommendation from the TAC that Significant Adverse Water Quality Impacts from Reallocation are Identified, Use the Water Quality Model to Evaluate Possible Mitigation Measures that can be Implemented to Address Identified Water Quality Impacts

- TAC would identify possible water quality mitigation measures that can be implemented to address water quality impacts.
- The water quality model from Modeling Objective 1 would be used by the Chatfield Water Providers to scenario test the effectiveness of possible mitigation measures identified by TAC. The results would be reported to TAC.
- TAC would review the results of the scenario tests and report on the effectiveness evaluation of possible water quality mitigation measures and recommend to the PCT mitigation measures to be implemented.
- PCT would provide comment/agreement on water quality mitigation measures to be implemented and submit recommendations for those mitigation measures to be implemented by the Chatfield Water Providers to the Corps for concurrence.

Modeling Objective 3 – Evaluate the Effectiveness of the Implemented Mitigation Measures

- Determine the effectiveness of implemented water quality mitigation measures evaluated from collected water quality data and water quality modeling. The findings would be included in the Annual Water Quality Monitoring Report and Annual Water Quality Modeling Report prepared by the Chatfield Water Providers and would be presented to TAC.
- TAC would review and comment on the effectiveness of implemented water quality mitigation measures in addressing water quality impacts and identify if additional mitigation measures should be considered if necessary, and would make recommendations to PCT.
- Based on the model results, the Annual Water Quality Modeling Report, and recommendations from TAC and the agencies (e.g., EPA and CDPHE), PCT would determine annually by May 1 if current mitigation measures need to continue to be implemented, if current mitigation measures need to be adjusted, if new mitigation measures need to be implemented, and if new mitigation measures need to be tested; and, if so, which new mitigation measures should be tested. The PCT will submit recommendations to the Corps for concurrence.

Feedback and Learning

The following actions will be taken to provide feedback and learning opportunities regarding the Chatfield Reservoir reallocation.

- Determine if mitigation actions need to be taken based on an assessment of collected water quality data and findings of the modeling.
- If mitigation actions are needed, use modeling to identify effective and reasonable actions that can be implemented.
- Properly implement selected water quality mitigation actions.
- Assess implemented water quality mitigation actions for effectiveness.
- As necessary, adjust implemented mitigation actions or implement new mitigation actions as determined by effectiveness assessments.
- Continue water quality monitoring and mitigation actions as needed.
- Determine when monitoring, modeling, or mitigation is no longer needed.

Critical Low Flows

Appendix J of the FR/EIS determined that the proposed Chatfield Reservoir reallocation could potentially reduce critical low flows in the South Platte River immediately downstream of Chatfield Dam by storing an average of 19 AF of water annually instead of releasing the water to the river during critical low-flow periods (Appendix J, Section 3.4). Appendix J also stated that it is difficult to determine if an average annual reduction of 19 AF of discharge from Chatfield Dam during critical low-flow periods will have significant adverse impacts on water quality in the South Platte River because the calculated critical low flows in the South Platte River quickly increase in a short distance downstream of Chatfield Dam.

The relatively small amount of water (19 AF), the relatively short reach of potentially affected river (about 1 mile), and relative infrequency of occurrence of the critical low-flow periods (currently an average of about 4 days per year) raises uncertainties regarding the potential effects on water quality associated with the estimated annual storage of 19 AF during crucial low-flow periods in the South Platte River below Chatfield Dam.

The existing critical low flows for water quality management of the South Platte River immediately downstream from Chatfield Reservoir are taken to be the monthly acute low flows identified by modeling for the "Below Chatfield" site as part of the nitrate total maximum daily load (TMDL) developed for Segment 14 (Appendix J,

APPENDIX B

FISH, WILDLIFE AND RECREATION MITIGATION PLAN (CHATFIELD REALLOCATION WATER PROVIDERS 2013)

Chatfield Reservoir Reallocation Project

Fish, Wildlife and Recreation Mitigation Plan

Prepared for:
The Colorado Parks and Wildlife Commission
In accordance with C.R.S. 37-60-122.2

Prepared by:
Chatfield Reservoir Reallocation Project Participants

November 2013

Table of Contents

Figures

Tables

Abbreviations

AF	Acre Feet (a measure of water volume equivalent to 325,851 gallons)
BMP	Best Management Practice
CDPHE	Colorado Department of Public Health and Environment
CDWR	Colorado Division of Water Resources
cfs	cubic feet per second, a measure of flow rate
CHU	Critical habitat unit (for Preble's meadow jumping mouse)
CMCC	Chatfield Marina Coordination Committee
CMP	Compensatory Mitigation Plan
CPW	Colorado Parks and Wildlife
CRMC	Chatfield Reallocation Mitigation Company
C.R.S.	Colorado Revised Statute
CSFU	Chatfield State Fish Unit
CWCB	Colorado Water Conservation Board
DNR	Colorado Department of Natural Resources
DWR	Colorado Division of Water Resources
EDAW	EDAW, Inc., a consulting recreational planning firm (now AECOM)
EFU	Ecological Function Unit
EIS	Environmental Impact Statement
ER	Engineering Regulation
ERO	ERO Resources Corporation, a consulting environmental planning firm
ESA	Endangered Species Act
Fed. Reg.	Federal Register
FEIS	Final Environmental Impact Statement
FR/EIS	Feasibility Report/Environmental Impact Statement
FWMP	Fish and Wildlife Mitigation Plan
msl	mean sea level
NEPA	National Environmental Policy Act
OHWM	Ordinary High Water Mark
PCT	Project Coordination Team
RFMP	Recreation Facilities Modification Plan
ROD	Record of Decision
RSUA	Reallocated Storage Users Agreement
SWSI	State Water Supply Initiative, a study by the CWCB
TBD	To be determined
USACE	U. S. Army Corps of Engineers
USDA	U. S. Department of Agriculture
USC	U. S. Code
USEPA	U. S. Environmental Protection Agency
USFS	U. S. Forest Service
USFWS	U. S. Fish and Wildlife Service
WSA	Water Storage Agreement

Executive Summary

This Fish, Wildlife and Recreation Mitigation Plan has been prepared in response to the requirements of C.R.S. §37-60-122.2. It identifies actions that the Chatfield Reservoir Storage Reallocation Project Participants will implement to mitigate unavoidable adverse impacts the Chatfield Reallocation Project will have on fish, wildlife, and recreation. (C.R.S. §37-60-122.2 does not require that a mitigation plan for recreation impacts be approved by the Colorado Parks and Wildlife Commission, however, significant efforts will be undertaken to mitigate unavoidable impacts to recreation facilities and amenities. These mitigations are included herein to ensure that Colorado Parks and Wildlife concerns are fully addressed).

The Chatfield Reservoir Storage Reallocation Project (Project) is a project whereby agricultural and municipal water users will use reallocated space in an existing federal facility to develop new water supplies. Chatfield Reservoir is a 350,653 acre foot (AF) reservoir south of Denver built and operated by the U. S. Army Corps of Engineers (USACE).

The USACE currently allows 27,405 AF of water to be stored in Chatfield Reservoir for recreational, environmental and water supply benefits. The Project will reallocate an additional 20,600 AF of flood space for water storage to benefit agricultural and municipal water users in the South Platte Basin resulting in up to 48,000 AF of storage space for recreational, environmental and water supply.

The Project began in 1996, when the Colorado Water Conservation Board (CWCB), as the Project sponsor on behalf of 15 water providers, formally requested that the USACE consider reallocating space within Chatfield Reservoir. This request was in response to a 1986 Congressional authorization allowing the USACE to determine whether additional water could be stored in the reservoir for water supply benefits while not compromising Chatfield's flood control function. The USACE has determined that up to 20,600 AF of space can be reallocated without diminishing the reservoir's flood control capability. The Project Participants currently include eleven municipal and agricultural water users and the CWCB.

This Project will contribute to meeting a portion of the water supply needs of the Project Participants. The reallocation of 20,600 acre-feet of storage is estimated to result in an average annual yield of 8,500 acre-feet of new water supplies. The CWCB Statewide Water Supply Initiative (SWSI) projected that Colorado's population will nearly double by 2050. This means that the water supply shortage in the South Platte basin (including the Denver Metro area), will be at least 100,000 AF per year assuming that previously identified projects such as Chatfield Reallocation are 100% successful. To the extent that identified projects are not all successful, the gap in the South Platte and Metro basins could be as large as 360,000 AF per year. As shown in Table 1-2 of the FR/EIS, the water supply shortage for project participants in 2020 is 119,200 AF with 85,000 AF of the shortage coming from agricultural participants. The opportunity to use an existing reservoir to store water and develop new surface water supplies partially addresses this significant water supply need.

The Draft FR/EIS identifies the reallocation of 20,600 AF as the Tentatively Recommended Plan. The Draft FR/EIS was made available for a 90 day public review from June through August, 2012, and the Final FR/EIS has been made available for a 30-day public comment period beginning on August 2, 2013. The Record of Decision is projected to be issued by late 2013 or early 2014.

The Project is located in Chatfield State Park, managed by the Colorado Parks and Wildlife (CPW). Environmental resources at Chatfield State Park will be negatively impacted by increased water storage in Chatfield Reservoir. Higher water levels will inundate some recreation facilities and environmental resources that have developed around the reservoir since it was constructed. In its 38 years of operation, the reservoir generally has been managed to maintain water levels within a 9-foot range (elevation 5,423 – 5,432 feet above mean sea level (msl)). The Project will result in an additional 12 feet of water level fluctuations. The Project will also impact environmental resources above and below Chatfield Reservoir. More detail regarding the actions to mitigate all identified adverse impacts are described in the FR/EIS.

The storage of additional water in Chatfield Reservoir is also expected to have beneficial effects to the aquatic and wildlife environmental resources at or near Chatfield Reservoir. These beneficial effects will include improving the in-reservoir fishery, enhancing raptor and bird habitat as a result of an improved in-reservoir fishery, enhancing the habitat for shoreline avian species and flow augmentation and probable temperature reduction in the South Platte River below the reservoir from summer and fall water releases from Chatfield Reservoir. Some of the mitigation measures will provide additional benefits beyond accomplishing the targeted mitigations. For example, improving habitat in Sugar Creek for the Preble's Meadow Jumping mouse will have the additional benefit of improving habitat for the brook trout fishery in Sugar Creek (an off-site mitigation site).

The Draft FR/EIS identified what the USACE considers to be the Project's significant adverse impacts and the mitigations necessary to compensate for them. Project Participants will address additional environmental and recreational concerns identified by Colorado Parks and Wildlife through the adoption and implementation of this State Fish, Wildlife, and Recreation Mitigation Plan. This plan is a compilation of, and includes by reference, the following documents:

- The Draft FR/EIS
- The Compensatory Mitigation Plan (CMP) (Appendix K of the Draft FR/EIS issued on 6/8/2012),
- The Recreation Facilities Modification Plan (RFMP) (Appendix M of the Draft FR/EIS)
- The new Marina Mitigation Plan being developed from an ongoing study,
- The Tree Management Plan (Appendix Z of the Draft FR/EIS),

- The USACE Adaptive Management Plan (Appendix GG of the FR/EIS), and
- Comparative Review of Reservoir Fluctuation Zone Chatfield Reallocation Project (Appendix HH of the FR/EIS)

There are two key contracts currently being developed for the Project, The Water Storage Agreement (WSA) and the Reallocated Storage Users Agreement (RSUA). The WSA is a mechanism whereby the USACE grants the permanent right to storage in Chatfield Reservoir in exchange for commitments to fulfill all financial and mitigation obligations. The Water Storage Agreement establishes an oversight committee, called the Project Coordination Team (PCT), consisting of representatives from the USACE, State of Colorado and Project Participants. The PCT will oversee the implementation of all aspects of the project. The USACE has ultimate responsibility for approval of Project plans and the completion of mitigation requirements.

The Chatfield Water Providers are committed to responsibly avoiding, minimizing and mitigating the Project's identified adverse impacts. The adverse impacts to the environmental and recreational resources caused by the Project and the proposed measures to mitigate such impacts, including costs, are summarized in the following Table 1.

Table 1: Chatfield Reallocation Project Fish, Wildlife and Recreation Mitigation Plan (FWRMP)				
Proposed Mitigations for Proposed Action				
RESOURCE	**IMPACT**	**MITIGATIONS**	**SECTION OF FWRMP WHERE DISCUSSED**	**ESTIMATED COST**
WILDLIFE RESOURCES				
Within Chatfield State Park				
In-Reservoir Aquatics			-	-
Fish - Walleye	Disruption of Walleye Spawn period March 1 - April 15	1) Participants commit to ensure releases do not exceed 420 cfs during March 1 - April 15 period, understanding that critical time is March 15-30. 2) Regular coordination meetings between Participants and CPW to forecast upcoming operations - close coordination to minimize adverse impact from releases.	4.1.3.3(B)(1)	
Fish - Smallmouth Bass	Disruption of Smallmouth Bass spawn period June 1 - June 30	Mitigation dealt with in operations agreements - Participants commit to limit releases May 1-July 15 water decline will not be greater than 8000 AFT, July 16-Aug 31 water level decline not greater than 4000 AFT, May 1-Aug 31 collective daily discharge shall not exceed 420cfS	4.1.3.3(B)(2)	
Water Quality	Increase in phosphate and ammonia loading; Decreased Dissolved Oxygen; Increased mercury methylation - from anoxic or increased dissolved oxygen in the reservoir	1) Participants agree to water quality monitoring and modeling program in coordination with Chatfield Watershed Authority. 2) Wetland creation and habitat improvements on Plum Creek in the CMP. 3) Plum Creek riparian restoration.	4.4.1; 4.5; 4.3.2	$1,300,000 (est.) for water quality monitoring and modeling, $6,088,600 for Plum Creek restoration
Terrestrial wildlife			-	-
Preble's Mouse - Plum Creek Critical Habitat	75 acres of critical habitat/ 65 EFU's	1) From CMP: Onsite: 6 acres / 3 EFUs habitat creation. 2) From CMP: Offsite: unknown acres private land protection and enhancement / 62 EFU's needed.	4.5	$58,500,000 for CMP
Preble's Mouse - South Platte Critical Habitat	80 acres/ 2.8 miles	1) From CMP: Onsite: 17 acres habitat creation; 2) Offsite: 73 acres private land protection and enhancement. Chatfield Res Mitigation Company will coordinate w CPW in the development of this process; 3) 4.5 miles and 381 acres of Sugar Creek improvements	4.5	
Preble's Mouse - Non Critical Habitat	298 acres / 210 EFUs	1) From CMP: Onsite: 111 acres of habitat creation / 43 EFUs. 2) From CMP: Offsite: unknown acres private land protection and enhancement / 167 EFU's needed	4.5	
Other terrestrial wildlife and Birds	586 acres (inundation zone)/ 377 EFUs	1) From CMP: Onsite: 165 acres habitat creation and enhancement / 9 bird EFU's. 2) Plum Creek Restoration Plan; 3) Tree mitigation plan will address impacts as well. 4) From CMP: Offsite: unknown acres / 368 EFU's needed.	4.5; 4.3.2	
Amphibians/ Reptiles	Grouped into Preble's/wetlands/terrestrial	Mitigation actions covered under Preble's/wetlands/terrestrial resources	4.5	
Erosion of land area /habitat	Sediment erosion - due to new storage and water fluctuation	1) Bank stabilization / Erosion control/ Plum Creek erosion and stream erosion	4.3.4; 4.3.2	$716,100 for shoreline stabilization plan
CMP			-	-

Mature Cottonwoods and other cottonwoods	42.5 acres	1) 13 acres - new cottonwood generation on-site (in CMP). 2) 22.5 acres - protection of existing off-site habitat (in CMP). 3) 10 acres - new cottonwood generation off-site (in CMP). 4) Recreation modification plan will mitigate for additional cottonwoods. 5) Tree management plan. 6) Res operations plan - water level in summer.	4.5.3; 5.1.1; 4.5.5; 4.1.3.3	
Wetlands	up to 159 acres / 123 EFU's	1) In CMP: Onsite: 47 acres / 30 EFUs. 2) In CMP: Offsite: Unknown acres / 93 EFU's	4.5	
Invasive Species/ Weeds	Increased invasives	1) BMPs to control spread (in CMP). 2) Monitoring and treatment of noxious weeds in project area (greater than 400ft) 3) Weed monitoring and weed control for 5 years in revegetation / mitigation sites (in CMP and AMP). 4) Weed control in fluctuation zone is ongoing obligation (in CMP).	4.3.3	
DOWNSTREAM OF CHATFIELD STATE PARK				
<u>Aquatic Resources</u>			-	-
Downstream aquatic habitat	Decreased streamflow impact on aquatic habitat; Increased low flows / zero flow days	1) 0.5 mi of stream habitat improvement (Chatfield Dam to Marcy Gulch), potential use of CPW water rights to create an environmental pool to mitigate low flow days. 2) Best efforts to target releases to limit zero flow days and mitigate with environmental pool. 3) Potential development of environmental pool for target releases (first goal) and/or environmental flow releases. 4) Required releases for critical low flows.	4.2.1.2; 4.1.3.3(D)	$265,000 for .5 mile stream enhancement
Aquatic Habitat - water quality	Increase E.coli from reduced flows; Increase temperature from reduced flows	1) Water quality monitoring program below dam. 2) Best efforts to target releases to limit zero flow days (in operations plan add citation). 3) Required releases for critical low flows. 4) Potential development of environmental pool for target releases and/or environmental flow releases.	4.4.2; 4.1.3.3(D)	
Chatfield State Fish Unit	Decreased flows	Agree not to exercise rights senior to the hatchery if would cause curtailment of CSFU rights (only if historic flows would have passed by CSFU).	4.1.3.3(A); 4.2.3	
	Increase in zero flow days	Potential development of environmental pool and/or environmental flow releases	4.2.1.2	
UPSTREAM OF CHATFIELD STATE PARK				
Aquatic habitat	Inundation of upstream fish habitat - Permanent habitat conversion from sediment deposition; Loss of stream channel for native fish - from inundation impacts on Plum Creek	1) Fund habitat improvement for 0.7 miles upstream. 2) Plum Creed Restoration plan. 3) Wetlands improvements in CMP - might mitigate intermittent stream mileage. 4) Sugar Creek Improvements.	4.2.1.1; 4.5.3; 4.3.2	$369,600 for .7 mile stream enhancement
RECREATIONAL RESOURCES				
WITHIN CHATFIELD STATE PARK				
Facilities and Recreational Use	Loss of facilities due to inundation.	1) RMP details mitigation measures for facilities and recreational uses - includes contingency approach that gives the plan flexibility. 2) New temporary CPW engineering employee hired during design and construction of recreational facilities	5.1.1; 5.1.3	$31,600,000 for recreational facilities modification plan, $225,000 (est.) for temporary resident engineer
	Marina - unusable due to inundation	Chatfield Marina Coordination Committee (CMCC) working on separate mitigation plan for the marina.	5.1.2	$15,700,000

	Loss of wildlife viewing and shade	1) CMP & Tree Management Plans detail mitigation for wildlife viewing and shade - Plum Creek restoration (if approved) would address access to viewing opportunities. 2) 13 acres of on-site mitigation (for mature cottonwoods). 3) 32.5 acres of offsite mitigation. 4) Tree management plan modified to leave trees down to 5432 and use of adaptive management to remove dead or dying trees within the fluctuation zone.	4.5.3; 4.5.5; 4.3.2	
	Facility vulnerability to future flooding	Could be addressed in the design phase to raise the roads by swim beach, balloon area and Deer Creek - to make roads still able to handle 10 year floods	5.1.1	
	Quality of Recreational Experiences	1) Restrict releases to 8,000 ac/ft total from May 1 - July 15th and 12,000 total to August 31st. 2) Fluctuation zone mitigations that includes: vegetation and weed control, new cottonwood regeneration along shoreline and facilities, shoreline stabilization plan, plum creek improvements.	4.1.3.3; 4.3.3; 4.5.3; 4.3.4; 4.3.2	
	Increased Boating Hazards	Funding of contract labor and equipment for hazard removal, signing, operational impacts due to increased inundation and fluctuations. Operational issues will be covered in the financial mitigation plan.	5.2	
	Water Quality - raised elevation causes erosion which will affect access below campground	1) Monitoring and modeling of water quality. 2)Plum Creek restoration plan	4.4.1; 4.3.2	
	Public Understanding	1) Project Participants have agreed to a marketing plan to be implemented prior to construction and continuing after construction is complete - part of financial mitigation plan, when approved.	5.2	$200,000
Stream fishing	Reduced Recreational Opportunities - reduced fishing from additional zero or low flow days	1) Establish an environmental pool to mitigate low flow days - use of hatchery, downstream uses. 2) Mitigation of 0.5 mi of stream habitat improvement 3) Operations plan language of good faith efforts to strategic releases.	4.2.1.2; 4.1.3.3(D)	
Stream fishing	Reduced Recreational Opportunities - reduced fishing from intermittent inundation	1) 0.7 mi of stream habitat improvements. 2) Sugar Creek improvements	4.2.1.1; 4.5.3	
Revenue and Operating Expenses				
Park Revenue	Decreased revenues during construction and post construction	1) Financial Mitigation plan. 2) WP to cover lost revenue	5.2	$1,000,000 (est.) for financial plan
Park Operating	Increased operating expenses	WP to cover increased operating costs attributable to project	5.2	
Estimated Cost Totals				
Costs for mitigations required by the USACE				$107,100,000
Additional costs for FWRMP mitigations				$8,864,300
Total Mitigation Costs				$115,964,300

1.0 Introduction

1.1 Purpose of Document

This Fish, Wildlife and Recreation Mitigation Plan (Mitigation Plan) has been prepared in response to the requirements of C.R.S. 37-60-122.2 and identifies actions that the Project Participants will implement to mitigate the unavoidable adverse impacts that the Chatfield Reallocation Project will have on fish, wildlife, and recreation. The 122.2 Colorado Statute requires that “fish and wildlife resources that are affected by the construction, operation or maintenance of water diversion, delivery or storage facilities should be mitigated to the extent, and in a manner, that is economically reasonable and maintains a balance between the development of the state’s water resources and the protection of the state’s fish and wildlife resources” and that “impacts on [fish and wildlife] resources should be mitigated by the project applicants in a reasonable manner.”

This Mitigation Plan includes mitigation for recreation impacts and represents the complete mitigation package addressing CPW concerns.

1.2 Project Overview

The proposed Chatfield Reallocation Project increases the beneficial components of Chatfield Reservoir by reallocating storage space to facilitate new water supply development.

<u>Chatfield Reservoir and Chatfield State Park</u>

Chatfield Reservoir is located within Chatfield State Park, southwest of Denver at the confluence of the South Platte River and Plum Creek (Figure 1). The reservoir, owned and operated by the USACE, was completed in 1975 to provide flood protection for the metropolitan Denver area following the disastrous South Platte River flood of 1965.

Chatfield Reservoir has a maximum capacity of 350,653 acre feet (AF). Up to 27,405 AF may currently be stored for recreational and water supply purposes. Denver Water is currently the only water user storing water in Chatfield Reservoir. In general the reservoir has been managed to maintain water levels within a 9-foot range (elevation 5,423 to 5,432 feet above mean sea level (msl)). The average range of mean monthly elevations has been approximately 3 feet from low to high reservoir periods. The current Ordinary High Water Mark (OHWM) elevation is 5,432 feet above msl.

Colorado Parks and Wildlife (CPW) manages recreation at Chatfield Reservoir and Chatfield State Park. Chatfield State Park covers about 5,300 acres, 1,500 acres of which include Chatfield Reservoir. The Park annually receives about 1.6 million “visitor days”, generating about $2.2 million in revenues that support operations and maintenance of Chatfield State Park and contribute to funding the State park system.

Chatfield Reservoir is one of three walleye brood lakes statewide, providing up to 33 million walleye eggs for stocking in Colorado waters statewide. The South Platte River above and below the reservoir is utilized by anglers on a year round basis and, given its close proximity to the Denver Metro area, is particularly valuable because it provides an opportunity to fish close to home.

CPW owns and operates a fish distribution hatchery unit, located below the dam that plays a critical role in enabling CPW to stock various front-range waters in the spring and summer. This unit is intended to function as a fully operational hatchery but does not due to water availability limitations.

History of the Chatfield Reservoir Storage Reallocation Project

In 1986, in Section 808 of the Water Resources Development Act, Congress authorized the USACE to conduct a reallocation study for joint flood risk management -conservation purposes, including whether storage for municipal and industrial water supply, agriculture, recreation, and fishery habitat protection and enhancement could be accomplished without risk to flood control. The authorization required that the Colorado Department of Natural Resources (DNR) be the local sponsor for the reallocation and that the Chief of Engineers conclude the reallocation is feasible and economically justified.

In 1996, on behalf of 15 water providers, the Colorado Water Conservation Board (CWCB) formally requested that the USACE consider reallocating space within Chatfield Reservoir for water supply purposes.

In 1999, a Feasibility Report and Environmental Impact Statement (FR/EIS) process was initiated to conduct the analyses required by the Chief of Engineers' findings (ER 1105-2-100, Ch. 4). The overall FR/EIS study area encompasses the area in the immediate vicinity of Chatfield Reservoir and extends downstream to where the river intersects the Adams/Weld county line (Figure 1).

The FR/EIS used the CWCB's SWSI, and other relevant planning studies, to identify alternatives for reallocation. A total of 37 concepts were evaluated in the initial screening process. The development of alternatives to reallocation and the screening process are described in detail in Chapter 2 of the FR/EIS. The FR/EIS evaluates, in detail, the environmental, social, and economic effects of the Proposed Recommended Alternative, as well as two other alternatives and a No Action alternative.

The alternative reallocating 20,600 AF of storage space in Chatfield Reservoir is both the locally preferred plan and the USACE's Tentatively "Recommended Plan" (hereinafter referred to as the Chatfield Project). The average annual water yield from the Recommended Plan is estimated at 8,500 AF. This provides a partial solution for the estimated 360,000 AF per year (year 2050) gap in water supply for the Front Range identified in the SWSI study. To the extent that identified projects such as Chatfield Reallocation are 100% successful, the remaining 2050 gap is still estimated to be roughly 100,000 AF per year. As shown in Table 1-2 of the FR/EIS, the water supply shortage for project participants in 2020 is 119,200 AF with 85,000 AF the shortage coming from agricultural participants.

The Draft FR/EIS was made available for a 90 day public review from June through August, 2012, and the Final FR/EIS is scheduled for completion by September 30, 2013. The Record of Decision is projected to be issued by late 2013 or early 2014.

The Chatfield Project Participants and their share of the reallocated storage space (Reallocation Space) are given below. The Participants' service areas are shown in Figure 2.

		Storage Amount, AF	% of Total
1	Central Colo. Water Conservancy Dist.	2,849.00	13.83%
2	Western Mutual Ditch Company	1,425.00	6.92%
3	Denver Botanic Gardens at Chatfield	40.00	0.19%
4	Centennial Water and Sanitation Dist.	6,434.94	31.24%
5	Castle Rock	1,013.16	4.92%
6	Castle Pines North Metro Dist.	941.58	4.57%
7	Castle Pines Metro Dist.	785.58	3.81%
8	South Metro Water Supply Authority	1,418.42	6.89%
9	Mount Carbon Metro Dist.	400.00	1.94%
10	Center of Colorado WCD	131.32	0.64%
11	Colorado Water Conservation Board	5,161.00*	25.05%
		20,600.00	

*Note: CWCB storage amount subject to change pending transfers with other entities

Upon final approval of the Project, the Participants will be responsible for the operation, maintenance, and repair of infrastructure, treatment, and distribution facilities associated with their water and their share of the Project rehabilitation and replacement costs. The Participants would fully fund the environmental mitigation and recreation modifications necessary to mitigate the impacts of operating the reservoir under the storage reallocation. The CPW will be integral in the implementation of the mitigation and will be able to ensure the site-specific plans for on-site mitigation are acceptable and consistent with its management of Chatfield State Park resources.

1.3 Regulatory Processes

The Project has undergone significant regulatory scrutiny at the federal, state and local levels. At the federal level, USACE performed extensive and detailed project feasibility and environmental studies pursuant to its regulatory and planning requirements. The culmination of the process is a joint Feasibility Report/ Environmental Impact Statement that will serve as the basis for issuance of the Department of the Army Record of Decision (ROD).

The following federal, state and local regulatory approvals are required to implement the Project:

- Federal: Compliance with Section 404 of the Clean Water Act (CWA) for dredge and fill activities in waters of the U. S. associated with the recreational facilities modification plan and other mitigation incident to the reallocation; Compliance with Section 7 of the Endangered Species Act (ESA) related to impacts to Preble's mouse and its designated critical habitat; and U. S. Forest Service (USFS) approval for work on USFS land (along Sugar Creek).

- State: Approval by CPW Commission and the Colorado Water Conservation Board of this Fish, Wildlife, and Recreation Mitigation Plan pursuant to C.R.S. §37-60-122.2; Colorado Department of Public Health and Environment (CDPHE) construction permits for air quality, water quality certification for any discharge-related mitigation activities, and permits for stormwater and construction dewatering.

- Local: Douglas County permits for construction work along Sugar Creek and at Chatfield Reservoir; and Jefferson County permits for construction work at Chatfield Reservoir.

1.4 Stakeholders

The stakeholder entities include:

- Federal: USACE, USEPA, USFS, and USFWS;

- State: DNR, CWCB, CPW, DWR and CDPHE;

- Local: (In addition to the Project Participants) Denver Water, City of Littleton, South Suburban Parks and Recreation District, City and County of Denver, Douglas County Commissioners, Jefferson County Commissioners, Weld County Commissioners, Metro Wastewater Reclamation District, Chatfield Watershed Authority, and Urban Drainage and Flood Control District; and

- Non-governmental organizations: The Greenway Foundation, Audubon Society of Greater Denver, Colorado Environmental Coalition, Sierra Club, Western Resources Advocates, Trout Unlimited, Chatfield Basin Conservation Network, and The Nature Conservancy.

The Project Participants have consulted and conferred with a broad range of federal, state, local and environmental stakeholders to solicit input on appropriate mitigation of adverse impacts associated with the Project. Public participation efforts included notices and public meetings to meet NEPA requirements during the release and review of the Draft FR/EIS. Meetings with stakeholder entities started in 1994 and continued with regularly scheduled, usually monthly, meetings hosted by the Colorado Water Conservation Board.

2.0 Avoidance and Minimization of Adverse Impacts

Throughout the process, the Project Participants sought an environmentally responsible project by, first, seeking to avoid adverse impacts to aquatic and wildlife resources whenever possible; second, minimizing unavoidable adverse impacts; and finally, developing mitigation measures to fully compensate for the remaining adverse impacts of the Project. Below are changes to the original Proposed Action made to avoid and minimize adverse impacts associated with the Project:

2.1 Avoidance and Minimization of Aquatic and Wildlife Environmental Impacts

Actions to avoid or minimize adverse aquatic and wildlife environmental impacts:

- Incorporation of Best Management Practices to clear land to be inundated of vegetation to minimize the nutrient loading into the reservoir.
- Agreement on timing and operational limitations on releases of stored water to avoid adverse impact to the walleye egg collection, other fishery operations, recreation and trees.
- Development of a coordinated operations plan to minimize water level fluctuations during critical recreation and fishery operations.
- The use of adaptive management approaches to minimize adverse impacts as management knowledge is gained from Project implementation. Adaptive management responses will be applied to water quality, vegetation, wildlife, wetlands, and threatened and endangered species.

2.2 Avoidance and Minimization of Wetlands and Recreational Impacts

In order to maintain the recreation experience of Chatfield State Park, recreation infrastructure must be relocated. The preliminary Recreation Facilities Relocation plan was presented to the USACE Denver Regulatory Office to discuss 404 permitting implications and how the discharge of fill material into waters of the U. S. could be avoided or the effects minimized. Each recreation related facility was reviewed and evaluated to determine if it could be located or constructed in a way to avoid or minimize the discharge of fill material into wetlands and other potential impacts to wetlands and sensitive resource areas. While it is feasible to accomplish these activities without a discharge, the desired approach for modification of recreation facilities will involve some discharge of material.

Components of the Recreation Facilities Modification Plan revised to minimize the discharge of dredge or fill material into wetlands and preserve unique recreational amenities include:

- Gravel Pond Area. The plan includes the rebuilding of the dike north of the gravel pond with a new park road on top, in the same location as the existing road, in order to minimize impacts to the surrounding area as well as to preserve the gravel pond. The side slopes of the road/dike were steepened and the road was realigned to further reduce the filling of wetlands. The road on the east side of the Gravel Pond was realigned to completely avoid the discharge of fill material into wetlands and, to preserve the gravel pond from inundation at 5,444 above msl, will include a new dike at an additional cost of approximately $500,000. These actions preserve the highly valued and relatively rare recreational experiences of scuba diving, long distance swimming, canoeing and kayaking (without the influence of nearby power boats) at Chatfield.

- North Boat Ramps. The extension of the north boat ramps was revised to minimize the discharge of fill material below the OHWM. Early conceptual alternatives for this area were replaced with a more extensive plan involving reconstruction of the parking lot, entry road, and boat ramps in order to minimize excavation below 5,432 feet above msl and to avoid impacts to wetlands.
- Swim Beach. Alternative configurations of the beach and causeway were analyzed to ultimately develop an approach that minimizes the amount of wetlands filled.
- Catfish Flats. The Catfish Flats recreation area was redesigned to avoid any discharge of dredge or fill material into waters of the U. S., including wetlands.
- Marina Area. The breakwaters of the marina were revised to reduce their footprint and the amount of cut and fill below the OHWM. Substantial modifications of this area were made, including relocation of the entry road, parking lot and facilities, and the reconfiguration of the breakwater.
- Plum Creek Area. The relocation of the Plum Creek Trail went through several iterations to minimize the discharge of fill into wetlands.

3.0 Benefits of the Project

Water Supply Benefits:

- Approximately 8,500 AF average year yield of new renewable surface water supplies are developed from this expanded use of an existing reservoir. These new water supplies benefit water users from Park County, to Douglas County, and to Weld County.
- 20,600 AF of new, on channel storage space is developed at a location high in the South Platte basin.

Environmental and Recreational Benefits:

- A potentially improved in-lake fishery:

    - "New Reservoir" effect of additional water, when available, may result in increased primary productivity within the reservoir and a resulting positive benefit to food chain production in virtually all trophic levels;
    - Positive impact to gizzard shad and other forage fish during increased pool elevations, except during mid-May to mid-June; and
    - Benefit to crayfish populations from increased shallow water areas with a resulting enhancement of forage for smallmouth and largemouth bass populations.
- New recreational and infrastructure facilities built to current codes.
- Additional water provides additional boating, canoeing or kayaking opportunities.
- Potential benefits to shoreline wildlife:
    - Increased exposure of shorelines may benefit migrating piping plovers; and
    - Increased shoreline areas benefit least terns, ducks, geese and other water birds and shoreline bird species.
- Potential benefits to other bird species from enhanced fishery or other factors:
    - Increased food supply for bald eagle and other raptors;
    - Increased fishery food supply for white pelican and other bird species; and
    - As some trees in the inundation area are left standing, herons and cormorants will benefit from the creation of a more secluded area of trees surrounded by water, providing new nesting habitat; cavity nesting birds will benefit.
- Keeping fallen trees as anchored fish structures would create positive shallow water habitat, so long as they are appropriately marked to prevent being boating hazards.
- Water that is released from Chatfield Reservoir during mid to late summer and throughout the fall and winter, to convey that water to downstream users, would improve the downstream fishery by increasing flow rates and possibly lowering otherwise higher water temperatures.
- New wetlands will be created as mitigation for the Project. These wetlands, along with mitigating the loss of other wetlands, are expected to improve upon current water quality conditions in the South Platte River and Plum Creek.
- Improvements to Plum Creek to repair serious existing degradation and provide some degree of channel stabilization will also enhance or improve water quality, restore wildlife habitat and may improve the fishery.
- The Sugar Creek Mitigation project, designed to preserve and enhance the Preble's Meadow Jumping Mouse habitat adjacent to Sugar Creek, will provide ancillary benefits to the brook trout fishery in Sugar Creek from reduced sedimentation.

4.0 Mitigation of Unavoidable Adverse Impacts: Fish and Wildlife

The storage of up to 20,600 additional AF of water in the Chatfield Reservoir will periodically inundate recreation infrastructure and environmental resources and may result in an additional 12 feet of potential water level fluctuations (Figure 3). The following measures address impacts to fisheries and aquatic habitat, wetland and riparian habitat, recreation and wildlife habitat.

4.1 Reservoir Operations Plan

The intent of the Reservoir Operations Plan is to ensure close communications between CPW and the Project Participants regarding reservoir operations and to coordinate operations to lessen impacts from the Project. The plan includes specific commitments designed to minimize the potential for adverse impacts on certain species, habitat and recreation.

4.1.1 General

Uncertainty: Reservoir operations are inherently uncertain due to a variety of factors (fluctuating demands, change in water usage, randomness and high variability of natural phenomena, climate change, extreme events, operational variability, and maintenance). The purpose of the Reservoir Operations Plan is to attempt to lessen the uncertainty associated with these factors.

Yield and Usefulness of the Water from use of the storage space: Subject to the commitments made in section 4.1.3.4 below, CPW will not seek any operation that would result in a reduction of the water right yield or significantly impair the usefulness of the storage space to each Project Participant.

Operations Plan only pertains to water stored by the Project Participants: The provisions of this plan do not change the April 3, 1979 agreement between Denver Water and the State of Colorado Department of Natural Resources related to storage in Chatfield.

4.1.2 Definitions:

Parties: CPW and the Project Participants

Fluctuations: Water being stored and released so as to cause the reservoir level to go up and down.

Good Faith Efforts: Whereby all Parties work together to use economically reasonable methods and means to achieve certain goals while maintaining a mutual understanding that in some situations, such as drought, prolonged periods of below average water years, acts of God, or other circumstances beyond the control of the Chatfield participants, these goals may not be fully attained.

4.1.3 Specific Provisions:

4.1.3.1 Meetings

Parties will meet bi-monthly February through October of each year to share their knowledge of current conditions and discuss forecasts for future Chatfield operations.

At the meetings, the Parties will review current conditions and forecasts; discuss operational strategies and expected diversions into and deliveries from storage and include fish health information to assist in protecting fish and their habitat.

Sources to be used for forecast information may include NOAA, National Weather Service Climate Prediction Center, Colorado Climate Center Precipitation Monitoring, NRCS, the State Engineers Office, current operating conditions of each participant, Denver Water, and others, as determined by the Parties.

The entities attending the meetings, the frequency and dates of meetings may be changed by mutual consent of the Parties.

4.1.3.2. Water Storage

Chatfield Reallocation Project Participants may store any legally storable water in Chatfield they are entitled to at any time.

4.1.3.3 Water Releases

A. In general, Project Participants, in consultation with CPW, will use good faith efforts to adjust the timing and amount of water releases from Chatfield so as to beneficially impact recreation and the environment. Upon request of CPW, water releases to the South Platte River from Participants' storage accounts will be made through the Chatfield State Fish Unit, so long as the water released can be appropriately administered by the State and Division Engineers and creates no injury to other water rights. CPW will be solely responsible for replacing in time, location and amount any out of priority depletions caused by the Project Participants' water being routed through the Chatfield State Fish Unit.

B. **1.** From March 1 to April 15, to avoid impacts to walleye spawning, Participants commit to limit the decrease in the reservoir water level elevation from the Participants' storage accounts to no more than 6” per day (which is equivalent to no more than 420 cfs of outflow in excess of inflow). The participants do not anticipate that, under normal circumstances, their releases will cause a rapidly decreasing pool. The Parties recognize that the only time during the period from March 1 to April 15 that releases would be greater than 6” per day is likely during a flood event or in anticipation of a flood event. In such instances, Project Participants are not responsible for decreases in elevation greater than 6”. At all times, Project Participants are only responsible for releases that occur as a result of their use of their stored water.

2. To avoid impacts on smallmouth bass spawning, Participants will consult with CPW on operational actions to minimize adverse impacts to smallmouth bass propagation.

C. Participants will limit releases from the reallocated project storage space, as accounted for by the Division of Water Resources and recorded on the Chatfield Storage Accounting Sheet, such that:

1. Between May 1 and July 15, the water level decline of that space attributed to Participant releases is not greater than 8,000 AF;

2. Between July 16 and August 31, the water level decline attributed to Participant releases will not exceed 4,000 AF; and,

3. During the period of May 1 to August 31, the collective daily discharge from the reservoir from the Chatfield Participants shall not exceed 420 cfs of outflow in excess of inflow.

However, for each of the above three provisions, if at any time during the calendar year the USDA Palmer Index indicates there exists a “severe drought” (also known as a D2 drought) anywhere in the South Platte River drainage basin that impacts the project participants water supply or demands, these commitments shall not be in effect for the remainder of that calendar year.

D. Between July 15 and the following May 1, so long as Participants will not lose yield and are reasonably able to make use of a release of water from storage, Participants will make good faith efforts to work with CPW to time the releases out of Chatfield in a manner that would benefit the fishery and riparian environment downstream of Chatfield dam.

This plan may be changed from time to time only by mutual agreement of the parties.

4.1.4 Adaptive Management for Operations

Adaptive management uses iterative decision-making to adjust compensatory mitigation to meet the core objectives. Results are evaluated and future actions are adjusted on the basis of what has been learned. Both the Fish, Wildlife and Recreation Mitigation Plan and the FR/EIS recognize that adjustments may need to be made as the mitigation activities in those plans are implemented. The details of the adaptive management required by the USACE are in the document entitled Adaptive Management Plan, which is Appendix GG of the FR/EIS. That document describes the core objectives, uncertainties and contingencies for each of the areas of water quality, reservoir operations, weed control, tree clearing, aquatic life and fisheries, and the subject of the CMP, the Target Environmental Resources.

In addition to unanticipated issues and challenges, the following are examples of what could require adjustments in the Fish, Wildlife and Recreation Mitigation Plan as currently proposed:

- All of the mitigation measures may not be completely successful;
- Some mitigation activities may provide more benefit than currently estimated;
- Other opportunities may become available to provide mitigation; and
- Natural disasters, such as forest fires or floods, could adversely affect mitigation activities.

By their very nature, adaptive management actions are implemented on an "as needed" basis and as informed by monitoring. The monitoring of impacts and mitigation will provide important information and feedback for an iterative process of refining action to minimize impacts and address uncertainties. Annual monitoring reports will include information on needed and proposed adjustments and uncertainties. Monitoring will be concluded when all of the core mitigation objectives are met, which will ultimately be decided by the USACE.

The core objectives for operations are:

1. Determine a target elevation range and seasonal schedule of storage and releases that would minimize adverse effects on the target environmental resources and recreation;

2. Determine operations that could meet the target elevation and seasonal schedule of storage and releases on a "best effort" basis without adversely affecting the yield of the Chatfield Water Providers as identified in this reallocation project;

3. Annually monitor the effects of storage in the reallocated space on the target environmental resources;

4. Continue to explore ways to adjust operations as circumstances allow minimizing adverse effects on the target environmental resources and recreation; and

5. Provide feedback and revisions as needed to the CMP regarding the need for more or less mitigation based on operation of the reallocated storage.

The Adaptive Management Plan, Appendix GG of the FR/EIS, gives further details.

4.2 Fisheries and Aquatic Habitat

4.2.1 Fisheries and Aquatic Habitat in the South Platte River

4.2.1.1 Habitat and Recreation in the South Platte above Chatfield Reservoir

Impact The Project will cause fishery and aquatic habitat to be negatively impacted by inundating up to 0.7 miles upstream of Chatfield Reservoir on the South Platte River and Plum Creek. This section of the South Platte River is a cold water trout fishery used for recreational fishing.

Mitigation The Project Participants will fund stream habitat improvements on up to 0.7 miles of the main stem of the South Platte River above Chatfield Reservoir above the highest point of potential inundation from the Project. The purpose of the habitat improvements is to improve the cold water trout fishery. The specific site and project design will be done at the direction of the CPW at a cost of up to $100 per linear foot (a total of $369,600 for this project), which the Participants and CPW have determined is adequate to accomplish the necessary stream habitat improvements. The habitat improvement work will be targeted to be completed within five years of issuance of the Record of Decision and before the initiation of storage of water in the reallocated storage space.

In addition, as part of the Compensatory Mitigation Plan, the Participants will implement the Sugar Creek Sediment Mitigation Project to substantially reduce sediment inputs into the approximately 4.5-mile reach of Sugar Creek, tributary to the South Platte River above Chatfield Reservoir. This project's primary goal is the restoration of Preble's mouse critical habitat but Sugar Creek in this area is a reproducing brook trout fishery and the sediment reduction efforts (costing an estimated total of $3,879,000) will have the ancillary effect of improving the aquatic habitat in Sugar Creek. The Sugar Creek Sediment Mitigation Project is a cooperative project among the US Forest Service, Project Participants and Douglas County, includes 29 new sediment traps, 5 culverts removing an existing fish passage limitation, and other features, and is fully described in Appendix E of the Compensatory Mitigation Plan.

As a third mitigation element, the Participants will construct the Plum Creek Restoration, which is described in further detail later in this document. The Plum Creek Restoration rebuilds portions of Plum Creek that have experienced significant erosion and, when the channel is rebuilt, it will have the benefit of providing more stable fishery habitat for two species of concern, the northern red-belly dace and the common shiner.

4.2.1.2 Habitat and Recreation in the South Platte below Chatfield Reservoir

Impact Water will be stored in Chatfield Reservoir from the Reallocation Project when the water is both physically and legally available. Increased storage of water in Chatfield Reservoir will result in additional zero and low flow days which may result in additional loss of stream habitat below Chatfield Reservoir.

Mitigation

1. **Stream Habitat Improvements:** To mitigate the potential impacts of increased storage in Chatfield Reservoir, the Project Participants will fund stream habitat improvements on up to 0.5 miles of the main stem of the South Platte River downstream of Chatfield Reservoir. The specific site and project design will be done at the direction of the CPW at a cost of $100 per linear foot (or $264,000 for this project), which the Participants and CPW have determined is adequate to accomplish this work. The habitat improvement work will be targeted to be completed within five years of issuance of the Record of Decision and before the initiation of storage of water in the reallocated storage space.

2. **Reservoir Operations:** The Reservoir Operations Plan (§4.1 above) includes an agreement wherein the Project Participants who release their stored water through the Chatfield Outlet Manifold and then subsequently leave the water in the South Platte River or divert their water at a downstream location will use their individual and collective good faith efforts to strategically coordinate their releases to assist in decreasing the number of low-flow or zero flow days in the South Platte River below Chatfield Reservoir. Such strategic releases of water provide the opportunity to increase the flows below Chatfield Reservoir when the flows are already low from pre-existing conditions.

3. **Minimum Flow Requirements for Critical Low Flows**. In order to avoid potential adverse effects on water quality during critical low flow periods, The USACE has required the Project Participants to pass flows through Chatfield Dam to the South Platte River during storage events that occur during critical low flows or would cause low flows. The Project Participants have the option to, at their discretion, pass flows or release previously stored water. If the Project Participants choose to release previously stored water, the requirement to pass flows will be deemed to have been met. If the Chatfield Water Providers choose to release previously stored water, they may work with the State Engineer to shepherd the released storage water through the reach sought to be protected by this requirement to any diversion point downstream that any of the Providers are legally entitled to use. The passed flow will equal the critical low flow for the month (Table 2), as measured at the Below Chatfield Gage (PLACHACO gage). The occurrence of critical low flows will be determined by monitoring the Below Chatfield Gage and the critical low flows in Table 2. Any releases required by the USACE will be included in determining operations pursuant to section 4.1 above.

Table 2. Acute (1-day) low flows (cfs) for the 10-year period 1-Oct-1999 through 30-Sep-2000 for the South Platte River below Chatfield Dam to Marcy Gulch (from Appendix J of FR/EIS).

Location	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Below Chatfield (cfs)	0.2	0.3	0.4	0.7	5.3	2.0	0.2	0.6	0.2	0.1	0.1	0.2

The Project Participants also have been given the option by the USACE of performing studies and monitoring to determine the effects of storage in the reallocated space on water quality during critical low flows or at times that would reduce existing flows to critical low flows or lower and, based on these studies, propose an alternative to the releases required by the USACE. This mitigation requirement and the study option are set forth in more detail in Appendices GG and J of the FEIS; and

4. **Environmental Pool:** The Project Participants, if requested, will collaborate with the CPW and/or CWCB in working with all interested parties to investigate the creation of an environmental storage space or pool, and/or to acquire a new, separate agreement(s) with one or more Project Participant(s) that includes a provision for timed environmental flow releases. Project Participants are not being asked to nor expected to contribute financially to the creation of an environmental pool. A potential environmental pool and/or separate agreement(s) for timed environmental flow releases could be used to maintain water levels in the reservoir, for water releases to alleviate low flow conditions downstream of Chatfield Reservoir or for augmentation purposes.

4.2.2 Fisheries and Aquatic Habitat within Chatfield Reservoir

In general, the fishery and aquatic habitat within Chatfield Reservoir is expected to potentially benefit from additional stored water and increase in varied habitat along the reservoir's edges. The potential beneficial effects to the in-reservoir fishery result from the additional water and nutrients stimulating the growth of multiple organisms in the food chain and generally improving the aquatic ecosystem. The populations of some fish and related species (for example, gizzard shad and crayfish) are expected to flourish.

Impact Walleye spawning could be negatively impacted if storage of water within the reallocated storage space results in larger or more frequent water level fluctuations during the walleye spawning season (March 1- April 15). The smallmouth bass reproduction could be negatively impacted by larger water level fluctuations during the smallmouth bass spawning season. In addition, increased fish migration out of Chatfield Reservoir may occur, due to higher water release rates.

Mitigation The Reservoir Operations Plan (§4.1 above) includes a commitment to limit the timing and magnitude of Participants' water releases during the critical walleye spawning period (March 1 to April 15 each year) so as not to cause the reservoir's water level elevation to decrease faster than one-half foot (6") per day. In addition, the operations plan includes the provision that to avoid impacts on smallmouth bass spawning, Participants will consult with CPW on possible operational actions to minimize adverse impacts to smallmouth bass propagation.

4.2.3 Chatfield State Fish Unit

CPW operates a facility, the Chatfield State Fish Unit (CSFU), below Chatfield Reservoir that receives water to maintain a fish hatchery that presently serves primarily as a fish holding facility supporting the distribution of fish in the metropolitan area. As discussed in section 4.1.3.3 (A), upon request of CPW, water releases to the South Platte River from Participants' storage accounts will be made through the Chatfield State Fish Unit, so long as the water released can be appropriately administered by the State and Division Engineers and creates no injury to other water rights.

CPW owns a 1980 water right to supply water to the facility. The most senior storage water right allowing storage in Chatfield reservoir for the Project Participants has a later priority date than the CPW water right. Thus, the exercise of the Project Participants' Chatfield storage water rights will not cause injury to the CPW water right. Additionally, change cases that have transferred the historic consumptive use of senior water rights upstream in the South Platte River basin for storage in Chatfield do not cause injury to the CPW 1980 water right. CPW intends to enter into an agreement with the CWCB that would define terms to prevent injury to the CPW Chatfield State Fish Unit water right that may result from the CWCB transfer of "orphan" shares to new water users.

4.2.4 Adaptive Management for Aquatic Life and Fisheries

As explained in §4.1.4, above, adjustments may need to be made as the Project Participants implement the mitigation activities set forth herein and in the CMP. Any necessary adjustments will be determined using the adaptive management principles and plan set forth in the document entitled Adaptive Management Plan, which is Appendix GG of the FR/EIS. That document describes the core objectives, uncertainties and contingencies for each of the areas of water quality, reservoir operations, weed control, tree clearing, aquatic life and fisheries, and the subject of the CMP, the Target Environmental Resources.

Adaptive management actions will be implemented on an "as needed" basis and as informed by the monitoring of impacts and mitigation on an ongoing basis to ensure the core mitigation objectives are met. Monitoring will be concluded when all of the core mitigation objectives are met, which will ultimately be decided by the USACE.

The core objectives for aquatic life and fisheries are:

1. Determine a target seasonal schedule of releases and maximum flow rate that would minimize adverse effects on CPW's walleye brood stock program and that can be implemented in the operations plan on a "best efforts" basis without adversely affecting the yield of the Chatfield Water Providers;

2. Determine operations that could promote strategic releases from Chatfield Reservoir to reduce the stressors on the aquatic habitat and therefore benefit the South Platte River downstream of Chatfield Reservoir on a "best efforts" basis without adversely affecting the yield of the Chatfield Water Providers;

3. Annually monitor the effects of the aquatic life and fisheries provisions of the operations plan for effectiveness;

4. Continue to explore ways to adjust operations as circumstances allow minimizing adverse effects and maximizing benefits to the aquatic life and fisheries within and below the reservoir; and

5. Provide feedback and revisions as needed regarding the need for possible adjustments to the operations plan based on the ongoing experiences operating the reallocated storage pool.

The Adaptive Management Plan, Appendix GG of the FR/EIS, gives further details.

4.3 Fluctuation Zone

4.3.1 Fluctuation Zone Mitigation Measures Overview

Impact Historic reservoir operations have seen approximate water level fluctuations of up to 9 feet. The uses of the reallocated space will add up to 12 feet of water level fluctuations. The resulting "fluctuation zone" could be up to 21 feet. Periodic inundation of up to 587 acres (the land area within the additional 12 feet of fluctuation) may lead to increased shoreline erosion, undesirable aesthetics, increased mosquitoes, creation of large mudflats, loss of wetlands, loss of wildlife habitat, and new weed proliferation.

Mitigation It is uncertain to what extent the conditions described above will occur in the future at Chatfield Reservoir. In response to comments about whether the impacts listed above might occur, the USACE conducted an additional study of six other Front Range reservoirs that have similar physical, hydrologic and recreational characteristics as Chatfield. The reservoirs are Barr Lake, Bear Creek Lake, Cherry Creek Reservoir, Jackson Reservoir, John Martin Reservoir and Pueblo Reservoir. The report, entitled "Comparative Review of Reservoir

Fluctuation Zone Chatfield Reallocation Project", dated November 13, 2012, is Appendix HH of the FR/EIS. The report concluded that:

- Mudflats were rarely observed at any of the reservoirs reviewed and are unlikely to commonly be a component of the fluctuation zone at Chatfield Reservoir;

- Noxious weeds were not commonly observed within the fluctuation zone of the reservoirs reviewed and are unlikely to become a significant problem for the fluctuation zone at Chatfield Reservoir;

- The establishment of vegetation within the fluctuation zone can vary widely in terms of vegetation cover and species composition;

- The reservoirs reviewed provide significant wildlife habitat even with, and sometimes because of, their broad fluctuation zones; and

- Reservoirs with substantial elevation swings in the fluctuation zone continue to support substantial recreation visitation.

Nevertheless, the Chatfield Participants propose the following mitigation measures to compensate for the possible adverse impacts from the creation of a larger fluctuation zone:

1. **Reservoir Operations Plan:** Because the Operations Plan allows the relatively rapid removal of up to 6 feet of the stored water within the months of the growing season, the reallocated storage pool may be operated to lessen the amount of vegetation that is lost from inundation, therefore decreasing the size of a fluctuation zone bare of vegetation. The Operations Plan (§4.1 above) includes the flexibility for release of 8,000 AF of water between May 1 and June 15 and an additional 4,000 AF of water between June 15 and August 31. These releases of water have the potential of lowering the reservoir water level up to 6 feet in this period; if this can be accomplished within the timeframe that the vegetation can tolerate inundation (which, depending on the vegetation, is estimated as being up to three months), then up to 6 feet of vegetation, or approximately 220 acres of vegetation, may not be lost. The resulting fluctuation zone will have retained its upper 6 feet of vegetation, lessening the newly impacted area by up to 50%. The mitigation requirements in the CMP are based on the actual vegetation lost, as measured periodically over time. Thus, the Project Participants are strongly motivated to minimize the amount of lost vegetation and will be able to attempt to remove some of the stored water relatively quickly to prevent vegetation from being lost.

2. **Plum Creek Restoration:** Plum Creek is currently experiencing environmental impacts from a stream erosion problem located above the area that will be inundated by the Project. Current devastating changes taking place including the major loss of vegetation, wildlife habitat, and degradation of water quality in the reservoir. These conditions

have not been caused by the Chatfield Reallocation Project, and, at present, are not being addressed or corrected by any entity. The proposed Plum Creek Restoration is a major construction effort to restore Plum Creek to a more stable condition. The current Plum Creek erosion and vegetation deterioration extends approximately 3,400 lineal feet and is progressing upstream at an estimated rate of approximately 300 feet per year. The proposed construction would be designed to repair the current devastation and to minimize the future threat to the entire Plum Creek riparian corridor within the Chatfield Park boundaries. This mitigation is a major, costly undertaking of such a magnitude (estimated at $6,258,600) that it is proposed by the Participants (along with Reservoir Operations, weed control and shoreline stabilization) as the means to adequately compensate for the Project's potential adverse effects to the fluctuation zone.

3. **Noxious and Invasive Weed Control:** The CMP and the Adaptive Management Plan detail measures to address weed control within the fluctuation zone. In short, The Project Participants will take permanent responsibility for controlling the spread of noxious weeds associated with the Project's increase in water level fluctuations.

4. **Shoreline Stabilization Plan:** The water level fluctuations on the southeast shoreline of the South Platte River arm of the reservoir contains steeper banks where existing fishing, boat docking and picnicking activities will be affected by water level fluctuations. Improvements are proposed to re-contour this area to maintain the recreational uses and improve the trail access in this area.

The Plum Creek restoration, noxious weed control and shoreline stabilization mitigations are more fully described below:

4.3.2 Plum Creek Restoration

The following information is a summary of work done for the Project Participants by Muller Engineering in 2012 and 2013 to understand the existing conditions on Plum Creek and to propose measures to eliminate the ongoing environmental degradation and protect the environmental resources that remain.

Existing Conditions: Field reconnaissance in 2012 along Plum Creek identified a large area of severe degradation upstream from where the Reallocation Project will impact Plum Creek. Multiple parallel channels have eroded up to at least ten feet deep in the upstream reaches of Plum Creek. As a result of the drop in localized water levels resulting from the erosion, the riparian and wetland vegetation adjacent to the eroded reaches was severely impaired and numerous trees and other vegetation, including wetlands vegetation, were either dead or dying. If the erosion problem continues to spread, it will cause extensive degradation to the Plum Creek riparian corridor and have continued adverse water quality impacts to Chatfield Reservoir from the release of nutrients in the eroded soils and decayed vegetation. The erosion is traveling upstream at a rapid pace (estimated as 300 feet per year), and threatens a large portion of the 395 acre Plum Creek alluvial basin within the USACE's Chatfield Reservoir property. See Figures 4 and 5.

In general, the Plum Creek channel is a very dynamic stream system. The channel is comprised of sand and small gravel material that is easily mobilized. The valley bottom within the park limits is extremely wide with a typical width of over 1500 feet. Within this wide valley bottom, there are two to three active channels that are 20 to 40 feet wide and convey base flows and small runoff events. These active channels appear to move and change location yearly and they convey a significant amount of sediment even during base flow conditions. This channel movement and braided condition appears to be primarily the result of a large inflow of sediment from upstream resulting from the gradual readjustment of sediments deposited from the major flood event on Plum Creek in June 1965.

The corridor is well vegetated with riparian and wetland vegetation including extensive stands of woody vegetation, such as sandbar willow shrubs, crack and peachleaf willow trees, and cottonwood trees. Riparian and wetland grasses include cattails, Baltic rush, and wooly sedge. Overall the Plum Creek channel within the park limits is an aggrading and braided stream system. The entire assessment of the condition of Plum Creek and proposed solutions developed by Muller Engineering can be found in their report entitled "Plum Creek Stream Stability Assessment", dated April 2, 2013.

Environmental Impacts:

The Plum Creek channel degradation and erosion problem has already had significant environmental impacts and these impacts will become more extensive in the future. These impacts include:

- Degradation of water quality in the creek and downstream reservoir due to elevated sediment loads from the channel degradation increasing turbidity and nutrient levels;
- Elevated erosion potential due to concentrated flood flows and increased velocities from the degraded channels;
- Significant loss of wetland and

riparian vegetation due to lower groundwater levels in the degraded reaches;

- Weakened floodplain erosion resistance during large flood events; and
- Impaired wildlife habitat due to the loss of wetland and riparian vegetation along Plum Creek. The Plum Creek corridor is habitat for numerous wildlife including coyotes, deer, foxes, amphibians, birds, raptors, rabbits, and mice including the Preble's meadow jumping mouse, currently a Threatened and Endangered species.

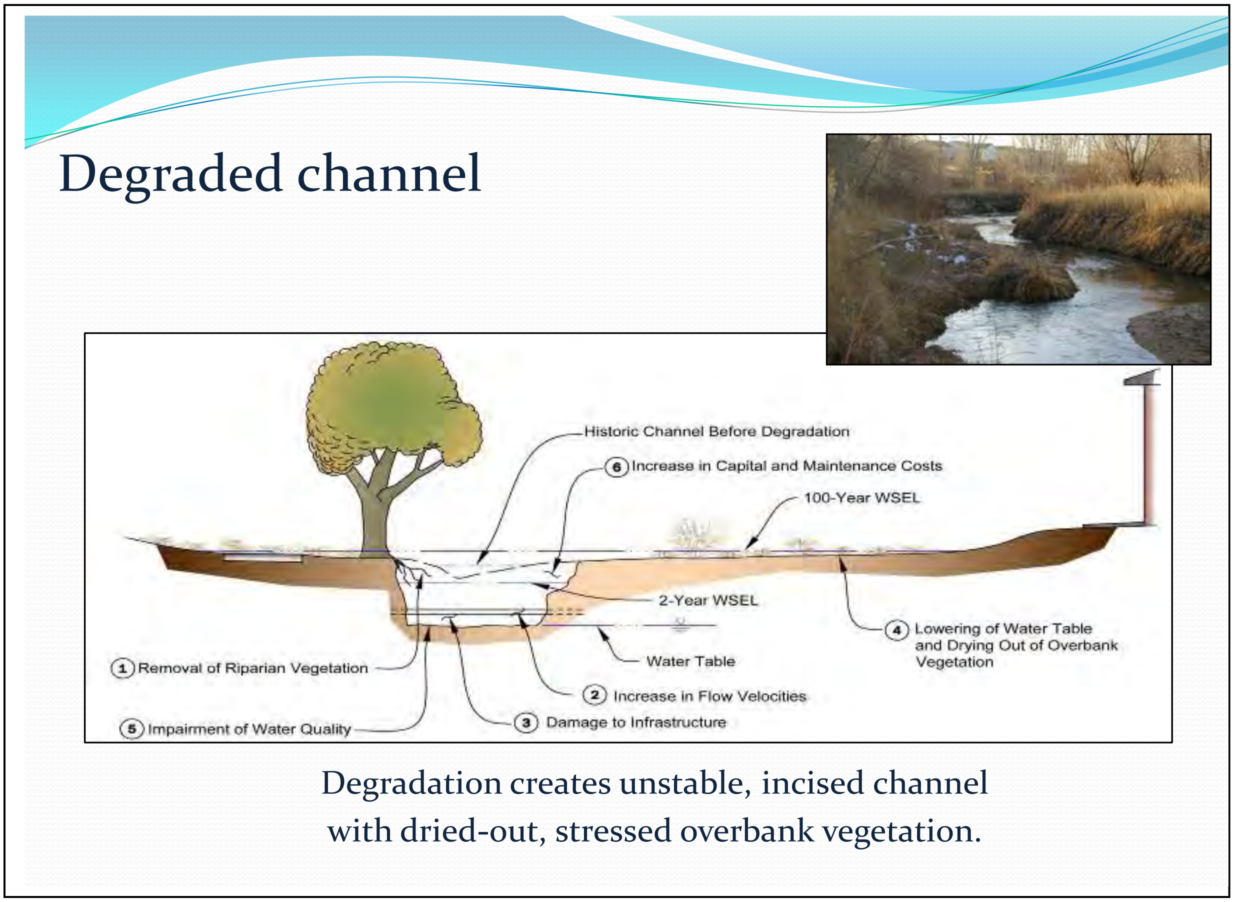
The total area of the current riparian degradation zone is estimated to be 37 acres. The area of the potential future riparian degradation is 395 acres and is shown to extend all the way upstream to the Park limits at the High Line Canal siphon crossing. While the limits of the potential future degradation zone are very conservative and would take many years to occur, it is expected that the current channel degradation and associated riparian degradation will expand and migrate upstream relatively quickly given the easily eroded sand and gravel material within Plum Creek.

Infrastructure Impacts:
The Plum Creek channel degradation and erosion problem is and will continue to impact park infrastructure including:

- Trails and parking lots. One parking lot is located only 400 feet upstream of the active headcuts in the downstream reach. These headcuts are migrating upstream and it is highly probable that in a few years the parking lot will be damaged if no action is taken. Several trails are already being inundated;
- Elevated sediment inflow to the reservoir which is and will continue to reduce water storage capacity; and
- Creation of debris in the reservoir problems after large flood events due to the numerous dead or dying trees.

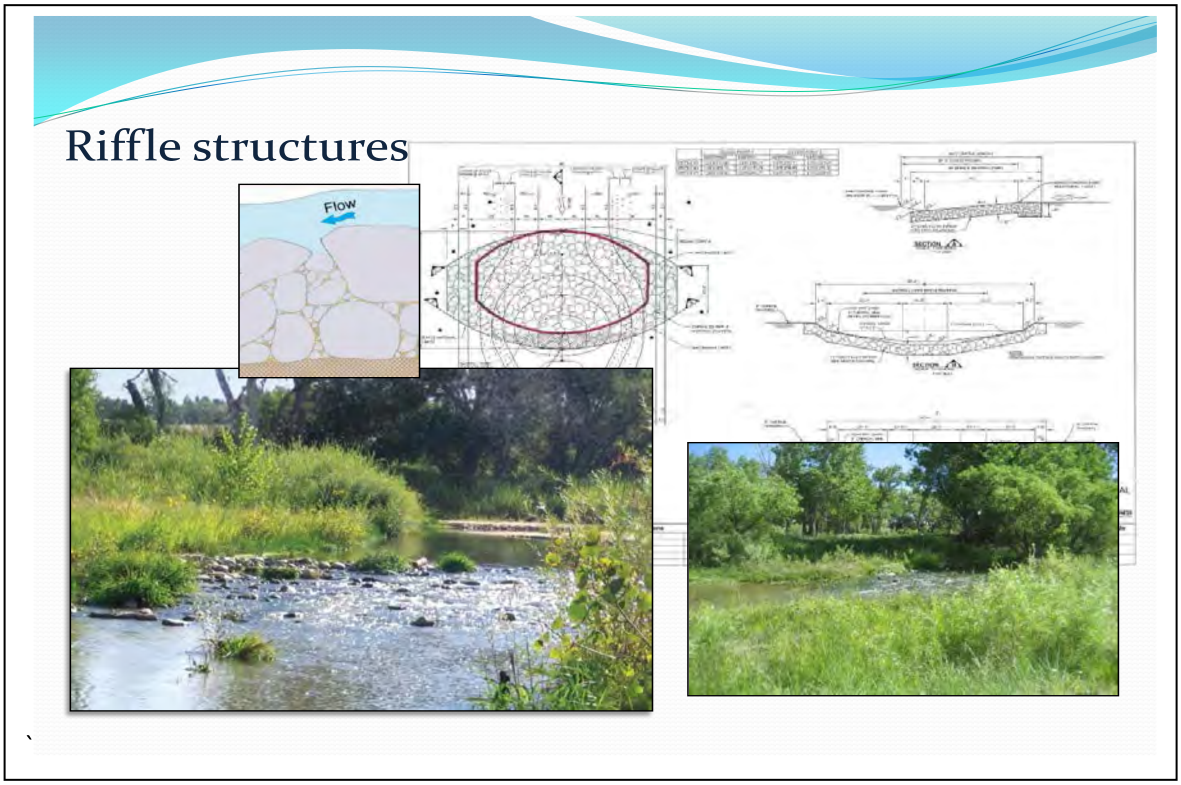
Conceptual Stream Restoration Improvements:

Drop Structures. A conceptual plan for stream restoration improvements was developed for the reach. The backbone of the restoration concept consists of raising and restoring the invert

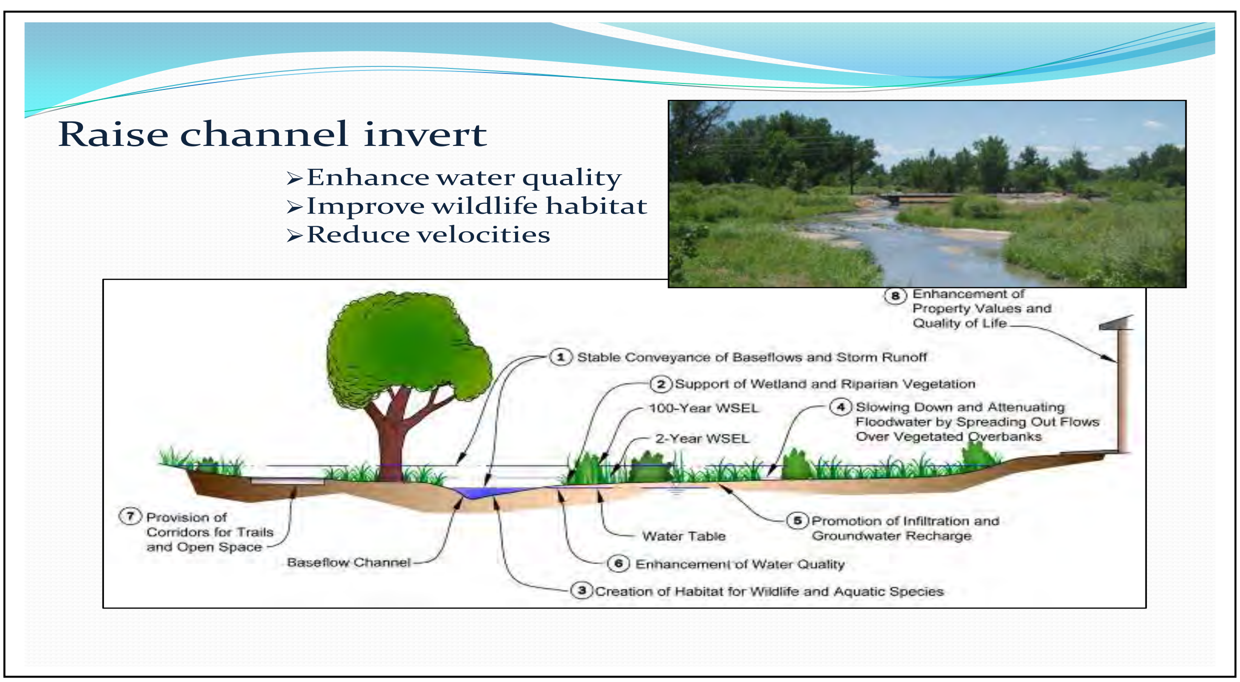


of the incised active channels to their pre-incised conditions. To achieve this, small drop structures are proposed to hold the raised condition and provide a flatter, more stable longitudinal slope of 0.2% compared to its present slope from .32 to .67%. Raising the active channel invert will help to spread flows out into the wide floodplain valley during storms and reduce the erosive stresses on the active channel banks. Allowing high runoff events to flood the valley also provides vegetative filtering and soil infiltration both which immobilize pollutants and enhance water quality of the system. In general, Muller Engineering recommends that low height drop structures (approximately 1 to 1.5-foot drop heights) be used. See Figure 6. By using low-height drops, the active channel inverts can be restored in a manner that more closely matches the original channel grades and also provide for a more uniform channel depth throughout the restored reaches. A conceptual layout of drop structures is provided in the full report. The restoration plan recommends a total of 40 drop structures are proposed in the downstream reach and 18 drop structures in the upstream reach with drop heights varying from 1.0 to 1.3-feet.

Muller Engineering determined that riffle drop structures will work well for Plum Creek given that they are very natural looking in appearance and function well in low drop height situations. Riffle-pool complexes – rocky chutes alternating with deeper stiller water – are commonly found in gravel and cobble bed streams and are nature’s way of dissipating energy. Even low-gradient sand-bed streams, like Plum Creek, develop occasional riffles made up of coarser, gravel material but typically the rock is not large enough to withstand large flood events.



Bank Protection. The drop structures will also help to improve the stability of the channel banks. With the flatter slope and the raised/restored channel invert, flows will spread out into the adjacent floodplain more quickly and reduce flow velocities within the low flow channel. This will reduce erosive stresses on the banks. Muller recommends additional bank protection at some of the sharper bend locations. The first improvement recommended for banks is to widen the channel and provide a preformed scour hole at the bend locations. Muller observed naturally occurring widening and scour-hole formation at the bends and felt that incorporating these elements at the bends will help to further dissipate flow energy during storms. Secondly, additional riprap toe protection combined with willow logs and stakes is recommended at



several of the sharper bends.

The ultimate design of stream restoration improvements on Plum Creek will be based on a detailed geomorphic evaluation and final design process guided by collaboration with a number of stakeholders and review agencies including the Division of Parks and Wildlife; therefore, the ultimate design configuration for Plum Creek will evolve and be refined from the conceptual approach shown. Sediment equilibrium approaches will be fully investigated, including qualitative and quantitative analyses (comparing anticipated sediment supply to transport capacity of the restored reach over a full spectrum of flow events). Channel alignment and form will also be considered, exploring channel width, depth, sinuosity, meander length, and the like.

Cost Estimate:

The conceptual level cost estimate for the 3,400 linear feet of the eroded reach from Station 21+00 to 65+00 proposed to be funded by the Project Participants is $6,088,600. This is approximately $886,000 less than the estimated costs for this work of $6,974,636 identified by Muller Engineering. To make up that difference, Participants will aid CPW in securing the full project amount by using the cash payments as leverage in pursing grants or other project funding opportunities to obtain additional funding. The project includes the construction of 33 larger riffle drop structures, 7 smaller riffle drop structures, band protection and significant earthwork, among other project components.

4.3.3 Noxious and Invasive Weed Control

Impact There may be a greater proliferation of noxious or invasive weeds due to more frequent water level fluctuations and disturbance of soils as part of new facilities construction and habitat conversions. Future water level fluctuations can also cause noxious weeds to more easily establish in the moist soils available to them as water levels decline. Upland areas within Chatfield State Park will be disturbed during the relocation of recreational facilities; creating opportunities for the establishment of noxious weeds, (e.g., borrow areas, temporary access and haul roads, relocation of utilities, and construction of the relocated recreational facilities).

Mitigation The Project Participants will take responsibility for controlling the spread of noxious or invasive weeds associated with the Project's increase in water level fluctuations.

Best management practices (BMPs) will be used to minimize the spread of noxious weeds (List A, B, and C species) at all areas where spreading of noxious weeds might occur. Implementing these BMPs will minimize the dispersal of noxious weeds and reduce the need for future weed control actions. The following BMPs will be implemented with compensatory mitigation actions that involve land disturbance:

- Major equipment (e.g., track equipment, rubber tire loaders, and backhoes) will be cleaned by high pressure air or water spray before being delivered to the project area to avoid introducing undesirable plants and noxious weeds.
- Topsoil containing any noxious weeds (List A, B, or C species) will not be used or otherwise will be strictly managed to preclude the spread of seeds and noxious weed species.
- Fertilizer or other soil amendments will not be used unless recommended by a re-vegetation specialist based on site-specific conditions. The use of fertilizers will be restricted because they can promote noxious weeds and can be detrimental to the native species in the seed mix.
- Disturbed areas will be reclaimed as soon as practicable after completion of construction and seeded with an appropriate native seed mix (certified as noxious weed-free).
- Certified weed-free mulch will be used for re-vegetation. Weed-free straw bales will be used for sediment barriers.
- Locally or regionally available seed and mulch will be used when practicable.

The project area will be monitored to determine if noxious weeds have invaded. Any noxious weeds found will be controlled as soon as practicable to prevent establishment.

The site-specific EFU replacement plans will include the following:

- A list of plant materials to be used including species (common and scientific name), type (e.g., balled and burlap tree, container, bare root, and stakes), size, quantity, and schedule;
- A planting and/or seeding plan including specifications for planting, plant spacing, temporary irrigation, and mulching. Seeding plans will include species (common and scientific name), percent of species in seed mix, seeding rate, seed bed preparation, seed application, schedule, and mulching;
- Weed control plans; and
- A monitoring plan to determine success.

Each disturbance of a vegetated upland within Chatfield State Park will require the restoration and re-vegetation of the disturbance according to established re-vegetation guidelines. The general re-vegetation requirements for disturbances in Chatfield State Park are presented in the CMP; Appendix F, Guidelines for the Restoration and Re-vegetation of Temporarily Disturbed Upland Areas at Chatfield State Park. Detailed, construction-level specifications that follow these guidelines will be included in the construction plans for any activity that temporarily disturbs upland vegetation and/or soil. These plans will be subject to review by CPW.

The re-vegetated sites will be monitored annually, during the growing season. The first two years of monitoring will be qualitative to determine if re-vegetation is progressing. Following the first two full growing seasons, monitoring will consist of the following:

- A visual inspection to determine if the areas seeded have germinated and are becoming established;
- A determination of the presence and distribution of bare areas[1] greater than 400 square feet;
- A determination of the presence and distribution of noxious weeds comprising 10 percent or more of the estimated vegetative ground cover or any area greater than 400 square feet dominated by noxious weeds[2]; and
- Photographic documentation of the re-vegetated area taken from fixed points for year-to-year comparisons.

The presence of bare areas greater than 400 square feet will require reseeding the bare areas per the re-vegetation guidelines. The presence of noxious weeds greater than 400 square feet will require weed control measures. C-list weed species will be controlled in the re-vegetation areas consistent with Chatfield State Parks management of C-list weed species.

The success criteria for vegetation mitigation are:

- Average ground cover is 90 percent or greater than the selected reference area;
- The relative cover of native species is 90 percent or greater than the reference area;
- Noxious weeds comprise less than 20 percent of the average estimated vegetated ground cover; and
- No area greater than 800 square feet is dominated by noxious weeds.

4.3.3.1 Adaptive Management for Weed Control

As more fully described in §4.1.4, above, Adaptive management actions, as determined using the USACE Adaptive Management Plan set forth in Appendix GG of the FR/EIS, will be implemented on an "as needed" basis and as informed by the monitoring of impacts and mitigation on an ongoing basis to ensure the core mitigation objectives are met.

Monitoring will be concluded when all of the core mitigation objectives are met, which will ultimately be decided by the USACE.

The core objectives for weed control are:

---

[1] For the purposes of the qualitative monitoring, "bare areas" are defined as areas where seed has not germinated or on average there is less than one desirable plant per square foot.

[2] For the purposes of the Compensatory Mitigation Plan, "noxious weeds" are those weeds listed in the Colorado Noxious Weed Act.

1. Eradicate all “A List” weeds on the State’s noxious weed list (www.colorado.gov/cs/Satellite/ag_Conservation/CBON/1251618780047);

2. Eradicate salt cedar (Tamarisk ramosissima); and

3. Control leafy spurge (Euphorbia esula), Russian olive (Elaeagnus angustifolia), cocklebur (Xanthium strumarium), and all “B List” species on the state’s noxious weeds list.

The Adaptive Management Plan, Appendix GG of the FR/EIS, gives further details.

4.3.4 Shoreline Stabilization Plan

Impact The increase in water levels along the shoreline on the Southeast side of the South Platte arm of the reservoir contains areas where boaters, fishermen and campground patrons use the existing gradual shoreline and short beach areas. The higher water levels will result in a reduction in this recreational use because the existing landforms consisting of relatively steep banks which would not accommodate the same fishing, boat docking and picnicking shoreline activity.

Mitigation A plan has been developed, as shown in Figure 7, where a combination of improvements will be made with the goals of:

- Improving access to the area for users of the campground and others by making improvements to 5 access trails in the area. These trails are now often steep, crumbly, and somewhat treacherous, gravel paths and the improvements, consisting of new boulder steps will significantly improve the safety of using these trails and their long term stability. Approximately 1100 linear feet of total trail improvements will be made.

- Stabilizing the banks using riprap at the existing overlook at the former heron rookery so that higher water levels do not cause degradation of the banks. This work will seek to remove any threat that the overlook will be adversely affected by new water level fluctuations.

- Creating new boat landing and fisherman access areas at higher water level elevations at 4 shoreline locations to accommodate the use by boaters and fisherman in these areas at higher water levels. This is a high use area by users of the several nearby campgrounds.

The improvements will continue the use of the areas as an attractive beach and picnic area for both boaters and users of the nearby campgrounds. The total estimated expense of the improvements is $716,100.

4.4 Water Quality

4.4.1 Water Quality within Chatfield Reservoir

Impact All of the following impacts currently occur at Chatfield Reservoir, but may increase in frequency and/or magnitude with the Chatfield Reallocation Project. Aquatic species within Chatfield Reservoir could be harmed by:

- The increased erosion of fine sediment caused by wave or wind action from water levels at higher levels from storage of water within the reallocated storage space and increased fluctuations.
- Decreased dissolved oxygen levels within localized areas of the Chatfield Reservoir due to the inundation of vegetation. The decomposition process increases biological oxygen demand.
- Exposure to higher levels of mercury by lower dissolved oxygen causing the methylation of mercury, which may be picked up in the food chain.
- Increased phosphate and ammonia loading as a result of periodic inundation and decomposition of vegetation also lowering dissolved oxygen.

Mitigation The following three actions will mitigate the potential impacts to water quality within Chatfield Reservoir:

1) **Water Quality Monitoring and Modeling**. As part of adaptive management, a water quality monitoring and modeling program, including the application of a dynamic water quality model, will be developed to assess the water quality changes to Chatfield Reservoir associated with the Project. The monitoring program will be conducted in coordination with the Chatfield Watershed Authority, the state designated water quality protection agency for Chatfield. The monitoring program will follow the specific directions as to the nature and extent of monitoring activities described in the Adaptive Management Plan. If the monitoring indicates the Chatfield Reallocation Project is the cause of adverse impacts to water quality, then compensatory mitigation measures will be implemented. The Participants' mitigation obligation for water quality impacts will be offset by the measured or calculated water quality benefits/improvements resulting from the Plum Creek Restoration project.
2) **Plum Creek Wetlands Creation.** The habitat improvements and creation of new wetlands along Plum Creek as part of the CMP will improve water quality. Wetland design concepts will be reviewed by the Chatfield Watershed Authority to identify design elements that may further enhance water quality. The monitoring program will identify the water quality benefits from creation of new wetlands along Plum Creek.

3) **Plum Creek Restoration.** The Plum Creek restoration is designed to stop the significant erosion now occurring into Chatfield Reservoir, which has been causing significant nutrients and sediments to enter the reservoir. This project is further described above.

4.4.2 Water Quality in the South Platte River below Chatfield Reservoir

Impact The Project may result in an increase in the time when lower flow rates impair water quality downstream of Chatfield Reservoir.

Mitigation The mitigation for possible water quality impairment below Chatfield includes the following:

1. **Water Quality Monitoring**. As part of adaptive management, the water quality monitoring program described above will include monitoring within several thousand feet downstream of Chatfield, in coordination with the Chatfield Watershed Authority and other existing water quality monitoring programs. The monitoring program also will make use of the water quality monitoring activities of others on the South Platte River below Chatfield;

2. **The Reservoir Operations Plan.** The Reservoir Operations Plan provides that Project Participants will use their individual and collective good faith efforts to coordinate releases in a strategic manner to assist in minimizing the number of low-flow or zero-flow days in the South Platte River below Chatfield Reservoir and to assist in the flow availability at the Chatfield State Fish Unit. The strategic release of flows during times of otherwise low flows will result in water quality improvement to the stream below Chatfield Reservoir;

3. **Minimum Flow Requirements for Critical Low Flows**. In order to avoid potential adverse effects on water quality during critical low flow periods, The USACE has required the Project Participants to pass flows through Chatfield Dam to the South Platte River during storage events that occur during critical low flows or would cause low flows. The Project Participants have the option to, at their discretion, pass flows or release previously stored water. If the Project Participants choose to release previously stored water, the requirement to pass flows will be deemed to have been met. If the Chatfield Water Providers choose to release previously stored water, they may work with the State Engineer to shepherd the released storage water through the reach sought to be protected by this requirement to any diversion point downstream that any of the Providers are legally entitled to use. The passed flow will equal the critical low flow for the month (Table 2), as measured at the Below Chatfield Gage (PLACHACO gage). The occurrence of critical low flows will be determined by monitoring the Below Chatfield Gage and the critical low flows in Table 2. Any releases required by the USACE will be included in determining operations pursuant to section 4.1 above.

Table 2. Acute (1-day) low flows (cfs) for the 10-year period 1-Oct-1999 through 30-Sep-2000 for the South Platte River below Chatfield Dam to Marcy Gulch (from Appendix J of FR/EIS).

Location	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Below Chatfield (cfs)	0.2	0.3	0.4	0.7	5.3	2.0	0.2	0.6	0.2	0.1	0.1	0.2

The Project Participants also have been given the option by the USACE of performing studies and monitoring to determine the effects of storage in the reallocated space on water quality during critical low flows or at times that would reduce existing flows to critical low flows or lower and, based on these studies, propose an alternative to the releases required by the USACE. This mitigation requirement and the study option are set forth in more detail in Appendices GG and J of the FEIS; and

4. **Environmental Pool.** The Project Participants, if requested, will collaborate with the CPW and/or CWCB in working with all interested parties to investigate the creation of an environmental storage space or pool, and/or to acquire a new, separate agreement(s) with one or more Project Participant(s) that includes a provision for timed environmental flow releases. Project Participants are not being asked to nor expected to contribute financially to the creation of an environmental pool. A potential environmental pool and/or separate agreement(s) for timed environmental flow releases could be used to maintain water levels in the reservoir, for water releases to alleviate low flow conditions downstream of Chatfield Reservoir or for augmentation purposes.

4.4.3 Adaptive Management for Water Quality

As explained in §4.1.4, above, adjustments may need to be made as the Project Participants implement the mitigation activities set forth herein and in the CMP. Any necessary adjustments will be determined using the USACE Adaptive Management Plan set forth in Appendix GG of the FR/EIS.

The monitoring program described in this §4.4 will follow the specific directions set forth in the USACE Adaptive Management Plan. Monitoring will be concluded when all of the core mitigation objectives are met, which will ultimately be decided by the USACE.

The core objectives for water quality are:

1. Internal loading from “new” anoxic sediments attributed to reallocation pool level increases will not be the sole cause (?) for chlorophyll a and total phosphorus standards to be exceeded.

2. External loading from “newly” inundated vegetation attributed to reallocation pool level increases will not cause water quality standards for chlorophyll a and total phosphorus or the total phosphorus TMAL to be exceeded.

3. Expansion of hypoxic conditions and potential release of reduced contaminants from anaerobic sediments will not cause other water quality standards (i.e., other than chlorophyll and total phosphorus) to be exceeded.

The Adaptive Management Plan, Appendix GG of the FR/EIS, gives further details.

4.5 Wildlife, Wetlands and Riparian Habitat

Impact Terrestrial wildlife will be impacted from the Project through loss of wetland and riparian habitat from inundation of new areas and facilities construction. The wildlife impacted by the Project includes terrestrial mammals, including the Preble’s meadow jumping mouse and its designated critical habitat, reptiles, amphibians and bird species.

In the worst case of maximum inundation and vegetation destruction to 5,444 ft. above msl, about 789 acres of environmental resources are estimated to be temporarily or permanently impacted by the Project, due to inundation and construction disturbance. Of the 789 acres impacted, 586 acres are impacted from inundation and 203 acres from construction activities.

Mitigation

The Compensatory Mitigation Plan (CMP) has been created by the USACE to address the impacts to wildlife, wetlands and riparian habitat. The CMP is Appendix K of the FR/EIS and is summarized below.

4.5.1 Overview of the Compensatory Mitigation Plan

The USACE developed the CMP to address unavoidable environmental impacts associated with the Recommended Plan in the FR/EIS, the reallocation of 20,600 AF of storage space. The CMP has been developed at a feasibility level and considers the ecological resources that will be adversely affected to a sufficient degree and detail to enable a reasoned judgment whether the recommended compensatory mitigation will be implementable and adequate to compensate for the functions and values of the resources to be impacted.

The draft FR/EIS identified Preble's meadow jumping mouse habitat, bird habitat and wetlands as resources of particular concern and warranting specific mitigation strategies for the estimated adverse impacts to those resources. These resources are referred to as the "Target Environmental Resources" in the CMP.

The CMP is a lengthy, detailed document. The CMP describes the proposed mitigation activities with sufficient specificity to understand why the mitigation proposed is appropriate and adequate. Although the CMP focuses mitigation activities on the Target Environmental Resources, it is structured to provide a diversity of ecological functions for a broad range of wildlife including birds, insects, amphibians, reptiles, and mammals.

The USACE's planning process created a plan that first avoided and then minimized negative impacts to the Target Environmental Resources. The CMP addresses the remaining unavoidable impacts associated with the Chatfield Project. The CMP was developed with substantial input from the stakeholders listed in §1.4 above.

The CMP is designed to replace the lost ecological functions and values, called ecological function units or EFUs, of the Target Environmental Resources from the effects of inundation, the relocation of recreational facilities, the use of borrow areas, and other construction activities. It establishes quantifiable objectives and maximizes the amount of mitigation that will occur on USACE lands in the vicinity of Chatfield Reservoir. The CMP also provides for ongoing monitoring, reporting, and adaptive management.

The CMP specifies:

- The location of the mitigation activities (maximizing on-site mitigation);
- The activities that will occur;
- When the activities will occur;
- The approximate scope of the activities;
- The estimated range of EFUs (further described below) to be created; and
- The criteria for determining success of the mitigation activity.

To ensure that the CMP is successfully implemented, the CMP establishes mitigation implementation milestones (section 7.2.2 of the CMP); specifies criteria for determining success of the mitigation activity (Adaptive Management Plan, Appendix GG, page 8); requires periodic monitoring; requires reporting to an implementation activities oversight committee, and requires meeting success criteria as a condition to storage. The mitigation milestones assure that the mitigation will be accomplished. Furthermore, the Project Participants have agreed to set aside 100% of the estimated expense of all mitigation activities into an escrow fund at the initiation of project implementation to assure the availability of all the funds needed to complete the mitigation activities.

The CMP estimates that it will take 6 years to implement the necessary mitigation and cost approximately $58.5 million (near-term costs only) for on- and off-site mitigation activities, including monitoring and maintenance. Upon final approval of the Project, the Participants will be responsible for the operation, maintenance, and repair of infrastructure, treatment, and distribution facilities associated with their water and their share of the Project rehabilitation and replacement costs. The Participants solely will fund the environmental mitigation and recreation modifications necessary to mitigate the impacts of operating the reservoir under the storage reallocation.

State Involvement and Oversight of the Mitigation Process

The CWCB will enter into a storage contract, called the Water Supply Agreement (WSA), with the USACE for the reallocated space. Each of the Project Participants will then enter into an assignment contract with the CWCB, called the Reallocated Storage Users Agreement (RSUA) where the right to store in Chatfield is assigned in return for taking on the financial and mitigation obligations of the Project. The WSA includes provisions that form the Project Coordination Team (PCT), consisting of co-chairs of the USACE, CWCB and Participants, which will oversee all project implementation actions.

The PCT will be responsible for determining when the defined CMP objectives have been met and the impacts to the Target Environmental Resources have been fully mitigated. The PCT can adjust the environmental mitigation requirements if it is determined that the actual impacts to the Target Environmental Resources are less than the maximum impact estimate.

The Participants also will form a new entity, the Chatfield Reservoir Mitigation Company, to coordinate the Participants' activities to fulfill the financial and mitigation commitments. All Project Participants must be members of the Mitigation Company, which would include the CWCB or any other state entity, if it retains or acquires a storage space allocation.

CPW will have a significant role in overseeing, monitoring and implementing the CMP. For example, CPW will review all design plans for on-site mitigation activities for acceptability and consistency with management of Chatfield State Park, participate in the decision-making related to all construction activities and review all post-construction monitoring reports to see that the mitigation activities satisfy the defined success criteria.

4.5.2 CMP Mitigation Approach

The CMP is ecologically based. The "currency" of the CMP is ecological functional units (EFUs). This ecological functions approach was taken because of the substantial geographic overlap in the Target Environmental Resources. For example, Preble's habitat is generally located adjacent to wetlands in riparian areas. The EFUs capture the ecological functions provided by the individual Target Environmental Resources as well as their overlap. The methodology to calculate EFUs is explained in section 7.1.4 of the CMP.

The mitigation actions will include habitat conversions, such as changing upland grasslands to new wetlands, habitat improvements or enhancements, such as adding new vegetation or weed control, or habitat restoration at disturbed areas. EFUs will be used as the quantification of improvements by measuring the EFUs in a given area before and after the mitigation activities.

Thus, the CMP discusses mitigation obligations in terms of the EFUs that are lost and must be replaced. The 789 acres impacted by the project has been determined to be equivalent to 1,180 EFUs lost. The success of mitigation activities will be determined by the amount of EFUs gained, which will be measured as part of annual reporting.

The CMP uses the following conservative assumptions as further protection to assure that the mitigation measures proposed will cover the full range of potential future conditions:

- All of the existing Target Environmental Resources will be lost below 5,444 feet in elevation (the high water level in the 20,600 AF plan);
- None of the Target Environmental Resources will re-establish below 5,444 feet in elevation;
- Off-site mitigation areas are generally limited to reaches of Plum Creek, West Plum Creek, and their major tributaries for which Preble's critical habitat has been designated; and
- Only 15 percent of the private land in the off-site target mitigation area will be available for habitat enhancement and protection.

The estimate that 1,180 EFUs may be lost is significantly influenced by the first two of these conservative assumptions. The CMP defined process of annual monitoring will determine what are the total of EFUs actually lost from the construction activities and the future operations of the Project over time and therefore if possibly less EFUs are required because the impacts are less that estimated. For example, if the vegetation surrounding the reservoir is not permanently lost up to 5,444 ' from inundation, then less EFUs will need to be developed.

The annual determination of EFUs owed and EFUs gained from mitigation activities will continue until it is judged by the PCT that the mitigation actions have proven to be reasonably sustainable and, therefore, that the mitigation obligations have been satisfied.

Preble's habitat has a diversity of components (wooded riparian, riparian wetlands, and adjoining uplands), it supports a broad diversity of wildlife including birds, large and small mammals, reptiles, amphibians, and insects. Mitigation of impacts to Preble's habitat tends to drive mitigation of the other target environmental resources because:

- Preble's habitat is geographically limited to well-developed riparian corridors with reliable sources of water;
- Preble's habitat has substantial functional and geographic overlap with bird habitat and wetlands;
- Preble's is a threatened subspecies protected under the ESA; and

- Impacts to Preble's designated critical habitat are required to be mitigated within the same critical habitat unit.

Therefore, the impacts to many of these other species will be addressed through mitigating impacts to Preble's habitat. The CMP is composed of three primary components, which focus on Preble's mitigation:

- On-site mitigation – Activities within the Chatfield State Park include the conversion of upland areas above 5,444' to wetland, riparian and Preble's habitat, the enhancement of habitat and the restoration of temporarily disturbed areas.

- Off-site mitigation – the permanent protection of private lands in the Plum Creek/West Plum Creek watershed upstream of Chatfield Reservoir, with management and enhancement to benefit the target environmental resources.

- Off-site Preble's "critical habitat" mitigation – the enhancement, restoration, and control of sediment along 4.5 miles of Sugar Creek in the Pike National Forest and the permanent protection, and enhancement and management as needed, of private lands in the West Plum Creek critical habitat unit (CHU) designated to support a large recovery population of Preble's.

Mitigation activities are based on the following criteria:

- Maximize on–site compensatory mitigation and then satisfy any remaining mitigation obligations with off-site mitigation;
- Target mitigation activities to occur within the Chatfield Reservoir Watershed;
- Locate off-site mitigation as close to Chatfield State Park as possible;
- Focus on mitigation activities that can provide benefits to all of the target environmental resources;
- To the degree practicable, implement off-site mitigation in a way that will expand connections to existing protected lands forming longer continuous corridors of protected lands; and
- Select locations for mitigation activities that provide a high likelihood for successful mitigation.

4.5.3 Summary of CMP Mitigation Measures

The mitigation measures are a combination of on-site and off-site mitigation. The table below gives the overview of the quantifications of the impacts, in EFUs, acres or stream miles, and the areas where the mitigation activities will be undertaken. A summary of the proposed mitigation activities are given in the table and text below and their proposed locations are shown in the referenced figures.

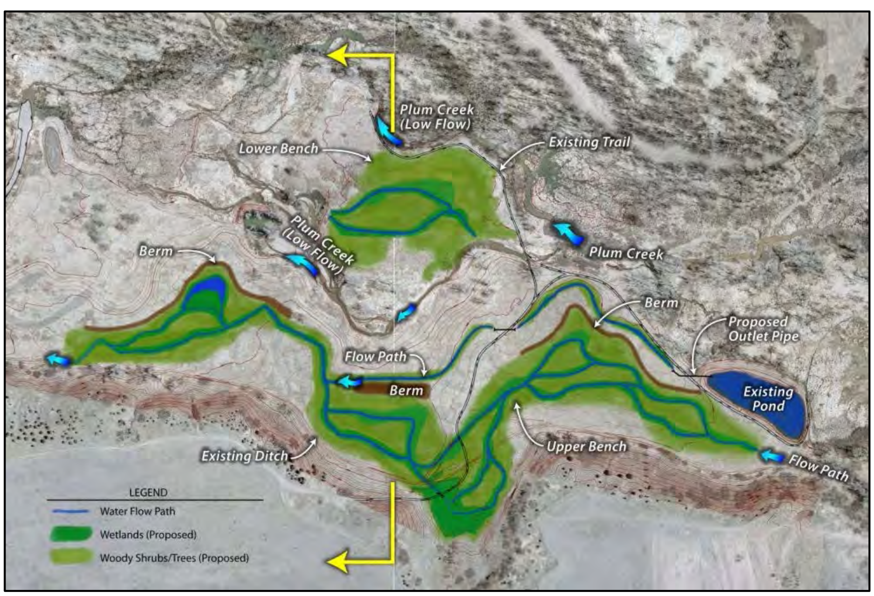
<u>Overview of Mitigation Measures</u>

Impacts			Mitigation			
Nature of Impact	Acres	EFUs	On-Site		Off-Site	
			Acres	EFUs	Acres	EFUs
Inundation	586	775	165	85	TBD	690
Recreation Facilities Construction	203	405	203	384	TBD	21
TOTALS	789	1,180	368	469	TBD	711

<u>On- Site Mitigation Activities</u>

On-site mitigation is mitigation that will occur on property owned by the United State and managed by the USACE in the vicinity of Chatfield Reservoir. The on-site mitigation will be maximized to the degree practicable. Figures 8, 9 and 10 show the existing on-site Preble's, bird, and wetland habitats, respectively.

The mitigation measures will include habitat conversion, habitat enhancement and restoration of disturbed areas from construction. The greatest gain in EFUs will be from habitat conversion activities. The greatest gain in EFUs per acre would result from converting upland grasslands to wetland habitat that also provides high value riparian habitat for Preble's.

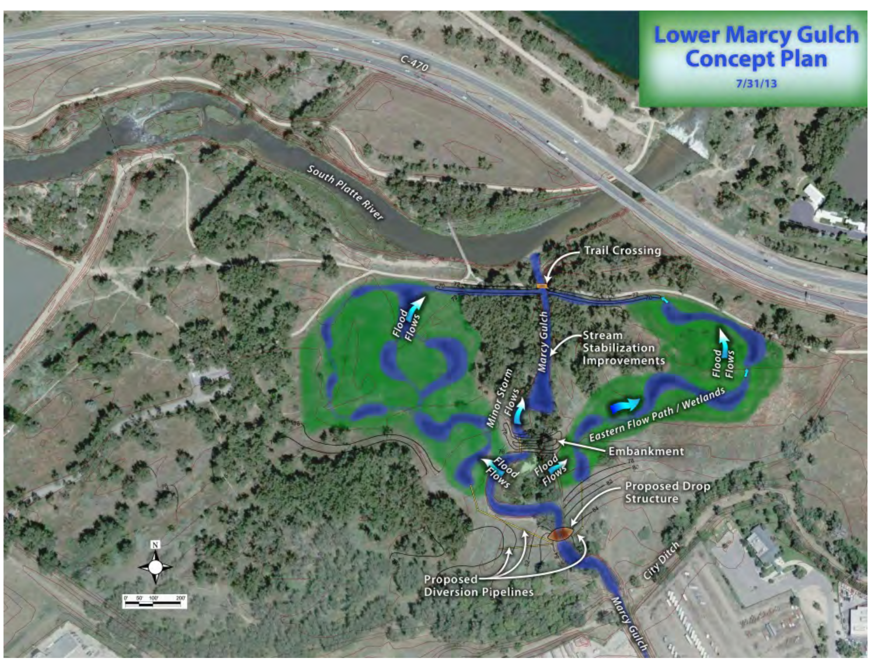


In many cases, a combination of these activities will likely be necessary to create desired mitigation conditions. Using currently available mapping, 165 acres on-site will be converted to a mosaic of riparian shrublands (89 acres), wetlands (33 acres), and riparian forest (43 acres). The proposed sites for creation of new wetlands on-site are shown in Figures 11 through 18.

The on-site mitigation areas proposed in the CMP are conservative outlines of areas estimated to have the best opportunities to provide mitigation that will result in a significant gain in EFUs. Engineers and wetland ecologists will design site-specific detailed plans to provide the most EFUs in the most cost-efficient manner.

The general land conversion mitigation approach is described below and examples of the mitigation approach are shown in the figures on this and the next page:

- Use an existing water source, such as a previously-created gravel pond or agricultural pond fed by regional groundwater flow, a tributary stream, such as Marcy Gulch, or existing groundwater from the lowering of the ground surface where material has been removed from a borrow area as the water source,
- Locate the new converted land, if possible, on terraces adjacent and above the stream flood plain,
- Use existing land features, such as previous irrigation ditches, or develop new land features from re-grading the land, to spread out and redirect new water flows over existing upland grasslands creating a new mosaic of wetland and riparian vegetation.
- If adjacent to an existing pond, possibly re-grade or bring in fill to the perimeter of the pond to create new fringe wetlands and riparian vegetation along the shoreline,
- Maintain some open water for waterfowl habitat, and
- Enhance the recreational potential of the area by possibly expanding trail systems.



In addition to compensatory mitigation activities, restoration activities will be undertaken to restore areas that are disturbed during relocation of the recreation facilities but are not part of the permanent footprint of the facilities. These areas include the borrow areas, haul roads, and the majority of areas filled to elevate the relocated facilities. These areas are shown in Figure 19. Construction plans for disturbed and borrow areas will include plans and specifications that follow guidelines developed for use in these areas (Appendix F of the CMP).

The approach for creation of wetlands and cottonwood riparian areas is to select and modify mitigation sites as needed to provide a supportive hydrology to sustain the wetland and riparian vegetation. The area of wetlands and riparian habitat that are proposed to be created do not exceed the maximum acres of wetlands and riparian habitat that have been estimated to be impacted by the inundation from the reallocation project. Therefore, the consumptive use associated with the creation of new wetlands and riparian habitat would not exceed the consumptive use of wetlands estimated to be lost.

Off-Site Mitigation Activities:

The CMP recognizes that mitigation requirements will exceed land available on-site. Approximately 5,917 acres of private lands, providing potentially 8,035 EFUs (more than enough), have been identified within the Chatfield Reservoir watershed that could be permanently protected and managed in a way that benefits habitats (Figure 20). Each private property or portion of a private property considered for permanent protection will need to be evaluated for the following:

- Fair market value of land to be protected (real estate appraisal);
- Baseline EFUs associated with the property and the potential net gain of EFUs associated with protection, enhancements and long-term management; and
- Suitability of property to contribute to meeting the off-site compensatory mitigation objectives.

The Project Participants will coordinate with the PCT, and any of its advisory committees, regarding the protection of properties. Mitigation areas will be permanently protected by deed restrictions or conservation easements put in place on property purchased from willing property owners or through conservation easement agreements with willing property owners.

All protected property will have a management plan developed by the Project Participants that is submitted to the PCT for review and final approval by the USACE. The management plan will identify specific management activities that, by example, may include:

- Managing livestock grazing and adverse recreation impacts by either eliminating grazing or erecting and maintaining fences to protect the riparian corridor;

- Providing signage and meeting with neighbors and the public to increase awareness of conservation efforts;

- Reducing the threat of fires using mowing, fire breaks, or controlled burns where needed;

- Coordinating fire response with local, state, and federal fire management entities; Stabilizing erosion or channel down-cutting, as needed, caused by increased urban runoff;

- Planting or seeding with native species to improve habitats; and

- Controlling invasive nonnative plants if necessary and feasible.

The mitigation measures for Preble's critical habitat and for cottonwood trees occur both on-site and off-site and are discussed in more detail below.

Preble's Meadow Jumping Mouse Critical Habitat Mitigation Measures

Critical habitat for Preble's has been designated on the South Platte River and Plum Creek arms of Chatfield Reservoir (75 Fed. Reg. 78430 (December 15, 2010)). Per U. S. Fish and Wildlife Service requirements, all mitigation for adverse impacts to designated critical habitat for Preble's will occur within the same critical habitat unit (CHU) in which the impacts occur. The Plum Creek arm of Chatfield Reservoir occurs in the West Plum Creek CHU and the South Platte River arm occurs in the separate Upper South Platte CHU.

With the exception of the South Platte River arm of Chatfield Reservoir, the Upper South Platte CHU occurs on the Pike National Forest. Opportunities for on-site critical habitat mitigation are limited, so most of the mitigation for loss of Preble's critical habitat on the South Platte River arm will occur off–site on the Pike National Forest. Following an analysis of the potential Preble's mitigation sites shown in Figure 21, Sugar Creek was selected as the site of greatest potential benefit from mitigation activities.

Because most of this critical habitat mitigation will occur in the montane environment of the Pike National Forest, and not the plains environment in the vicinity of Chatfield Reservoir in which the ecological functions approach and EFUs were developed, impacts and mitigation for critical habitat in the Upper South Platte CHU are expressed in acres or stream miles and not in EFUs.

The following proposed mitigation for impacts to Preble's designated critical habitat has been discussed with the USFWS and was included in the Biological Assessment submitted to the USFWS.

- Reduction of sediment inputs into Sugar Creek, a tributary to the South Platte River on the Pike National Forest, and its associated wetlands and riparian areas that are Preble's designated critical habitat;
- Creation and enhancement of riparian habitat. Figure 22 shows Sugar Creek mitigation site in greater detail.

The activities involving the reduction of sediment material into wetlands and riparian habitats bordering Sugar Creek and related improvements include:

- Construction of stilling basins for culvert rundowns from sediment traps to minimize bank erosion;
- Construction of low head water control structures to raise alluvial ground water levels to provide supportive hydrology to expanded riparian areas; and
- Replacement of road crossings of Sugar Creek with culverts designed to promote fish and small mammal passage.

The required offsetting of impacts to Preble's will be determined through the ESA Section 7 consultation process between the USACE and the USFWS. A Biological Assessment addressing ESA compliance has been prepared by the Corps as part of the draft FR/EIS (Appendix V of Draft FR/EIS). The USFWS's Biological Opinion will be included in the final FR/EIS. The Biological Opinion will identify conservation activities that address adverse impacts to Preble's and its designated critical habitat.

The mitigation of designated critical habitat within the Plum Creek arm will be mitigated in the West Plum Creek CHU. About 6 acres and 4 EFUs will be mitigated within the proposed designated critical habitat within the on-site Plum Creek arm of the reservoir. The remainder of the mitigation for impacts to the Plum Creek critical habitat would be addressed through off-site mitigation within the West Plum Creek CHU. The West Plum Creek CHU covers generally the same area as the off-site mitigation target area (Figure 23). The Preble's mitigations are summarized in the table below:

Preble's Designated Critical Habitat Summary

Location	Impacted Area			Mitigation				
	Acres	Stream Miles	EFUs	On-Site, Acres		Off-Site		
				Stream Miles	EFUs	Acres	Stream Miles	EFUs
South Platte Arm	80	1.3	--	17	--	381*	4.5*	--
Plum Creek Arm	75	2.8	65	6	3	--	--	62**

* Sugar Creek
** West Plum Creek

Cottonwood Tree Mitigation Measures

There will be loss of wetlands and trees, including mature cottonwoods, which also provide habitat for terrestrial mammals. The CMP includes activities specifically intended to compensate for adverse impacts on up to 42.5 acres of mature cottonwood bird habitat. Because mature cottonwood habitat has been specifically identified as an important habitat type in Chatfield State Park, mitigation for this resource will include compensating for lost acres. The CMP addresses the actions to be taken to mitigate impacts to riparian habitat, including mature cottonwood woodlands.

Proposed activities include designating at least 13 acres of on-site mitigation for recruitment of new cottonwood growth, protecting at least 22.5 acres of existing mature cottonwood habitat in off-site compensatory mitigation areas, and designating at least 10 acres of off-site mitigation areas for recruitment of new cottonwood growth. Areas designated for new recruitment will contribute to the long–term persistence of multi-aged patches of cottonwoods, including future stands of mature cottonwoods.

The locations of the cottonwood regeneration areas are shown in Figures 14 and 15 and labeled as SPR 2, 3, 5 and 8. The bird habitat complexes targeted for cottonwood regeneration and mature cottonwood conservation off-site are shown in figures 24.

Areas suitable for cottonwood preservation and regeneration have been defined. Conditions suitable to support large stands of mature cottonwood off-site are limited to stream reaches with broad floodplains and perennial sources of both surface and ground water. The CMP recognizes that the existing mature cottonwood habitat that will be impacted is part of a larger habitat complex supporting a variety of bird species including several uncommon and sensitive species. Mitigation activities for mature cottonwood habitat will take place within the boundaries of the mapped bird habitat complex. The cottonwood tree mitigation is summarized below:

Cottonwood Tree Mitigation Summary

Impacted Acres	Mitigation, Acres			
	On-Site Regeneration	Off-Site Preservation	Off-Site Recruitment	Total
42.5	13.0	22.5	10.0	45.5

4.5.4 Adaptive Management for the Wildlife, Wetlands and Riparian Habitat

As explained in §4.1.4, above, adjustments may need to be made as the Project Participants implement the mitigation activities set forth herein and in the CMP. Any necessary adjustments will be determined using the USACE Adaptive Management Plan set forth in Appendix GG of the FR/EIS. Adaptive management actions will be implemented on an "as needed" basis and as informed by the monitoring of impacts and mitigation on an ongoing basis to ensure the core mitigation objectives are met. Monitoring will be concluded when all of the core mitigation objectives are met, which will ultimately be decided by the USACE.

The core objectives for the Target Environmental Resources are:

1. Provide up to 796 EFUs to offset the 796 EFUs conservatively estimated to be permanently lost with reallocation, comprised of up to 211 EFUs for noncritical Preble's habitat, up to 65 EFUs for West Plum Creek critical habitat, up to 396 EFUs for bird

habitat, and up to 124 wetland habitat EFUs that will contribute to the estimated maximum total of 796 EFUs conservatively estimated to be permanently lost;

2. Mitigate for the conservatively estimated loss of 1.3 miles of designated critical Preble's habitat along the South Platte River arm; and

3. Compensate for the conservatively estimated loss of 42.5 acres of mature cottonwood bird habitat by protecting up to 22.5 acres of cottonwood woodlands off-site and creating up to 13 acres (on-site) and 10 acres off-site of cottonwood recruitment areas, all of which will contribute to the compensatory mitigation goal of 796 EFUs.

The Adaptive Management Plan, Appendix GG of the FR/EIS, gives further details.

4.5.5 Tree Management Plan

The FR/EIS includes a separate Tree Management Plan (Appendix Z of the Draft FR/EIS). There is some degree of uncertainty in estimating the elevation at which trees would likely be killed from periodic inundation resulting from the Reallocation Project. The uncertainty is due in part to the variability in the availability of water for storage, variability in how reservoir operations would occur under the proposed reallocation, and uncertainty in how the trees would respond to inundation.

In the Tree Management Plan, a conservative approach was taken by limiting the trees to be removed to those areas where it is judged highly likely that the trees would be killed, at elevations up to 5439 ft. above msl. The plan currently calls for clear-cutting trees below elevation 5439 subject to periodic determinations by CPW of whether to remove trees.

For areas between 5439 and 5444 ft. above msl, which includes approximately 61.1 acres of trees, an adaptive management approach is planned. The adaptive management approach would entail leaving these trees in place and then monitoring the trees for signs of severe stress and mortality, and removing unhealthy and dead trees from this area on an as needed basis to eliminate potential risks to visitors and dam safety.

The USACE Adaptive Management Plan allows the Tree Management Plan to be more flexible. Understanding that trees and other vegetation below 5439' ft above msl may not necessarily be inundated to a point of killing the trees and other vegetation, Project Participants and CPW agree that Project Participants may first seek to operate their storage space in a manner that minimizes the length of inundation between elevations 5,444 and 5,439 ft above msl.

If the trees between 5,432 and 5,439 ft. above msl are not cleared and grubbed, Project Participants would need to:

- Remove the dead and down trees along with all other debris on the ground;
- Perform selective thinning to provide a healthier environment and ease of access for implementation of BMP's;

- Require a yearly evaluation and monitoring of trees from 5,432 to 5,444 ft. above msl; and
- Increase debris removal in the reservoir, as needed, and provide funds to offset additional operational costs. Debris will need to be removed and taken off site.

These activities will provide a more pleasing aesthetic look at lower water levels, more bird habitat and possibly new rookery areas. In addition, the activities will maintain or increase watchable wildlife opportunities and possibly decrease required mitigation including off-site mitigation.

4.5.6 Adaptive Management for the Tree Clearing within the Fluctuation Zone

As more fully described in §4.1.4, above, Adaptive management actions, as determined using the USACE Adaptive Management Plan set forth in Appendix GG of the FR/EIS, will be implemented on an "as needed" basis and as informed by the monitoring of impacts and mitigation on an ongoing basis to ensure the core mitigation objectives are met. Monitoring will be concluded when all of the core mitigation objectives are met, which will ultimately be decided by the USACE.

The core objectives for the tree clearing within the fluctuation zone are:

1. Limit tree clearing to areas where trees have a high likelihood of being killed by inundation as determined by CPW;

2. Leave trees in selected areas below 5,439 ft msl for fish and wildlife habitat, to the degree practicable and safe;

3. Decisions on trees removed (including stumps) and trees retained, must also consider dam, boater and visitor safety;

4. Maximize the use of downed trees for fish and wildlife habitat; and

5. Remove downed woody material from the area below 5,439 ft msl to minimize impacts to water quality except as placed or retained for aquatic and wildlife habitat.

The Adaptive Management Plan, Appendix GG of the FR/EIS, gives further details.

5.0 Mitigation of Unavoidable Adverse Impacts: Recreation

5.1 Recreational Facilities Mitigation

The CPW and the Project Participants have worked together to ensure reasonable mitigation measures will be in place for the Chatfield Reallocation Project. These measures address impacts to fisheries and aquatic habitat, wetland and riparian habitat, and wildlife habitat. Table 1 summarizes the proposed mitigation components.

5.1.1 The Recreational Facilities Modification Plan: A Summary

Impact

The Recommended Plan, storing up to 20,600 additional A.F. of water in the Chatfield Reservoir, will inundate recreation infrastructure and environmental resources and result in an additional 12 feet of potential water level fluctuations (Figure 3).

Mitigation

The Recreation Facilities Modification Plan (RFMP), Appendix M of the Draft FR/EIS, has been prepared under the guidance of CPW to address the required mitigation from the inundation of recreational facilities. The Plan includes a separate study of the marina, as discussed below.

The development of the RFMP included considerations of operating conditions, including the relationship between water levels and existing facilities and how visitors use the park. The plan is based on the like-kind replacement of facilities and their operational functions in order to maintain a quality of recreational experience as similar as possible to that presently experienced by park visitors.

Major facilities at Chatfield include 197 campsites, 10 group sites, 4 major group picnic areas, 139 family picnic sites, 3 major boat ramps, 20 miles of hard surface trail, 2,528 parking spaces, 33.3 miles of paved highway, 9.6 miles of unpaved roadway, 38 restrooms, 6 shower buildings, a maintenance shop, and a swim beach complex. Recreational activities include hiking, fishing, biking, picnicking, swimming, model airplane flying, horseback riding, boating, hot air ballooning, bird watching, wildlife viewing, and environmental education programs.

Below is a summarized list of impacted areas, modifications to occur, and estimated cost for the modifications. Appendix M includes additional details about the recreation facilities modifications. Figure 25 shows the location of these facilities within Chatfield State Park.

- *North Boat Ramp:* Construction of new boat ramps. Changes in ramp gradients, and facility relocation. Parking areas, concrete boat ramp, trails, day use shelter, picnic tables, trash receptacles, bollards, grills, regulatory signs, and water hydrants. Estimated cost: $1,220,183.

- *Massey Draw:* Relocation of facilities. Restroom, asphalt trails, picnic tables, benches, trash receptacles, grills, beach volleyball court, and horse shoe pit. Estimated cost: $686,301.

- *Eagle Cove:* Reconstruction of facilities and parking. Parking area, portable restroom, dumpsters, trash receptacles, regulatory signs, and fencing. Estimated cost: $426,589.

- *Deer Creek Day Use and Balloon Launch area:* Reconstruction of facilities and parking and road relocation. Parking area, trails, picnic tables, trash receptacles, grills, and regulatory sign. Estimated cost: $1,494,655.

- *Swim Beach:* Reconstruction of beach, facility and parking and road relocation. Parking area, shower/restroom building, concession, first aid station, information kiosk, picnic tables, Benches, water fountain, dumpsters, trash receptacles, bollards, grills, regulatory signs, fencing, beach volleyball court, horses shoe pits, sand and utilities. Estimated cost: $9,799,203

- *Jamison Area:* Reconstruction of facilities and parking and road relocation. Parking area, trails, restroom, picnic tables, benches, water fountain, dumpsters, trash receptacles, grills, regulatory signs, utilities, and electrical transformer. Estimated cost: $1,917,629

- *Catfish Flats:* Relocation of facilities and parking. Parking areas, trails, restroom building, group picnic shelters, picnic tables, benches, water fountain, dumpsters, regulatory signs, utilities, and electrical transformer. Estimated costs: $1,731,060

- *Fox Run:* Relocation of facilities and parking. Trails, group picnic area, picnic tables, benches, water fountain, dumpsters, trash receptacles, regulatory signs, beach volleyball court, and horse shoe pits. Estimated cost: $307,955

- *Kingfisher Area:* Creation of new parking areas, facility relocation. Parking area, portable restrooms, dumpsters, trash receptacles, regulatory signs, fencing. Estimated costs: $295,884.

- *Gravel Ponds Area:* Creation of new parking areas, facility relocation. Construction of bridge over South Platte River. Parking area, portable restrooms, picnic tables, dumpsters, trash receptacles, regulatory signs and fencing. Estimated cost: $217,943.

- *Platte River Trailhead Area:* Construction of new trails. Estimated cost: $112,337.

- *Roxborough Cove:* Facility relocation. Restroom, regulatory signs, picnic tables, trash receptacles, grills, and sand. Estimated cost: $410,320.

- *Plum Creek Picnic Area:* Relocation of parking area, entry read, and day use area, rerouting of trail and relocating sanitary sewer line. Parking areas, trails, restroom building, picnic tables, benches, dumpsters, regulatory signs, fencing, and volleyball court. Estimated cost: $479,351.

- *Roads and Bridges at multiple locations:* Estimated cost: $12,502,055.

- *Gravel Pond Area Preservation:* Gravel Pond Area. The plan includes the rebuilding of the dike north of the gravel pond with a new park road on top, in the same location as the old road. This addition was made in order to minimize impacts to the surrounding area as well as to preserve the gravel pond and its unique recreational features. The side slopes of the road/dike were steepened to 3:1 and the road was realigned to further reduce the filling of wetlands. The road on the east side of the Gravel Pond was realigned to completely avoid the discharge of fill material into wetlands and, to preserve the gravel pond from inundation at 5,444 feet above msl, will include a new dike at an additional cost of approximately $500,000. These actions preserve the highly valued and relatively rare recreational experiences of scuba diving, long distance swimming, canoeing and kayaking (without the influence of nearby power boats) at Chatfield. Estimated cost: $500,000 (This cost is included in the estimate for roads and bridges above)

- Total Cost for all Recreation Facilities Modifications: $31,600,000

All parties agree that the RFMP is a conceptual design and best efforts were used to determine the final costs of the RFMP. There are instances in the RFMP where there are items listed but associated costs with the item or facilities were not included. It is the intent of the Project Participants to make sure that every facility or infrastructure listed or not listed in the RFMP that is affected by the reallocation project will be relocated or modified to the same functionality to the extent possible that is currently in place. These issues will be addressed and refined in the design process for the project. Two specific issues are further discussed below:

- One of the concerns of CPW is how the park will function during a 10 year flood event. Currently Chatfield is able to stay open during a 10 year flood event and the Deer Creek entrance is not effected, the North Ramp is usable, and access is not restricted on the west side of the park. Post reallocation, under the RFMP, it maybe that the Deer Creek entrance and the west side of the park would have to be shut down. This issue will be further addressed in the final design.

- There are three different easements on the west side of the park that are impacted by the reallocation project and not included in the RFMP. Denver Water has transformers and a pump station at Fox Run. South Chatfield Water District has a waterline running from the water board road that crosses the South Platte River and provides water to residents south of Chatfield. Trailmark has an easement for gas out of the Catfish Flats parking area. The Project Participants will work with each of these entities to determine how to mitigate the impacts to their easements.

5.1.2 The Marina Replacement Plan

Impact

The Project will inundate portions of the Chatfield marina area and the additional 12 feet of potential water level fluctuations will impact the operations of the marina facilities and increase its exposure to wind and wave action.

Mitigation

The following summary provides an update on planning and design for the development of replacement facilities within the marina area on the reservoir in Chatfield State Park. It describes the process used to build consensus around the meaning of "like-kind," and provides an overview of the solutions for relocating and replacing existing facilities.

The mission of the Chatfield Marina Coordination Committee (CMCC) is to advance plans for replacement of the current marina area improvement with like-kind facilities. The CMCC includes representatives from key stakeholders including the Chatfield Water Providers (Providers), Colorado Parks and Wildlife (CPW), and Chatfield Marina, Inc. Through a competitive proposal process, the CMCC selected the consultant team of SmithGroupJJR (SGJJR) and Wright Water Engineers (WWE) to assist with the project. The standards for like-kind replacement were established through analysis of the existing project facilities, interviews with key stakeholders and meetings with the CMCC, review of existing data, and the collection of new wind and wave data.

Two alternative design concepts are described within this summary and illustrate different approaches for developing like-kind replacement facilities. While both solutions are valid, the alternatives have different implications with regard to the complexity of construction phasing and potential for interruption to existing marina operation and park usage. Future work will be completed to verify the feasibility of each of the alternatives and allow the CMCC to finalize its selection of a preferred alternative.

<u>Planning Process</u>

The formation of the CMCC was critical in establishing a consensus on the definition for like-kind replacement. Actively engaging each group in one planning process allowed members to share individual perspectives while developing a broader understanding of the goals and challenges that surround development of replacement facilities.

The planning process was key to building consensus among the diverse interests of the stakeholders, and helped to advance the project. The SGJJR / WWE team toured the project area and completed a series of individual interviews with CMCC members and other key stakeholders (i.e. vendors servicing the marina, regulatory agencies, etc). The observations and results of the individual sessions were reviewed with the entire CMCC so that all members were able to raise questions, seek clarifications and provide additional input. Over the course of the meetings, the CMCC arrived at a shared understanding of:

- The current and future water levels and the effects of these conditions on existing and future replacement facilities;
- The physical improvements that will require replacement or relocation;
- The functional considerations critical to maintaining marina operations;
- The recreational opportunities afforded within the current park areas; and
- The influence new code requirements have on the design of replacement facilities.

Like-Kind Determination

The definition of "like-kind" facilities is based on details documented within an Existing Conditions Inventory and Analysis. The analysis is organized into four primary sections (described below). Within each section, the existing conditions are documented in both quantitative and qualitative terms. The elevation of each existing physical improvement is identified along with the frequency of inundation based on historic water levels within the reservoir. Through an analysis of the existing conditions, a basis of design section defines the specific standards that like-kind facilities must achieve.

The four primary sections of the Existing Conditions Inventory and Analysis are summarized below.

- Hydraulic Analysis – Analysis of the current and future projected wind, wave and ice influences on current and future like-kind facilities.
- Upland Improvements and Infrastructure – Quantitative and qualitative aspects of facilities such as the number and size of shelters, and important relationships between elements such as parking areas and recreational amenities which are critical in providing similar recreational opportunities and access.
- Marina Facilities and Operations – Important factors like the operable range of water levels for access ramps and anchorage, vendor service requirements, and the level of maintenance and staffing required to manage and operate facilities.

- Codes and Regulations – Requirements for the development of replacement facilities resulting from changes to codes and regulations.[3]

The basis of design discussion within each section establishes the requirements for like-kind replacement facilities, and is the foundation for development the marina area modification alternatives.

Marina Area Modification Alternatives

Both alternatives presented as part of this summary fulfill the like-kind replacement requirements for facilities within the marina area. While the alternatives consider different organizational patterns, development of the replacement facilities will be accomplished within the same general project area. Similarly, the development of either alternative requires a similar amount of earthwork to raise the upland areas in response to increasing water levels and result in comparable levels of disturbance and environmental impact. Other similarities between the two alternatives include:

- Reuse of a majority of the existing marina's floating infrastructure including such elements as the dockage, administration building, sanitary and fueling systems;
- Reliance on new floating wave attenuators to mitigate waves and help address concerns over ice impacts on the docks;
- Use of a series of gangways to provide access to marina facilities and the new floating fishing platform;
- Reconstruction of a new launch ramp and access drive located in approximately the same area as the existing launch;
- Development of a trail system that connects regional trails to and through the project area;
- Creation of new beaches that allow for use through the full range of anticipated pool levels;
- Replanting of disturbed areas to achieve a similar landscape character and shade recreational users; and
- Installation of a new anchoring system for the docks, administration building and new attenuators that accommodate increased water levels.
- Construction of like-kind replacement facilities are estimated to cost approximately $12.1 million. A recommended construction contingency of 20% and design/engineering allowance of 15% bring the total budget range for either alternative to approximately $15.7 million.

[3] Current facilities comply with the existing codes and regulations. Changes to existing elements to accommodate the Reallocation Project trigger the need to modify or upgrade certain elements in ways not specifically required by the "like-kind" replacement standards.

Alternative A (Existing Marina Location)

This alternative maintains the same general organization for replacement facilities (see Figures 26, 27 and 28). Fill material from excavation of the western shoreline, and other material imported from off-site borrow pits, is used to raise upland areas to accommodate the increased water level. Segments of the shoreline to the west and east of the marina are shaped to create new beaches. The replacement parking lots, service areas, picnic and overlook areas, utilities and other facilities are rebuilt to meet like-kind requirements.

Water level increases within the reservoir result in the existing peninsulas being submerged a majority of the time. Therefore, floating wave attenuators will replace the docks along the northeast and northwest sides of the marina. These new structures will provide comparable levels of tranquility for boat slips while remaining available for mooring of boats. A new anchoring system, designed to accommodate the increased water elevation and fluctuation, is used for the docks, floating fishing pier, attenuators and administration building. Two new sets of gangways link upland facilities with the floating docks.

Alternative B (Roxborough Cove Marina Location)

Unlike Alternative A, this alternative flips the organization of the major site features. The marina moves into Roxborough Cove and the bay where the marina is currently located becomes part of a beach cove that supports outdoor recreation activities (see Figures 29, 30 and 31). Dredging within Roxborough Cove creates sufficient depth to accommodate the marina and a channel is cut through the existing peninsula to provide access to the marina.[4] Fill generated from the dredging and excavation work, along with some material from off-site borrow pits, is used to raise the upland areas. As with the first alternative, the replacement parking lots, service areas, picnic and overlook areas, utilities and other facilities are rebuilt to meet like-kind requirements.

While the existing peninsula between the two coves is submerged a majority of the time, the Roxborough Cove marina is also protected with floating wave attenuators. As with Alternative A, a new anchoring system is employed and sets of gangways are used to link the upland improvements with the floating docks.

Although both alternatives are valid, the CMCC preference is toward Alternative B. This alternative offers some unique advantages that include:

[4] It is assumed that dredged material from within Roxborough Cove is suitable for reuse as fill within the upland areas. Preliminary review of analyses completed by the COE do not suggest significant amounts of sediment within the cove area are the result of stream sediment deposition. However, future work should be undertaken to confirm the viability of dredged sediment reuse and confirm that deposition from Plum Creek will not create long-term issues with relocated facilities.

- The ability to complete earthwork operations and construct the marina improvements and upland support facilities within and around the perimeter of the near south bay while the existing marina and park facilities remain operable;
- Minimizing or eliminating required marina concessionaire compensation resulting from lost revenue due to interruptions in operations, lower than normal slip occupancy resulting from boaters transferring to slips at other facilities, or employee compensation for lost wages due to shortened seasons[5];
- An increased level of natural protection for marina facilities from extreme storm events; and
- The opportunity to generate the greatest amount of fill material from excavation and dredging of the near shore and lakebed areas for use in elevating upland areas in response to the new reservoir pool levels.

Future work commissioned by the Water Providers will confirm the validity of each alternative and aid in determining the final preferred solution for developing like-kind replacement facilities.

Conclusions and Next Steps

CMCC consensus on the standards that constitute like-kind replacement facilities represents a critical project milestone. It results in a set of common goals and expectations that become the foundation for current and future planning and design efforts.

While the two alternatives presented as part of this summary meet the consensus like-kind replacement requirements, the CMCC prefers Alternative B. Additional work will be necessary to confirm this preference and validate assumptions related to the feasibility of reusing material from dredging of the marina basin and near shore excavations as fill to raise upland areas above the new pool level. Once these additional investigations are complete and the preferred plan is selected, detailed design, engineering and permitting will be advanced.

5.1.3 Hiring of Temporary CPW Resident Engineer

The project participants will fund the temporary hiring by CPW of a qualified engineering employee during the design and construction activities related to recreational facilities modifications and environmental mitigation within the Chatfield State Park property. This temporary employee will function as a full-time resident engineer and will be involved in the development of information and products of the project related to the CPW interests at the Chatfield State Park. This mitigation measure is being undertaken to assure that CPW is intimately involved in all of the decision-making during the on-site recreational facility and on-

[5] Compensation for lost revenue is not reflected in the estimated cost for developing like-kind replacement facilities identified within this section of this summary.

site environmental design and construction phases of the project. It is estimated that this process of employing a temporary CPW resident engineer will take a total of three years and cost an estimated $225,000.

5.2 Financial Plan

Mitigation Company

The Mitigation Company will be a Colorado non-profit corporation named the Chatfield Reservoir Mitigation Company (CRMC). It will be formed to accomplish the financial and mitigation obligations from the Chatfield Reservoir Reallocation Project (Reallocation Project)

Capital Improvements

Background: As part of the Chatfield Reallocation Project, certain capital improvements in the park will be replacing roads, facilities and infrastructure located below the new high water level of 5444 feet. Listed below are capital improvements that were planned to be funded through the Parks and Wildlife Capital funds and a Cost Share Agreement with the Army Corp of Engineers (Corps). These improvements were delayed due to the pending outcome of the Reallocation Project.
Purpose: To provide the Water Providers reimbursement or other form of compensation acceptable to the Water Providers for costs they incur in relocating or replacing the identified capital improvements affected by the project, which improvements would otherwise have been replaced by CPW at CPW's expense.

Steps:

1. CPW recognizes that the below capital improvements and related, estimated capital costs would have been incurred by CPW with a 50/50 share from the Corps in absence of the Reallocation Project. Identified Capital Improvements affected by the Reallocation Project that have not been completed by CPW are limited to the following ("Capital Improvements").
    a) Widen and overlay the Perimeter Road from where Phase 4 ended to the west side of the South Platte River Bridge - .99 miles, 2010 cost $925,000.
    b) Widen and overlay the Perimeter Road from the east side of the South Platte River Bridge to the East side of the South Platte River Day Use Parking Lot - .15 miles, 2010 cost $140,000.
    c) Catfish and Jamison sewage lift station renovation (replace pumps, rails and controls)- $180,000.
    d) Parking lot Improvements to include pothole repair, crack sealing and overlays as needed (Swim beach, Catfish, Boat Launch, North Boat Ramp and Marina - $550,000
    e) Building renovations to include new partitions, painting, and fixtures as needed(Swim beach Buildings, Catfish Restroom, Jamison Restroom, Balloon Launch Restroom, Marina Restroom) - $500,000

Total Estimated Cost = $2,300,000 (CPW's share $1,150,000)

2. The Water Providers shall construct all Capital Improvements in accordance with CPW's design standards. Once CPW concurs that construction is complete and in accordance with CPW's design standards, CPW will then reimburse the Water Providers for their 50% share of the actual Capital Improvements costs identified in Step 1 above. CPW's financial liability for its share of the Capital Improvements will not exceed $2,500,000, is subject to appropriation of the necessary funds and will be diligently pursued.

3. Full title to all facility modifications, including the Capital Improvements and any other facility or infrastructure modifications within Chatfield State Park, shall vest in CPW upon completion of construction.

Reservoir Incremental Water Level Fluctuation Costs

Background: After construction, reservoir water levels may fluctuate more than they have in the past as a result of the Reallocation Project. It is uncertain when these fluctuations will occur but the potential for wider fluctuations will continue as long as the Water Providers use Chatfield Reservoir for water storage purposes.

Chatfield State Park will likely experience incremental costs to manage these wider water level fluctuations. The Park Manager estimates these costs might include temporary personnel plus related equipment and supplies, as described below.

Purpose: To provide Chatfield State Parks with sufficient funds to manage the impacts of these wider water level fluctuations.

Steps:

1. CPW and Water Providers agree on the definition of reservoir water level fluctuations above current (pre-Reallocation Project) water level fluctuations and the types of incremental costs that are eligible for reimbursement. There are two general types of incremental costs: temporary personnel and related equipment and supplies.

2. Each fall, prior to October 15th, the Chatfield Park Manager estimates and the Water Providers approve estimated costs for temporary personnel and related equipment and supplies for the following year. These two figures become a basis for the annual authorization amounts. Temporary personnel are expected to include 3 to 5 temporary staff, 9 months per year.

3. Water Providers direct the Mitigation Company to authorize payment for costs associated with the incremental water level fluctuations up to the Annual Authorization Amounts from the CPW Escrow Account. The CPW Escrow Account will be replenished by the Water Providers on an annual basis as it is depleted. Mitigation Company authorizes funding for these purposes up to the Annual Authorized Amounts, to reimburse CPW for costs incurred. CPW may submit invoices on a monthly or less frequent basis. If CPW determines during the year that supplemental funds are needed, they will present a supplemental funding request with supporting documentation to the Water Providers for approval before expenditures are made. Water Providers will give reasonable consideration to requests for supplemental expenditures. If a supplemental request is granted, the Annual Authorized Amount(s) will be adjusted.

4. CPW will be reimbursed for costs as follows:

   - CPW hires temporary personnel for the following summer. CPW bills the Mitigation Company monthly for actual temporary personnel costs incurred in connection with managing the impacts of fluctuating water levels. Upon approval by the Mitigation Company, it pays invoices from the escrow account to reimburse CPW up to the Annual Authorized Amount.

   - CPW purchases equipment or supplies and submits invoice to Mitigation Company for reimbursement of expenses. Upon approval by the Mitigation Company, it pays invoices issued by Chatfield Park Manager from the CPW Escrow Account to reimburse CPW up to the annual authorized amount. Examples of equipment that might be needed are: trucks or all-terrain vehicles for staff, chainsaws, tools and radios. Examples of supplies that might be needed are: signs and sign hardware, buoys and buoy hardware, sand, portable trash cans, trail supplies, lumber and temporary worker uniforms.

   - If a dispute arises regarding CPW's request for funding or for reimbursement, a 3-person panel will convene to propose a resolution of the dispute. The panel will consist of one person selected by CPW, one person selected by the Water Providers and one person selected jointly by those two people.

5. This section of the agreement continues at least for the duration of the current lease between CPW and the Corps (year 2028). At that time, and at the end of each subsequent lease period between the Corps and CPW, a determination will be made by the parties of the reasonableness of continuing this section.

Chatfield State Park Revenues

Background. Chatfield State Park revenues from annual and daily passes, marina and livery concessions, individual campground fees, group campground and picnic fees flow into the State Parks "Cash" Fund (Actual Revenues). Chatfield State Park revenues are a significant portion of the statewide total. CPW and the Water Providers agree that there may be adverse financial impacts to these revenues during construction that are attributable to the Reallocation Project. After construction, there may be adverse financial impacts for up to five years as prior year visitors are welcomed back and new visitors are invited to experience Chatfield State Park.

Purpose: To agree on and adopt a method to calculate and reimburse CPW, as needed, for future revenue impacts to the State that are attributable to the Reallocation Project.

Steps:

1. Parties have set annual Baseline Revenues, based on actual revenue figures, using 2009 through 2013. Baseline Revenues for the year 2014 are $2,119,529. The Baseline Revenues will escalate at two percent (2%) per year, compounded each year through construction, for two years after construction and potentially for three additional years as described in this section of the agreement (Baseline Revenues). As an illustration, Baseline Revenues for 2015 are $2,161,920.

2. Each year during construction of the Reallocation Project facilities that impact Chatfield recreation activities the following formula will be used to calculate whether a payment is due to CPW:

   Formula During Construction:
   Actual Revenues – Baseline Revenues = Payment to CPW of the result if the figure is negative.

   Any abnormal events at the park such as fires, floods or other events that result in a park closure or limited recreational opportunities that obviously decrease Actual Revenue other than Reallocation Project activities will be given consideration in estimating the payment to CPW, upon request of the Water Providers.

3. The duration of construction of the Reallocation Project facilities that impact Chatfield recreation activities is defined by the parties for purposes of these calculations as follows: The Start of Construction is the date when the contractor mobilizes equipment inside Chatfield State Park for recreational mitigation construction activities, following a "Notice to Proceed" from the CRMC. Current estimates are that this construction activity may take about 36 months, which might extend more than three State fiscal years. The Completion of Construction is when the owner, contractor and engineer, as may be appropriate, each sign a "Recommendation for Final Acceptance/Payment and Release of Retainage", or equivalent document, for the last recreational facility constructed.

4. Any payments to CPW will be documented in an invoice to the Water Providers. The invoice will be paid by the Mitigation Company from the CPW Escrow Account 30 days after receiving an invoice and verifying the documentation.
   In any year after construction, if Actual Revenue is greater than Baseline Revenue, then no payment is due to CPW and a credit will accrue to the Water Providers against the current year and continue into future years (Cumulative Credit). A new credit is added to the Cumulative Credit only if the Actual Revenues – Baseline Revenues are positive for that year. The amount of the new credit would be the difference between the Actual Revenues and Baseline Revenues. If the (Actual Revenues + Cumulative Credit) – Baseline Revenues calculation is zero or negative, the Cumulative Credit is lost. The Water Providers are not eligible for a credit during construction.

   Formula After Construction:
   (Actual Revenues + Cumulative Credit, if any) – Baseline Revenues = Payment to CPW of the result if the figure is negative and Credit to Water Providers of the result if the figure is positive

5. Water Providers will make payments, if necessary, through construction plus two years and possibly three additional years, depending on the conditions described below.
   a) After construction, the same formula as noted above in Step 4 will continue for another two years and, if at the end of that period the Water Providers are in a credit position, the obligation of the Water Providers to make payments to CPW will terminate.

   b) At the end of the first two years after construction, if payments are due to CPW, then this portion of the agreement will extend for three more years and then terminate. The formula noted above in Step 4 will continue to be utilized for this last three year period. At termination, whether two or five years after construction, any cumulative credit to the Water Providers will be cancelled.

6. Mitigation Company will retain a specialist to manage Reallocation Project-related marketing and public relations needs during and after Reallocation Project construction. This will include information on a unique page of the Chatfield Reallocation Project web site which is updated regularly with ongoing construction information. Mitigation Company and CPW will collaborate regarding message content, schedule and methods of distribution. The objectives are to inform users and stakeholders regarding progress during construction and to welcome prior and new users to Chatfield after Project construction is complete. This effort will begin with Project construction and will continue as long as annual payments are due to CPW or for 8 years, whichever occurs first. Mitigation Company commits to spend approximately $20,000 per year for each year that the marketing and public relations initiative is in effect. Mitigation Company will provide CPW $5,000 per year for Project-related marketing and public relations as long as annual payments are due to CPW or for 8 years, whichever occurs first.

CPW Escrow Account

An independent escrow agent will be selected and paid for by the Water Providers to manage mitigation contributions and payments and prepare an annual report documenting activity. Instructions regarding the escrow account will be developed based on CRMC direction, per its governance provisions. Upon execution of this Agreement, the Water Providers will establish an interest-bearing CPW Escrow Account with initial funding equivalent to 12 months of future, expected annual mitigation payments so that CPW is assured that funds would be available. For the term of the Agreement, the minimum balance will be $100,000 in cash or credit.

The escrow agent will receive contributions from individual Water Providers, based on their percentage of participation, make payments to State Parks, consistent with the terms of the Agreement and provide annual reports to State Parks and the Water Providers. The obligation to fund the escrow account will be effective when this or other agreements require funding and prior to the Start of Construction.

Financial Mitigation – Chatfield State Park Concessionaires

This agreement affirms that the Water Providers will present a mitigation proposal to the marina and livery concessionaires that CPW determines to be fair and reasonable. The intent of the proposals is to backfill adverse financial impacts including increased operating costs and lost revenue to these concessionaires that are attributable to on-site construction and post construction impacts of the Project that impact their operations.

5.0 Schedule

The general schedule for Project implementation is as follows:

Record of Decision signed	2013 or 2014
Water Storage Agreement signed	2014
Recreational modifications completed	2017
On-site environmental mitigations completed	2017
Storage initiated, if escrow account used (See CMP, p. 67)	2017
Stream enhancements completed	2019
Off-site environmental mitigations completed	2024

6.0 Conclusion

This Fish, Wildlife and Recreation Mitigation Plan sets forth mitigations that are "economically reasonable and maintains a balance between the development of the state's water resources and the protection of the state's fish and wildlife resources" per C.R.S. 37-60-122.2. All impacts are mitigated in a reasonable manner.

The Chatfield Reallocation Project brings needed new surface water supplies to a basin considered to be severely short of water supply. The yield from the project of 8,500 AF/yr. is only a part of the solution for the identified water supply shortage in the South Platte basin of from 100,000 to 360,000 AF/yr in 2050. This Plan includes the mitigations required by the USACE, which will cost an estimated $123,500,000, and additional fish, wildlife and recreation mitigations specifically in response to CPW concerns which will cost an additional estimated $8,864,300. The total of all mitigations combined are $132,364,300.

These mitigation measures and their estimated costs are summarized in the table below:

Mitigation Measures Required by the USACE:	Near-term costs
Compensatory Mitigation Plan	$ 58,500,000
Recreation Facilities Modification Plan	31,600,000
Marina Plan	15,700,000
Water Quality Monitoring and Modeling (est.)	1,300,000
Required Releases for Critical Low Flows	--
Sub Total	$107,100,000
Additional C.R.S. 37-60-122.2 Mitigation Measures Included in Response to CPW Concerns:	
Plum Creek Restoration Plan	$ 6,088,600
Financial Plan (est.)	1,000,000
Stream Enhancement Upstream	369,600
Stream Enhancement Downstream	265,000
Hiring of Temporary CPW Resident Engineer (est.)	225,000
Shoreline Stabilization Plan	716,100
Marketing/ Public Relations Plan	200,000
Commitments in Reservoir Operations Plan	--
Assistance with Environmental Pool and/or Environmental flow releases	--
Sub Total	$8,864,300
Grand Total	$115,964,300

The proposed mitigation measures strike the appropriate and economically reasonable balance between comprehensive, responsible mitigations to mitigate the CPW concerns and the development of additional, urgently needed new water supplies.

References

1. Colorado Water Conservation Board, Statewide Water Supply Initiative. Final Report. January, 2011. http://cwcb.state.co.us/public-information/publications/pages/studiesreports.aspx.

2. U. S. Army Corps of Engineers, Draft Integrated Feasibility Report and Environmental Impact Statement, June 2012.

3. ERO Resources Corporation and Tetra Tech EC, Draft Compensatory Mitigation Plan, February, 2013. Appendix K of the Draft FR/EIS.

4. EDAW/AECOM, Chatfield Reservoir Recreation Facilities Modification Plan, January 2010. Appendix M of the Draft FR/EIS.

5. SmithGroupJJR, Draft Marina Area Modification Plan, June 2013.

6. U. S. Army Corps of Engineers, Tree Management Plan, June 2012, Appendix Z of the Draft FR/EIS.

7. ERO Resources Corporation, Chatfield Reallocation Project Adaptive Management Plan, March 12, 2013, Appendix GG of the Draft Final FR/EIS.

8. ERO Resources Corporation, Comparative Review of Reservoir Fluctuation Zone Chatfield Reallocation Project, November, 2012. Appendix HH of the Draft Final FR/EIS.

9. Muller Engineering Company, Inc., Draft Plum Creek Stream Stability Assessment Chatfield State Park, April 2, 2013.

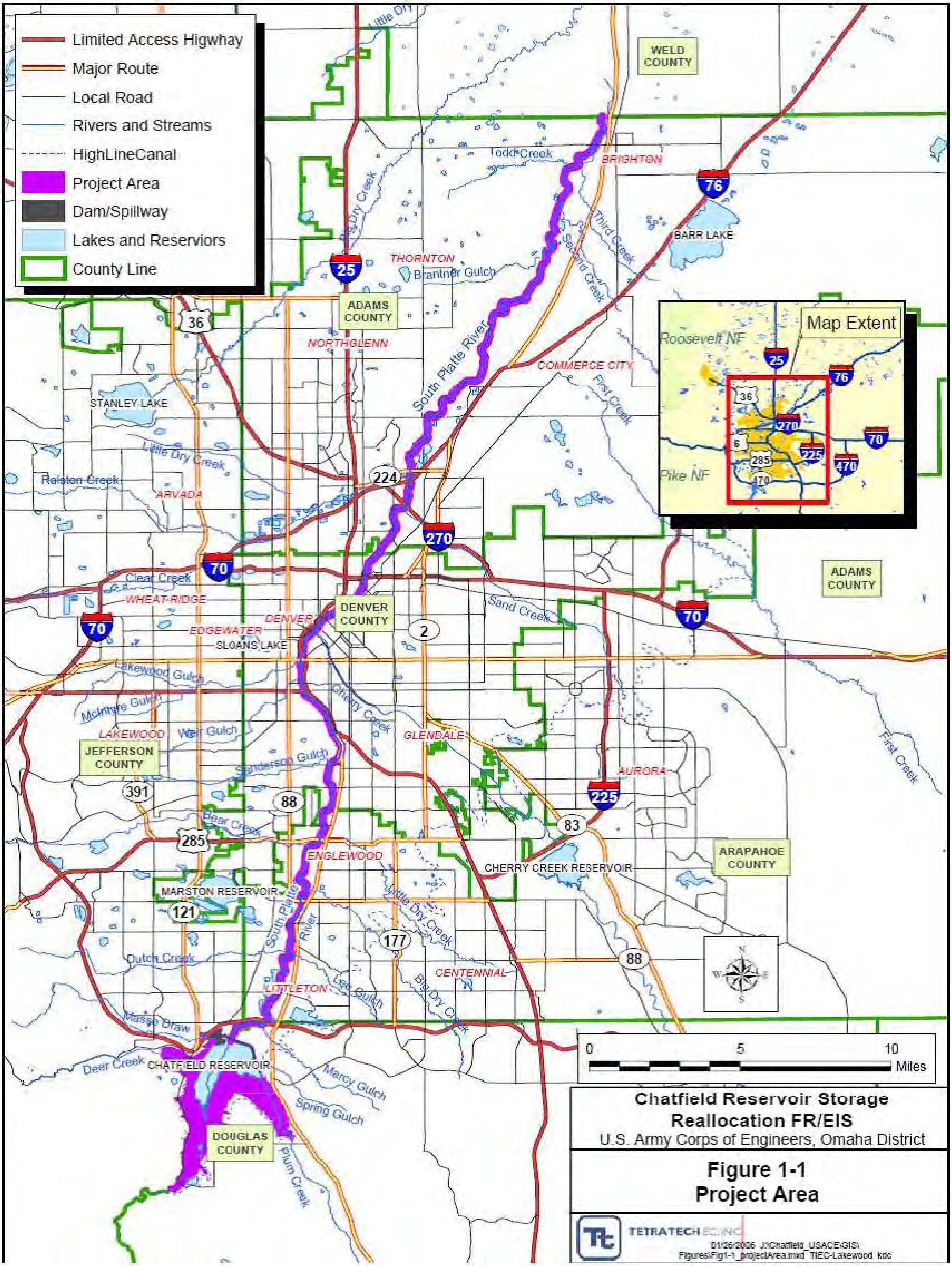
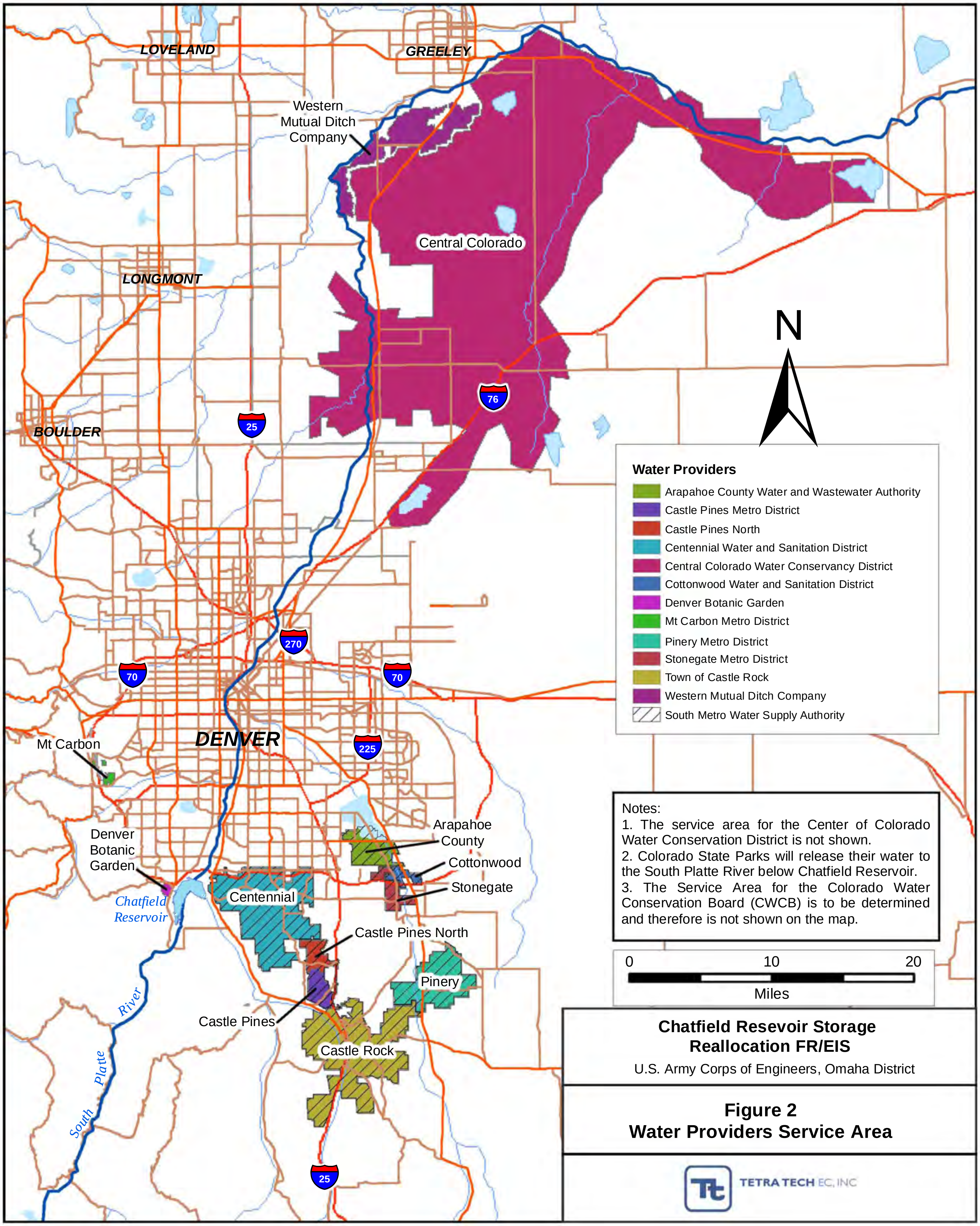
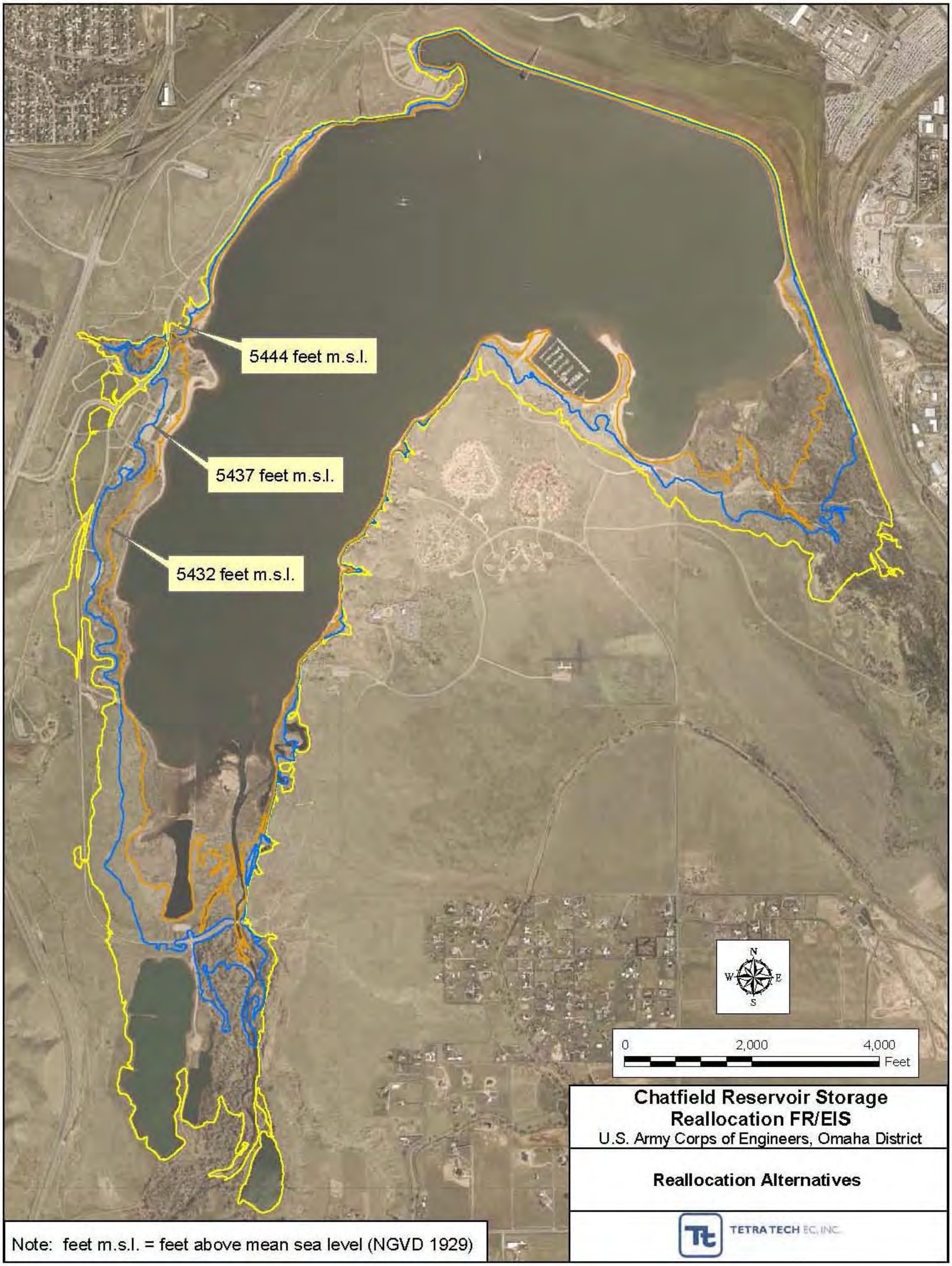
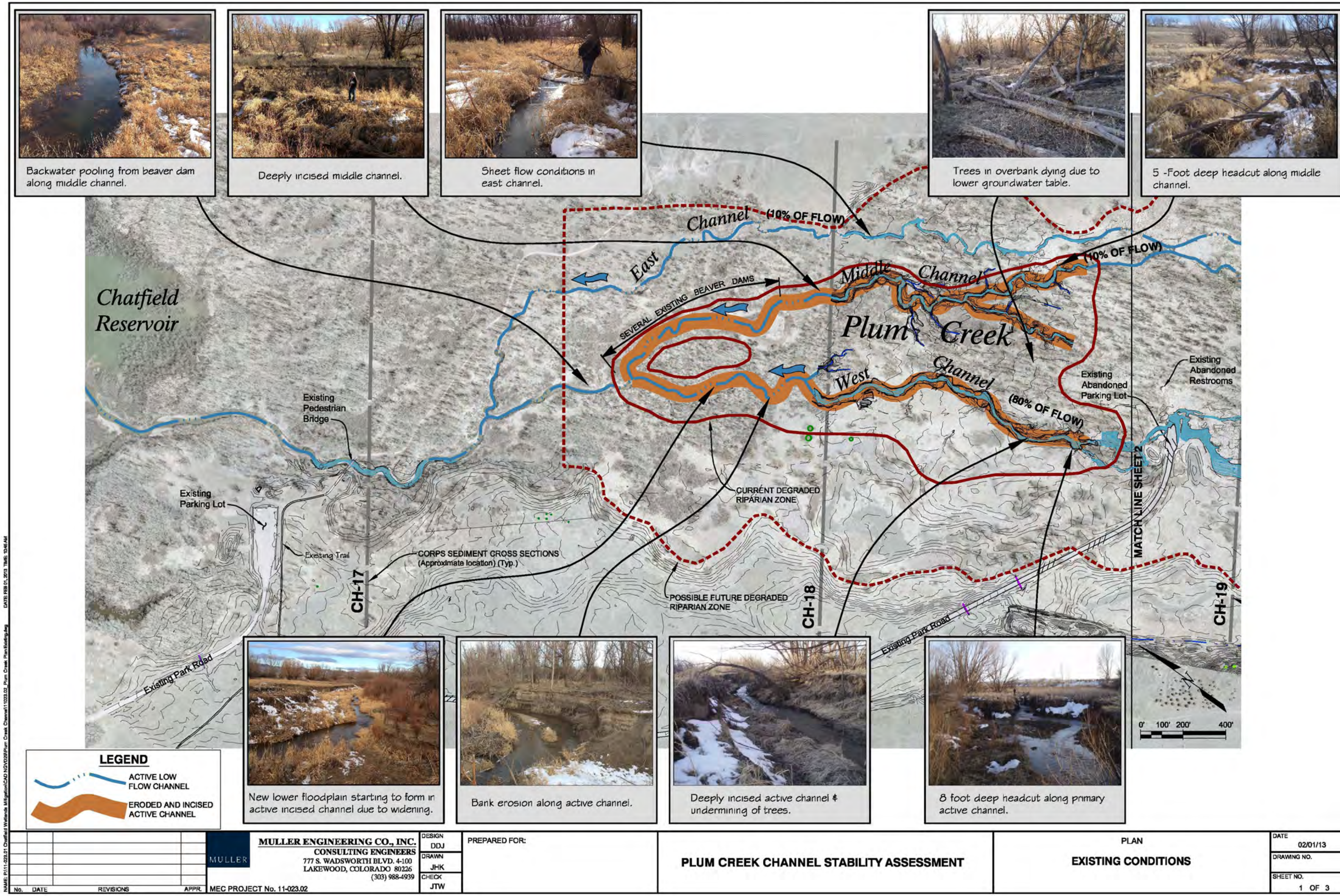
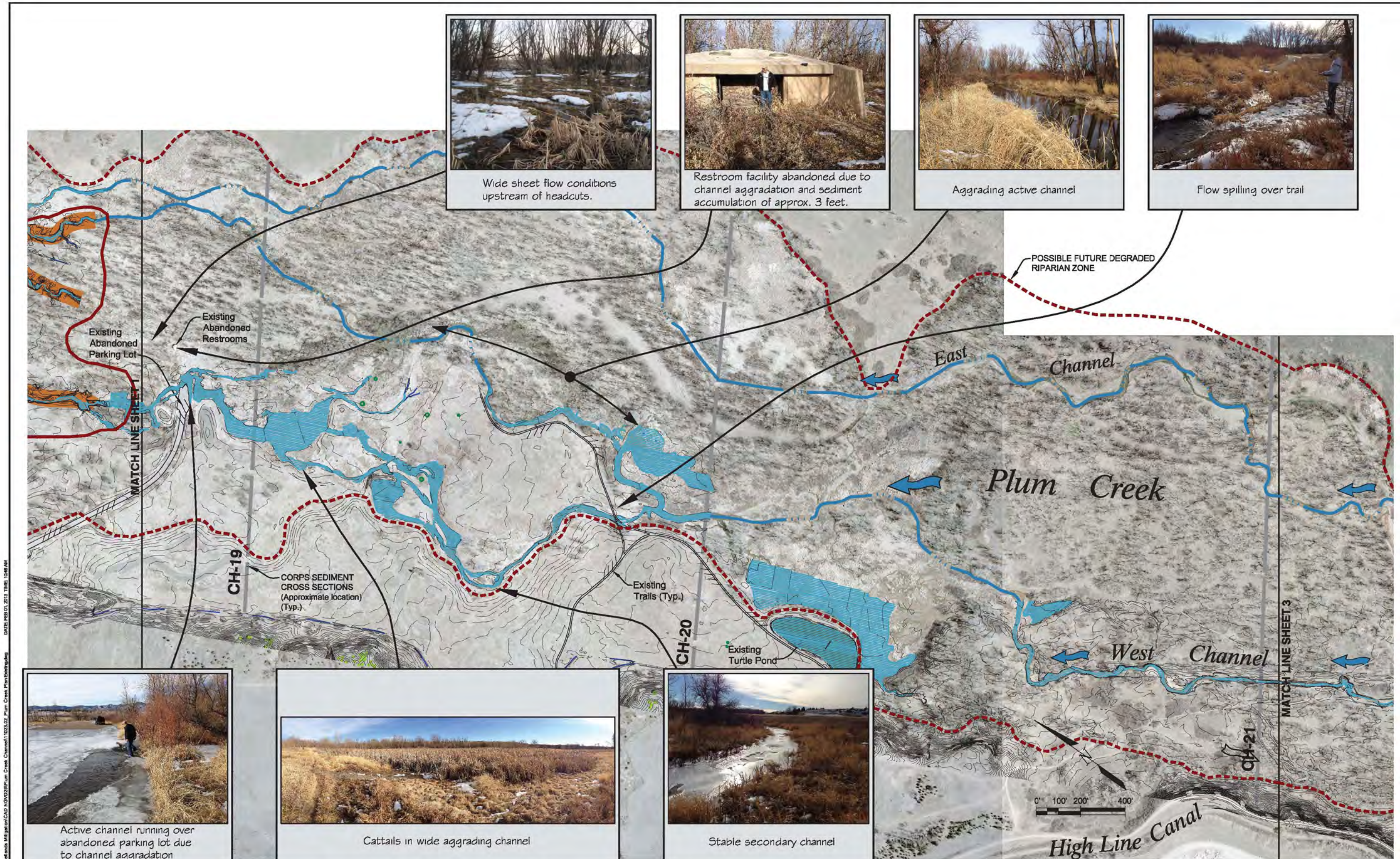

Limited Access Higwhay
Major Route
Local Road
Rivers and Streams
HighLineCanal
Project Area
Dam/Spillway
Lakes and Reserviors
County Line
WELD COUNTY
ADAMS COUNTY
DENVER COUNTY
JEFFERSON COUNTY
ARAPAHOE COUNTY
DOUGLAS COUNTY
BRIGHTON
THORNTON
NORTHGLENN
COMMERCE CITY
ARVADA
WHEAT RIDGE
EDGEWATER
DENVER
LAKEWOOD
GLENDALE
AURORA
ENGLEWOOD
LITTLETON
CENTENNIAL
BARR LAKE
STANLEY LAKE
SLOANS LAKE
MARSTON RESERVOIR
CHERRY CREEK RESERVOIR
CHATFIELD RESERVOIR
South Platte River
Todd Creek
Third Creek
Second Creek
First Creek
Brantner Gulch
Big Dry Creek
Little Dry Creek
Ralston Creek
Clear Creek
Sand Creek
Lakewood Gulch
McIntyre Gulch
Weir Gulch
Sanderson Gulch
Bear Creek
Cherry Creek
Dutch Creek
Lee Gulch
Massey Draw
Deer Creek
Marcy Gulch
Spring Gulch
Plum Creek
Map Extent
Roosevelt NF
Pike NF
0 5 10 Miles
N S E W
Chatfield Reservoir Storage Reallocation FR/EIS
U.S. Army Corps of Engineers, Omaha District
Figure 1-1
Project Area
TETRATECH EC, INC
01/26/2006 J:\Chatfield_USACE\GIS\Figures\Fig1-1_projectArea.mxd TIEC-Lakewood kdc

Figure 2 Chatfield Project Participant's Service Areas




5444 feet m.s.l.
5437 feet m.s.l.
5432 feet m.s.l.
N
W
E
S
0
2,000
4,000
Feet
Chatfield Reservoir Storage
Reallocation FR/EIS
U.S. Army Corps of Engineers, Omaha District
Reallocation Alternatives
TETRA TECH EC, INC.
Note: feet m.s.l. = feet above mean sea level (NGVD 1929)


Backwater pooling from beaver dam along middle channel.
Deeply incised middle channel.
Sheet flow conditions in east channel.
Trees in overbank dying due to lower groundwater table.
5 -Foot deep headcut along middle channel.
Chatfield Reservoir
East Channel (10% OF FLOW)
Middle Channel (10% OF FLOW)
SEVERAL EXISTING BEAVER DAMS
Plum Creek
West Channel (80% OF FLOW)
Existing Pedestrian Bridge
Existing Parking Lot
Existing Trail
Existing Abandoned Parking Lot
Existing Abandoned Restrooms
CURRENT DEGRADED RIPARIAN ZONE
POSSIBLE FUTURE DEGRADED RIPARIAN ZONE
CORPS SEDIMENT CROSS SECTIONS (Approximate location) (Typ.)
CH-17
CH-18
CH-19
MATCH LINE SHEET 2
Existing Park Road
0' 100' 200' 400'
LEGEND
ACTIVE LOW FLOW CHANNEL
ERODED AND INCISED ACTIVE CHANNEL
New lower floodplain starting to form in active incised channel due to widening.
Bank erosion along active channel.
Deeply incised active channel & undermining of trees.
8 foot deep headcut along primary active channel.
No. DATE REVISIONS APPR.
MULLER
MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226
(303) 988-4939
MEC PROJECT No. 11-023.02
DESIGN DDJ
DRAWN JHK
CHECK JTW
PREPARED FOR:
PLUM CREEK CHANNEL STABILITY ASSESSMENT
PLAN
EXISTING CONDITIONS
DATE 02/01/13
DRAWING NO.
SHEET NO. 1 OF 3



No.	DATE	REVISIONS	APPR.

MULLER ENGINEERING CO., INC.
CONSULTING ENGINEERS
777 S. WADSWORTH BLVD. 4-100
LAKEWOOD, COLORADO 80226
(303) 988-4939

MEC PROJECT No. 11-023.02

DESIGN DDJ
DRAWN JHK
CHECK JTW

PREPARED FOR:

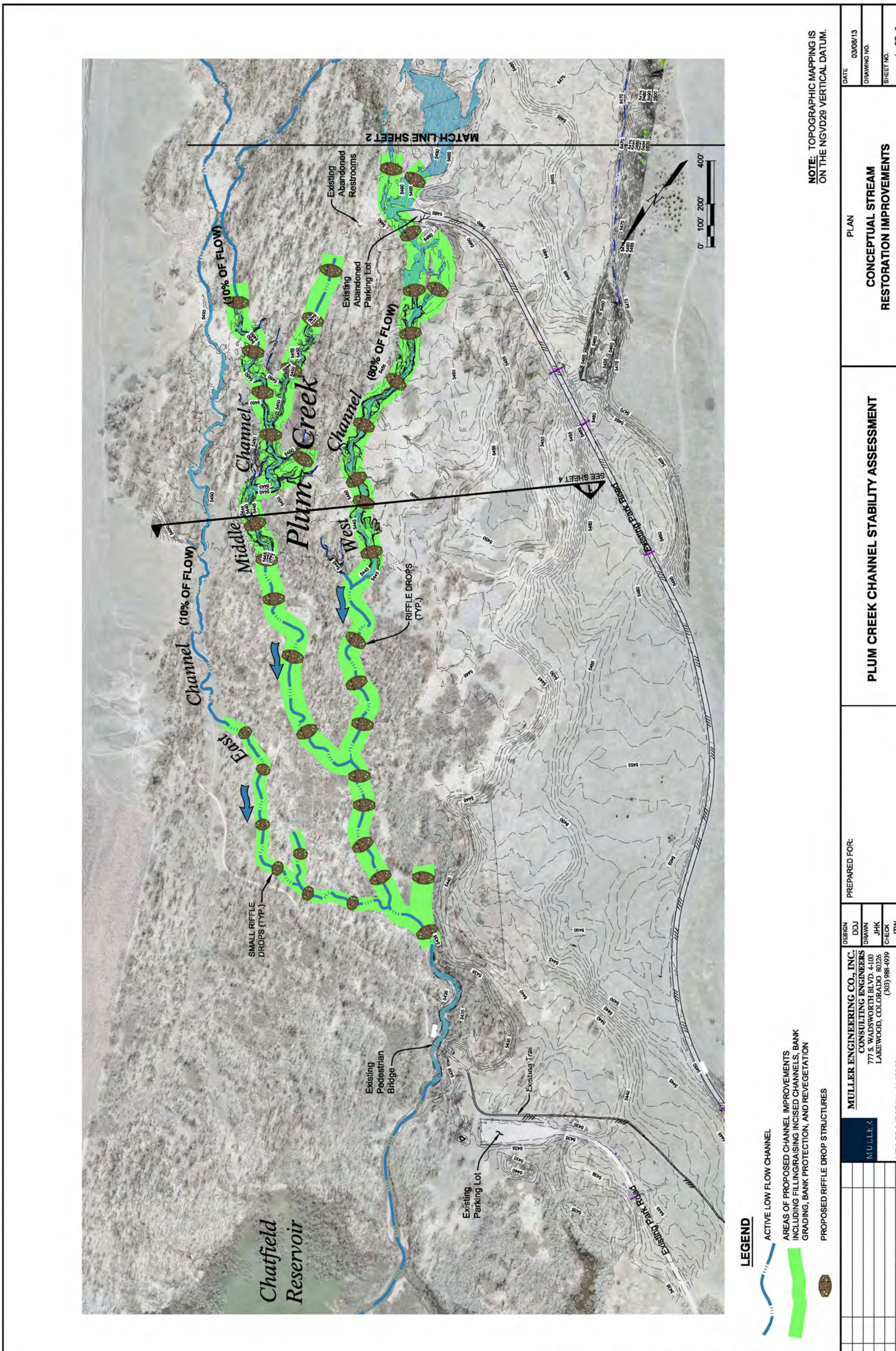
PLUM CREEK CHANNEL STABILITY ASSESSMENT

PLAN
EXISTING CONDITIONS

DATE 02/01/13
DRAWING NO.
SHEET NO. 2 OF 3

Figure 5
Plum Creek Existing Conditions (2)

Figure 6 Plum Creek Conceptual Stream Restoration Improvements



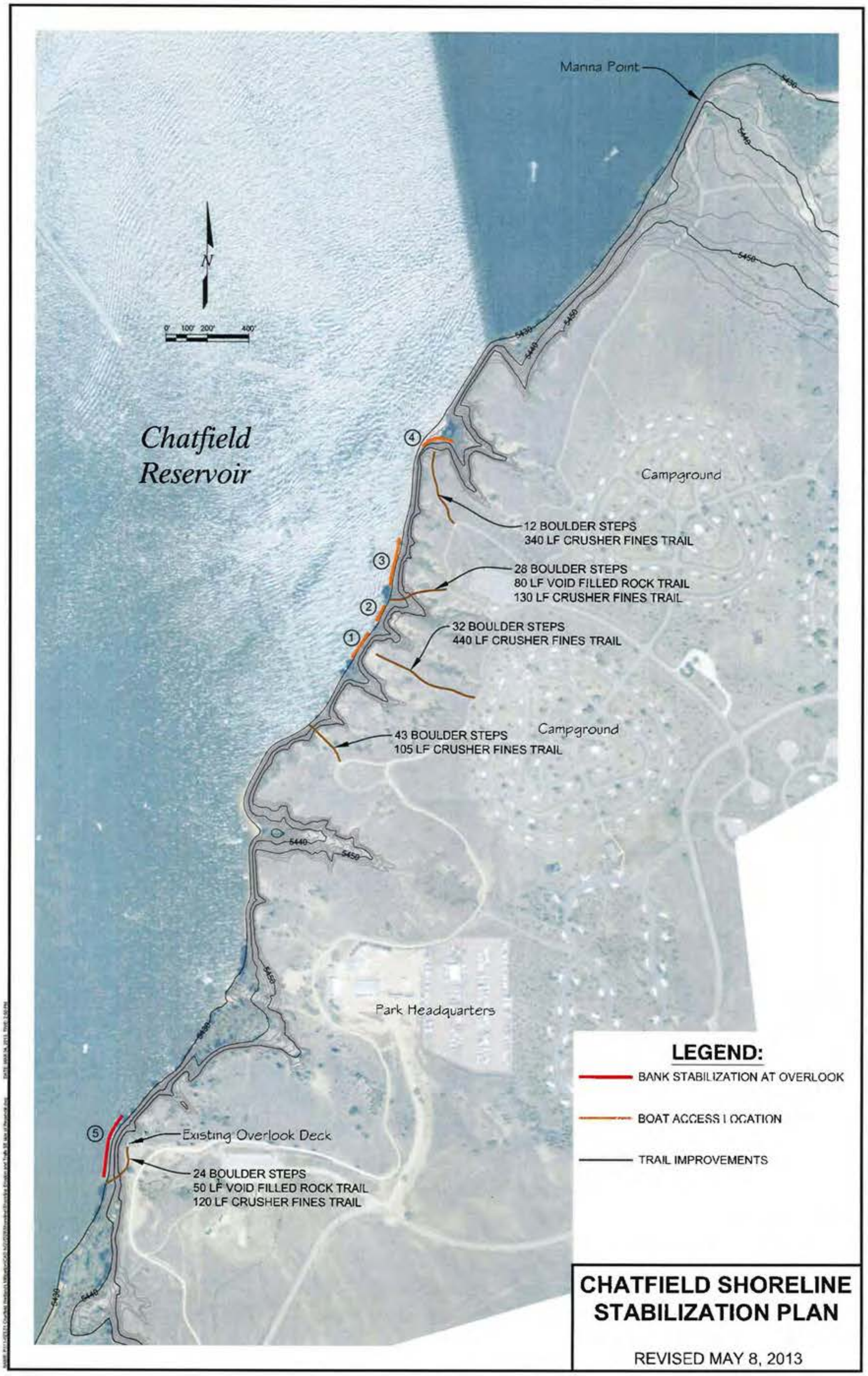

Marina Point
Chatfield Reservoir
Campground
12 BOULDER STEPS
340 LF CRUSHER FINES TRAIL
28 BOULDER STEPS
80 LF VOID FILLED ROCK TRAIL
130 LF CRUSHER FINES TRAIL
32 BOULDER STEPS
440 LF CRUSHER FINES TRAIL
43 BOULDER STEPS
105 LF CRUSHER FINES TRAIL
Campground
Park Headquarters
Existing Overlook Deck
24 BOULDER STEPS
50 LF VOID FILLED ROCK TRAIL
120 LF CRUSHER FINES TRAIL
LEGEND:
BANK STABILIZATION AT OVERLOOK
BOAT ACCESS LOCATION
TRAIL IMPROVEMENTS
CHATFIELD SHORELINE STABILIZATION PLAN
REVISED MAY 8, 2013

Figure 8 Preble's Habitat at Chatfield State Park

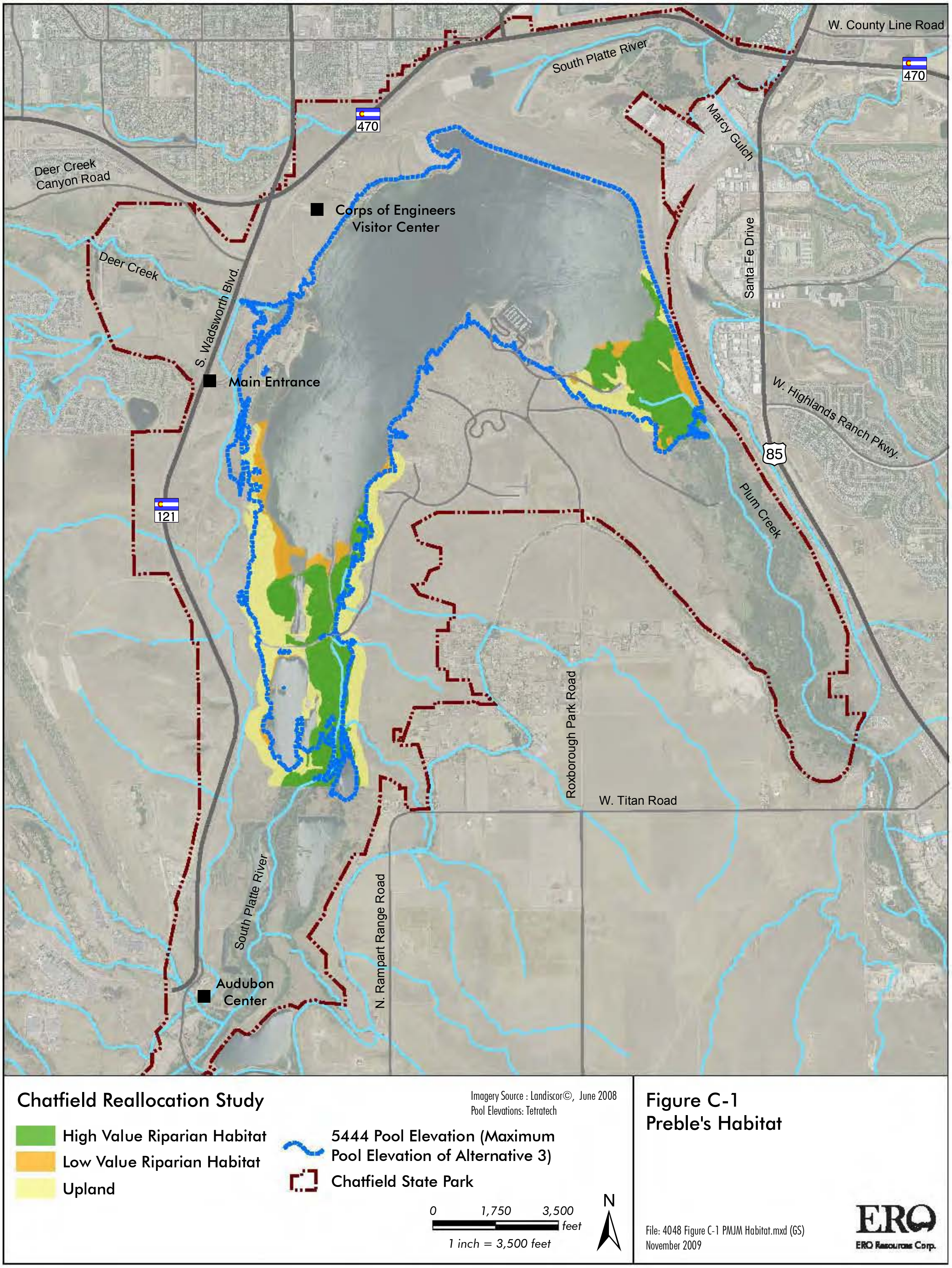


Figure 9 Bird Habitat at Chatfield State Park

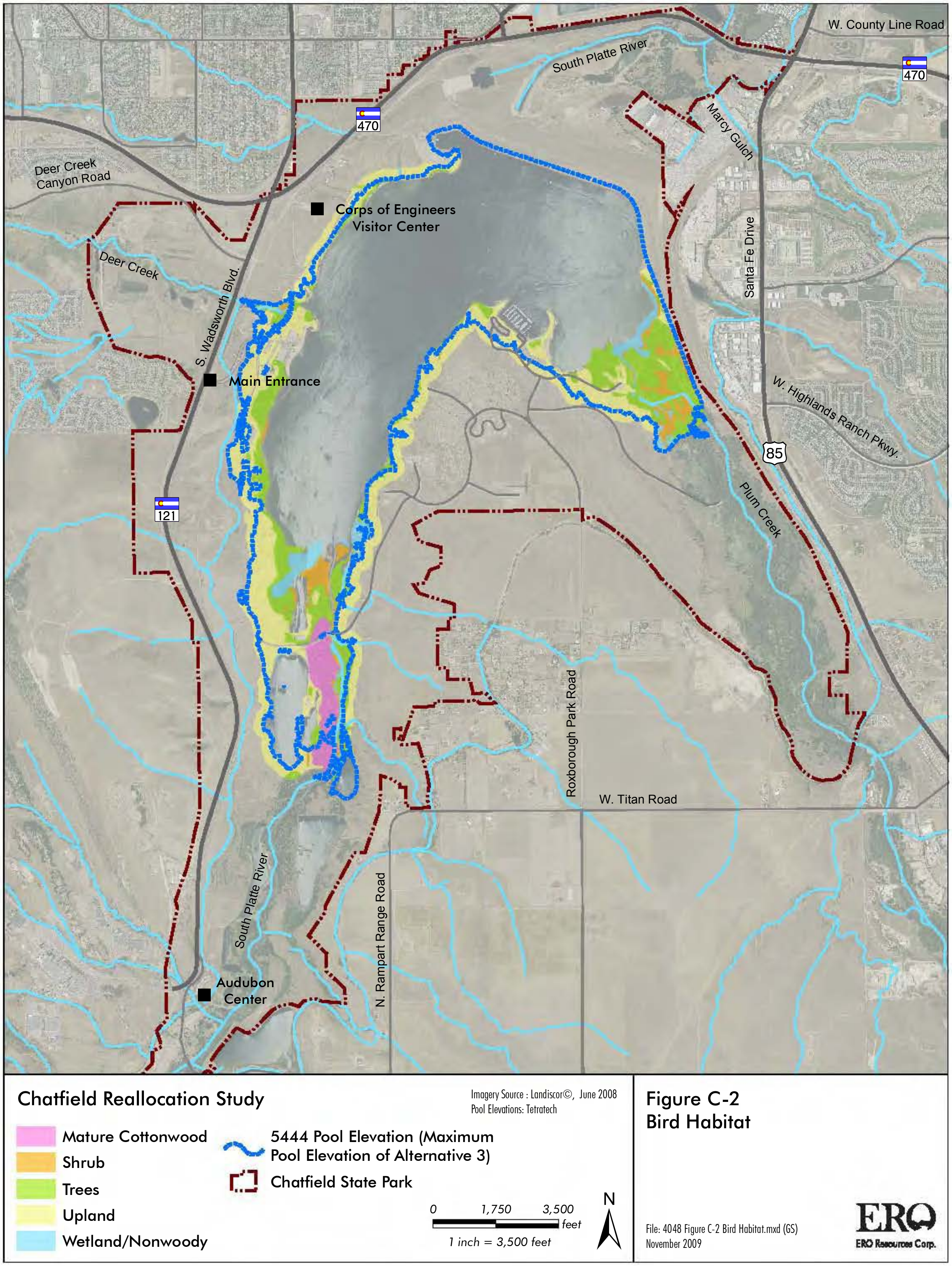


Figure 10 Wetland Habitat at Chatfield State Park

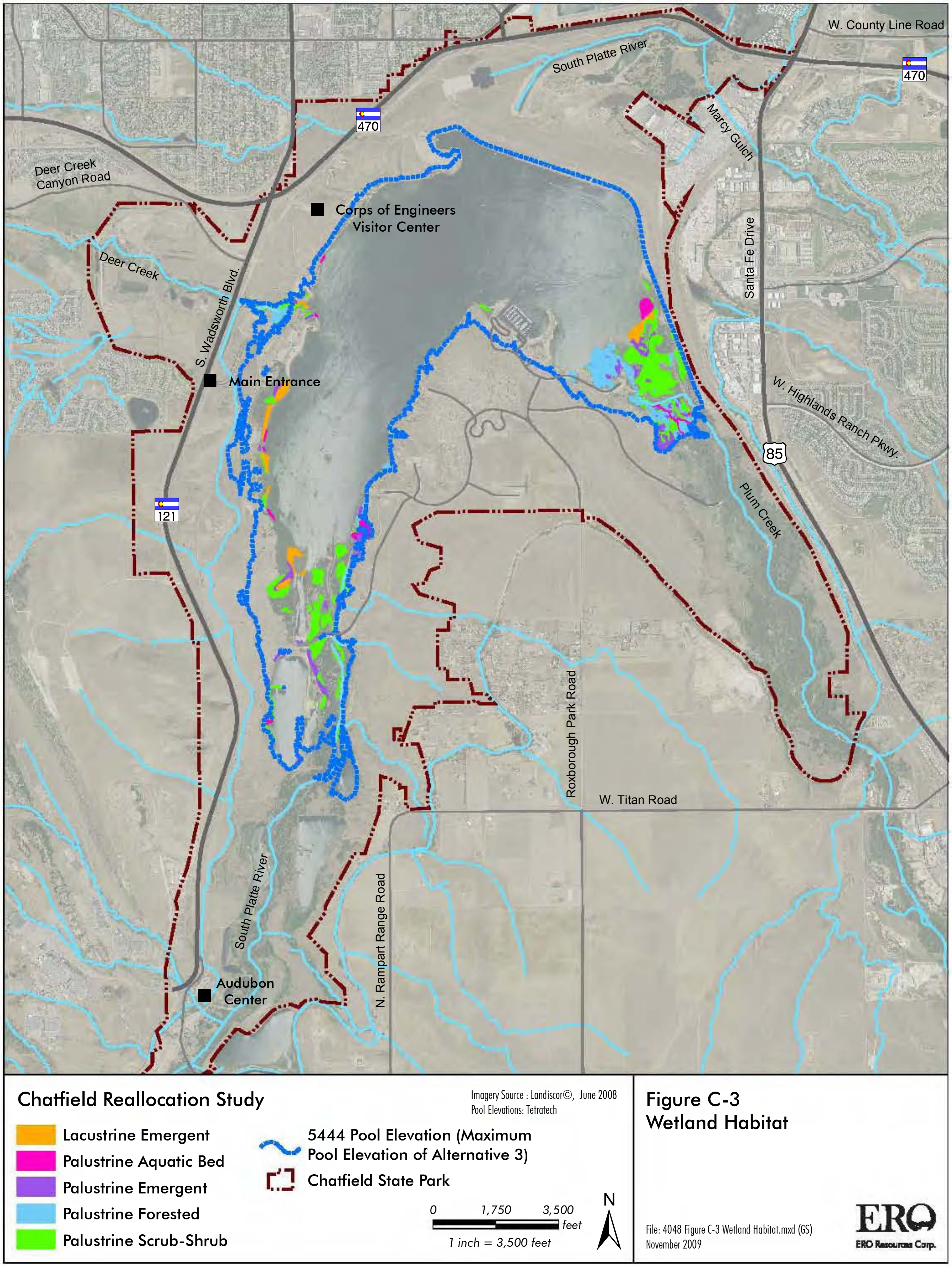


Figure 11 Location of Potential On-Site Mitigation Areas

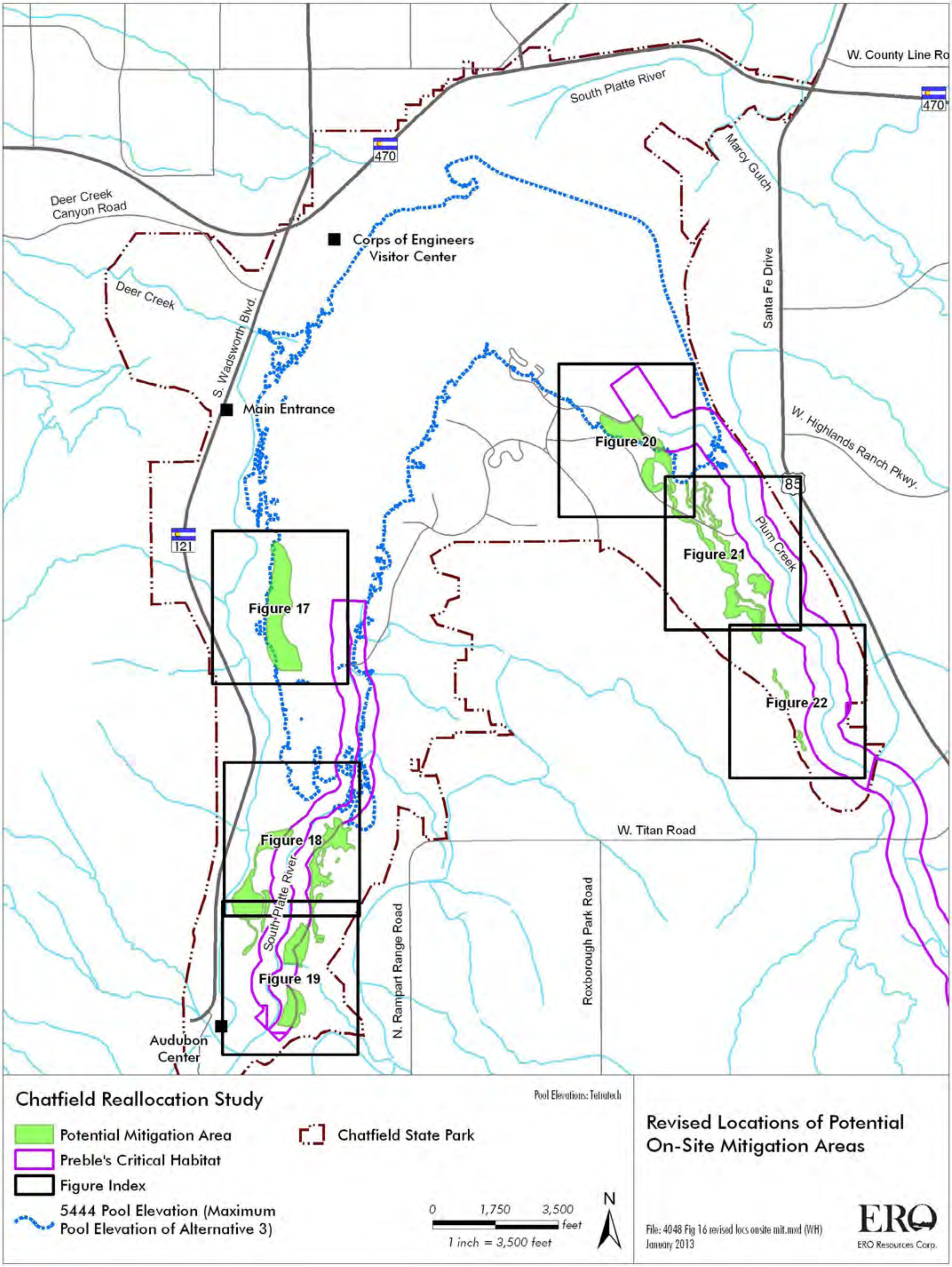


Figure 12 Lower Marcy Gulch Potential On-Site Mitigation Area

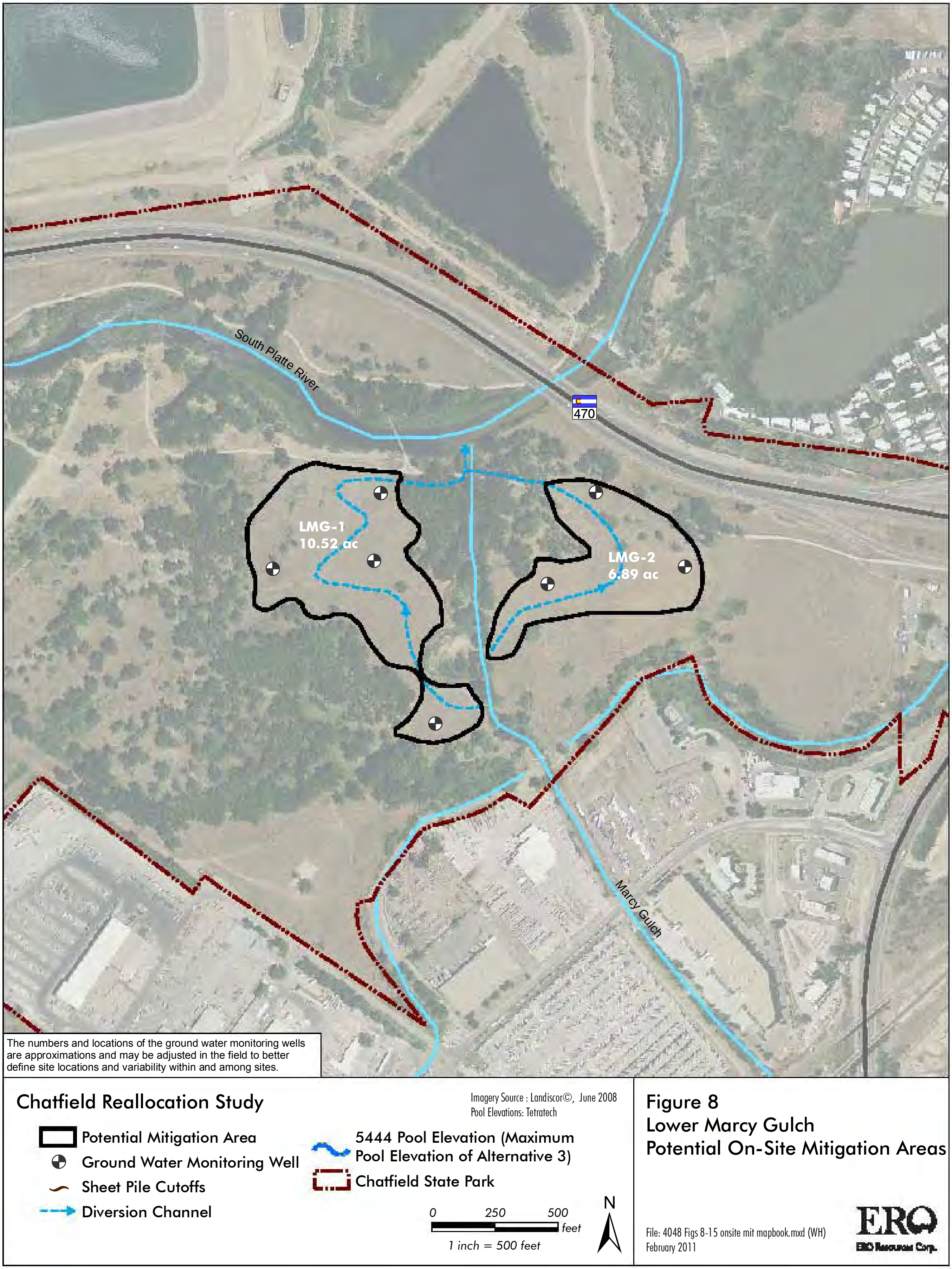


Figure 13 South Platte River Potential On-Site Mitigation Area (1)

Figure 14 South Platte River Potential On-Site Mitigation Area (2)

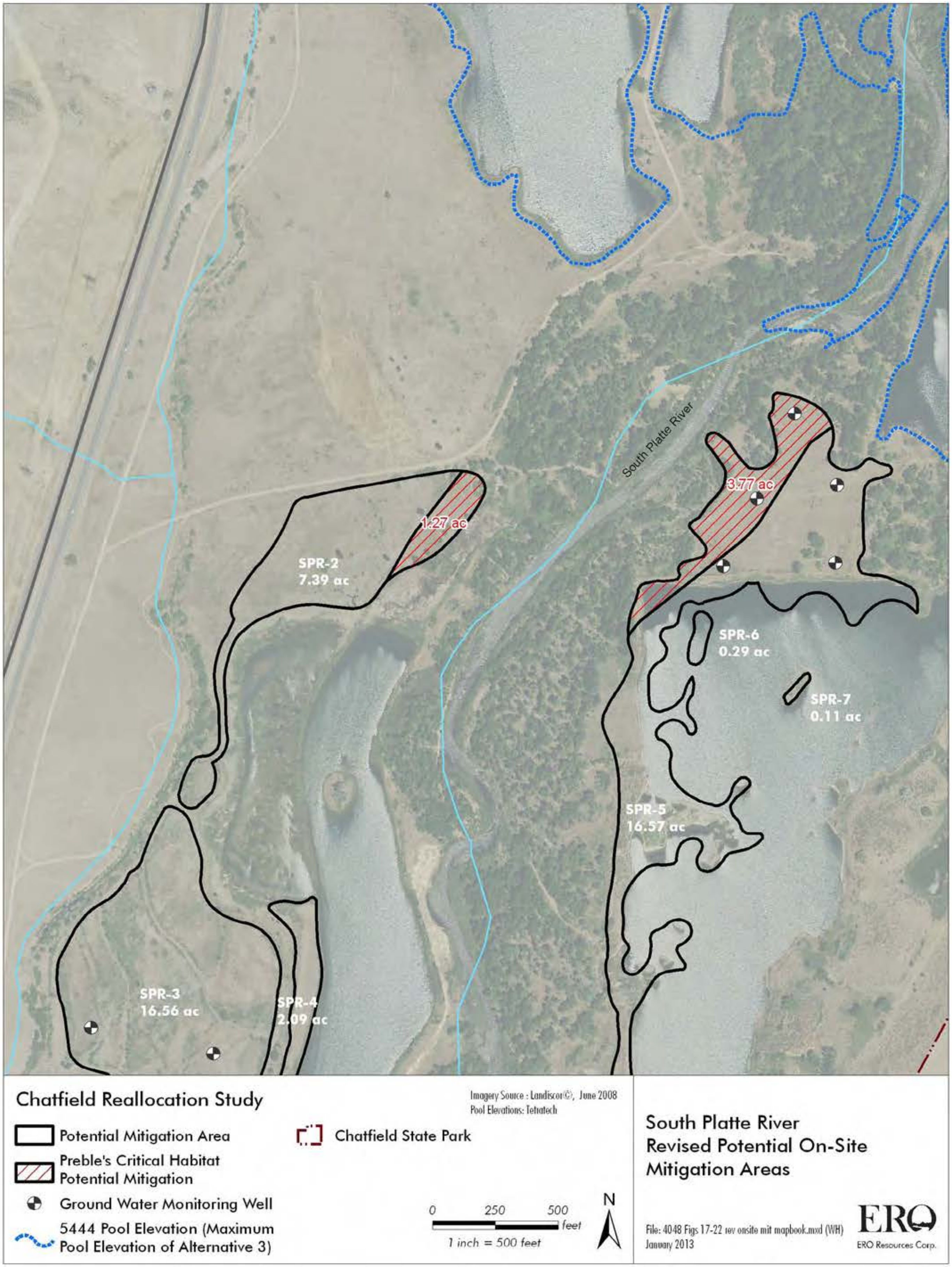


Figure 15 South Platte River Potential On-Site Mitigation Area (3)

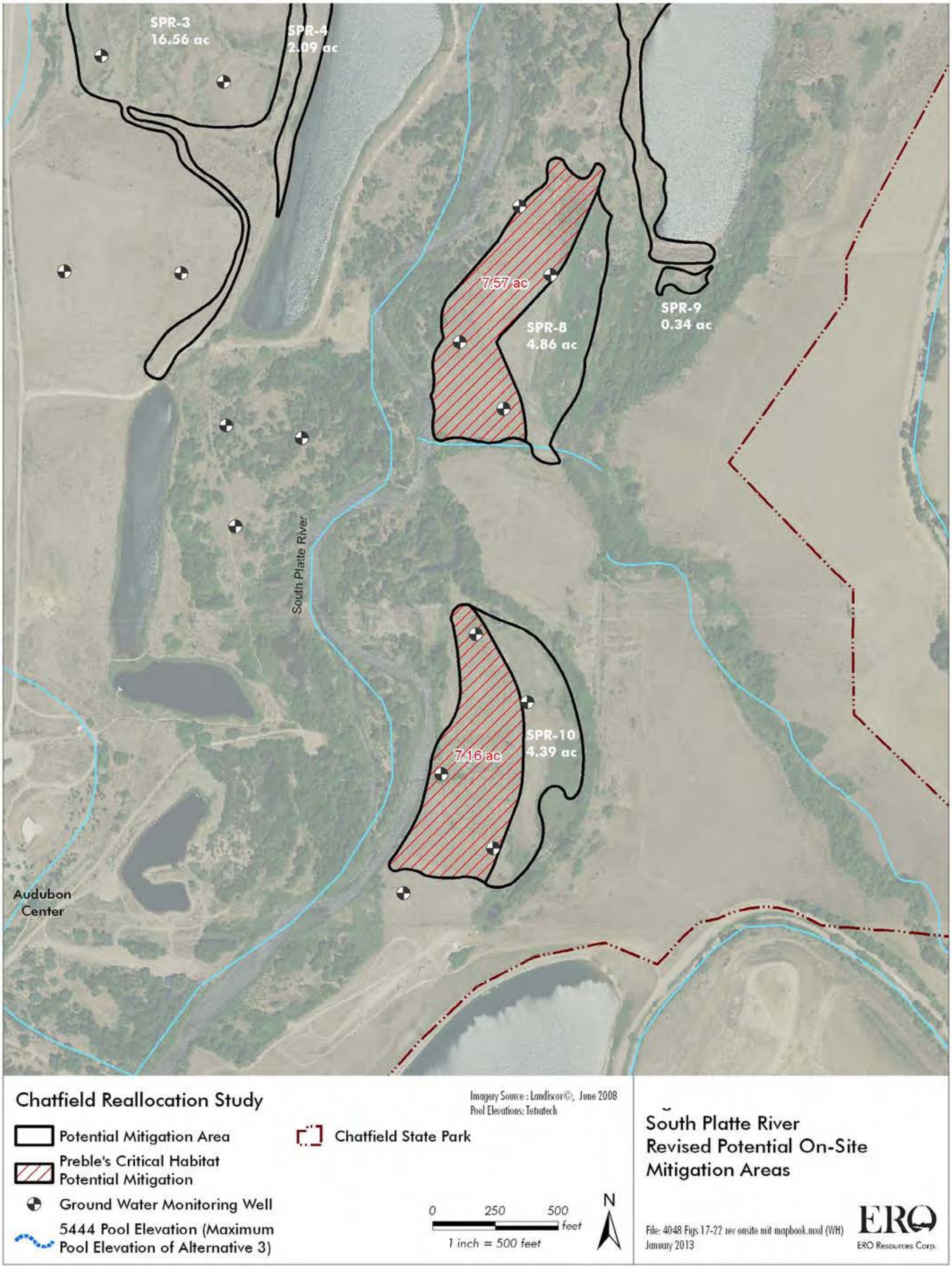


Figure 16 Plum Creek Potential On-Site Mitigation Area (1)

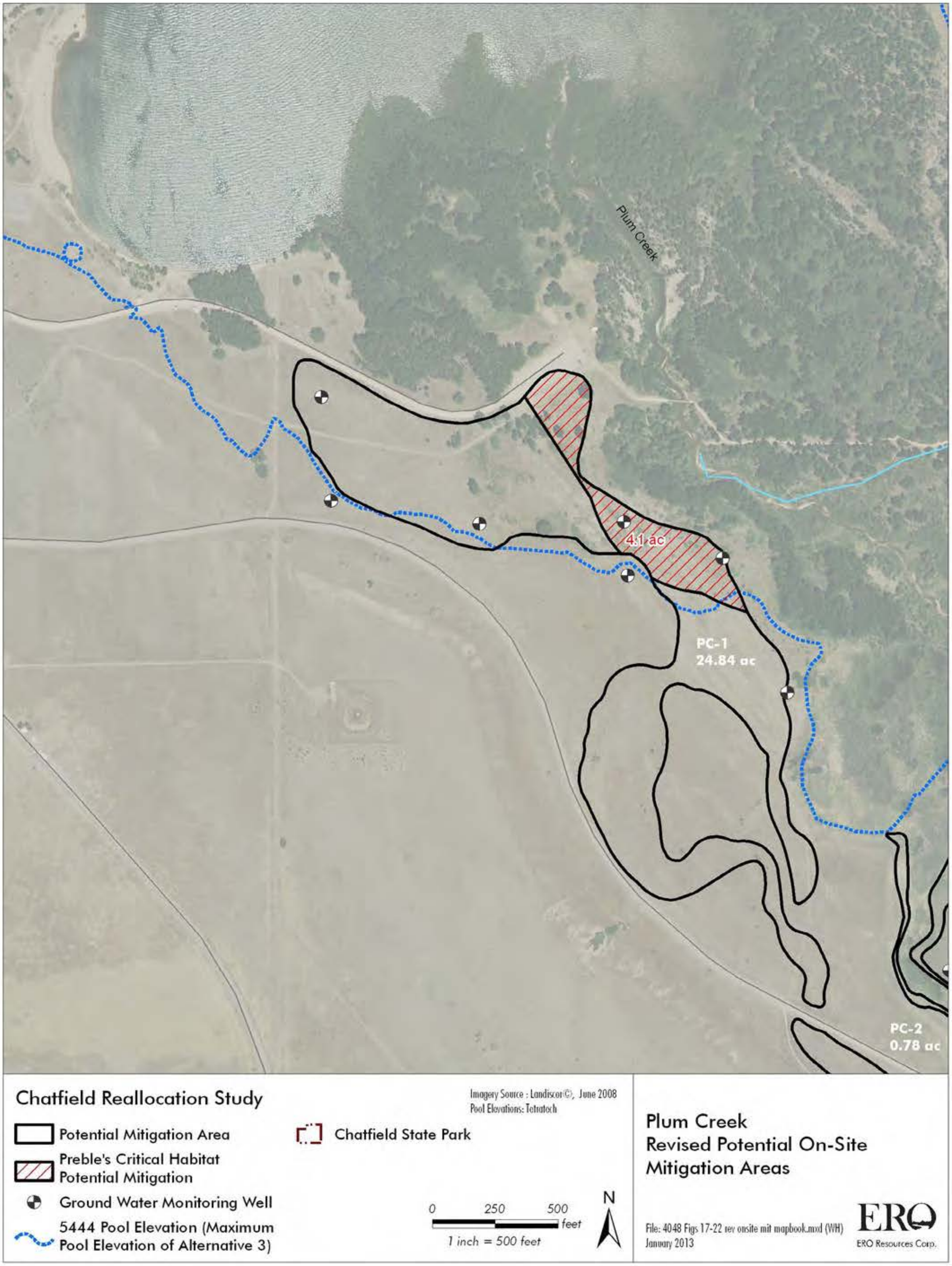


Figure 17 Plum Creek Potential On-Site Mitigation Area (2)

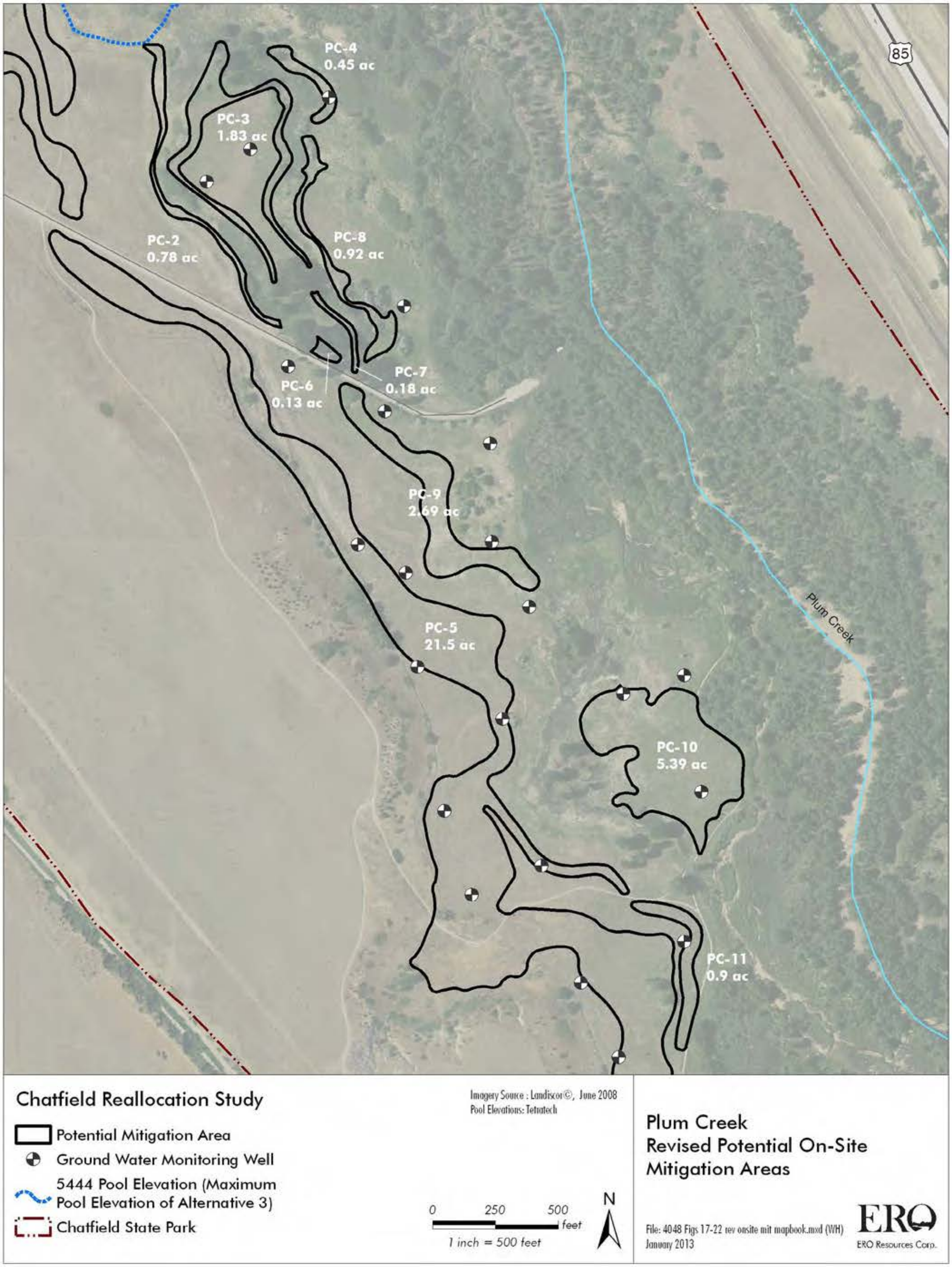


Figure 18 Plum Creek Potential On-Site Mitigation Area (3)

Figure 19 Areas Impacted by Recreational Facilites Relocation, Borrow Areas, and Haul Roads

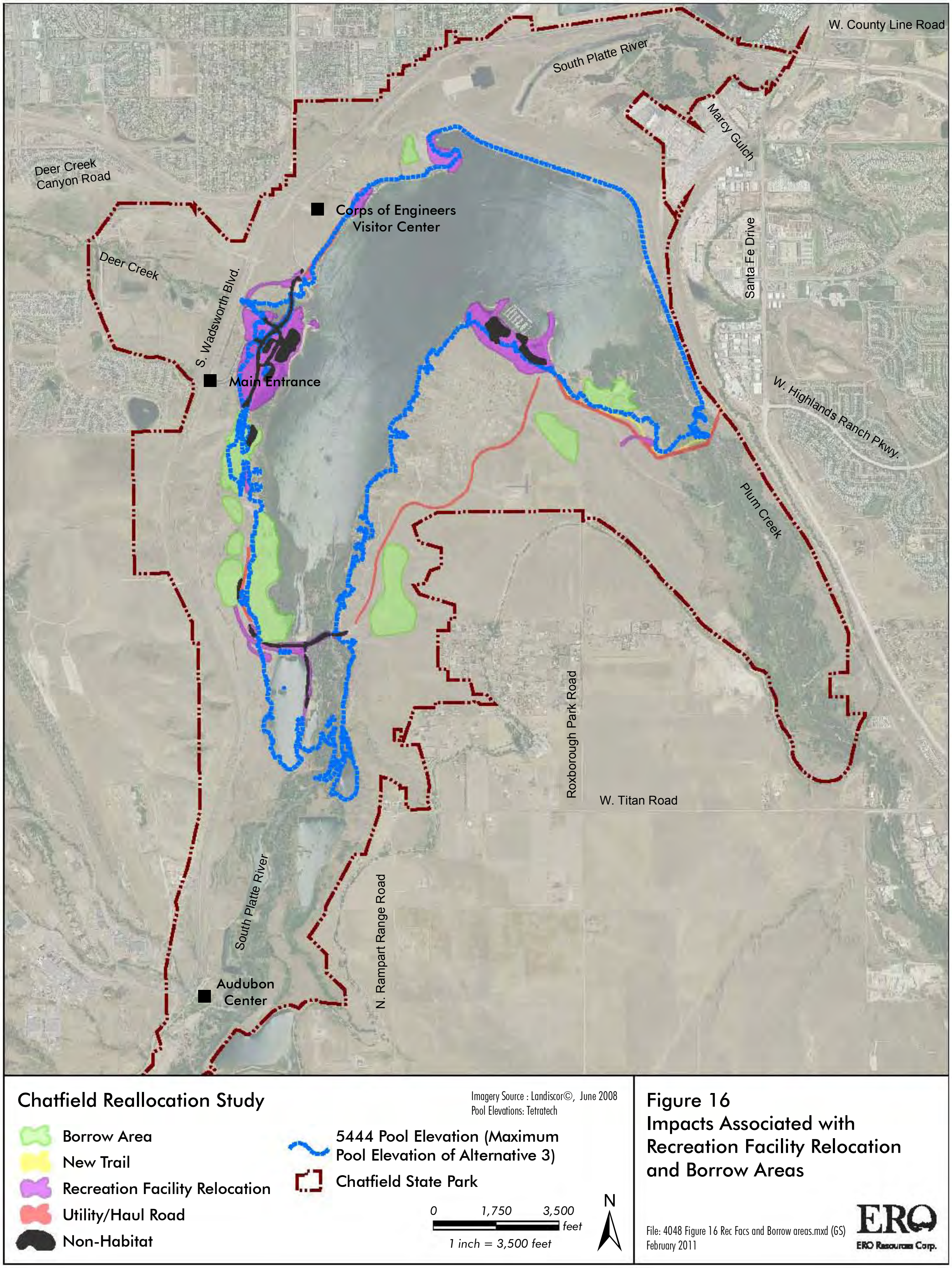
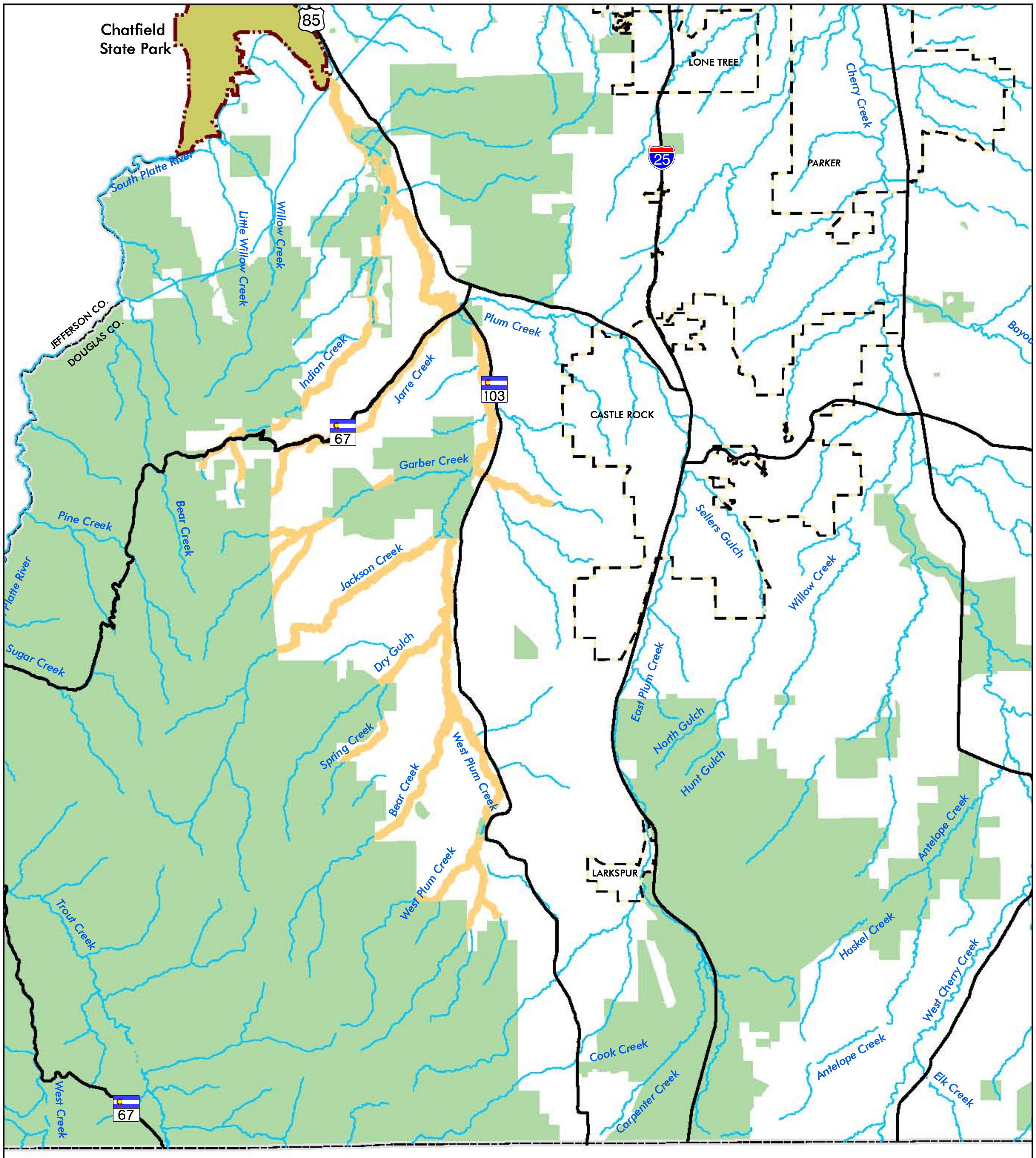


Figure 20 Potential Off-Site Mitigation Areas



Chatfield Reallocation Study

- Primary Target Off-Site Mitigation Area
- Protected Lands
- Incorporated Towns
- Chatfield State Park

Unshaded areas are unprotected lands in Douglas County

Imagery Source : Landiscor©, June 2008
Pool Elevations: Tetratech

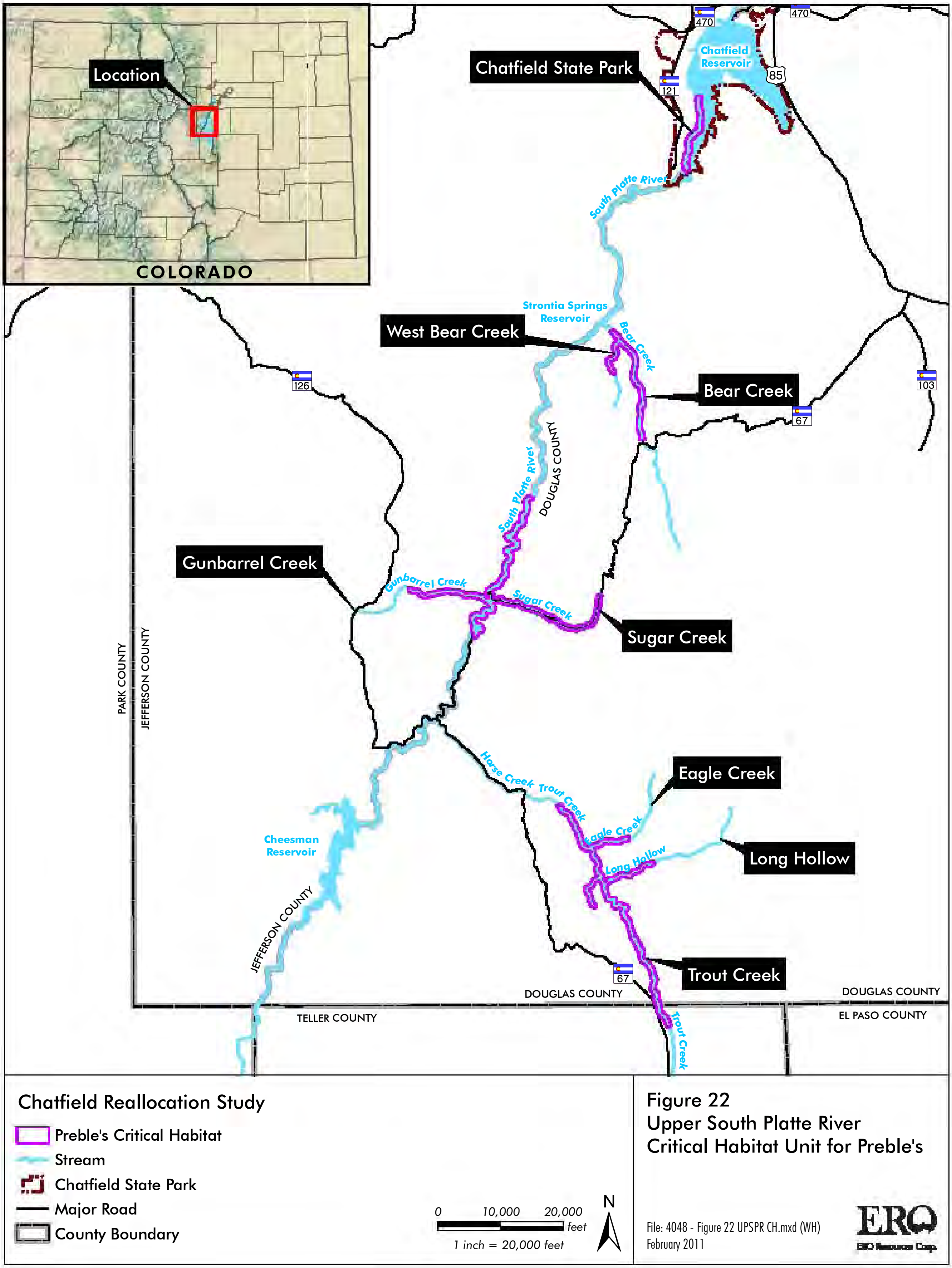
0 9,000 18,000 Feet
1 inch = 18,000 feet
N

Figure 18
Off-Site Mitigation Target Habitat within Private Douglas County Parcels

File: 4048 - Figure 18 Off-Site Mit Target.mxd (GS)
February 2011

ERO Resources Corp.

Figure 21 Sugar Creek Off-Site Mitigation Area within the Upper South Platte



Portions of this document include intellectual property of ESRI and its licensors and are used herein under license. Copyright © 2010 ESRI and its licensors. All rights reserved.

Figure 22 Potential Preble's Critical Habitat Mitigation at Sugar Creek

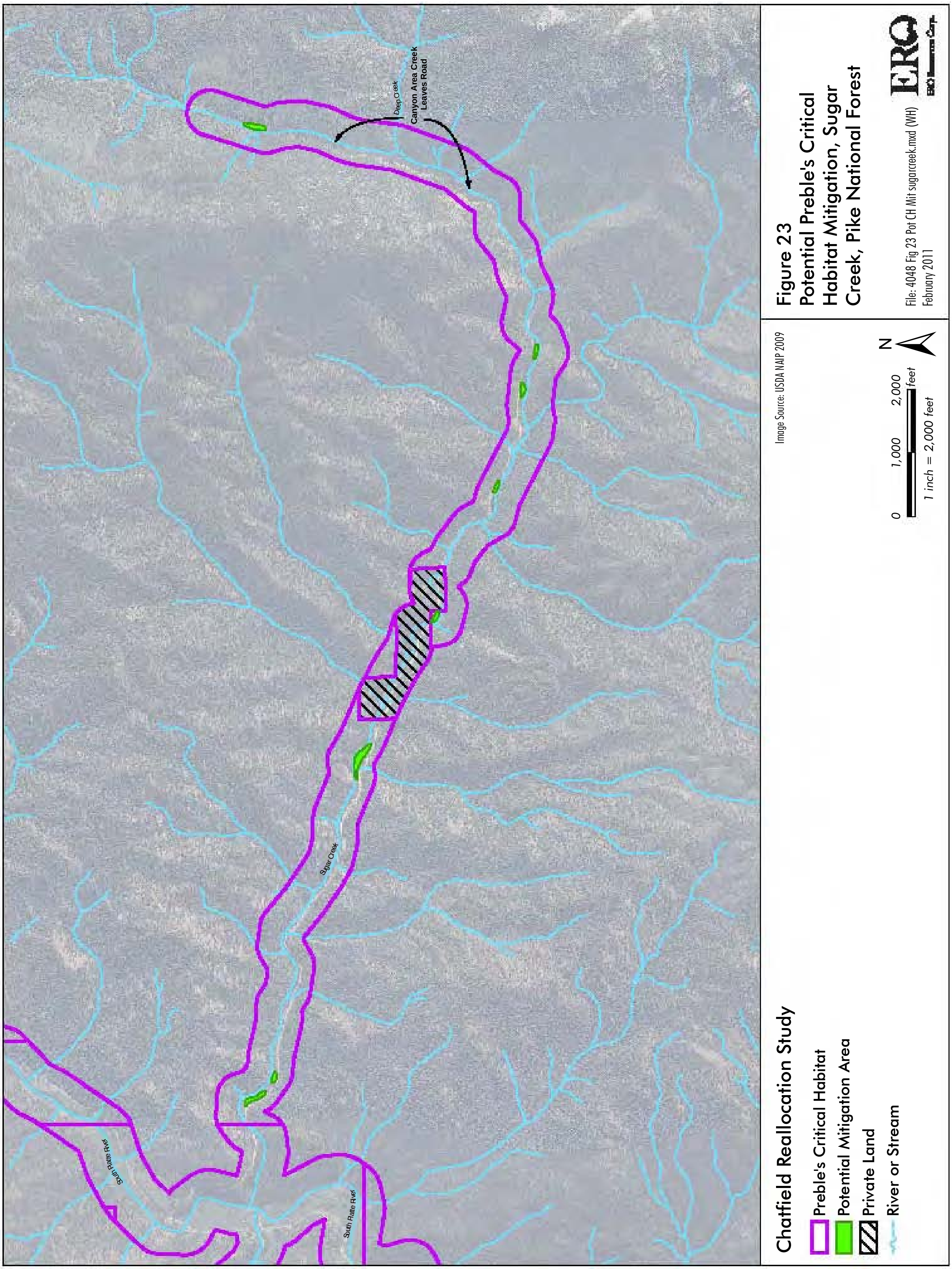


Figure 23 West Plum Creek Critical Habitat Unit for Preble's

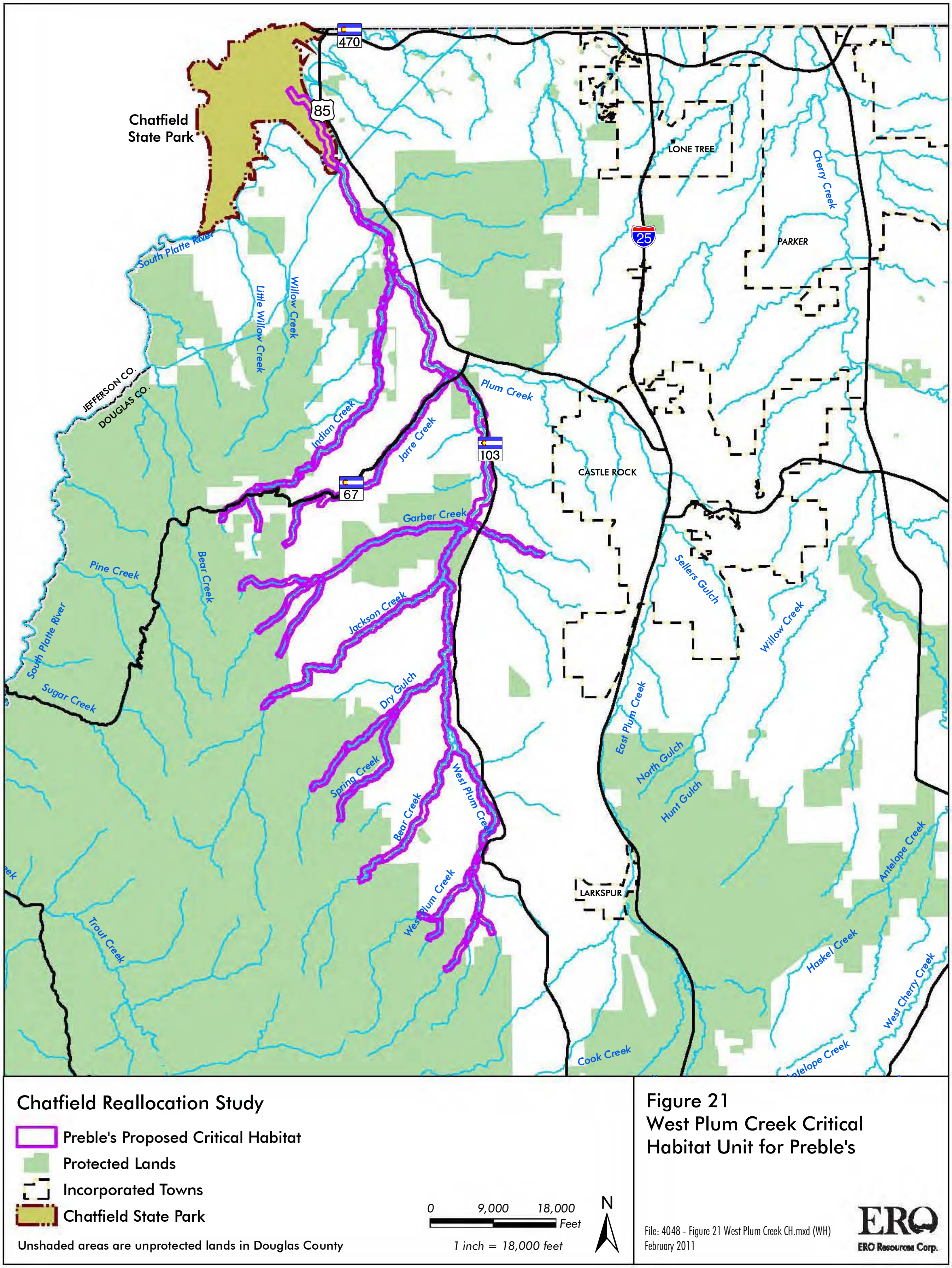


Figure 24 Bird Habitat Complex Targeted for Cottonwood Regeneration and Mature Cottonwood Conservation

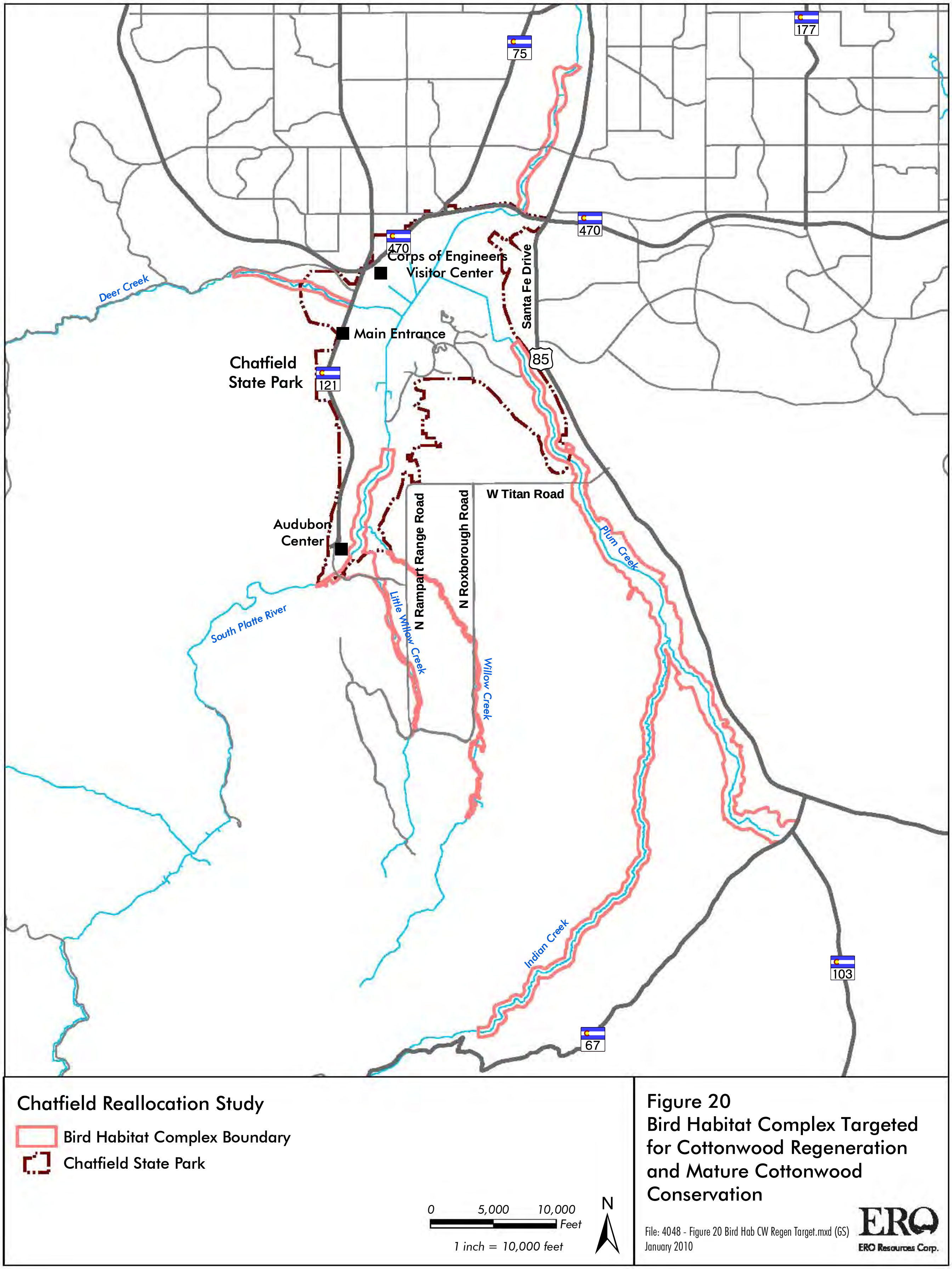


Figure 25 Chatfield State Park Recreational Areas

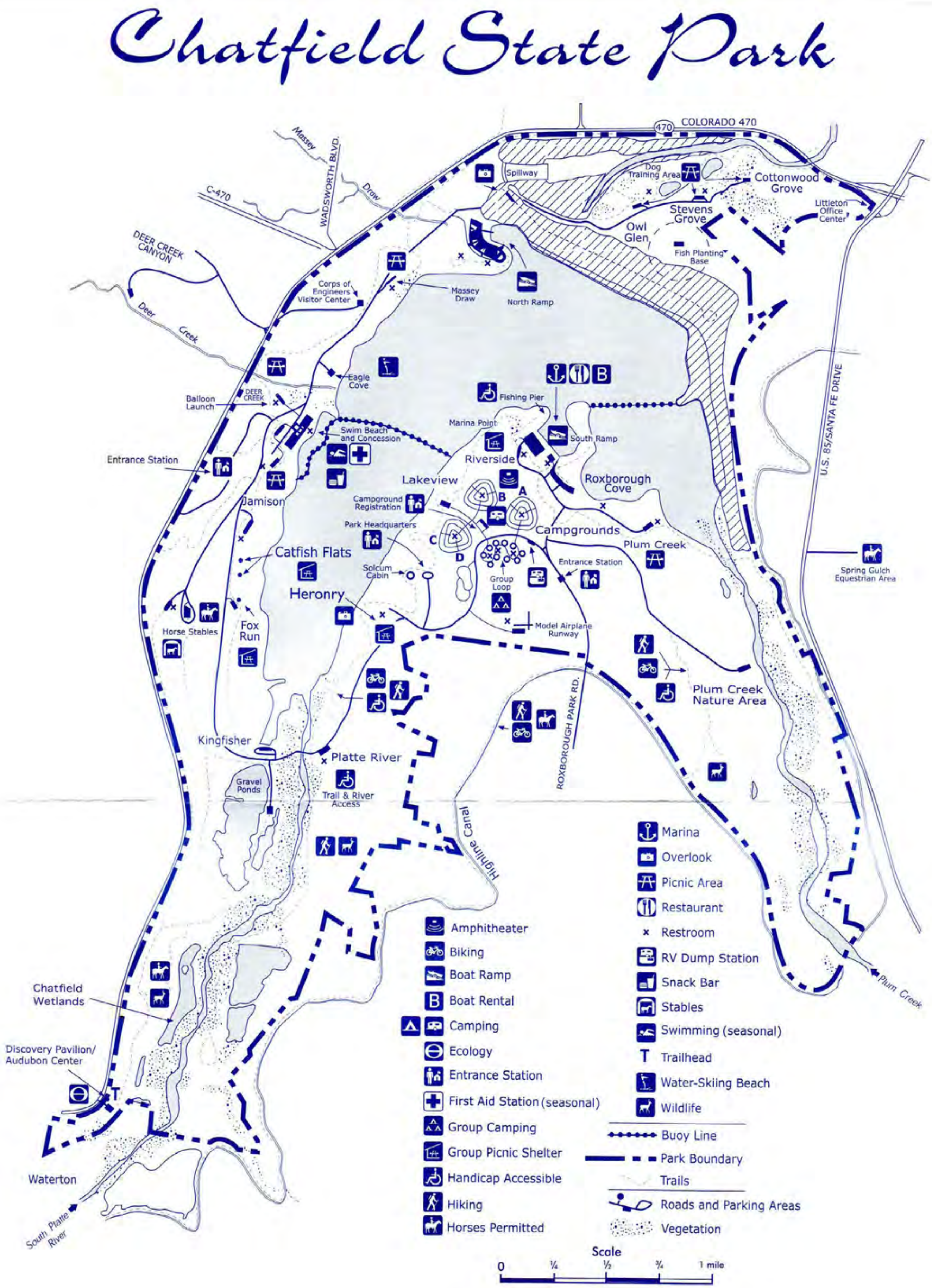


Figure 26 Chatfield Marina Existing Marina Location (5,426' Elevation)

Figure 27 Chatfield Marina Existing Marina Location (5,440' Elevation)

Figure 28 Chatfield Marina Existing Marina Location (5,444' Elevation)

Figure 29 Chatfield Marina Roxborough Cove Location (5,426' Elevation)

Figure 30 Chatfield Marina Roxborough Cove Location (5,440' Elevation)

Figure 31 Chatfield Marina Roxborough Cove Location (5,444' Elevation)

APPENDIX C

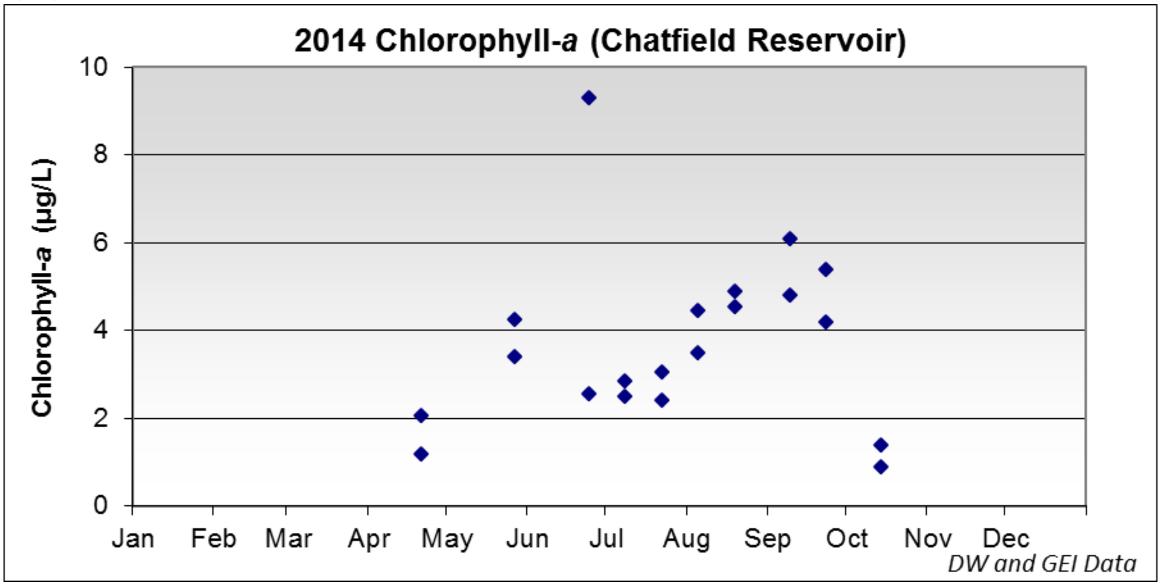
SUMMARY OF RECENT WATER QUALITY DATA

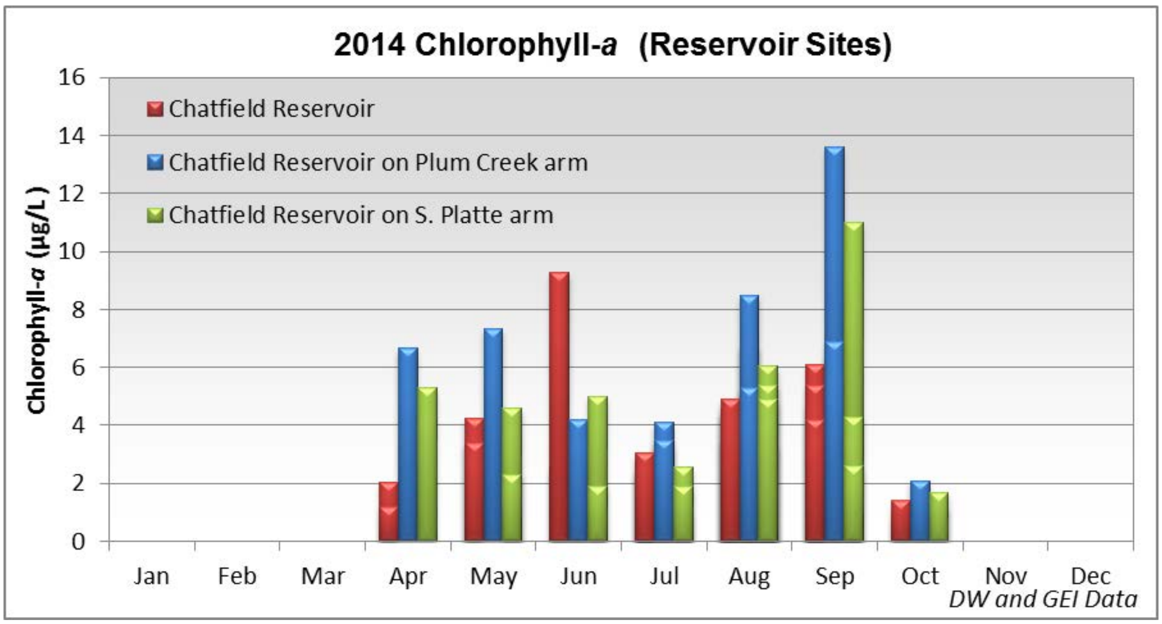
Chatfield Water Quality Data (2014)

This Appendix presents water quality trends observed within the Chatfield Watershed in 2014. Data presented are collected by Denver Water (DW) and GEI Consultants. Sites sampled include three Chatfield Reservoir sites (Centroid, S. Platte arm, and Plum Creek arm), S. Platte River at Waterton Canyon, and Plum Creek at Titan Road. This Appendix is divided into 4 sections:

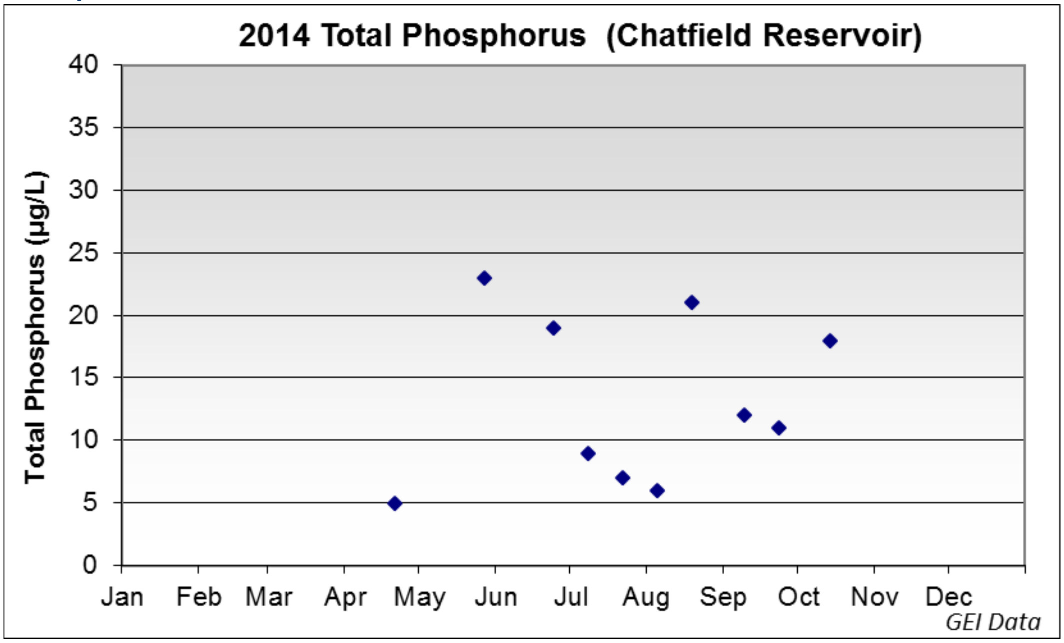
- Chatfield Reservoir Compliance Metrics
- Nutrients throughout Chatfield Watershed
- Microbiology (phytoplankton and zooplankton)
- Conventional Parameters

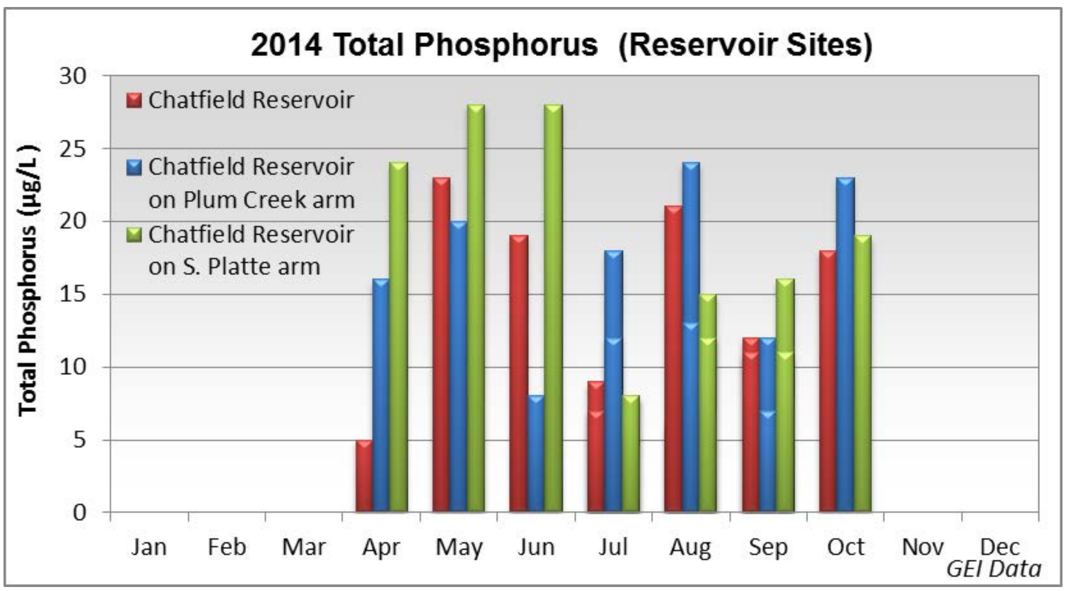
Chlorophyll-a





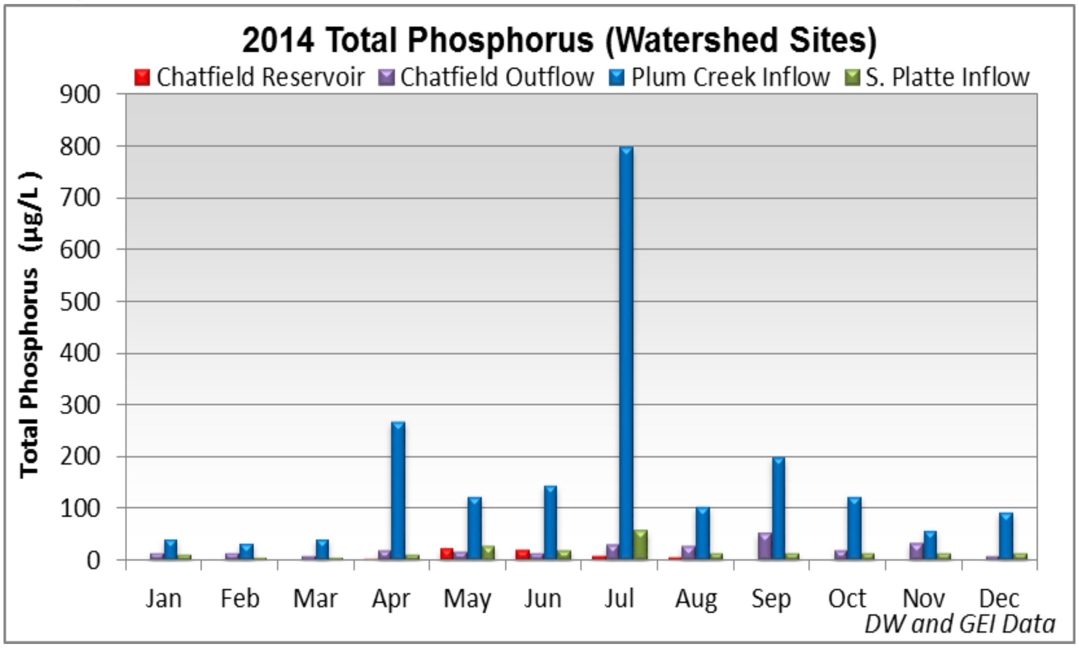
Total Phosphorus



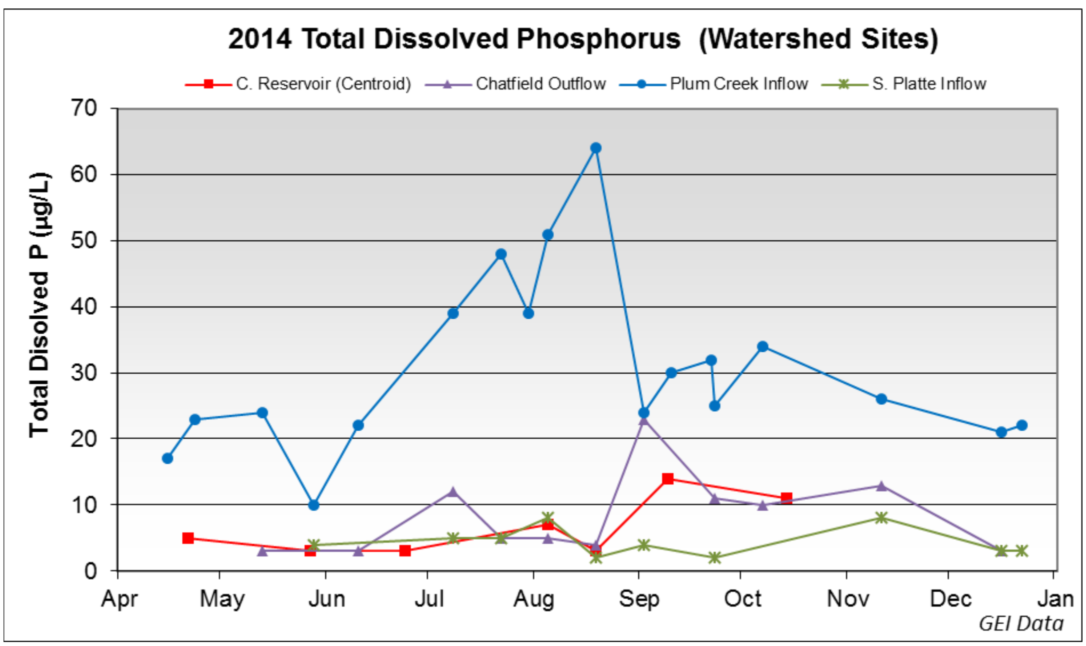


Nutrients

Total Phosphorus

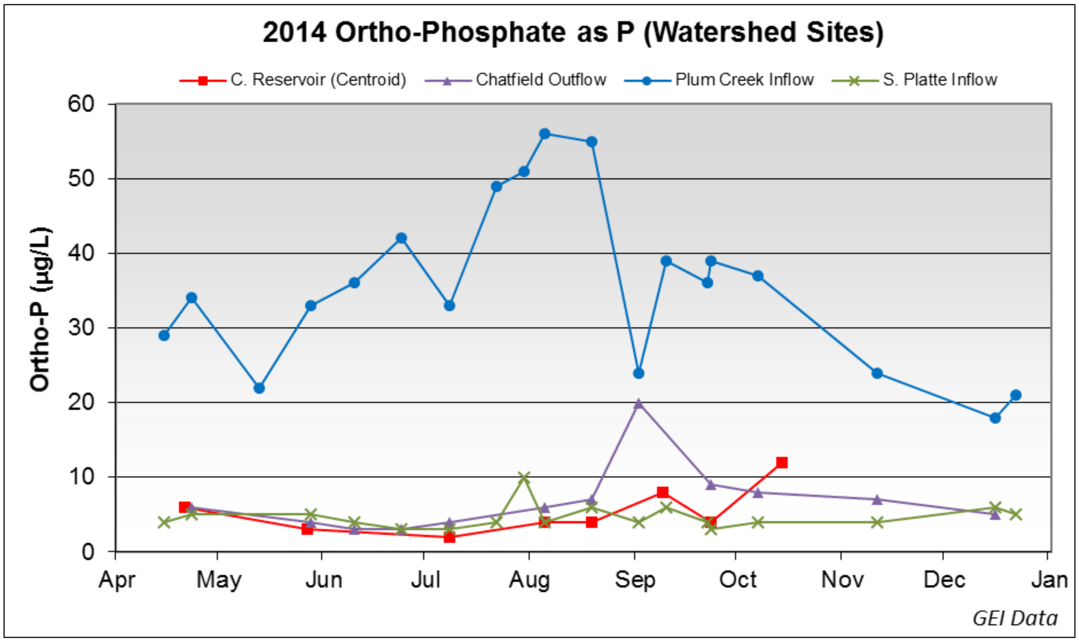


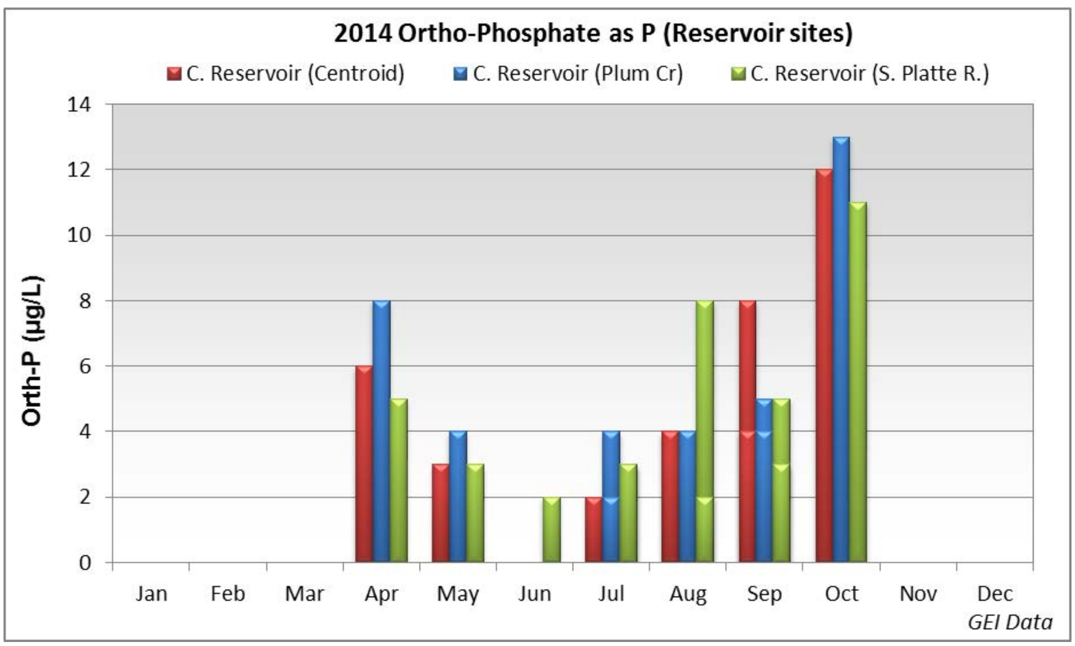
Total Dissolved Phosphorus



Nutrients

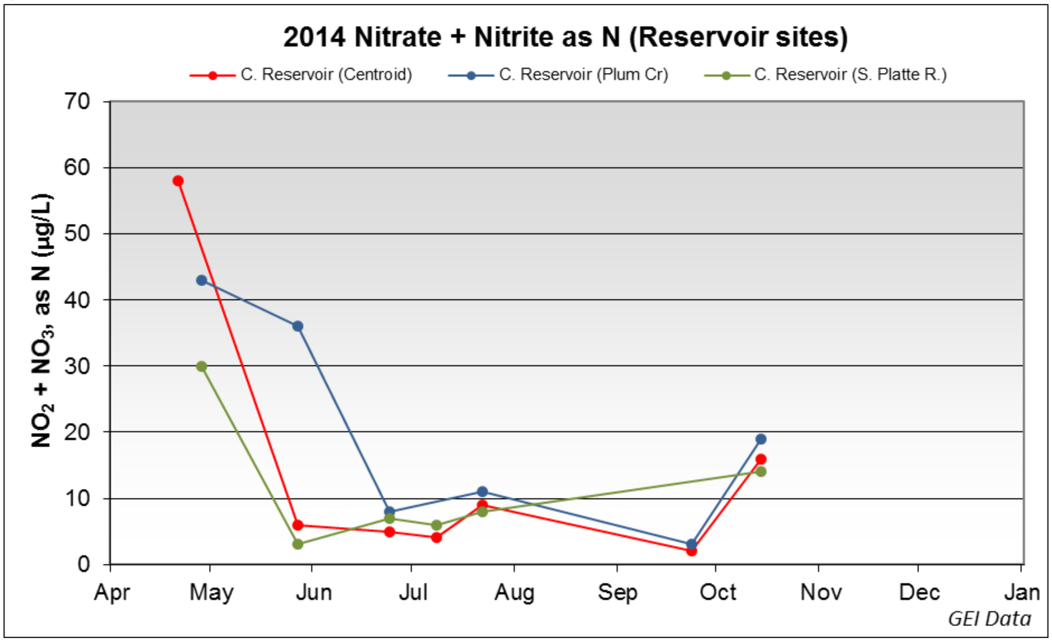
Ortho-Phosphate

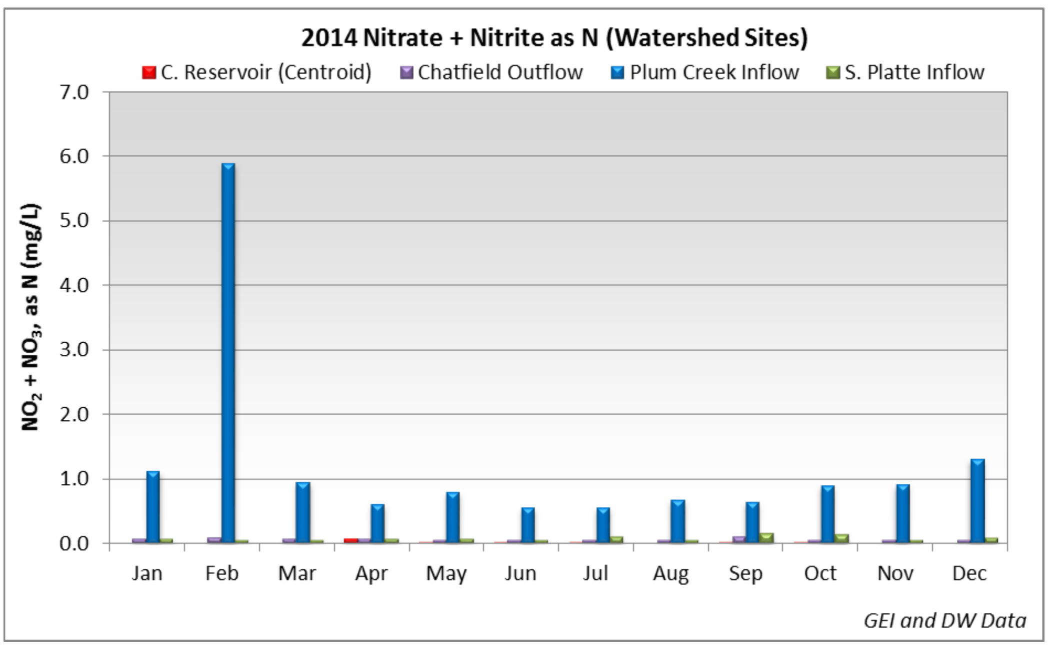




Nutrients

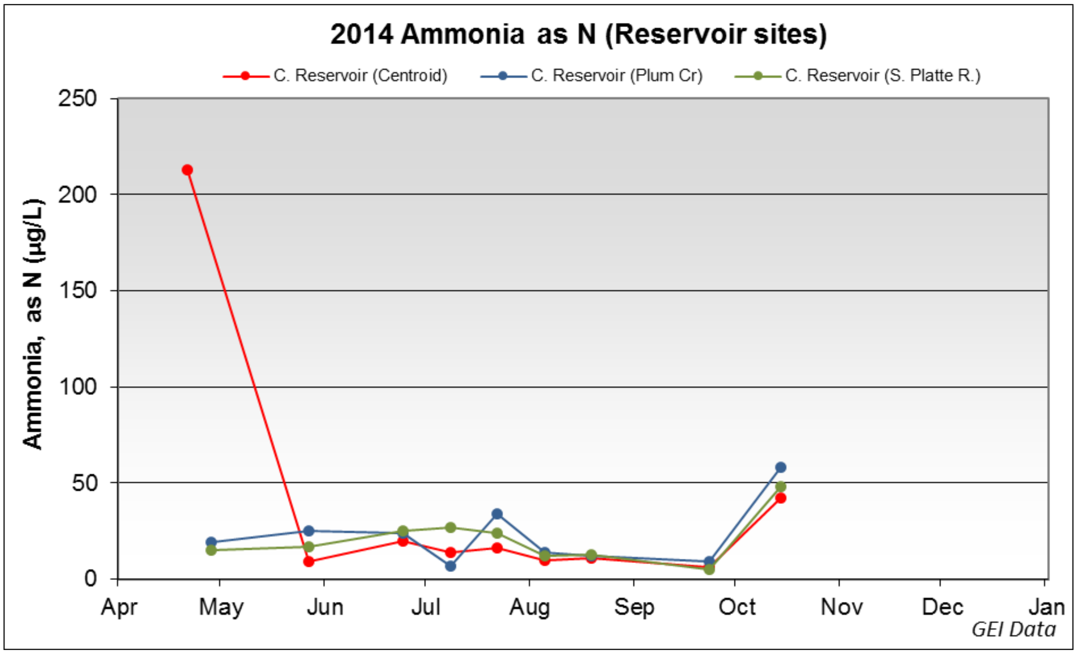
Nitrogen (Nitrite-Nitrate, NO_2-NO_3)

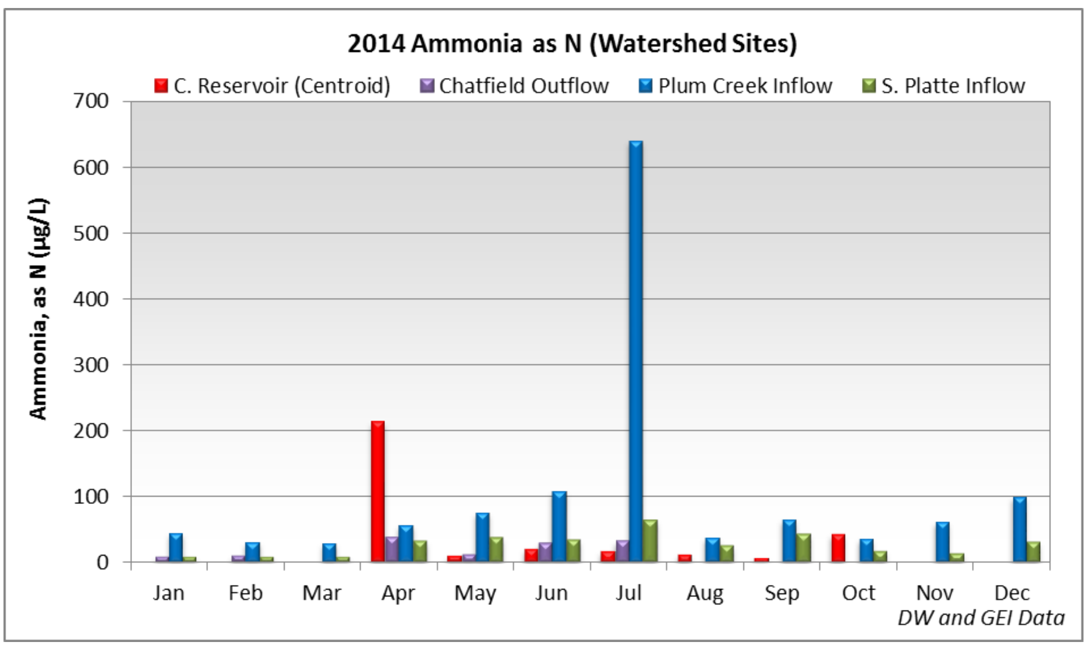




Nutrients

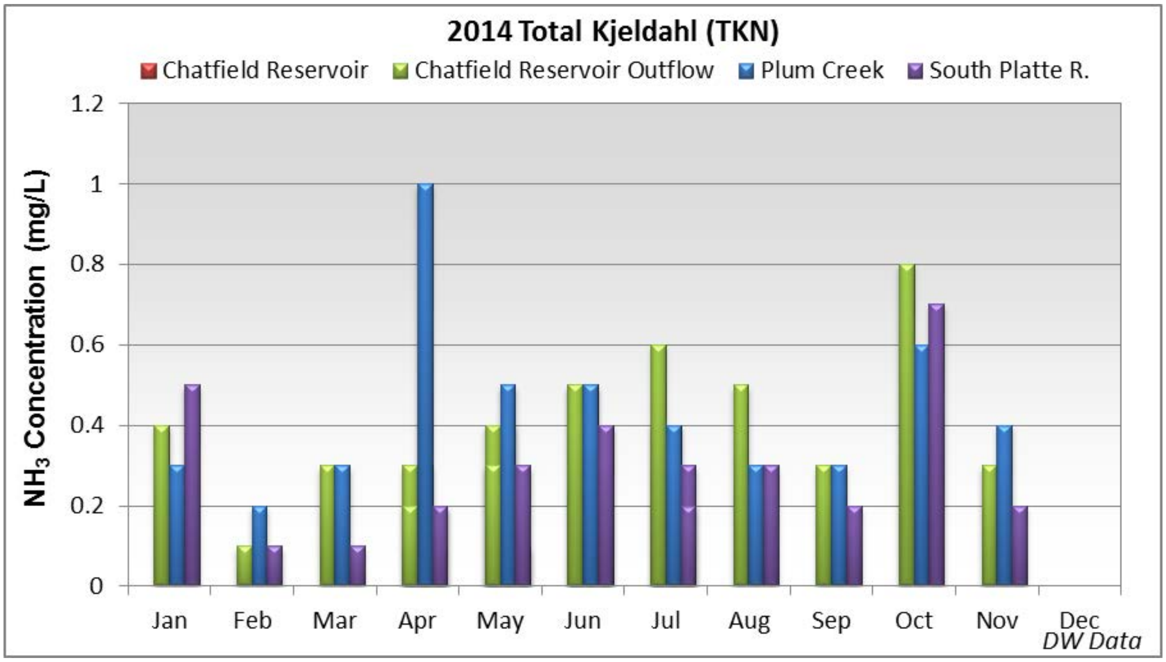
Nitrogen (Ammonia, NH_3)





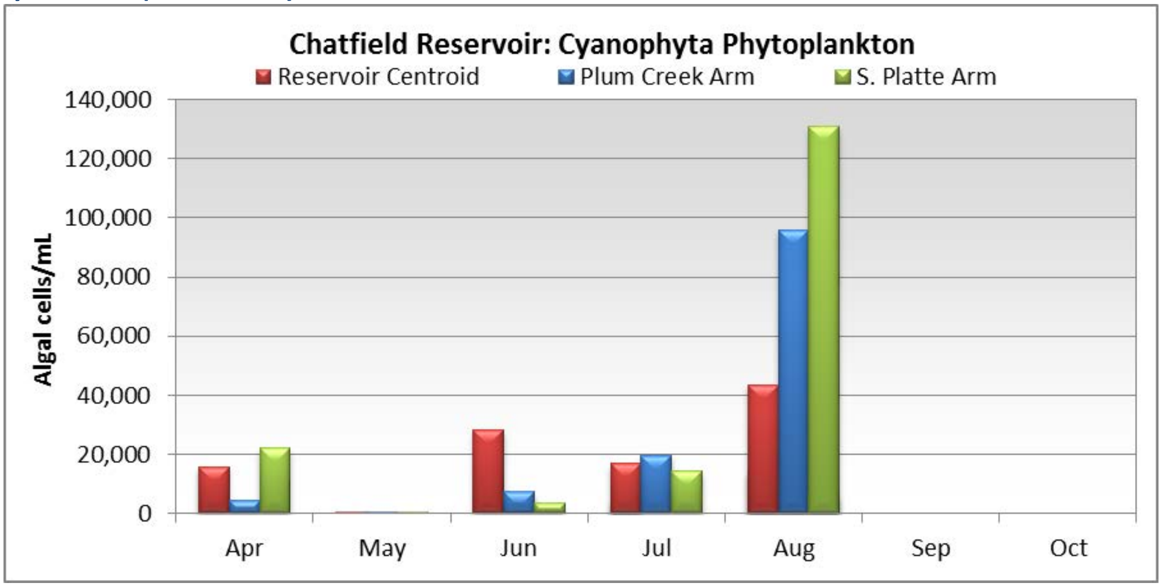
Nutrients

Nitrogen (Total Kjeldahl Nitrogen, TKN)



Microbiology (phytoplankton and zooplankton)

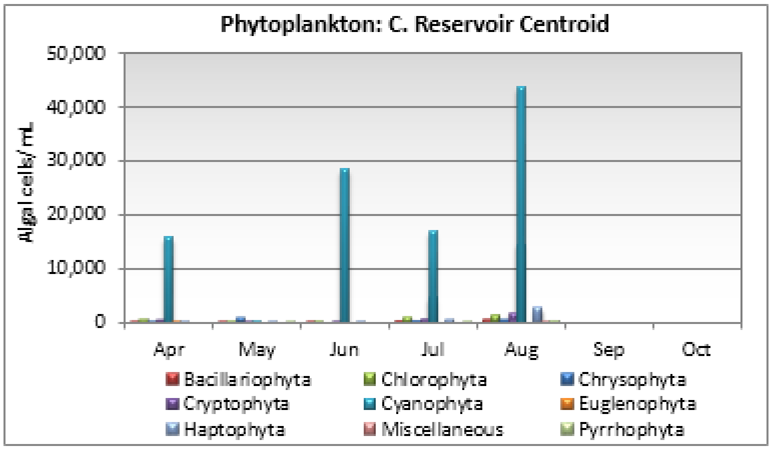
Phytoplankton (Anabaena)

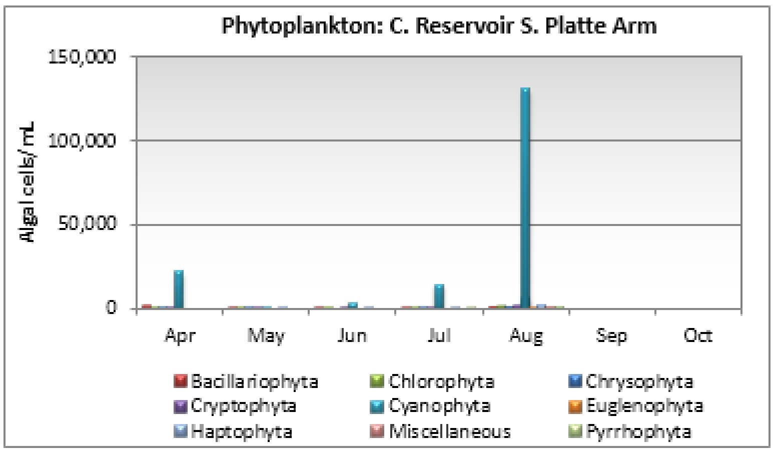


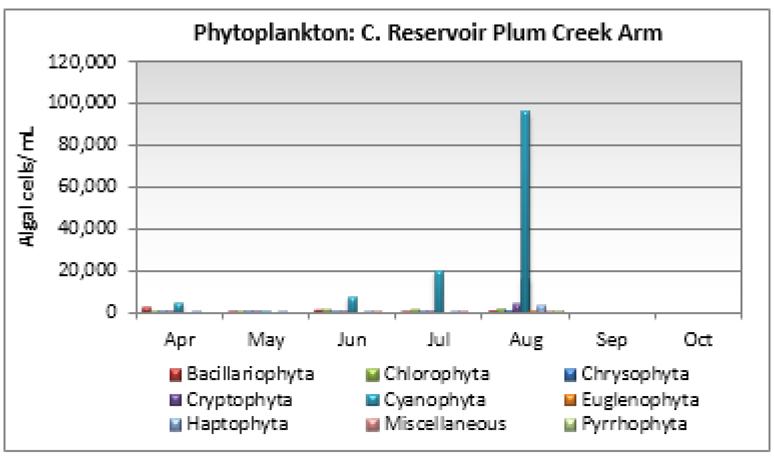
Date	Reservoir Centroid		S. Platte Arm		Plum Creek Arm	
	Total Cyanophyta (cells/mL)	Anabaena (cells/mL)	Total Cyanophyta (cells/mL)	Anabaena (cells/mL)	Total Cyanophyta (cells/mL)	Anabaena (cells/mL)
4/21/2014	15,818					
4/28/2014			22,196		4,592	
5/27/2014	459		61		51	
6/24/2014	28,411		3,609		7,373	
7/8/2014	4,668					
7/22/2014	16,839		14,315		19,754	28 (0.1%)
8/5/2014	14,410	50 (0.3%)	6,526	1,071 (16%)	16,314	233 (1.4%)
8/19/2014	43,615	1,118 (2.6%)	130,695	499 (0.4%)	95,986	2,400 (2.5%)

Microbiology (phytoplankton and zooplankton)

Phytoplankton (all species)

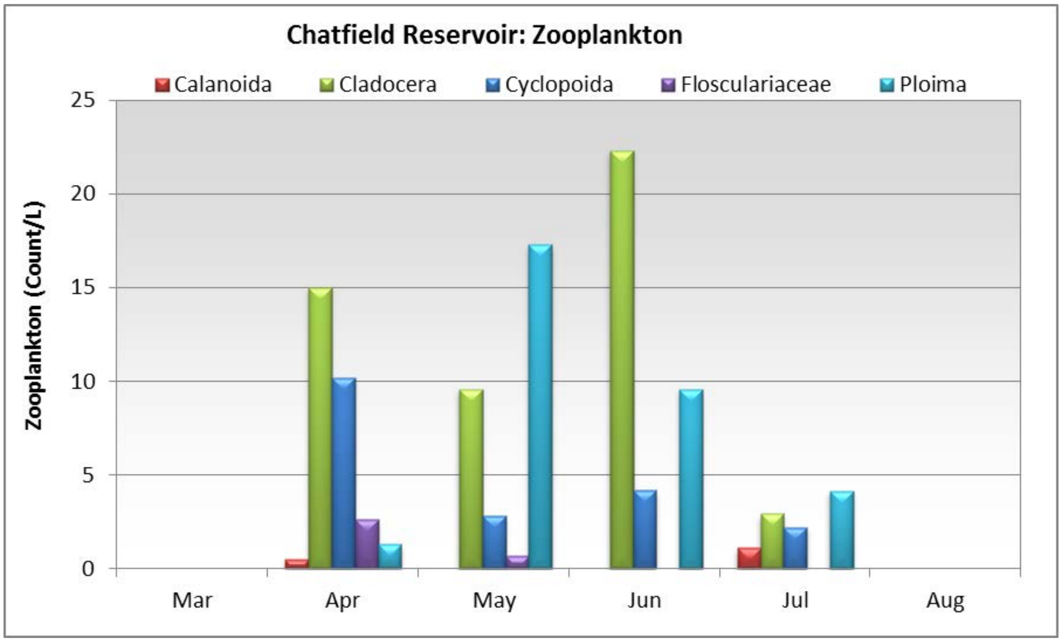






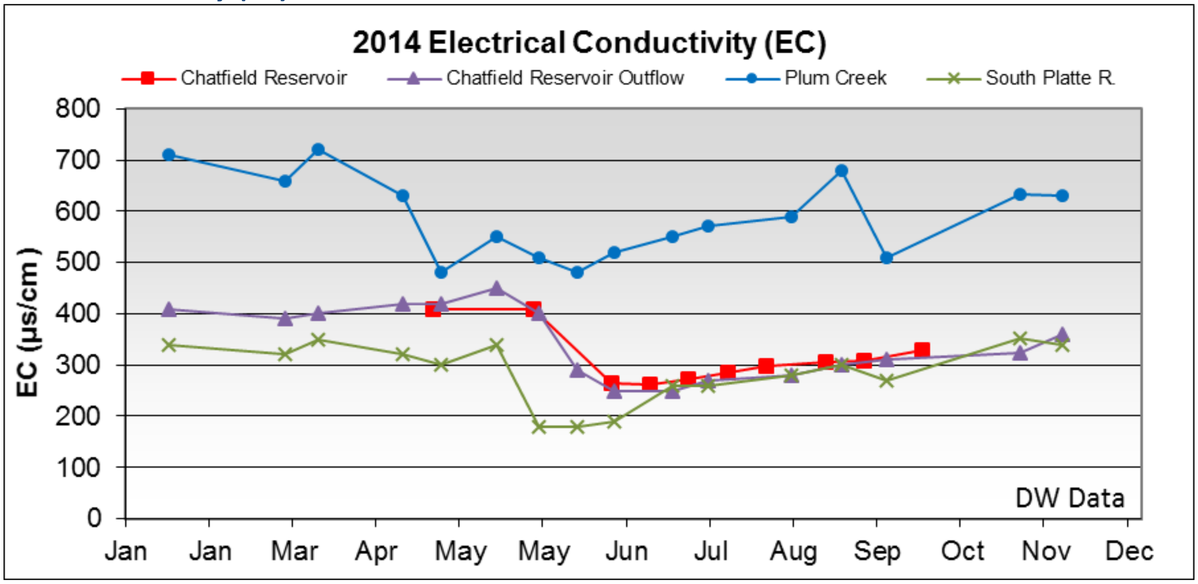
Microbiology (phytoplankton and zooplankton)

Zooplankton

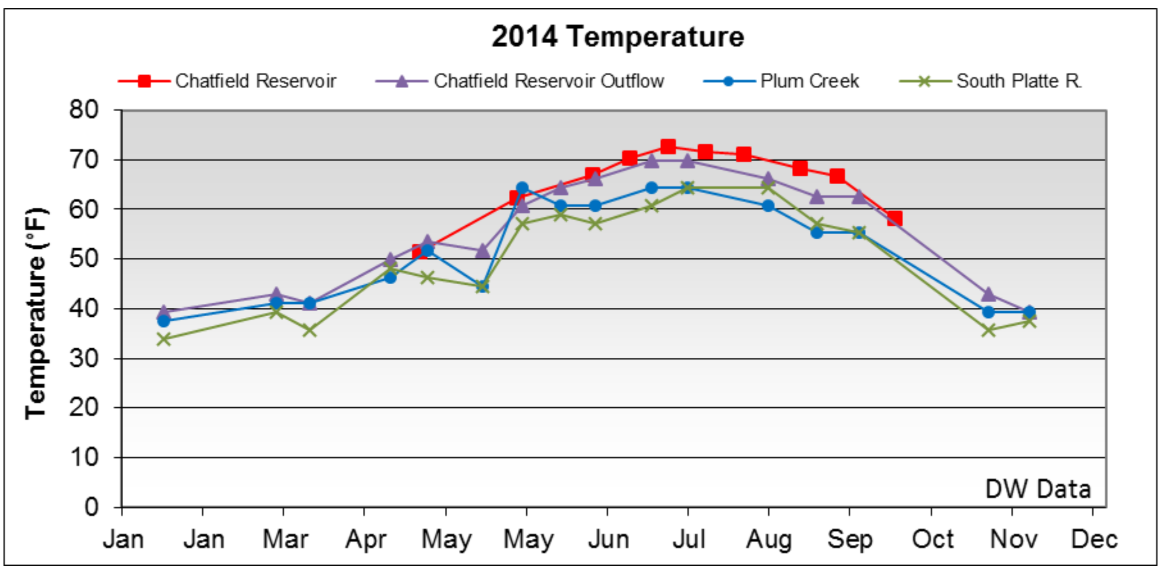


Conventional Parameters

Electrical Conductivity (EC)

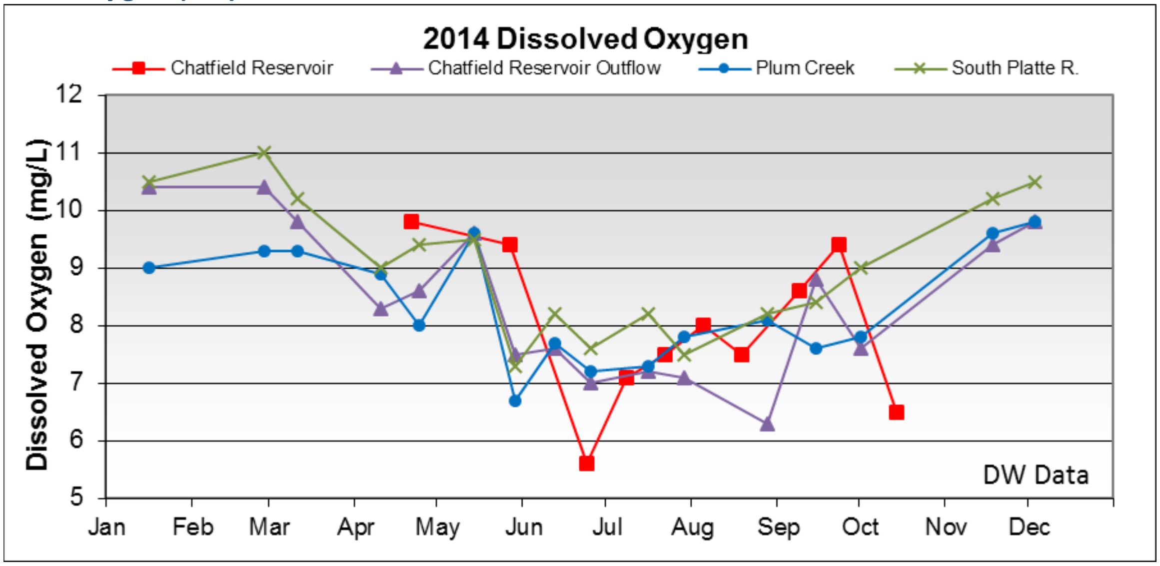


Temperature

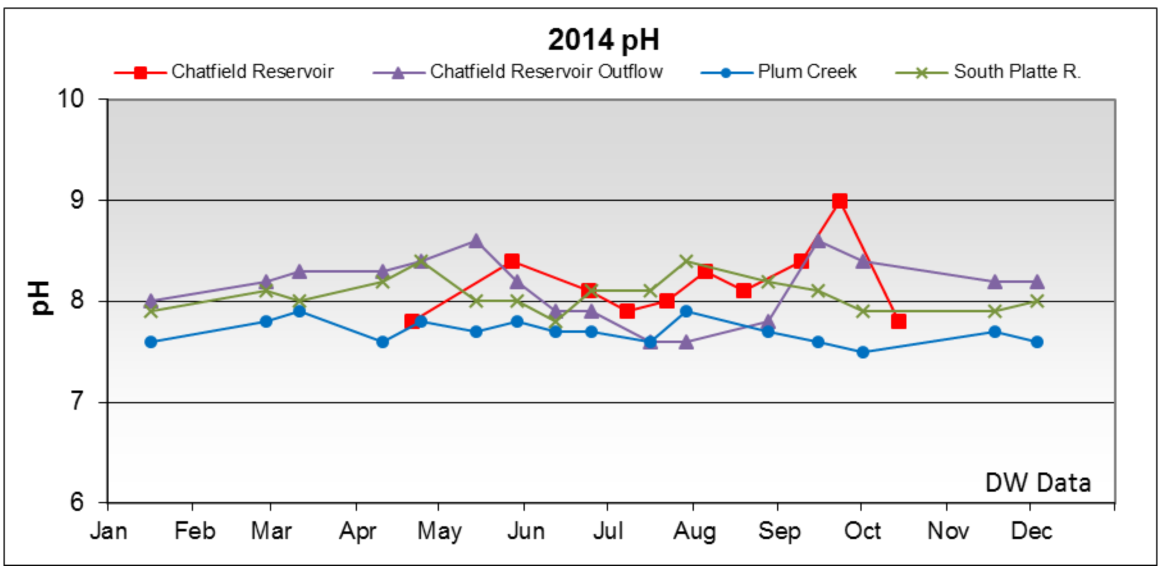


Conventional Parameters

Dissolved Oxygen (DO)

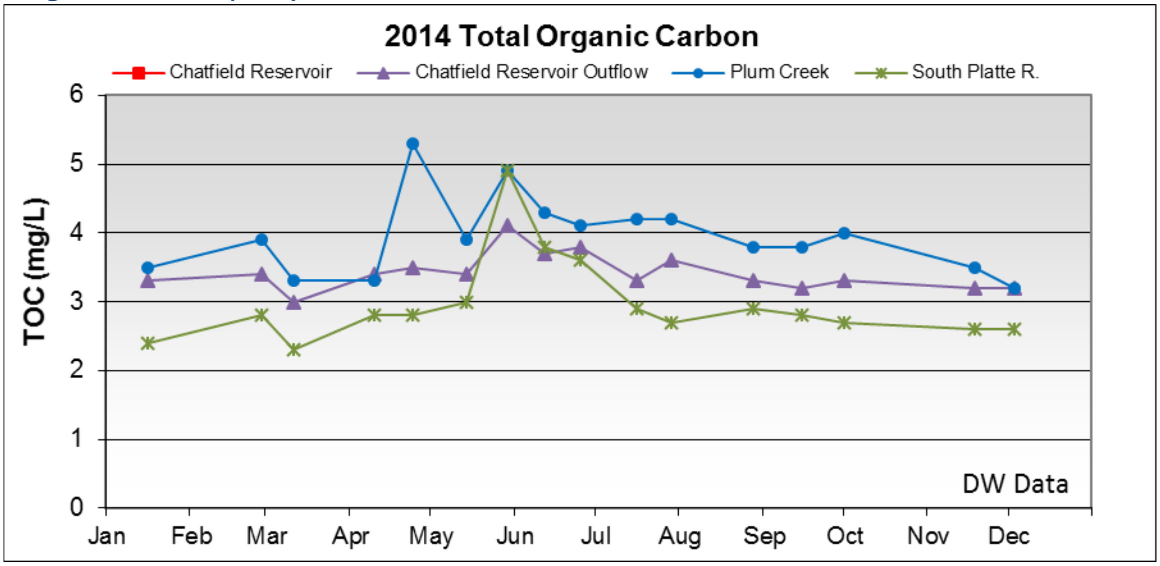


pH

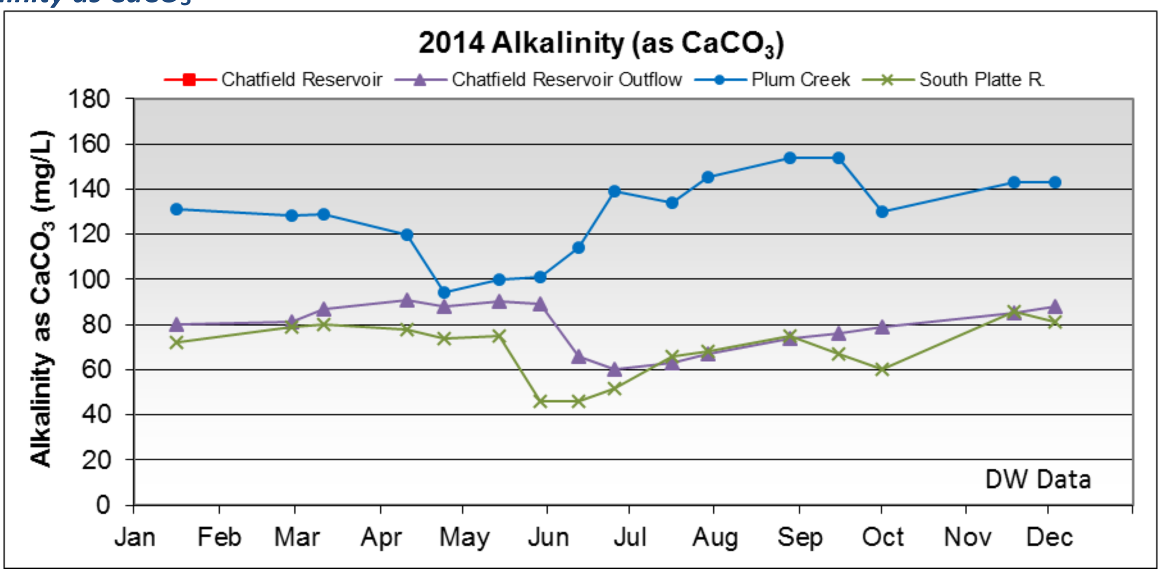


Conventional Parameters

Total Organic Carbon (TOC)

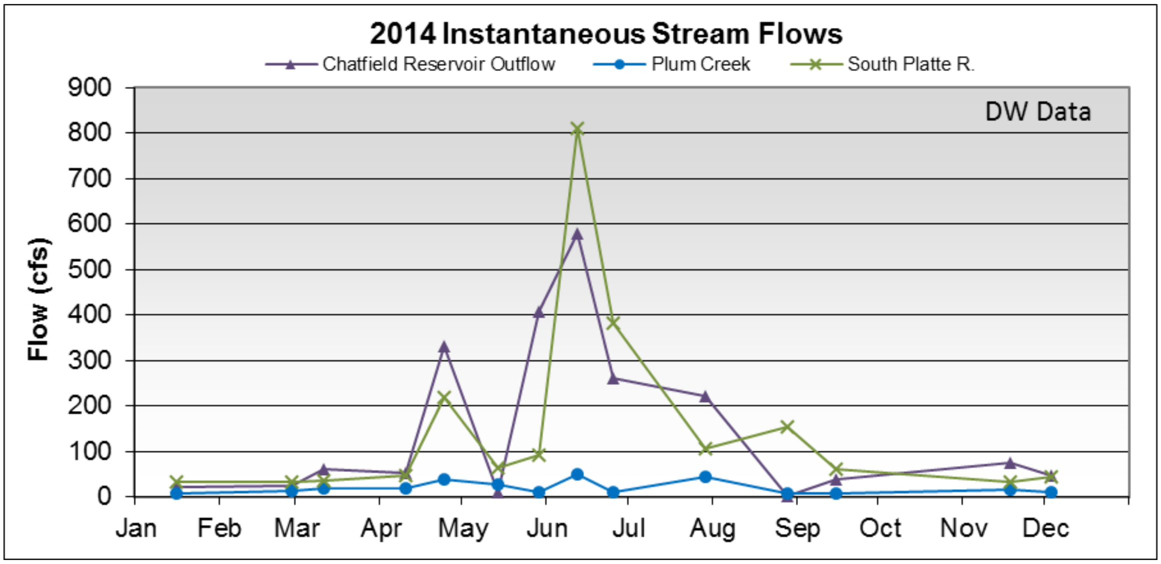


Alkalinity as $CaCO_3$

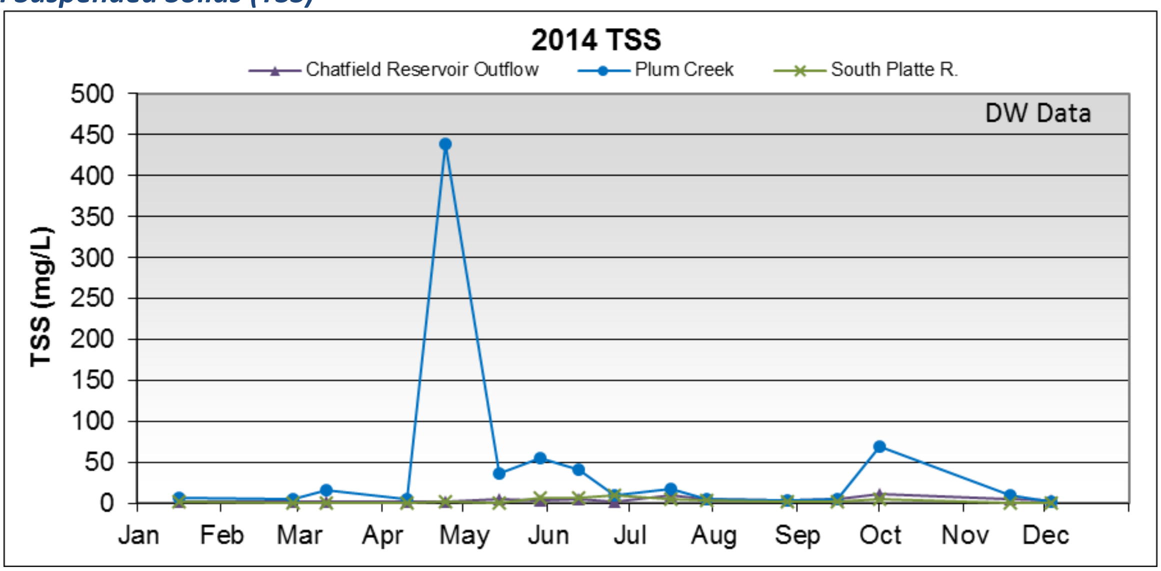


Conventional Parameters

Flow



Total Suspended Solids (TSS)



APPENDIX D

SUMMARY OF EXAMPLE NATIONAL AND REGIONAL PHOSPHORUS LOADING RATES BY LAND USE

Pollutant Loading Sources

To find land-based pollutant load values applicable to the Chatfield Watershed, several watershed modeling reports were examined locally and regionally. Criteria for applicable pollutant loads included representativeness of Chatfield Watershed landscape, land-based or area load units, and a full suite of parameters from a single source to the maximum extent practicable. It is important to gather a collection of values from one source, or as minimal sources as possible, so that values present a holistic and accurate depiction of pollutant loading relative to both land use and to other environmental parameters. To determine loadings most representative of the Chatfield Watershed, it is critical to use a suite of parameters that includes values for pasture lands, rather than agricultural or croplands. Local studies containing pasture-type lands, unfortunately, could not be used in these load estimating efforts as they did not include area-based loads but used event mean concentrations.

One primary modeling study was used to represent nitrogen, phosphorus, and bacteria loadings (Table 1), and several modeling studies were used to develop sediment loading values (Table 2). Note these values were converted for pollutant estimating calculations and scaled to fit pollutant concentrations observed in the Chatfield Watershed.

Table 1. Sediment Loading Rates

Land Use	Rate	Units	Source
Hay/Past	22.75	lbs/acre/yr	PADEP, 2004
Cropland	198.33	lbs/acre/yr	PADEP, 2004
Coniferous Forest	0	lbs/acre/yr	PADEP, 2004
Transitional	959	lbs/acre/yr	PADEP, 2004
Low Intensity Dev.	49.66	lbs/acre/yr	PADEP, 2004
High Intensity Dev.	44.92	lbs/acre/yr	PADEP, 2004
Natural	72	m tons/km2/yr	Lewicki and Mckee, 2008
Agriculture	2461	m tons/km2/yr	Lewicki and Mckee, 2008
Low Density Urban	450	m tons/km2/yr	Lewicki and Mckee, 2008
High Density Urban	996	m tons/km2/yr	Lewicki and Mckee, 2008
Industrial	1836	m tons/km2/yr	Lewicki and Mckee, 2008
Hay/Pasture	76.67	lbs/acre/yr	Gellis, 2008
Cropland	1267.93	lbs/acre/yr	Gellis, 2008
Developed	89.17	lbs/acre/yr	Gellis, 2008
Cropland	0.03	lbs/acre/day	City of Griffin PWSD, 2008
Residential	0.03	lbs/acre/day	City of Griffin PWSD, 2008
Commercial	0.03	lbs/acre/day	City of Griffin PWSD, 2008
Forest	0.03	lbs/acre/day	City of Griffin PWSD, 2008
Impervious	0.03	lbs/acre/day	City of Griffin PWSD, 2008

Table 2. Bacteria, TN, and TP Loading Rates

Land Use	Entero (#/acre/day)	TN (lbs/acre/day)	TP (lbs/acre/day)	Source
Agriculture	1.25E+08	0.34476	0.18	SDRWQCB,2010
Commercial	2.86E+09	0.4	0.04	SDRWQCB,2010
Industrial	8.88E+09	0.4	0.04	SDRWQCB,2010
Forest	214000	0.00978	0.004	SDRWQCB,2010
Open	62607000	0.01112	0.022	SDRWQCB,2010
Residential	2.8E+10	0.45	0.07	SDRWQCB,2010
Transportation	1.74E+09	0.55	0.07	SDRWQCB,2010

References

Pennsylvania Department of Environmental Protection (PADEP). 2004. C5.0 Total Maximum Daily Loads (TMDLs) Development Plan for Sub-basin #1 of West Branch Neshaminy Creek. Available at: http://www.dep.state.pa.us/dep/deputate/watermgt/wqp/wqstandards/tmdl/neshaminy_3.pdf. Accessed on October 07, 2013.

Lewicki, M. and L. McKee. 2008. Watershed Specific and Regional Scale Suspended Sediment Load Estimates for Bay Area Small Tributaries. Sources Pathways and Loading Workgroup. December 2008. Available at: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=6&cad=rja&ved=0CEsQFjAF&url=http%3A%2F%2Flegacy.sfei.org%2Frmp%2FSPLWG_meetings%2F12-08-08%2FItem%25203a%2520Suspended%2520sediment%2520loads%2520from%2520Bay%2520Area%2520small%2520tribs%2520-%2520M%2520Lewicki.ppt&ei=jblFUqSrGobCqQHQ_4CgAg&usg=AFQjCNHSD4f0kelHseWDmtFgij12fgQgng&bvm=bv.53217764,d.aWM. Accessed on October 07, 2013.

Gellis, A. 2008. Method to Identify Sources of Sediment. Presented at Potomac Monitoring Forum 2008: Better Monitoring for Better Water Resources Management. March 10-11, 2008. Cacapon Resort State Park. Berkeley Springs, WV. Available at: http://www.mwcog.org/environment/potomacforum/Forum_PPts/Gellis_Methods_to_ID_Sediment_Sources.pdf. Accessed on October 07, 2013.

City of Griffin Public Works & Stormwater Department (PWSD). 2006. Potato Creek Watershed Management Plan. Available at:

http://www.cityofgriffin.com/Portals/1/Documents/Public%20Works/Stormwater/WatershedManagement/WatershedAssessments/Potato_Creek_Watershed_Management_Plan_2005.pdf. Accessed on October 07, 2013.

San Diego Region Water Quality Control Board (SDRWQCB). 2010. Revised Total Maximum Daily Loads for Indicator Bacteria Project I – Twenty Beaches and Creeks in the San Diego Region (including Tecolote Creek). Final Technical Report. February 2010.

APPENDIX E

EXAMPLE AGRICULTURAL EFFICIENCIES

Example Agricultural BMP Efficiencies

Practice	Location	Practice effects	Source
Vegetative cover	North Carolina	Mean TN export was greatest from bare ground and was reduced by at least 85% at cover levels from 45%–95%.	Butler *et al*. 2007
Rotational grazing	Wisconsin	Stations with intensive rotational grazing or grassy buffers had the least bank erosion and fine substrate in the channel compared to continuous grazing stations. Station riparian land use had no significant effect on width/depth ratio, cover, percent pools, habitat quality index, trout abundance, or IBI score.	Lyons *et al*. 2000
Short-duration grazing	Minnesota	Low IBI scores are associated with streams draining continuously grazed pasture; whereas, higher IBI scores occurred on ungrazed sites. Ungrazed sites are associated with reduced soil compaction and higher bank stability compared to continuously grazed sites. Short-duration grazing sites were intermediate.	Magner *et al*. 2008
Buffer strips, riparian buffers	Various	Regardless of the area ratio of buffer to agricultural field, a 10-m buffer and a 9 percent slope optimize the sediment-trapping capability of vegetated buffers. This study demonstrated a sediment trapping efficiency for vegetated buffer strips to range from 50-98% efficiency, with a mean efficiency of 81%. The sediment trapping efficiency of riparian buffers ranged from 53-98%, with a mean efficiency of 83%.	Liu *et al*. 2008
Natural/ constructed wetlands	Illinois	Natural or constructed wetlands can potentially reduce NO3 by 37-65 percent in agriculture drainage water. A combination of controlled-drainage, constructed wetland, and in-stream de-nitrification could result in more than 75% NO3 removal before release to larger streams or other surface waters. Two runoff wetlands achieved a combined P mass reduction of 53 percent.	Appelboom and Fouss 2006
Reducing nutrients in feed	New York	On two New York dairy farms, fecal P concentrations decreased 33 percent following dietary adjustments; milk production was not adversely affected.	Cerosaletti *et al*. 2004
Waste Storage	Various	General pollutant reductions associated with containment structures were reported as 60 percent for TP, 65 percent for TN, 70 percent for sediment, and 90 percent for fecal coliform.	USEPA 2003

Practice	Location	Practice effects	Source
Waste Storage	Virginia	This study, comparing runoff from uncovered and covered poultry manure stockpiles, concluded that protecting litter piles with the common 95 percent plastic coverage technique was unsuccessful in reducing environmental pollution. It was recommended that poultry litter be stored in a litter shed that prevents all contact from precipitation and runoff.	Habersack 2002
Livestock exclusion fencing	North Carolina	Fencing dairy cows from a 10- to 16-m wide riparian corridor along a small stream resulted in 33, 78, 76, and 82 percent reductions in weekly nitrate + nitrite, total Kjeldahl nitrogen (TKN), TP, and sediment loads, respectively. Fecal coliform and *enterococci* levels decreased 65.9 percent and 57.0 percent, respectively, after livestock exclusion.	Line *et al*. 2000

APPENDIX F

HOT SPOT ANALYSIS FOR POTENTIAL POLLUTANT IMPACTS FROM SEPTIC SYSTEMS AND STREAM BANK EROSION IN THE PLUM CREEK WATERSHED (GORMAN 2013)

Chatfield Watershed Authority

Spatial Analysis of Nonpoint Source Pollution Impacting the Plum Creek Watershed

Jaclyn Gorman
Colorado School of Mines
Civil and Environmental Engineering
January 6, 2014

Table of Contents

Section 1: Project Abstract and Deliverables

Nonpoint source pollution (NPS) is defined by the Environmental Protection Agency (EPA) as any source of pollution that doesn't meet the legal definition of "point source" in section 502(14) of the Clean Water Act [1]. Nonpoint source pollution commonly results from land runoff, precipitation, drainage, seepage, volatilization or leaching. This type of pollution includes: bacteria and nutrients from livestock, pet and septic system waste; sediments from improperly managed construction sites, crop lands, forest lands, and eroding stream banks; and surplus fertilizers, herbicides and insecticides from agricultural and residential areas [1].

Plum Creek flows through both rural and suburban sections of Douglas County. The Plum Creek Watershed is inundated with many different sources of nonpoint pollution including: individual sewage disposal systems (ISDS), horse sanctuaries and agricultural activities, mining operations, and stream bank erosion and degradation. These pollution sources adversely impact water quality and elevate nitrate, bacteria and phosphorus levels within the Plum Creek Watershed. If these pollution sources are not identified and properly managed, wildlife, property values and drinking water supplies could continue to be impacted.

The scope of this project focuses on nonpoint source pollution within the Chatfield Reservoir Watershed in the vicinity of Plum Creek. This watershed is administered by the Chatfield Watershed Authority (CWA) with its goal being to develop a watershed plan that builds partnerships with stakeholders, characterizes the watershed, and identifies areas for potential programs and projects [2]. This analysis will attempt to help prioritize areas within the Plum Creek Watershed that need either further monitoring or direct actions.

This project was executed in three parts: research; analysis; and the final deliverables for the watershed master plan. A final component of this project will be constructing an informative summary for the master plan that highlights "hot spots" of concern that should be further investigated by the Chatfield Watershed Authority through water quality testing and onsite analysis. This project focuses on a spatial analysis of ISDS and soil erosion based on the physical characteristics of the watershed. The following sections of this report summarize the findings regarding ISDS and soil erosion. The master plan summary, after its completion, will be included in the Chatfield Watershed Authority's master plan as an appendix.

Section 2: Individual Sewage Disposal Systems (ISDS) Spatial Analysis

Introduction to ISDS

Individual sewage disposal systems (ISDS) are onsite wastewater treatment systems used in rural and suburban settings when public collection and treatment systems are not available. When functioning properly the ISDS removes many pollutants that have the potential to cause adverse environmental and human health issues. As populations in rural and suburban areas increase, however, the growth in the density of septic systems puts a strain on the groundwater supply, and the aquifers exhaust their ability to dilute wastes which leads to a steady deterioration of water quality in the surrounding area [3]. ISDS within Douglas County Colorado are managed by the Tri-County Health

Department (TCHD) under Regulation Number I-11 titled "Individual Sewage Disposal Systems." Tri-County regulates ISDS within Douglas, Adams and Arapahoe counties by: performing site evaluations; system selection and layout designs; ensuring proper installations of the systems; inspections and maintenance [4]. The current regulations are designed to protect public health from water-borne pathogens and nitrates, but it is difficult for local governments to enact effective measures to address the threat that ISDS pose on the ecosystems of lakes and streams [3].

Water quality and quantity issues are a major concern for the state of Colorado due to climatic conditions and population growth. According to the United States Census Bureau, between 2000 and 2010 the total population in Colorado increased by 17%, and within just Douglas County, the population grew by 62% [5]. There are multiple municipal water and wastewater systems located throughout Douglas County, however, not every household is within a service area and consequently requires wells linked to both groundwater and individual septic systems. According to the Colorado Division of Water Resources over 8,000 "domestic" or "household use only" water wells have been permitted for well construction under C.R.S. Section 37-92-602 since 1938. This type of permit generally requires waste water disposal through a non-evaporative onsite system like an ISDS [6]. Of the 8,000 water well permits, 3,000 are located within the boundary of the Chatfield Watershed. Along with the water well permit data is the septic permit data, and according to the TCHD there are approximately 1,500 permitted septic systems within the Douglas County section of the Chatfield Watershed.

General Information Regarding ISDS

Conventional septic tank and drain field systems treat wastewater by settling solids and partially processing the organic matter, allowing liquid effluent, which still contains nutrients and pathogens, to be discharged into the soil beneath the drain field for further treatment through biological processes, absorption and filtration [3]. Figure 1 below depicts a conventional onsite individual sewage disposal system.

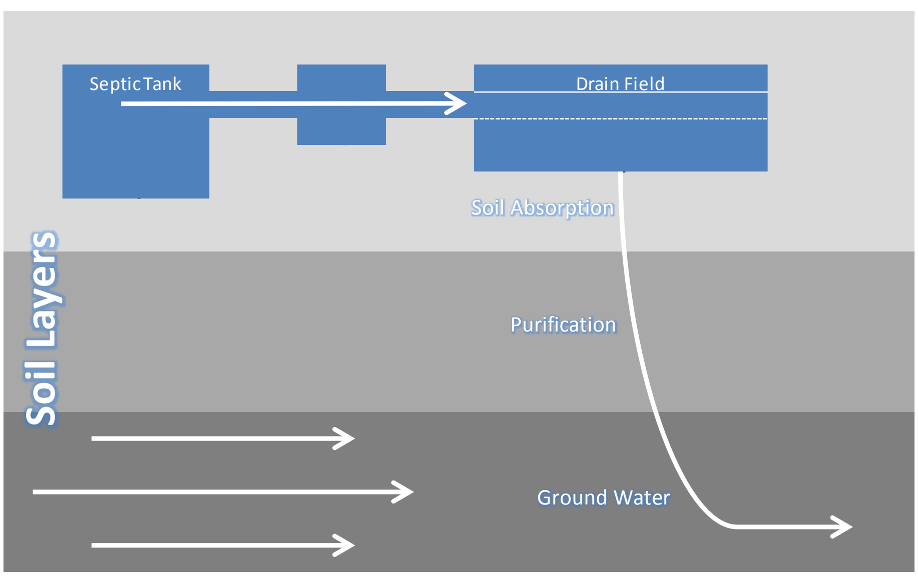


Figure 1. Conventional onsite individual sewage disposal system

Conventional septic systems work well if they are installed in areas with suitable soils, and are appropriately designed and consistently maintained. Important soil properties include depth to water table, permeability, depth to bedrock, depth to cemented pan, depth to permafrost, slope, flooding, ponding, susceptibility to downslope movement, and susceptibility to pitting [7]. In general the soil encasing a septic system should be naturally undisturbed and not excessively wet. It is important to ensure that the vertical separation between the bottom of the drain field and the water table is large enough so that unsaturated conditions will be maintained even during wet periods. Water travels more slowly through an unsaturated soil and the slower the velocity of flow, the longer the residence time of the effluent in the unsaturated zone, and the greater the opportunity for cleanup of the effluent as it moves through the soil. The soil texture should have good aggregation and shouldn't be overly populated with sand or clay. Areas that have rock close to the surface, very sticky clays, or soil layers that restrict the downward flow of water should be avoided [7]. According to the EPA only about one-third of the land area in the United States has soils suited for conventional subsurface soil absorption fields [8]. Additional issues with ISDS are that system densities in some areas exceed the capacity of soil to assimilate flows and transform their contaminants, and the systems are located too close to ground or surface water [8]. It has also been shown that ISDS might not be adequate for minimizing nitrate contamination of ground water, removing phosphorus compounds, and abating pathogenic organisms [8]. Nitrates and phosphorus discharged into surface waters directly or through subsurface flows can incite algal growth and lead to eutrophication and low dissolved oxygen in lakes and streams.

The path of the contamination flow seeping out of septic systems is related to its proximity to the water table or a water body, topography, precipitation, soil conductivity, and other soil and geological characteristics. The septic plume created tends to be long, narrow and noticeably defined. In a study of mean effluent plume dispersion it was found that, after 12 years, septic plumes in the study had sharp lateral and vertical boundaries, extending to a length of 130 meters, and a width of about 10 meters [9]. In a second study, an investigation of Turkey Creek Basin in Colorado, the research showed that septic plumes migrated a distance up to 100 meters from the ISDS [10] . The effluent initially forms a distinct pool beneath the dispersal area surrounded by the natural groundwater. The pool of effluent, over the years will then begin to flow laterally in the direction of the hydraulic gradient [11]. For the purpose of this analysis the potential impact of the septic plume will be evaluated based on the ISDS' proximity to Plum Creek or the surrounding tributaries. The predominating type of soil, amount of precipitation and runoff potential will play a significant role in the plume formation. It is considered rare for an ISDS to contribute any contaminants to surface runoff during a storm event if the system is well maintained [11]. The system could become temporarily flooded and in a properly maintained system the effluent would be contained below ground and eventually dispersed into the soil as the storm event and the subsequent water receded.

General information regarding ISDS systems was used with specific soil properties to spatially model potential locations contributing to the pollution loading into Chatfield Reservoir via the Plum Creek Watershed. The model utilized the best available data and set up modeling criteria based on researched information.

ISDS Analysis Factors

The spatial factors taken into consideration for the ISDS hot-spot analysis included hydrologic soil group, depth of wells, concentration of systems per acre, proximity to streams, age of septic structure, and location relative to the flood plain. Average precipitation was not taken into consideration since it was reasonably consistent over the entire modeling extent, and in terms of average annual precipitation, the Chatfield Watershed is dry averaging less than 20 inches of precipitation per year. The following list represents the priority given to each of the potential ISDS factors causing contamination loading into the Plum Creek Watershed.

A. Proximity to stream
B. Hydrologic soil group
C. Age of structure
D. Depth of well and aquifer
E. Flood zone location
F. Concentration of people and structure density

Areas within the Plum Creek Watershed with the highest potential loading were identified and these zones should be considered for future monitoring efforts and potentially nonpoint source mitigation actions.

Proximity to Stream

Each of the ISDS were evaluated based on their distance to Plum Creek and tributaries within the watershed. Data for ISDS locations in Douglas County were obtained through the TCHD. The data was geocoded in ArcGIS 10.1 creating a point shapefile. The ESRI proximity toolset was used to determine the distance from each point in the ISDS layer to the stream layer. The near tool, specifically, was used since it determines the distance from each feature in the input features to the nearest feature in the near features. After the tool was executed, a location distance was created in a new column in the ISDS shapefile. Based on research performed by Robertson (1991) and Solomon & Knowles (2002) any ISDS within 150 meters of the Plum Creek or any of its tributaries was considered to have a considerable impact.

Hydrologic Soil Groups

When considering the impacts of ISDS on the surrounding water quality it is important to consider the movement of water into and over the soil. To best illustrate how soil could impact the septic plume, the hydrologic soil groups created by the Natural Resource Conservation Service (NRCS) were evaluated [7]. The NRCS has divided soils into four hydrologic soil groups. These four groups are based on the saturated hydraulic conductivity. The saturated hydraulic conductivity is defined as a quantitative measure of a saturated soil's ability to transmit water when subjected to a hydraulic gradient [7]. It can be thought of as the ease with which pores of a saturated soil permit water movement. Table 1 shows a breakdown of the hydrologic soil groups (HSG) defined by the NRCS.

Hydrologic Soil Group	Criteria
A	Saturated hydraulic conductivity is *very high* or in the upper half of high and internal free water occurrence is *very deep*
B	Saturated hydraulic conductivity is in the lower half of *high* or in the upper half of *moderately high* and free water occurrence is *deep* or *very deep*.
C	Saturated hydraulic conductivity is in the lower half of *moderately high* or in the upper half of *moderately* low and internal free water occurrence is deeper than *shallow*.
D	Saturated hydraulic conductivity is below the upper half of *moderately low*, and/or internal free water occurrence is *shallow* or *very shallow* and *transitory* through *permanent*.

Table 1. NRCS Hydrologic Soil Groups

HSG A have the lowest runoff potential due to high infiltration rates and tends to consist primarily of deep, well-drained sands and gravels. On the other end of the spectrum HSG D tend to have a high runoff potential due to very slow infiltration rates. HSG D consists primarily of clays, soils with high water tables, and thin soils over nearly impervious parent substrate [7]. A study performed by the Charlotte Harbor Environmental Center estimated that soil groups A or B have a 10 percent septic failure rate, group C has a 30 percent failure rate, and group D has 50 percent failure rate [12]. The poorer draining soil makes it harder for the septic tank effluent to absorb and could prevent the septic tank or absorption field system from working properly. For modeling purposes, groups A and B were ranked with the same factor.

The hydrologic soil groups were obtained through the NRCS Soil Data Mart and mapped in ArcGIS 10.1. When the data was downloaded from the NRCS it was contained in zip file comprising of a Microsoft Access database and accompanying tables, spatial information and help documents. The file was unzipped and the Microsoft Access database was opened to identify the fields needed for the spatial analysis. The polygon shapefile was then located in the unzipped file and loaded into ArcGIS. This file contained the basic information regarding the soil layer. To obtain additional information it was necessary to load the components table from the tabular data and join it with the soil shapefile in ArcGIS using the “mukey field.” The different hydrologic soil groups were identified by changing the color schemes of the shapefile. If a HSG wasn’t assigned to a polygon after the mukey fields were joined, it was designated the same value of the adjoining polygon.

Age of Structure

Aging and unmaintained infrastructure is a major concern when analyzing the potential failure of ISDS. A number of homes still rely on outdated and underperforming technologies. A nationwide survey performed by the US Census in 1997 found that about half of the occupied homes with onsite treatment systems were more than 30 years old and a significant number of the respondents reported significant system problems [8]. Structure age data was not available for each septic system, but there was age information available from the Colorado Division of Water Resources water well file and the Douglas County parcel file. The date of the certificate of occupancy from the parcel file was first used to assign a date to the ISDS file. If no date was supplied in the parcel file the water well permit date from the Colorado Division of Water Resources water well file was used. Since “domestic" or "household use only" water wells require an ISDS system, it was presumed that the water well and septic system were installed at the same time. Any system older than 30 years was considered a potential threat.

Depth of Well and Aquifer

Shallow, unconfined groundwater aquifers are potentially impacted by contamination from ISDS. An assessment of shallow groundwater sources in Nigeria found that the extent of contamination of groundwater was strongly influenced by depth of the aquifers, the recharge rate and availability of permeable soil beneath the ISDS [13]. It has also been established through an analysis performed on the South Platte watershed in Nebraska that septic systems within 45 feet of a shallow, thin aquifer could potentially cause groundwater contamination (Verstraeten et al., 2004). For the purpose of modeling ISDS hazards, parcels with water wells located above 45 feet were identified as a potential risk, as these shallow wells indicate the presence of shallow groundwater depths. The water well height and well locations were downloaded from the Colorado Division of Water Resources. If the well closest to the ISDS didn't have a depth listed, the next closest well depth was assigned to that septic system.

Flood Zone Location

Flood zones are geographic regions that the Federal Emergency Management Agency (FEMA) has defined according to fluctuating levels of flood risk. Each zone reflects the severity or type of flooding in the area. Within the Plum Creek Watershed the high risk flood zone designations included zone A, AE and AO. FEMA defines zone A as "areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage." [14]. Zones AE and AO are very similar to zone A and deal with 100-year shallow flooding.

Flood zone data for watersheds within Douglas County was obtained from the town of Castle Rock's GIS data website [15]. The ISDS location was spatially joined in ArcGIS 10.1 to the flood plain shapefile. If the ISDS was located in a category A, AE or AO flood zone within the Plum Creek Watershed, the ISDS was considered to have the potential to have an impact on water quality.

Concentration of People and Structure Density

Several studies applying measurements and modeling have confirmed a positive relationship between water contamination and ISDS density. Additionally, the total number of people using an individual septic system could impact failure rates and contamination. Many studies estimated that the minimum lot size necessary to safeguard against contamination is roughly one-half to one acre. The majority of the reports were limited in scope and only focused on nitrate, so it was presumed that other contaminants, like phosphorus, could be released and have a similar impact on the surrounding environment.

Ford et al. (1980) reported that nitrate contamination of ground water was associated with increased housing density in unsewered residential areas of Jefferson County, Colorado. The study confirmed that ISDS densities exceeding 1 ISDS per acre could have a direct impact on water quality. The next report looked at persons per acre and the percent chance of an ISDS causing private well water contamination. The analysis was performed in Coon Rapids, Minnesota and found that an area with a population density of 2.7 people per acre had more than 29 percent of its private water wells contaminated with nitrate [16]. The last study, based in Dutchess County New York, found that the acreage requirement per structure was contingent on the hydrologic soil group [17]. Table 2 shows the breakdown of structure density based on the NRCS hydrologic soil group utilized in the Dutchess County NY report.

Hydrologic Soil Group	Sustainable Parcel Size
A	Between 1.2 and 1.4 acres per system
B	Between 1.6 and 1.9 acres per system
C	Between 3.0 and 3.5 acres per system
D	Between 5.4 and 6.2 acres per system

Table 2. System Density based on the Hydrologic Soil Groups

Based on the hydrologic soil group, the parcel layer and the ISDS layer, a factor for the septic density was created. First, in ArcGIS 10.1, the ISDS shapefile was joined with the parcel data supplied by Douglas County to get a count of septic systems per parcel. With the per parcel septic systems count determined, the acres per system was calculated. This value was transferred back to the ISDS layer, so that each point had an "acres per system" value. Next the majority soil type per ISDS was determined. The suitable parcel size from table 2 was used to determine whether a parcel was too small based on the density of systems and soil type. If there was a significant effect from the density, the ISDS points residing in the parcel were characterized as having a structure density impact.

Factor Matrix

The matrix in table 3 shows how each of the factors were broken down and calculated. The final spatial factors are shown in the third column in table 3. The hot-spot analysis was performed in ArcGIS based on the final factor value.

Factor	Ranking Attributes	Factor Value
Proximity to Stream	≥151 meters	0
	≤ 150 meters	2
Hydrologic Soil Group	Soil Group A & B	0
	Soil Group C	1
	Soil Group D	2
Age of Structure	≤ 30 years old	0
	> 30 years old	2
Depth of Well and Aquifer	≥ 46 feet	0
	≤ 45 feet	2
Flood zone location	ISDS not in flood zone	0
	ISDS in flood zone	2
Concentration of People and Structure Density	Suitable parcel size	0
	Not a suitable parcel size	2

Table 3. Matrix for ISDS

The map in Figure 2 is the result of combining the six factors and running the kernel density spatial analyst tool in ArcGIS 10.1. The kernel density tool calculates a magnitude per unit area from the ISDS shapefile using a kernel function to fit a smooth curved surface to each point. The combined final spatial factor was entered into the kernel density tool as the "population field" which is essentially the volume under the surface being calculated and rounded by the kernel function. The entire Chatfield Watershed is shown, but calculations were only for the Plum Creek Watershed and its tributaries.

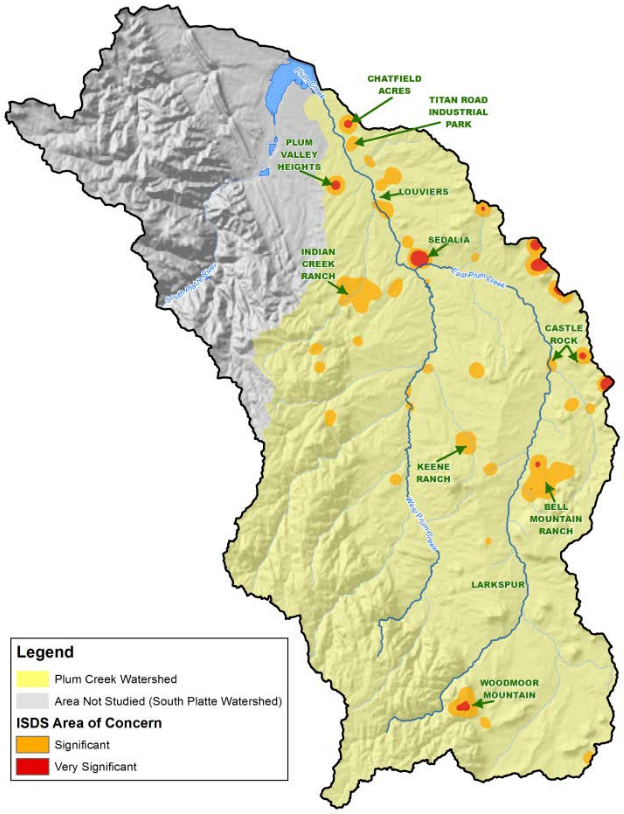


Figure 2. Final ISDS Hot-Spot Analysis

Table 4 lists the locations within the Plum Creek Watershed with the greatest potential ISDS impacts based on contributing spatial factors.

Location	Factors Causing Impact
Sedalia	Age of structure, proximity of septic tank to the stream, and density based on HSG
Chatfield Acres	Age of structure and density based on HSG
Plum Valley Heights	Age of Structure and HSG
Happy Canyon	HSG, age of structure and density based on HSG
Castle Ridge East	HSG and density based on HSG
Woodmoor Mountain	HSG and density based on HSG

Table 4. Significant ISDS Impacts by Subdivision

Data Quality and Concerns

The ArcGIS spatial analysis was created with the best data available. However, the data for this area is not fully comprehensive and could use improvement. There were data availability limitations as well as data quality issues. The incompleteness of the records could have impacted the calculation performed by the kernel density tool.

The ISDS data points were generated based on a file provided by TCHD. The data acquired from TCHD did not include a robust geographical reference for geocoding. This limitation can be attributed to the timing in which data was acquired. At the time of data request, TCHD was redesigning their database management system. To assist with future geocoding efforts, however, it is recommended that GPS coordinates are used over location or parcel addresses. Other recommended information to store in the TCHD database would be the septic systems' proximity to water wells, depth and when the system was installed, permitted or repaired. There was a date associated with the ISDS file, but it referenced when the ISDS was added to the TCHD database. The water well data was downloaded from the Colorado Division of Water Resources' webpage. It included GPS coordinates making it possible to accurately locate the wells on a map. The data fields, however, were not complete for all data points. This occurred in the depth of the well field, which was a factor used in the analysis to estimate groundwater elevation.

Section 3: Soil Erosion Spatial Analysis

Introduction to Soil Erosion

Soil erosion is a naturally occurring process involving the removal or movement of soil by wind and water. Soil particles detach from the larger soil body due to erosive agents or specific activities. When the erosion process is accelerated by manmade activities, it becomes necessary to implement practices that help reduce the rate of soil loss. The Universal Soil Loss Equation (USLE) was originally developed by the United States Department of Agriculture (USDA) as a field scale model in the 1960s by Wischmeier and Smith to help quantify the average annual rate of erosion based on rainfall pattern, soil type, topography, crop system and management practices [18]. It was later revised (RUSLE) in 1997 in an effort to better estimate the values of the various parameters [18]. The RUSLE uses the formula: $A = R * K * L * S * C * P$ where;

- A is the computed soil loss per unit area.
- R is the rainfall and runoff factor
- K is the soil erodibility factor
- L is the slope-length factor
- S is the slope-steepness factor
- C is the cover and management factor
- P is the conservation practice factor [19].

Each parameter is the mathematical estimate of a specific condition that affects the severity of soil erosion at a particular location [18]. The calculated erosion values reflected by the model can vary significantly due to fluctuating weather conditions. As a result of changing weather patterns the computed soil loss values obtained from the RUSLE more accurately represents long-term averages rather than a short term prediction [19].

This study will use the RUSLE to help predict areas along Plum Creek within the Chatfield Watershed that could suffer from severe rates of erosion. The study area will focus on Plum Creek and its tributaries, but the final RUSLE values will be calculated for the entire Chatfield Watershed. The data for this analysis came from the USDA, the U.S. Geological Survey (USGS) and the Natural Resources Conservation Service (NRCS) which is an extension of the USDA. The original geographic coordinate system for this data was in a WGS 1984 projection, but the output maps were projected as NAD 1983 State Plane Colorado Central. The cell size for the original and calculated rasters was 10 meters, which is approximately 33 feet.

Geospatial Soil Erosion Parameter Analysis

Rainfall and Runoff Factor (R)

The R-factor represents the rainfall and runoff, and it was derived from the PRISM average yearly precipitation dataset for the 30 year period spanning between 1981 and 2010 [20]. The R-factor is highly affected by storm intensity, duration, and the potential for precipitation [19]. The data from the PRISM average yearly precipitation dataset was clipped for the Chatfield Watershed and the polygon was converted to a polyline file. The clipped polyline precipitation file was then converted to a raster to assist in the final formula calculation. The assumption regarding precipitation was that higher amounts of precipitation would lead to a higher probability for soil erosion. Figure 3 depicts the raster interpolation of the precipitation file used to create the R-factor dataset and the data flow used to create the GIS layer.

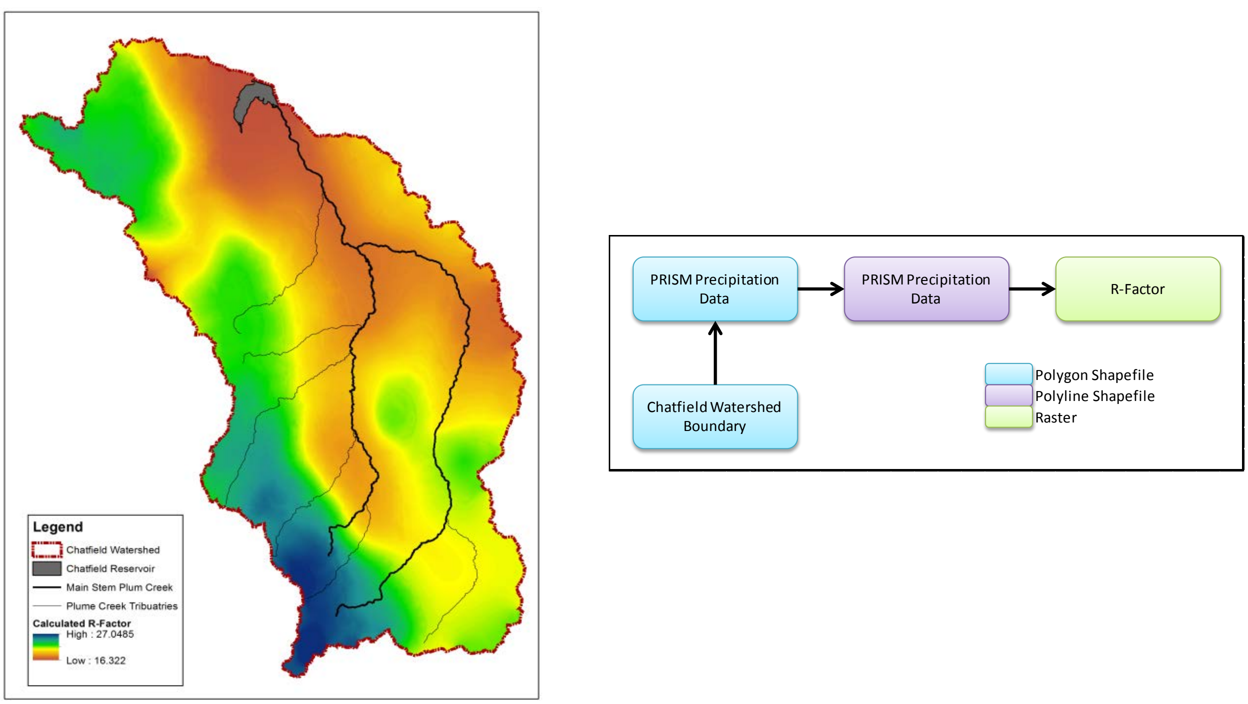
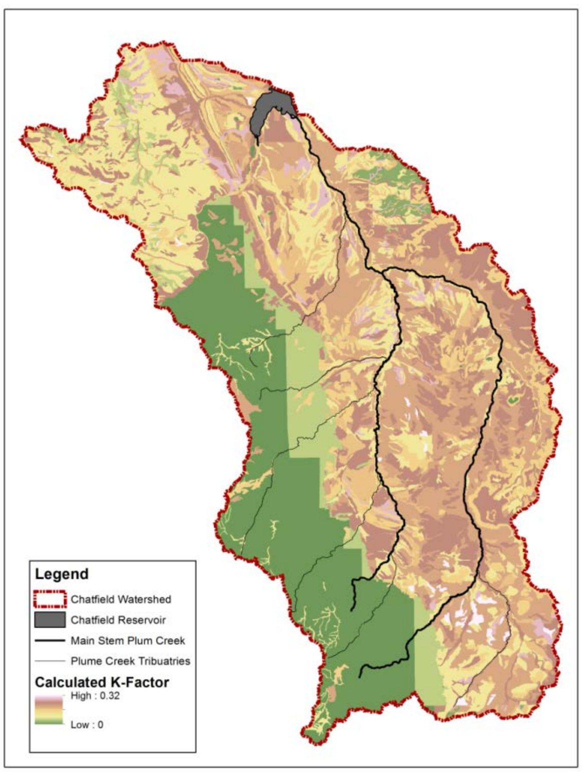


Figure 3. R-factor layer and data map

Soil Erodibility Factor (K)

The K-factor represents the soil erodibility factor and it was generated from the NRCS soil survey information. The K-factor designations have a direct relationship with soil erosion since the type of soil will determine the susceptibility of the soil to erosion and the rate of runoff [7]. Erosion is defined as a process of detachment and transportation of soil material by erosive agents. Soil detachment is the sub process of erosion where soil particles are extricated from the soil mass on the soil surface [21]. This dislodgment is caused by erosive agents, like raindrops, applying force on the soil particles [21]. The K-values are assigned to soil types based on soil characterizes like runoff potential, texture and resistance to detachment. Soils high in clays have low K values around 0.05 to 0.15 because they are more resistant to detachment [7]. In general, coarse textured soils, such as sandy soils, have low K values of about 0.05 to 0.2 because of low runoff even though they are easily detached [7]. Medium textured soils, which include silt loam soils, have a moderate K values ranging from 0.25 to 0.4 [7]. This type of soil is moderately susceptible to detachment and creates moderate runoff. Soils that have high silt contents are the most susceptible soils to erosion. They are easily detached, tend to crust and produce high runoff rates. Values of K for these soils tend to be greater than 0.4 [7].

The final raster for the K-factor was created by first joining the soil shapefile layer to a tabular text file containing the NRCS K-values. The polygon layer was then turned into a polyline layer based on the K-factor and finally converted to a raster. Rocky areas with high slopes did not have an assigned K value so those areas were assigned a value of zero. The locations with zero K-factor values were generally west of the main stem of Plum Creek. Figure 4 shows the raster created for the K-factor and the data flow used to create the GIS layer.



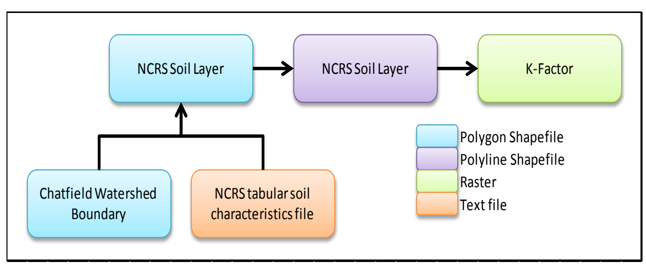


Figure 4. K-factor layer and data map

Slope Length and Steepness Factor (LS)

The LS-factor is a combination of slope length and steepness and can be calculated as a single parameter. The LS factor is calculated as the product of the slope length and steepness constituents converging onto a point of interest. There are different methods available to calculate the LS-factor including taking actual field measurements or using computer programs designed to calculate algorithms for quantifying slope length, but the method used in this report uses the equation initially defined by Wischmeier and Smith [22] in 1978 for the USDA. The equation expresses the ratio of soil loss per unit area on a slope to corresponding loss.

$$\boldsymbol{LS} = \left(\frac{\gamma}{\varphi}\right)^{\boldsymbol{m}} (\boldsymbol{0.065} + \boldsymbol{0.045s} + \boldsymbol{0.0065s^2}) \quad \text{Equation 1}$$

Where
γ = slope length (m)
ϕ = constant 22.13
s = slope gradient (%)
m = constants based on slope

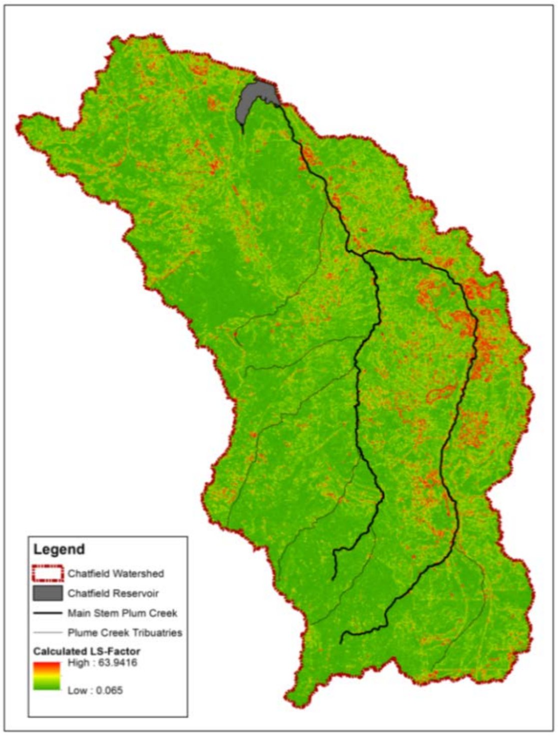
The values of "γ" and "s" can be derived from a Digital Elevation Model (DEM). The slope was directly calculated using the DEM of the area with the ArcGIS Spatial Analyst toolset. To calculate the "γ" value, flow accumulation was derived from the DEM after conducting a fill and flow direction raster analysis. Flow accumulation and raster cell size can be used in place of slope length. The value "m" was defined by Wischmeier and Smith [22] and varies from 0.2 to 0.5 depending on the slope. Table 5 below shows the values for "m" pertaining to a specific % slope range.

M value	Slope (%)
0.5	>5
0.4	3-5
0.3	1-3
0.2	<1

Table 5. M-values by percent slope

The m-value raster was calculated by reclassifying the calculated slope to percent slope and adding in the m factor classes. The final LS-factor was calculated using the Spatial Analyst raster calculator and inputting equation 1 and the appropriate raster layers. Figure 5 displays the created raster for the LS-factor and the data flow used to create the GIS layer.

The stream velocity is directly related to the cross-sectional area and channel slope, and inversely related to channel roughness [6]. Channel geometry is inherently correlated to stream flow characteristics and because of this relationship changes in the geometry can directly impact stream velocity and discharge. The velocity controls the stream's capacity to erode and transport material through its channel. In general, the cross-sectional area and discharge increases downstream due to tributary and ground water flow into the channel. It is assumed that velocity increases in the downstream direction, but as the stream grows larger their downstream slope decreases, preventing a continuous buildup of energy and creates a more uniform distribution of energy along its length [6]. To better understand how slope is impacting the transportation of downstream sedimentation, the geomorphology of the Plum Creek channel should be further analyzed.



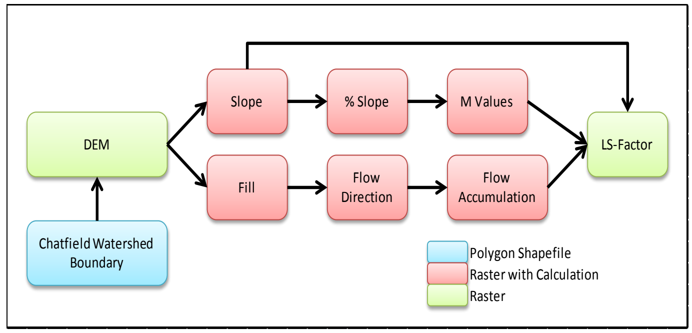


Figure 5. LS-factor layer and data map

Cover and Management Factor (C)

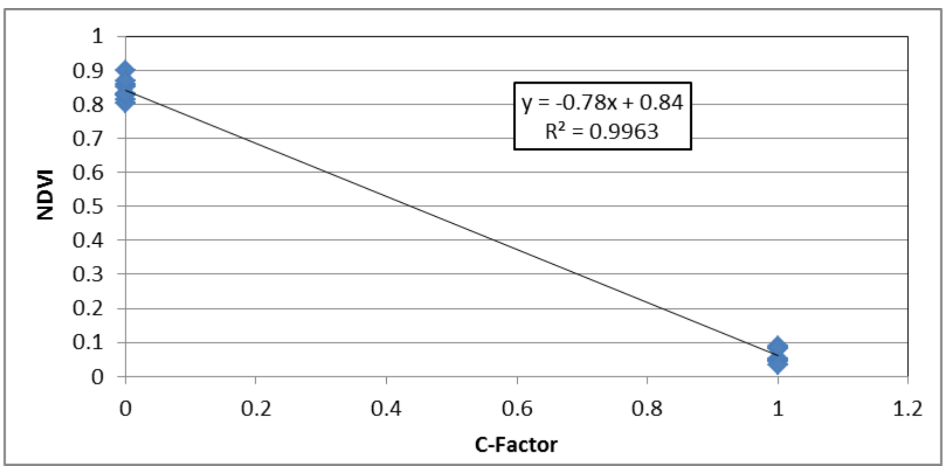
The C-factor examines the ratio of soil loss based on a specific vegetation cover or other land type. The C-factor indicates how the average annual soil loss and soil-loss potential will be impacted due to human management schemes like construction or crop rotation [23]. Vegetation cover is essential in protecting the ground from erosion and acts as a buffer between the atmosphere and soil. Vegetation helps to reduce the energy released by precipitation before it reaches the soil. The impact from the precipitation is variable based on vegetation canopy height and ground cover density. Vegetation also helps to protect the soil from surface flow erosion. Surface flow velocity reduction usually occurs with dense, spatially uniform, vegetation cover [24]. With proper management of vegetation, plant residue, and tillage, soil erosion can be effectively limited [24]. The C-factor for this analysis was evaluated using Landsat 7 imagery, creating a raster of the Normalized Difference Vegetation Index (NDVI), a remote sensing vegetation cover indicator, and an equation obtained from preforming a linear regression analysis on the NVDI and known C-factor values.

NDVI is one of various mathematical combinations of satellite bands within Landsat imagery that is sensitive to the presence and condition of green vegetation. It is based on the reflectance properties of vegetation in comparison with water features and bare soil. Vegetated areas have high reflectance in the near infrared and low reflectance in the visible red, while water features and bare soil, have larger visual reflectance than near-infrared reflectance [25]. Due to these reflectance properties, areas with dense vegetation yield high NDVI values, water features have negative values and bare soil gives indices around zero [25]. The NDVI is a normalized index and therefore compensates for changes in illumination conditions, surface slopes and aspect [25]. The NDVI for this study was calculated from Landsat imagery using the following equation:

$$NDVI = \frac{(band\ 4 - band\ 3)}{(band\ 4 + band\ 3)} \quad \text{Equation 2}$$

The Landsat data used for this calculation was from the Landsat 7 satellite and the imagery was taken on September 14, 2000. In order to calculate the NDVI the data was converted to reflectance data which was achieved by first converting the data to radiance data. The methodology used to calculate the final NDVI raster was taken from a Colorado State University document provided by the National Resource Ecology Laboratory [26].

This study assumed that there was a linear correlation between the NDVI and C-factor values, and used bare soil and densely forested NDVI values as reference points. The C-factor values based on the NDVI vary between 0 and 1, with 0 representing forest and 1 representing bare soil [25]. The final values produced by the analysis should be in the range between these values. Based on the Landsat imagery and corresponding aerials, 20 indiscriminate locations were chosen based on whether they were either heavily forested or bare soil. The linear regression equation was constructed using a correlation analysis between NDVI values obtained from the Landsat data and corresponding C-factor values. The C-factor value, due to the NDVI conversion, will range from 0 to 1 so the bare soil and forest land cover were set to their respective values for the regression analysis. Figure 6 shows the equation and graph produced by performing the regression analysis.



Regression Statistics	
Multiple R	0.998
R Square	0.996
Adjusted R Square	0.996
Standard Error	0.025
Observations	20

Figure 6. Linear regression of NVDI and C-factor values

The final C-factor raster layer was calculated in ArcGIS using the Spatial Analyst raster calculator. Based on the regression line describing the relationship between the C-factor and NVDI layer generated in Figure 7 the equation to calculate the C-factor was found as;

$$C = (-0.78\ x\ NDVI) + 0.84. \quad \text{Equation 3}$$

The final image generated from equation 3 can be seen in Figure 7 below with the data process map. The forested areas are represented by a 0.0 to 0.2 C-factor class while bare soil areas and water features are represented by a C-factor class of 0.8 to 1.0 [23].

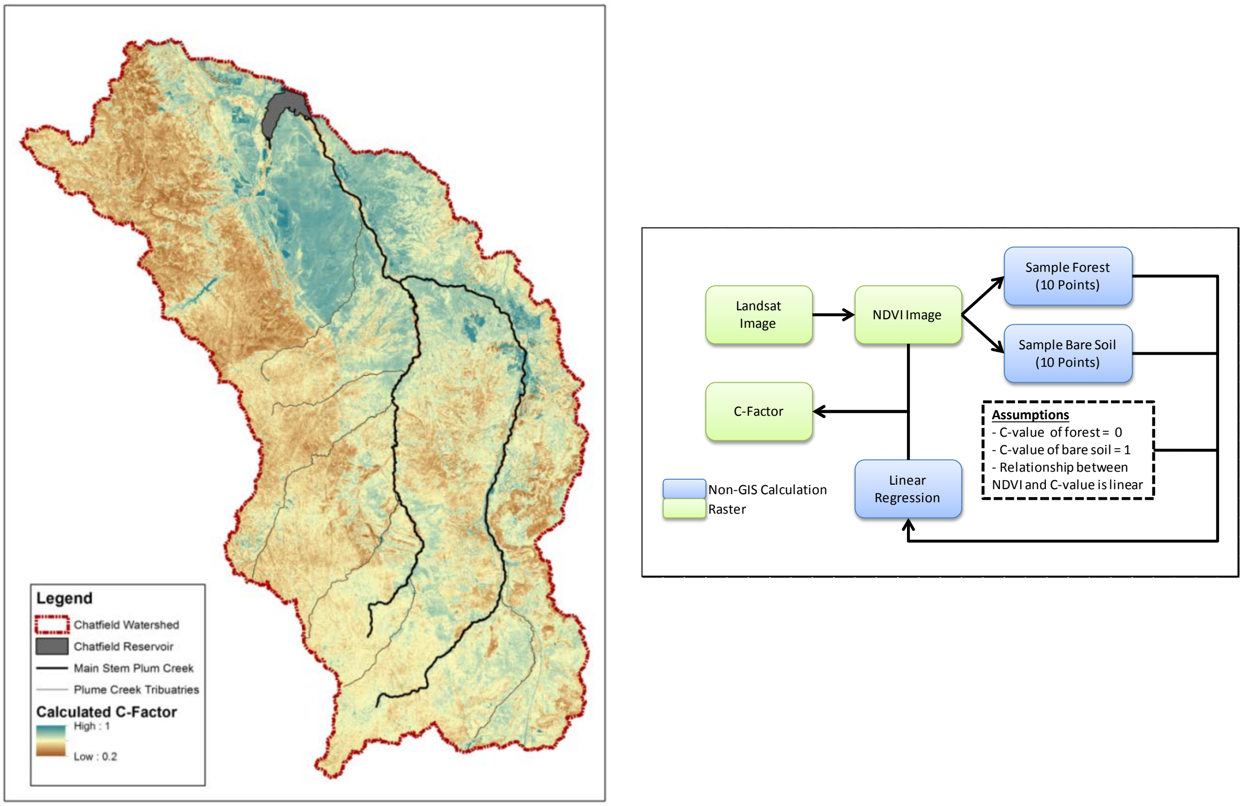


Figure 7. C-factor layer and data map

Conservation Practice Factor (P)

The P-factor takes into consideration the conservation practices being implemented in a particular location. It is a measure of the effects of practices designed to modify flow pattern, grade and the direction of surface runoff. Common conservation practices include: cross slope cultivation; contour farming; strip-cropping; terracing; and grassed waterways [18]. For this study it was assumed that there were no conservation practices in place within the Chatfield Watershed. The raster created to represent the P-Factor was set equal to 1. The final P-factor raster is depicted in Figure 8.

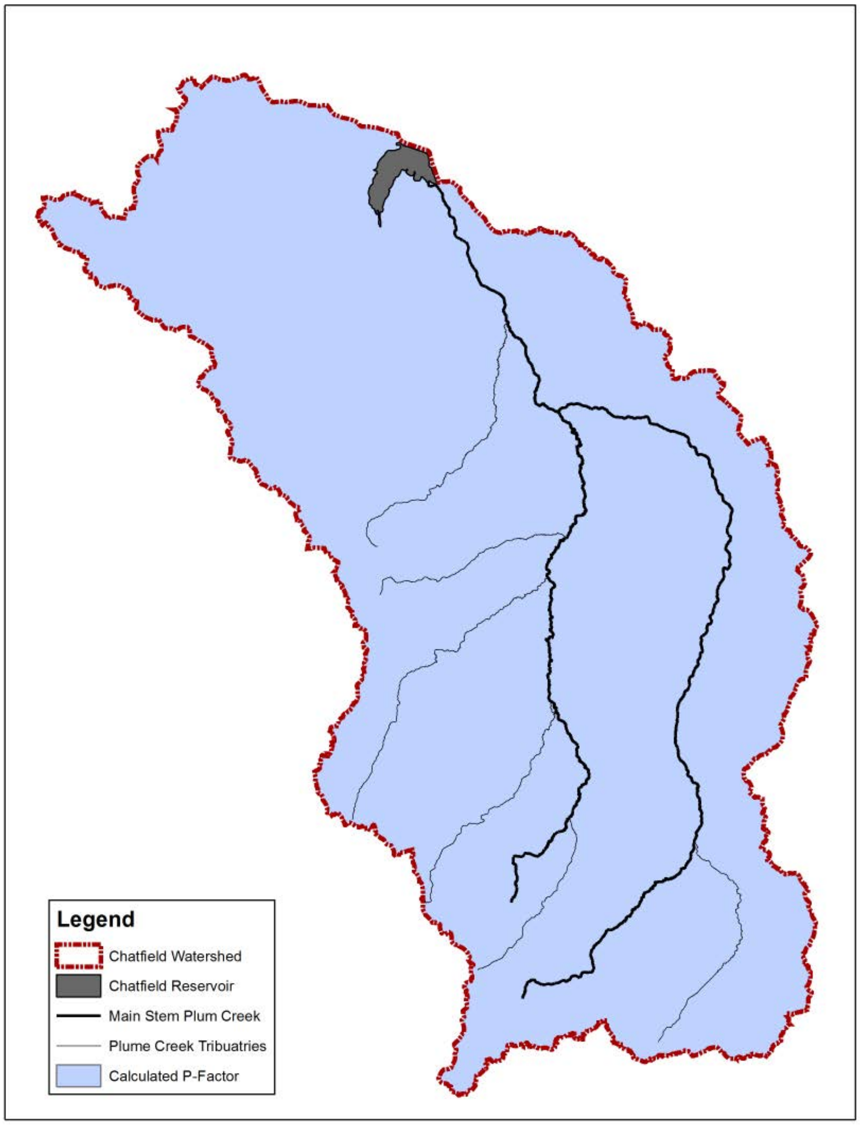


Figure 8. P-factor layer

Final RUSLE Output and Plum Creek Analysis

The computed soil loss per unit area (A) was calculated by combining the five computers rasters through multiplication. The ArcGIS Spatial Analyst raster calculator was used to generate the final raster layer. The computed A-value raster layer is depicted in Figure 9. In order to evaluate the soil based on its proximity to the stream, the values within the Plum Creek floodplain were assessed with the ArcGIS Spatial Analyst kernel density tool. The goal of this study was to target areas directly along the stream bank, including Plum Creek and the surrounding tributaries. The final map of the impacted stream banks can be seen in Figure 10.

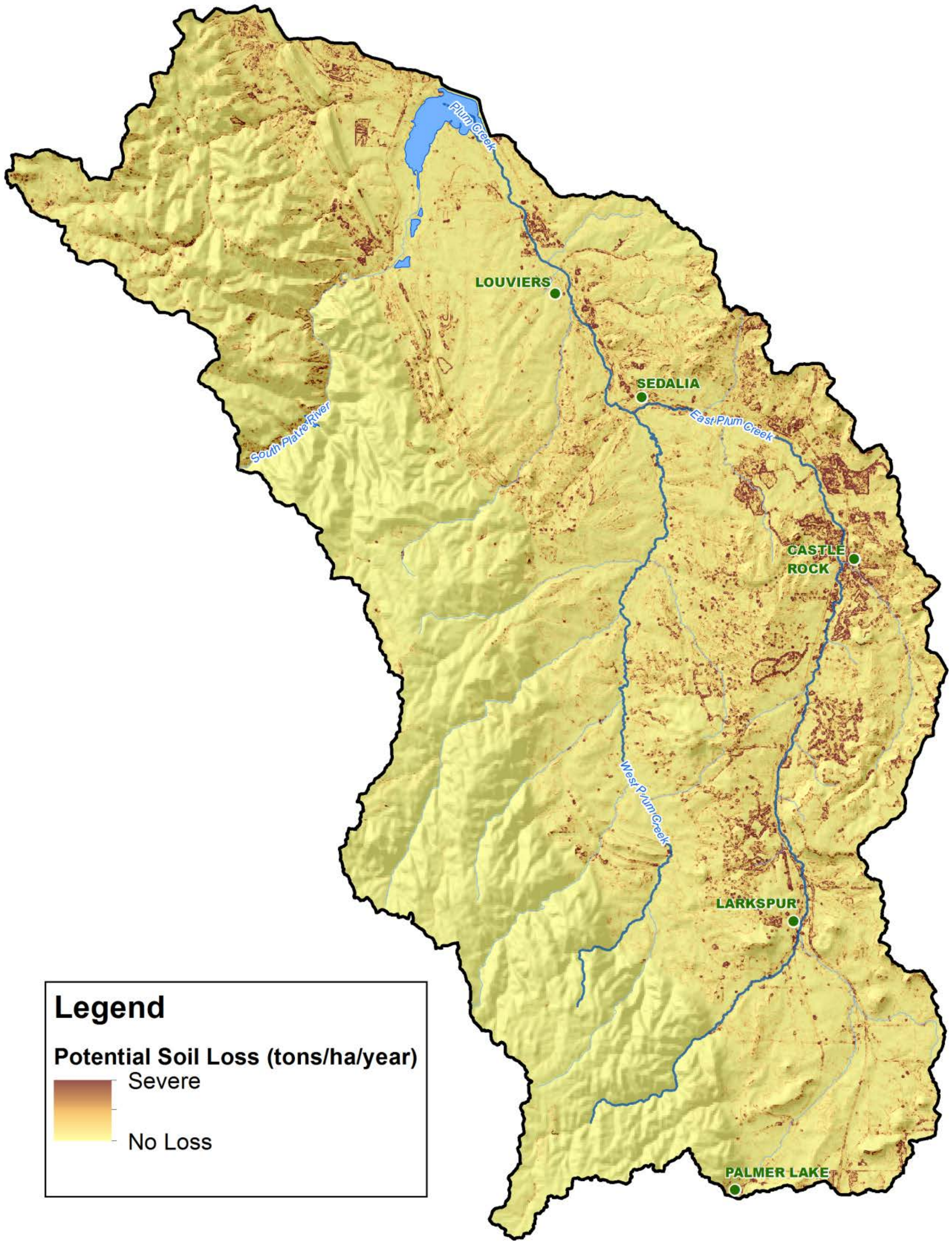


Figure 9. Computed soil loss per unit area

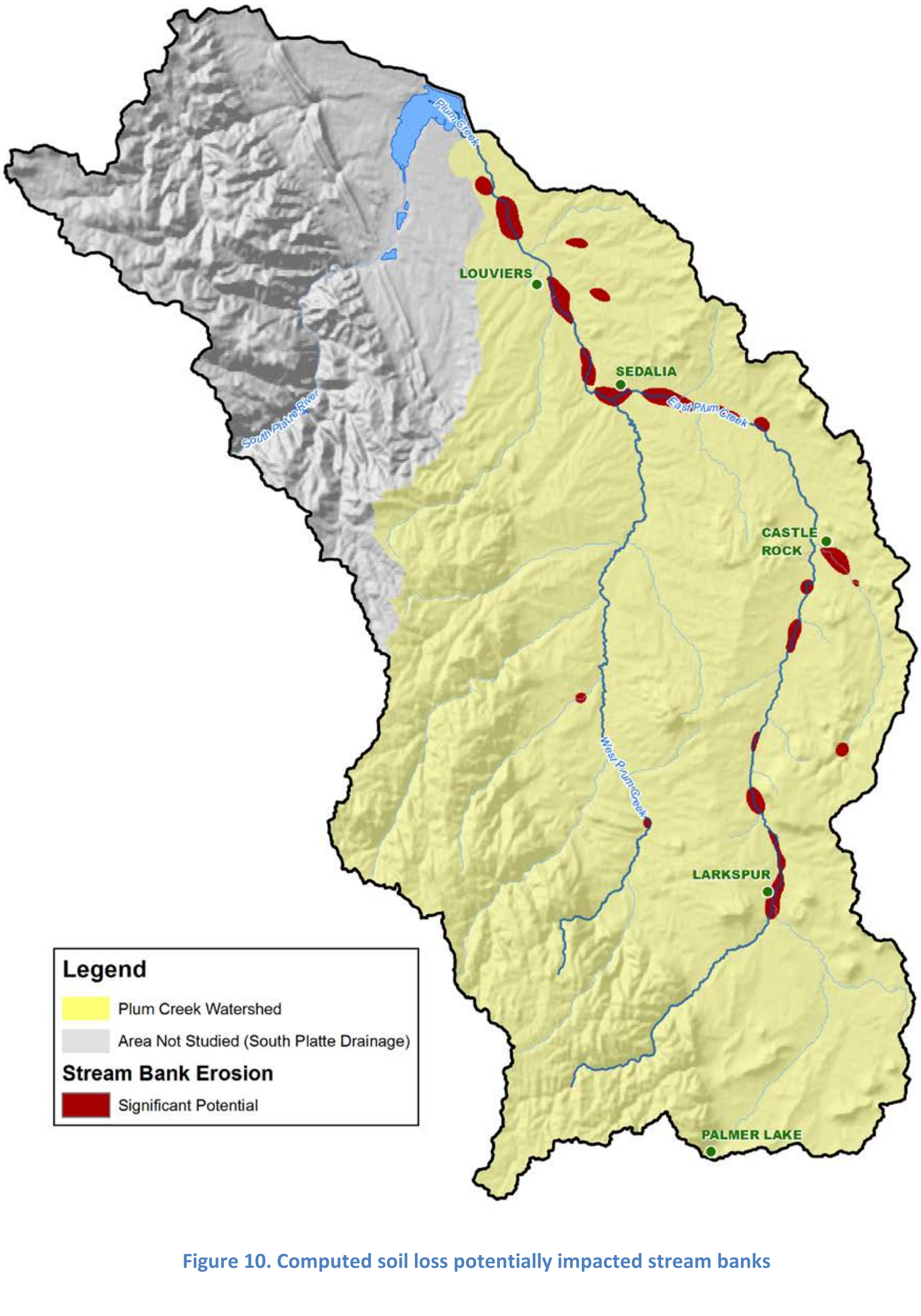


Figure 10. Computed soil loss potentially impacted stream banks

Data Quality and Concerns

This report highlights potential areas of concern and to better understand sediment loading and erosion in the Plum Creek Watershed, the geomorphology of the stream channel and flow characteristics should be further analyzed. Ground-truthing of the results was not conducted and should be used to confirm the data analyzed in this report. This is especially important for the modeling factors that used the Landsat data and DEMs. The best available Landsat data was taken on September 14, 2000. When Landsat 8 imagery becomes more widely available it might be useful to repeat the C-Factor analysis. Currently, there are no clear images available for the land area covered in this study. For the Conservation Practice Factor (P) the worst case scenario was used. If data becomes available regarding the land management practices in the area, the shapefile used in this report should be updated to better characterize the watershed.

Works Cited

[1] U.S Environmental Protection Agency, "Protecting Water Quality from Agricultural Runoff," EPA Publication No. EPA 841-F-05-001, Washington DC, 2005.

[2] C. W. Authority, "Chatfield Watershed Plan," 2012.

[3] W. McDowell, C. Brick, M. Clifford, M. Frode-Hutchins, J. Harvala and K. Knudsen, "Septic System Impact on Surface Water," Tri-State Water Quality Council, 2005.

[4] TCHD, "Septic Systems - Onsite Wastewater Systems," 2013. [Online]. Available: http://www.tchd.org/septic.htm. [Accessed 19 September 2013].

[5] US Census Bureau, "American Fact Finder," 2013. [Online]. Available: http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t. [Accessed 19 September 2013].

[6] DWR, "Well Permitting," 2013. [Online]. Available: http://water.state.co.us/groundwater/wellpermit/Pages/default.aspx. [Accessed 20 September 2013].

[7] U.S. Department of Agriculture , Soil Survey Manual, Lincoln: National Soil Survey Center, 1993.

[8] EPA, *Onsite Wasewater Treatment Systems Manual,* 2002.

[9] W. Robertson, "A case study of ground water contamination from a domestic septic system: 7. persistence of dichlorobenzene," *Environmental Toxicology and Chemistry,* pp. 1-192, 1991.

[10] K. Dano, E. Poeter and G. Thyne, "Investigation of the Fate of Individual Sewage Disposal System Effluent in Turkey Creek Basin, Colorado," Colorado School of Mines, Golden, 2004.

[11] C. Solomon and G. Knowles, "Onsite Sewage Disposal System Management," South Carolina Department of Health and Environmental Control, Beaufort County, South Carolina, 2002.

[12] Charlotte Harbor Environmental Center, "Assessing the Densities and Potential Water Quality Impacts," Charlotte, 2003.

[13] A. Adaikpoh, "Assessment of Shallow Aquifers Contamination by Failure of on-Site Sewage Disposal System in Ughelli, Western Niger Delta, Nigeria," *Journal of Environment and Earth Science,* pp. 208-216, 2013.

[14] FEMA, "Definitions of FEMA Flood Zone Designations," 2013. [Online]. Available: http://www.fema.gov/.

[Accessed 22 September 2013].

[15] Town of Castle Rock, "Town Mapping Catalog," 13 June 2012. [Online]. Available: http://crgov.com/index.aspx?nid=1253. [Accessed 22 September 2013].

[16] F. L. Woodward, F. J. Kilpatrick and P. Johnson, "Experiences with groundwater contamination in unsewered areas in Minnesota," *American Journal of Public Health,* no. 51, pp. 1130-1136, 1961.

[17] Dutchess County Water & Wastewater Authority, "Dutchess County Aquifer Recharge Rates & Sustainable Septic System Density Recommendations," The Chazen Companies, Poughkeepsie, NY, 2006.

[18] G. Wall, D. Coote, E. Pringle and I. Shelton, "Revised Universal Soil Loss Equation for Application in Canada," Agriculture and Agri-Food Canada, Ottawa, 1997.

[19] K. Renard, G. Foster, G. Weesies, D. McCool and D. Yoder, "Predicting soil erosion by water: a guide to conservation planning with the revised universal soil loss equation (RUSLE)," U.S. Government Printing Office, Washington DC, 1997.

[20] Natural Resources Conservation Service, "Geospatial Data Gateway," United States Department of Agriculture, 8 7 2013. [Online]. Available: http://datagateway.nrcs.usda.gov/. [Accessed 21 10 2013].

[21] North Carolina State University, "Erosion and Sediment Control," 1999. [Online]. Available: http://www.bae.ncsu.edu/bae/workshops/dot/. [Accessed 22 10 2013].

[22] W. Wischmeier and D. Smith, "Predicting Rainfall Erosion Losses- A Guide to Consrvation Planning.," U.S. Department of Agriculture, Washington, D.C., 1978.

[23] J. M. Van der Knijff, R. A. Jones and L. Montanarella, "Soil Erosion risk Assessment in Europe, European Commission, European Soil Bureau," 2000. [Online]. Available: http://eusoils.jrc.ec.europa.eu/ESDB_Archive/pesera/pesera_cd/pdf/ereurnew2.pdf. [Accessed 22 10 2013].

[24] S. Lee, "Soil erosion assessment and its verification using the universal soil loss equation and geographic information system: A case study at Boun, Korea," *Environmental Geology,,* vol. 45, p. 457–465, 2004.

[25] T. Lillesand and R. Kiefer, Remote sensing and image interpretation 4th Edition, New York: Wiley, 1999.

[26] G. Firl and L. Carter, "Mosaicking and Clipping Landsat Data," [Online]. Available: http://ibis.colostate.edu/WebContent/WS/ColoradoView/TutorialsDownloads/CO_RS_Tutorial8.pdf. [Accessed 22 October 2013].

Geospatial Analysis of Individual Sewage Disposal Systems and Stream Bank Erosion Within the Plum Creek Watershed

Project Goals and Approach

Goals

The goals of the geospatial analysis of the Plum Creek Watershed were to:

- Determine areas of concern regarding individual sewage disposal systems (ISDS)
- Identify potential areas of erosion along the stream bank and within the floodplain

ISDS

Assess physical land characteristics within the Plum Creek Watershed.

- Aquifer information
- Soil characteristics
- Extent of floodplain

Gather data on wells and population characteristics.

Description of Analysis

Using the ArcGIS program suite's data management, spatial analyst and raster management tools, areas of concern were determined for ISDS within the Plum Creek Watershed.

Stream Bank Erosion

Assess physical land characteristics within the Plum Creek Watershed.

- Soil characteristics
- Slope length and gradient
- Runoff factors

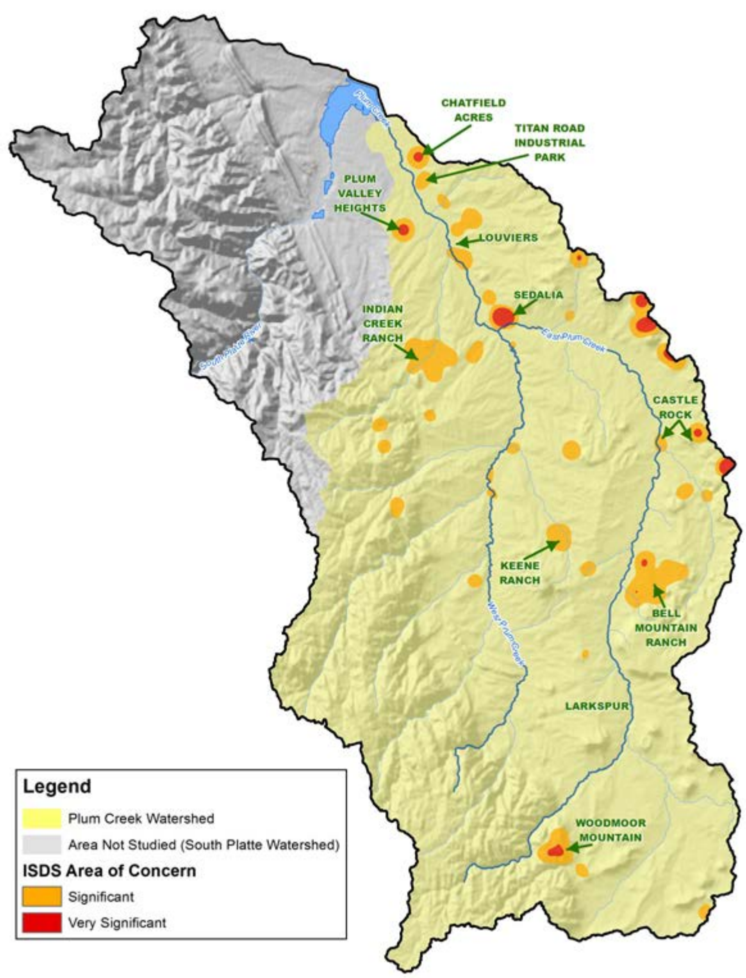
Gather data on land cover, conservation practices and annual precipitation.

Description of Analysis

Using the Revised Universal Soil Loss Equation (RUSLE), and the ArcGIS program suite's spatial analyst and raster management tools, areas with high erosion potential within the floodplain were identified.

ISDS: Project Findings and Conclusions

General information regarding ISDS was combined with specific soil properties to spatially analyze potential locations contributing to pollution loading via the Plum Creek Watershed into Chatfield Reservoir. The areas identified should serve as a starting point for further water quality analysis. Hydrologic soil type, density of structures and the age of the structures had the largest impact on the spatial calculation. 2.5% of the ISDS within the watershed were located in a concerning proximity to Plum Creek and its adjoining tributaries.



Characteristics Used to Determine Areas of Concern
Proximity to stream
Hydrologic soil group
Age of structure
Depth of well and aquifer
Flood zone location
Concentration of people and structure density

Stream Bank Erosion: Project Findings and Conclusions

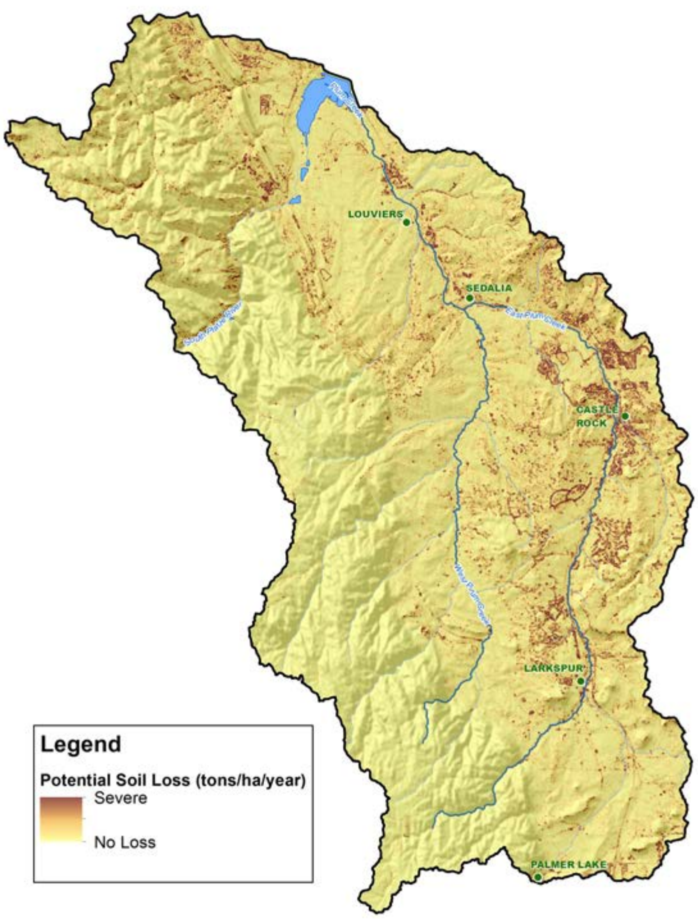
The RUSLE was originally developed by the United States Department of Agriculture (USDA) as a field scale model to help quantify the average annual rate of erosion based on rainfall pattern, soil type, topography, crop system and management practices. It has been modified over time resulting in the following equation:

$$A = R * K * LS * C * P$$

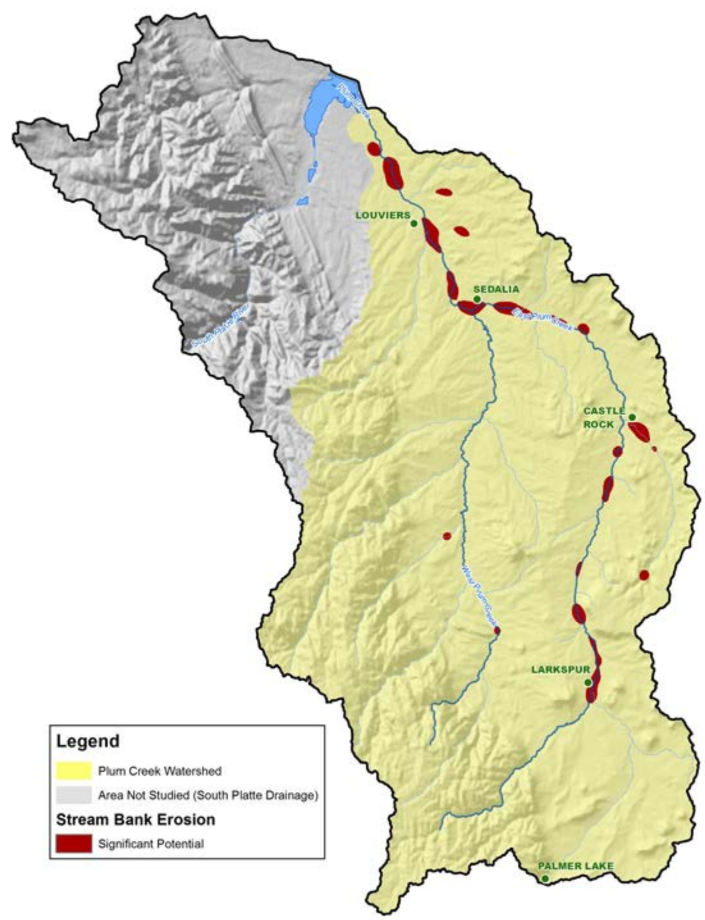
A =	Computed soil loss per unit area
R =	Rainfall and runoff factor
K =	Soil erodibility factor
LS =	Slope-length and slope-steepness factor
C =	Cover and management factor
P =	Conservation practice factor

Each parameter in the equation is a mathematical estimate of a specific condition that affects the severity of soil erosion at a particular location. The ArcGIS program suite's spatial analyst and raster management tools were used to spatially compute soil loss per unit area for the Chatfield Watershed and the potentially impacted stream banks within the Plum Creek Drainage.

Computed Soil Loss Per Unit Area



Potentially Impacted Stream Banks Within the Plum Creek Drainage



APPENDIX G

AGENCIES RESPONSIBLE FOR WILDFIRE MANAGEMENT

Agencies Responsible for Wildfire Management Activities

A summary of entities who are currently involved with pre-and post-wildfire management activities is presented in Table F-1. Wildfire issues require the ability to work together in a multi-jurisdictional environment; therefore, the Chatfield Watershed Plan encourages continued collaboration between these entities as well as strong outreach to and involvement of private landowners. Private landowners play a significant role in protecting the watershed's resources by providing opportunities for fuels treatment projects.

Table F-1. Partners and Resources for Wildfire Management Efforts

	Pre-wildfire efforts	Post-wildfire efforts
USFS	•	•
CSFS	•	•
Local CSFS and NRCS districts	•	•
Counties (Jefferson and Douglas)	•	•
Local government entities	•	•
FRWWP	•	
FRFTP	•	
CUSP	•	•
SPEB	•	

- *U.S. Forest Service (USFS)*

The U.S. Forest Service (USFS) manages national forests for multiple uses and benefits and for the sustained yield of renewable resources such as water, forage, wildlife, wood, and recreation. The USFS manages approximately 48,500 acres of public land in Chatfield Watershed (USFS 2013b). Lands managed within the Upper South Platte River basin are part of the Upper South Platte Watershed Protection and Restoration Project (USPWPRP), which the study area did not include the Chatfield Watershed; however, it does impact the downstream waterbodies as described above. The USPWPRP is a long-term partnership between the USFS, Colorado State Forest Service (CSFS), Denver Water, and other federal, state, and local stakeholders. The goals of the USPWPRP are to protect water quality for all users, reduce risks of large catastrophic wildfires, create sustainable forest conditions in the Upper South Platte River basin, and integrate research, monitoring, and management. Over 30,000 acres have been treated on Denver Water and USFS lands in the Upper South Platte Watershed through USPWPRP (Douglas County 2011). In July 2010, Denver Water and the USFS collaborated to improve forest and watershed health by reducing the risk of wildfires through a 5-year Operating Plan (2011-2015) also known as From Forests to Faucets Program. The Operating Plan identifies and implements joint projects aimed at reducing catastrophic fire risk in Denver Water's priority watersheds to promote water quality in Jefferson and Douglas counties (Denver Water 2013).

- *National Resources Conservation Services (NRCS)*

The USDA Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service, is a federal agency that works to conserve natural resources on private lands. NRCS administers the Emergency Watershed Protection (EWP) Program, which responds to emergencies created by natural disasters. EWP is an emergency recovery program designed to help people and conserve natural resources by relieving imminent hazards caused by fires and other natural occurrences. Recovery activities include providing financial and technical assistance to remove debris from streams, protect destabilized streambanks, establish cover on critically eroding lands, repairing conservation practices, and the purchase of flood plain easements. NRCS may bear up to 75 percent of the construction cost of emergency measures, but the remaining 25 percent must come from local sources and can be in the form of cash or in-kind services (NRCS 2013).

NRCS consists of conservation districts that serve as local units that work alongside local, state, and federal partners to conserve natural resources within district boundaries. Jefferson Conservation District and Douglas County Conservation District are two districts whose jurisdictions include in the Chatfield Watershed.

- *Colorado State Forest Service (CSFS)*

The Colorado State Forest Service (CSFS) is the lead state agency for forestry and wildfire mitigation. The primary responsibility of CSFS is to provide technical assistance to private landowners and communities on forest management and wildfire mitigation projects. CSFS also works with federal partners to implement forestry projects across jurisdictional boundaries. In the Upper South Platte River basin, CSFS and Denver Water have partnered since 1998 to manage Denver Water properties within the watershed. Projects include forest restoration activities, post-fire erosion control, reforestation, defensible space around infrastructure, and forest health improvement.

CSFS also administers the Forest Agriculture Program (Forest Ag Program). This is a voluntary program through which Colorado landowners with a minimum of 40 forested acres can actively manage their properties under the guidance of a forest management plan with the intent of producing tangible wood products for the primary purposes of obtaining a profit. In return, landowners are eligible to receive similar tax valuation as traditional agricultural lands (CSFS 2013b). The Forest Ag Program promotes forest health and stewardship, wood products utilization, sustainable forest management, reduced threat of catastrophic wildfire, and reduced fragmentation of forested lands. Properties involved with the Forest Ag Program carry out work plans such as forest thinning, beetle-kill trees, and fire mitigation work, all which are aimed towards promoting watershed health, including water quality.

- *Local Districts (NRCS and CSFS)*

Many state and federal agencies have local districts that can serve as resources for private land owners or local organizations. The NRCS has several conservation districts that work within the Upper South Platte River basin and Chatfield Watershed boundaries such as the Jefferson Conservation District and Douglas County Conservation District. Local districts within CSFS that also work in these Front Range watersheds include the Franktown and Golden CSFS Districts.

To help implement forest management plans or CWPPs, local districts connect private landowners with financial, educational, and technical resources. Technical assistance can come in the form of providing technical information, making management recommendations, and writing technical guidances. These local districts may also help identify funding resources or assist in writing grant applications. For example, local districts can guide qualifying landowners through the Environmental Quality Incentives Program (EQIP) application and planning process. Although these local districts do not award EQIP funding, they can help facilitate project implementation by managing funds once they are awarded. EQIP is a federal program administered by NRCS and the Farm Service Agency (FSA). EQIP funds can only be directed to individual landowners that meet certain requirements. For landscape-scale projects, local agencies can apply to state, federal, and private grant programs to fund larger-scale forest health projects covering multiple landowners. These larger scale projects make a real impact on the health of the forest across a wider area, and grant funds typically come from the CSFS and NRCS (JCD 2013; Pam Brewster, personal communication, July 17, 2013).

- *Douglas County*

Douglas County works to reduce fire hazards and potential for catastrophic loss through active forest management of its forested open space parcels, such as Spruce Mountain and Dawson Butte Ranch. Forest management plans have been developed for these two large tracts of open space and efforts have already taken place to improve forest health and reduce wildfire hazards.

In 1999, Douglas County recognized the need to bring wildfire mitigation and forest management issues related to wildfire to the forefront of the land use process. Douglas County created the Wildfire Hazard Overlay District, a Zoning Overlay District, as part of the County Zoning Resolution, which identifies hazard areas and required mitigation measures. Implementation of this overlay district places responsibility of mitigating hazards (hazardous fuels reduction) on the developer instead on the property purchaser, resulting in a pro-active approach in implementing fire mitigation actions and promoting water quality (Douglas County 2011).

- *Front Range Watershed Wildfire Protection Working Group and the Front Range Fuels Treatment Partnership*

Front Range Watershed Wildfire Protection (FRWWP) Working Group and the Front Range Fuels Treatment Partnership (FRFTP) consist of federal and state agencies, land management agencies, water supply providers, private landowners, and conservation organizations. These organizations are committed to reducing wildfire risks in the Front Range watersheds and are working together to develop a strategic action plan with three main focuses:

1. Improving watershed data for GIS analysis and creating a model for conducting watershed assessments that identify and prioritize 6th-level watersheds for potential treatment.
2. Developing guidelines for Critical Community Watershed Wildfire Protection Plans to promote prompt and effective forest treatments that reduce wildfire hazards in critical source watersheds.
3. Developing a strategy for public education that will help build broad support and promote investments in actions that fortify forests against severe wildfires in source watersheds.

The Front Range Fuels Treatment Roundtable (Roundtable) serves as a focal point for diverse stakeholder input into the FRFTP's efforts. The Roundtable is made up of several working teams, one of which is the Community Protection Working Team (FRFTP 2013). This working team focuses on funding for implementation of CWPP and aims to develop a case study on positive, effective aspects of CWPPs. In 2009, the Front Range Watershed Protection Data Refinement Work Group prepared a report that adapted and refined methods to assess individual watersheds within the 10-counties of the FRFTP. This report summarizes information and provides a template for watershed assessments to identify critical watersheds that supply community or municipal water (Front Range Watershed Protection Group 2009).

- *Neighboring Watershed Organizations*

To promote successful and effective wildfire management efforts, Chatfield Watershed wildfire-related activities should extend beyond the Chatfield Watershed boundary and consider actions within the larger Upper South Platte River Basin, which includes the Chatfield Watershed. Key organizations for coordination and support include the Coalition of the Upper South Platte (CUSP) and the South Platte Enhancement Board (SPEB). Both CUSP and SPEB are committed to protecting valuable watershed resources by supporting cooperative management strategies and projects related to planning, implementation, and monitoring. These organizations have also established relations with federal, state, and local entities. Working through CUSP and SPEB, as well as Front Range entities such as FRWWP and FRFTP, provides opportunities to support larger causes and work within established relationships to achieve the shared goal of protecting valuable resources.

APPENDIX H

FRAMEWORK FOR VOLUNTEER WATER QUALITY MONITORING

INTRODUCTION

Volunteers are critical to developing and sustaining the Chatfield Watershed Plan, building stewardship of local waters, and assessing the conditions of the waterbodies in our watershed. Volunteer monitoring promotes our education and outreach efforts in the Chatfield Watershed by enabling citizens, including students in the watershed, to learn more about their water resources, become advocates for the Chatfield Watershed, and increase the availability and amount of needed water-quality information.

Volunteer monitoring can help produce and convey water quality information needed to understand and protect our waters. This proposed monitoring framework document discusses how trained volunteers can support Chatfield watershed monitoring efforts, including collecting data and information on the condition of waterbodies in Chatfield Watershed, including Plum Creek, South Platte River, Deer Creek, and Massey Draw, and groundwater resources.

Building off the Chatfield Watershed Authority's (Authority) existing monitoring programs and the National Water Quality Monitoring Council's (NWQMC) systematic monitoring framework, this proposed volunteer monitoring framework for the Chatfield Watershed will be used to:

- Facilitate communication among the Chatfield Watershed Authority members and potential volunteers who may work on different elements of monitoring programs in the future (e.g. collecting samples, data analysis/interpretation, documentation, etc.);
- Guide the design of volunteer water quality monitoring programs to ensure that all monitoring network design components are included, balanced, connected, and collectively focused on producing quality information; and consistent with the Authority's Quality Assurance Protocols, Sampling and Analysis Plans, and Standard Operating Procedures (QAP/SAP/SOP, 2007).
- Underscore the need for high quality data and consistent information on water monitoring design methodologies.

VOLUNTEER MONITORING FRAMEWORK

Figure 1 depicts the volunteer monitoring framework with key focus on the need for communication, coordination and collaboration within and among volunteer monitoring entities with the Chatfield Watershed Authority at every step of the process. As shown, the six steps of the monitoring process are:

Develop Monitoring Objectives

The monitoring process begins when information goals are defined to respond to specific water resource management needs. Volunteers should coordinate with the Authority on the monitoring effort and objectives. Questions that need to be

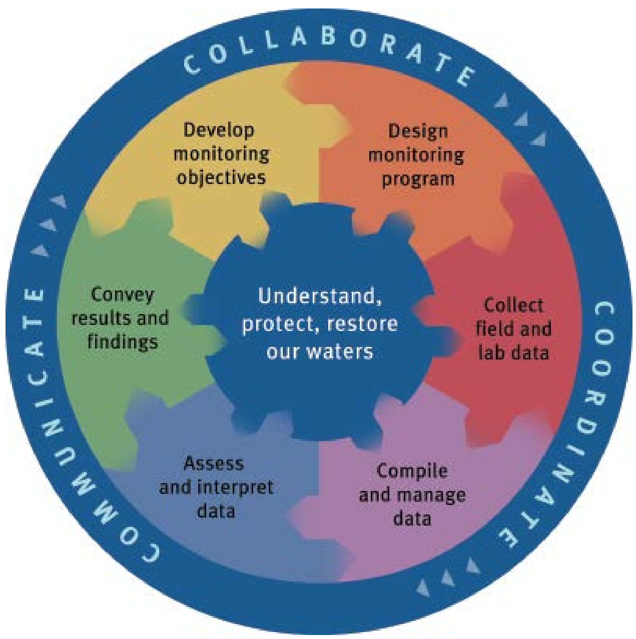


Figure 1 - Volunteer Monitoring Framework Schematic
Source: NWQMC, http://acwi.gov/monitoring/vm/index.html.

answered at this stage include: What is the purpose of the monitoring effort, who will use the data, and how will the data be used?

Design Monitoring Program

The monitoring design must be developed to meet the monitoring objectives. Factors that must be considered and documented at this stage of the process include the environmental setting, location of sampling sites, frequency of sample collection, the constituents to be measured, and the methods to be used in the field and the laboratory. The "Sampling and Analysis Plan" (SAP) document defines sample locations, schedules, list of analytes, and quality assurance/quality control (QA/QC) procedures. The SAP shall be used by monitoring volunteers to guide the sampling effort.

Collect Field and Laboratory Data

Measurements taken in the field and laboratory translate the water's properties into quantitative data that provide information about the status of water quality. Accurate and complete documentation of procedures is essential at this stage of the process. The Chatfield Watershed Authority's standard operating procedures (SOP), adopted by the Board in November 2007, describes the collection, preparation, and handling of surface water samples from streams and reservoirs, alluvial well, and sediment samples (Chatfield Watershed Authority, 2007). These SOPs are applicable to any volunteer water quality monitoring program in the Chatfield Watershed and incorporated by reference. SOPs should be used in conjunction with the SAP.

Compile and Manage Data

Data need to be usable and accessible. It is essential that the data is stored and managed in a manner to allow data evaluation, analyses, and includes sufficient descriptive information about the data (i.e., "metadata") so that it can be shared and compared among managers and the public. Software tools such as Microsoft (MS) Excel© and Access© are recommended by the Authority to compile and manage data.

Assess and Interpret Data

At this point, data starts to become information that will address the monitoring objectives. Ideally, the data interpretation methods have been identified prior to sampling so that the data are collected in direct support of the analysis methodology. Graphical analyses are ideal ways to interpret and evaluate the data for temporal and spatial trends. Anomalous data canl also be identified and flagged in the database so they are not used in statistical analyses.

Convey Findings and Evaluate Program

The information resulting from data interpretation is disseminated, by various means, for use by all stakeholders, including water quality managers, policy makers and the public. Information may be conveyed in various forms depending on the needs and preferences of the audience. User-friendly formats, with graphical representations of tabular data, are typically the best ways to describe data and information, including the following suggestions:

- Seasonality graphical interpretations of watershed data (as sufficient number of data allows).
- Box and whiskers plots of data.
- Time series graphs of data.
- Identification of anomalous data.

- Laboratory procedures and MDLs.
- Comparison of monitoring results to standards and assessment thresholds.
- Discussion of elevated concentrations at certain sampling locations; discussion of field conditions that may have contributed such concentration increase (i.e. large rainfall event occurred over the past 24 hours and the TSS concentration was very high)
- Occasional data discrepancies or potential outliers.
- Follow up on field documentation and conditions (i.e. no free flow of river, only a stagnant puddle of water, etc.)

One of the strengths of the volunteer monitoring framework is the emphasis on feedback with the Chatfield Watershed Authority at every step. The successful application of the volunteer monitoring framework will help to assure that the results of water quality monitoring can be used in the Chatfield Watershed to understand and protect the water we all enjoy.

REFERENCES

Chatfield Watershed Authority. 2007. *"Chatfield Watershed Authority Monitoring Plan - Quality Assurance Project Plan, Sampling and Analysis Plan, and Standard Operating Procedures."* November 2007.

Colorado Water Conservation Board (CWCB). 2013. "*Plum Creek Watershed Monitoring Report*". Data Collection and Analysis. April 2012 – March 2013. Prepared by: Tetra Tech, Inc.

National Water Quality Monitoring Council, http://acwi.gov/monitoring/vm/index.html.

U.S. EPA. 1994. "*Surface Water Sampling,*" EPA ERT SOP #2013, November 1994.

U.S. EPA. 2001. *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.* U.S. Environmental Protection Agency, Region 4, Athens, Georgia. November. Available at: http://www.epa.gov/region4/sesd/eisopqam/eisopqam.pdf.

U.S. EPA. 2004, "*USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review,*" EPA 540-R-04-004, Office of Superfund Remediation and Technology Innovation (OSRTI), October.

U.S. EPA. 2006. "*Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4,*" Office of Environmental Information, EPA/240/B-06/001, February 2006.

U.S. EPA. 1996. "The Volunteer Monitor's Guide to Quality Assurance Project Plans", EPA 841-B-96-003, September 1996.

APPENDIX I

SUMMARY OF CURRENT OR ONGOING CHATFIELD WATERSHED PROJECTS

Implemented or On-going Projects and Efforts in Chatfield Watershed

Agricultural Activities

- Zoning regulations (within Jefferson and Douglas Counties)
- Manure Management Policy (adopted by the CWA)
- CALF at Lowell Ranch (hosting volunteering and education programs)
- CALF at Lowell Ranch, East Plum Creek baseline inventory of the impaired reach of the creek at Lowell Ranch with the assistance of an NRCS EQIP grant (2014)

Septic Systems

- Septic System Use Permit programs requiring inspections and Use Permits prior to property sales (Jefferson County Health Department and Tri-County Health Department)
- Tri-County Health Department (2008) Douglas County Nitrate Study (Study to assess the impacts of nearby ISDS on nitrate levels in wells)

Streambank Stabilization

- East Plum Creek Watershed Master Plan (2009, Town of Castle Rock)
- Sellars Gulch Stabilization (2009, Town of Castle Rock)
- 6400 West Tributary Stabilization (2011, Town of Castle Rock)
- Hangmans Gulch Stabilization (2011, Town of Castle Rock)
- East Plum Creek Stabilization (2012, Town of Castle Rock)
- Massey Draw Water Quality and Habitat Improvement Project (2006)
- Massey Draw Stream Restoration at Ken Caryl Ranch (2011, Ken Caryl Ranch Master Association and CWCB)
- Marcy Gulch Channel Improvement Project (South Platte Tributary)
- Iron Horse Open Space – Streambank stabilization, grade control, wetlands plantings (2014, Douglas County and CPW)

Wildfire Management

- County-wide Community Wildfire Protection Plans (Jefferson and Douglas County)
- From Forests to Faucets (Denver Water and USFS Watershed Management Partnership dedicated to improving forest and watershed conditions to protect water supplies and water quality)