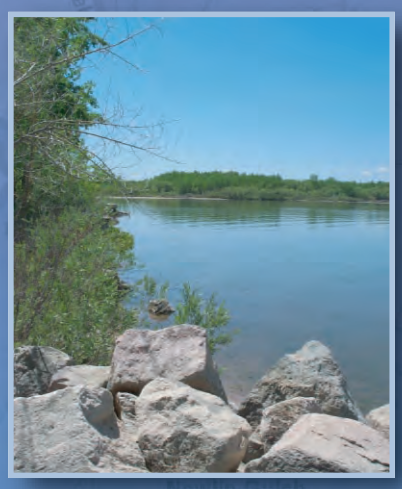
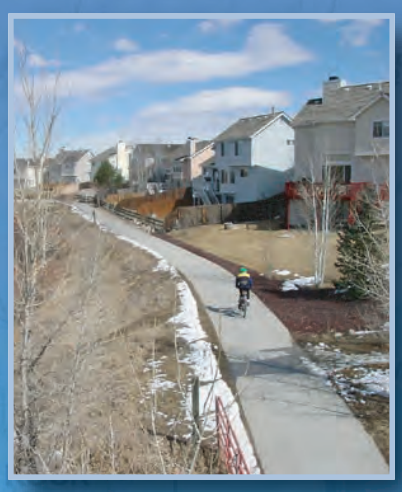




CHERRY CREEK RESERVOIR WATERSHED PLAN 2003

August 2003 Edition

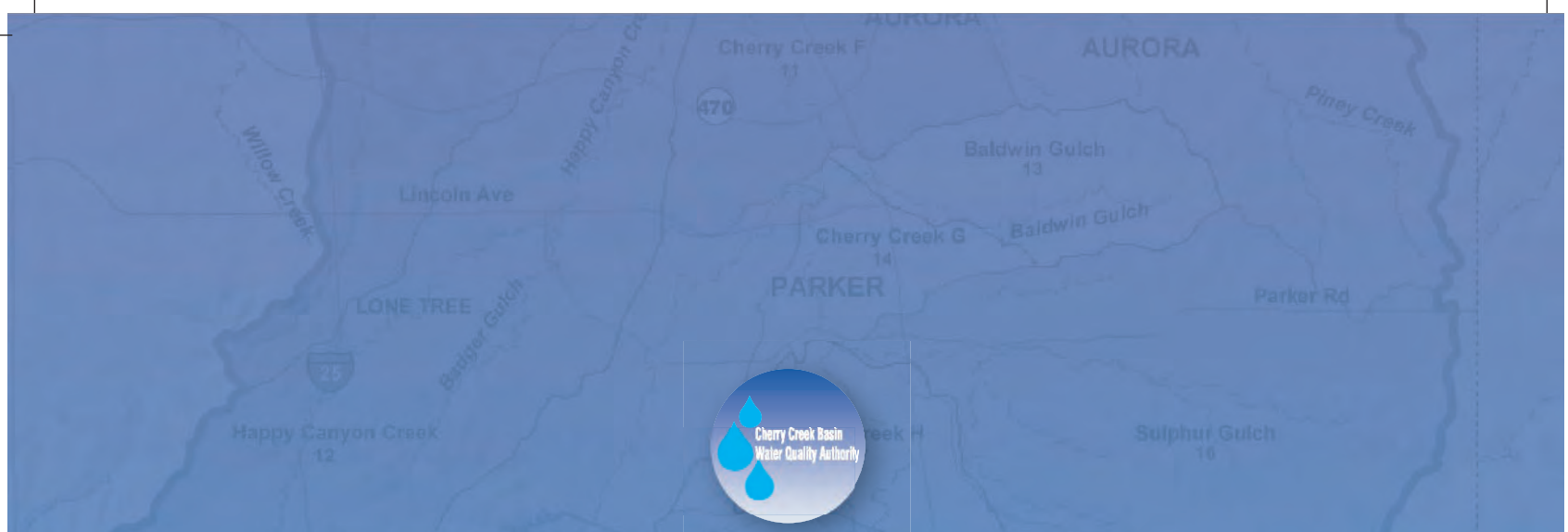
a strategic approach for achieving water quality goals

prepared for:

Cherry Creek Basin
Water Quality Authority
R.S. Wells Corporation
6399 South Fiddlers Green Circle
Suite 102
Greenwood Village, CO 80111

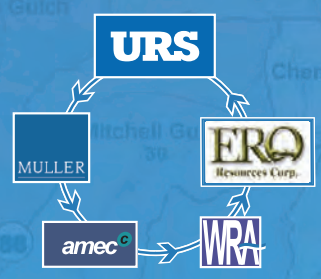
prepared by:

URS Corporation
Muller Engineering
AMEC, WRA, ERO



CHERRY CREEK BASIN WATER QUALITY AUTHORITY

R.S. Wells Corporation
6399 South Fiddlers Green Circle
Suite 102
Greenwood Village, CO 80111



URS CORPORATION
8181 E. Tufts Ave.
Denver, CO 80237

MULLER ENGINEERING CO., INC.
Irongate 4, Suite 100
777 South Wadsworth Blvd.
Lakewood, CO 80226

AMEC
3800 Ezell Road, Suite 100
Nashville, TN 37211

WATER RESOURCE ASSOC., INC.
P.O. Box 3326
Kirkland, WA 98083-3326

ERO RESOURCES CORP.
1842 Clarkson St.
Denver, CO 80218

Table of Contents

Executive Summary

ES.1 Water Quality Goals Support Vision ES-04
ES.2 Plan Recommendations and Identified Opportunities ES-05
ES.3 Conceptual Costs to Implement the Plan ES-09

Chapter 1 - Watershed Vision And Strategy

1.1 Cherry Creek Watershed Vision 1-03
1.2 Cherry Creek Reservoir Watershed Goals and Objectives 1-04
1.3 Public Information, Education and Outreach 1-05

Chapter 2 Watershed History

2.1 Reservoir Condition and Trends 2-01
2.2 Watershed Condition 2-08
2.2.1 Stream and Alluvial Monitoring 2-08
2.2.2 Cherry Creek Stream Stability 2-10
2.2.3 Land Use 2-11
2.2.4 Impervious Cover 2-11
2.3 Water Supplies 2-12
2.4 Point Source Discharges 2-13
2.5 Stormwater Discharges 2-15
2.6 Other Nonpoint Sources 2-16
2.7 Pollutant Reduction Facilities 2-17
2.8 Watershed-Based Trading 2-19
2.9 Watershed Management Structure 2-20
2.10 Cherry Creek Stakeholders 2-21
2.11 Other Watershed Programs 2-22

Chapter 3 Watershed Analysis

3.1 Existing and Projected Conditions in the Watershed 3-01
3.1.1 Phosphorus in the Watershed 3-02
3.1.2 Urbanization Effects 3-05
3.1.3 The Cherry Creek Stream Network 3-19
3.2 Strengths, Weaknesses, Opportunities and Threats 3-36
3.3 Conclusions and Recommendations 3-37

Chapter 4 Cherry Creek TMAL

Chapter 5 Funding Needs and Alternatives

5.1 Funding Concepts 5-02
5.2 Funding Sources and Opportunities 5-03
5.3 Business Plan 5-09
5.4 Summary of Funding Recommendations 5-11

Chapter 6 Recommendations and Water Quality Management Strategies

Chapter 7 References

Tables

Table ES-1 Cherry Creek Reservoir Watershed Plan Goals
Table ES-2 Watershed Plan 2003 Recommendations and Opportunities
Table 1-1 Reservoir and Watershed Goals and Objectives
Table 1-2 Public Information, Education and Outreach Goals and Objectives
Table 2-1 Water Quality Standards for Cherry Creek Reservoir Watershed
Table 2-2 Reservoir Water Quality Summary
Table 2-3 Subwatershed Categories in the Cherry Creek Reservoir Watershed
Table 2-4 Total Maximum Annual Load
Table 2-5 Annual Allocations of Phosphorus by WWTF
Table 2-6 2003 CIP Plan
Table 3-1 Subwatershed Categories and Management Implications
Table 3-2 Cherry Creek Subwatershed Priorities
Table 3-3 Potential Stormwater Runoff in Cherry Creek Watershed
Table 3-4 Strengths, Weaknesses, Opportunities and Threats Summary
Table 4-1 Cherry Creek TMAL
Table 4-2 Summary of Phosphorus Wasteload Allocations
Table 4-3 Summary of Future Activities to Revise the TMAL- Years 1-3
Table 4-4 Control Regulation Review and Status
Table 6-1 Watershed Plan 2003 Recommendations and Opportunities

Figures

Figure ES-1 Phosphorus Flows and Loads
Figure ES-2 Chlorophyll a Trends
Figure ES-3 Total Phosphorus Trends in Cherry Creek Reservoir
Figure 1-1 Cherry Creek Reservoir Watershed and Subwatershed Locations and Names
Figure 1-2 Vision Supports Goals and Objectives
Figure 2-1 Cherry Creek State Park Visitation
Figure 2-2 Cherry Creek Reservoir
Figure 2-3 Sampling Sites on and near Reservoir
Figure 2-4 Increase in Phosphorus Loads to the Reservoir
Figure 2-5 Chlorophyll a Trends
Figure 2-6 Reservoir Transparency
Figure 2-7 Total Phosphorus Concentrations Upstream of Reservoir
Figure 2-8 Total Phosphorus Concentrations at Cottonwood Creek Upstream of Reservoir
Figure 2-9 Total Phosphorus Trends in Cherry Creek Reservoir
Figure 2-10 Cherry Creek Phosphorus Loading Mass-Balance Schematic (2002)
Figure 2-11 Surface and Groundwater Monitoring Points
Figure 2-12 Total Dissolved Phosphorus Concentrations Near the Reservoir
Figure 2-13 2002 Phosphorus Loads Along Cherry Creek
Figure 2-14 Nitrogen Concentration from Nonpoint Sources
Figure 2-15 Original PRFs (Historic Trade Projects) Constructed by the Authority
Figure 2-16 Lower Cottonwood Creek Stream Reclamation PRF
Figure 2-17 Bowtie Wetlands PRF
Figure 2-18 Cherry Creek State Park Wetlands
Figure 3-1 Total Phosphorus Concentrations
Figure 3-2 Year 2000 Land Use
Figure 3-3 Year 2020 Land Use
Figure 3-4 Urbanization in Cherry Creek Watershed
Figure 3-5 Estimated Storm Runoff for 1963 Development Conditions
Figure 3-6 Estimated Storm Runoff for 2000 Development Conditions
Figure 3-7 Estimated Storm Runoff for 2020 Development Conditions
Figure 3-8 Estimated Total Phosphorus Loads from Storm Runoff for 1963 Development Conditions
Figure 3-9 Estimated Total Phosphorus Loads from Storm Runoff for 2000 Development Conditions
Figure 3-10 Estimated Total Phosphorus Loads from Storm Runoff for 2020 Development Conditions

Figure 3-11 Major Subwatershed Prioritization
Figure 3-12 Subbasin Boundaries
Figure 3-13 Subwatershed Prioritization
Figure 3-14 Estimated Stormwater Runoff for Cherry Creek Mainstem
Figure 3-15 Estimated Stormwater Runoff for Cherry Creek Tributaries
Figure 3-16 Estimated Percent Increase in Storm Runoff 1963-2000
Figure 3-17 Estimated Percent Increase in Storm Runoff 2000-2020
Figure 3-18 Estimated Percent Increase in Storm Runoff 1963-2020
Figure 3-19 Stormwater Quality Rating
Figure 3-20 Degradation Impacts to Cherry Creek Corridor
Figure 3-21 Stream Stabilization Costs
Figure 3-22 Example Stream Inspection Inventory Map
Figure 3-23 Water/Phosphorus Balance
Figure 5-1 Economic Value of Cherry Creek State Park

ACRONYMS & ABBREVIATIONS

ac-ft acre-feet

AWT Advanced Water Treatment

BMPs Best Management Practices

BUREC Bureau of Reclamation

CDPHE Colorado Department of Public Health & Environment

CEC Chadwick Ecological Consultants, Inc.

CIP Capital Improvement Project

COE U.S. Army Corps of Engineers

CWSD Cottonwood Water and Sanitation District

DRCOG Denver Regional Council of Governments

EPA Environmental Protection Agency

EQIP Environmental Quality Incentives Program

ESC/WQ Erosion and Sediment Control and Water Quality

FEMA Federal Emergency Management Association

FHWA Federal Highway Administration

ft/ft feet per foot

HUD Housing Urban Development

MS4 Municipal Separate Storm Sewer System

NPDES National Pollutant Discharge Elimination System

NPS National Park Service

NRCS Natural Resource Conservation Service

PRFs Pollutant Reduction Facilities

SWOT Strengths, Weaknesses, Opportunities and Threats

TABOR Taxpayers Bill of Rights

TMAL Total Maximum Annual Load

TPL Trust for Public Lands

UDFCD Urban Drainage & Flood Control District

USFWS U.S. Fish and Wildlife Service

USGS U.S. Geological Survey

WHIP Wildlife Habitat Incentives Program

WQCC Water Quality Control Commission

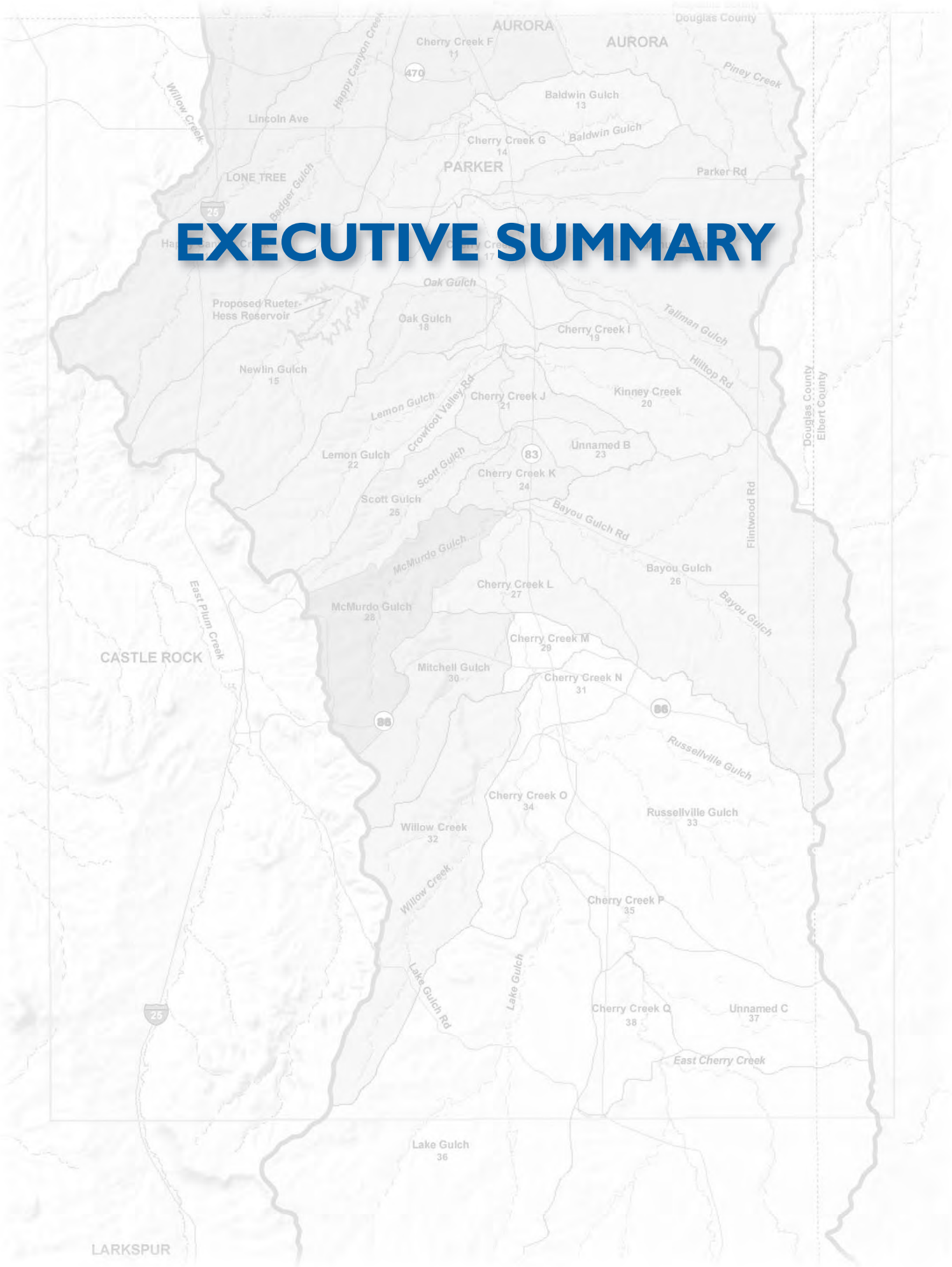
WQCD Water Quality Control Division

WRDA Water Resources Development Act

WRP Wetlands Reserve Program

WWTF Wastewater Treatment Facility

WWTP Wastewater Treatment Plant



EXECUTIVE SUMMARY

The Cherry Creek Reservoir *Watershed Plan 2003* is a strategic plan for achieving water quality goals.

The *"Cherry Creek Reservoir Watershed Plan 2003"* (*Watershed Plan 2003*) provides a menu of water quality management strategies developed to achieve water quality goals and objectives. The Cherry Creek Reservoir and surrounding State Park serve as an important urban recreational amenity, providing opportunities for wildlife habitat, sport fishing, boating, swimming, bicycling, bird watching, horseback riding, and hiking. Located in metropolitan Denver, this "oasis" is an urban jewel to citizens along the Front Range of Colorado.

Reservoir health and quality is generally measured as a function of a variety of chemical, physical, and biological constituents, namely, transparency (Secchi depth), phytoplankton density, chlorophyll a levels, temperature, dissolved oxygen concentration, total phosphorus concentration, total nitrogen concentration, and inflow. Phosphorus and chlorophyll a are key constituents of concern in the Cherry Creek Reservoir. Water quality standards have been adopted to control algal production, or eutrophication, of the reservoir, through limits on phosphorus and chlorophyll a concentrations.

The chlorophyll a standard of 15-µg/L and the phosphorus goal of 40-µg/L were established by the Colorado Water Quality Control Commission (WQCC) to protect the aquatic life and recreational uses of the reservoir. These standards and goals often have not been met. Water quality data collected since 1987 demonstrates the water quality/quantity nexus of flows and phosphorus loads - with the increases and decreases in flows leading to a corresponding increase and decrease in phosphorus loads (**Figure ES-1**). This was

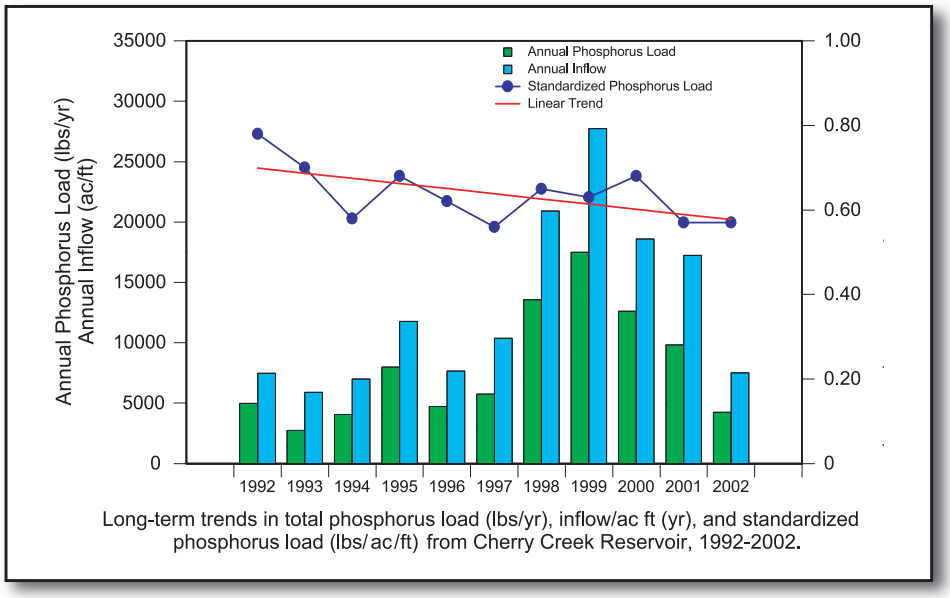


Figure ES-1. Phosphorus Flows and Loads

particularly evident during the recent drought period. Further, during the July through September period, data suggests slight increasing trends for chlorophyll a (**Figure ES-2**) and a generally increasing trend for phosphorus in the reservoir (**Figure ES-3**).

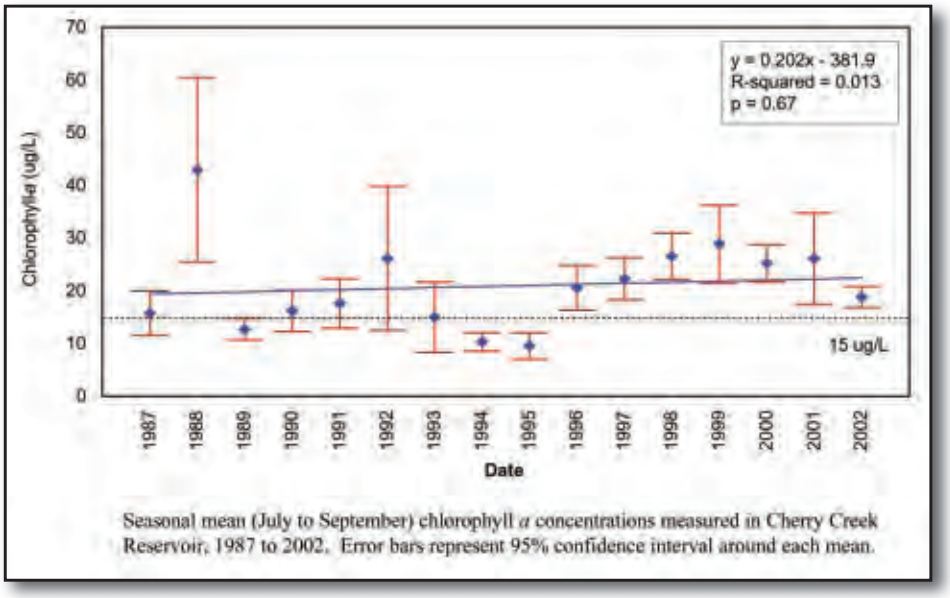


Figure ES-2. Chlorophyll a Trends

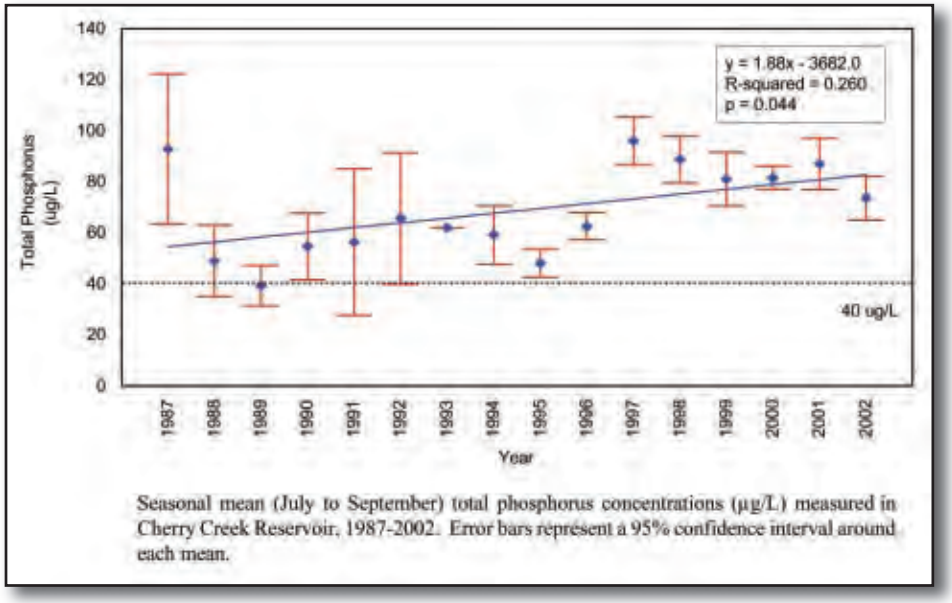


Figure ES-3. Total Phosphorus Trends in Cherry Creek Reservoir

Conversely, the phased Total Maximum Annual Load (TMAL) of 14,270 pounds has consistently been met. This phased TMAL will evolve, as further studies refine the TMAL and identify constituents to be controlled or additional control measures. However, until sufficient studies and investigations are completed, a new TMAL cannot be calculated. The phased TMAL process provides for the adoption of both point source and nonpoint source controls that will provide protection for the reservoir, while additional studies of contributing problems to reservoir quality are investigated and any additional necessary

control programs are formulated (WQCC, 2000). Additional studies to update the phased TMAL are under way; in the meantime a variety of water quality control measures have been implemented and new projects investigated.

Regardless of the uncertainty of what the new TMAL may be, water quality control strategies need to be implemented and phosphorus loads need to be reduced.

Without additional management strategies, overall phosphorus loading from the watershed is expected to increase in the future, primarily as a function of the following predicted increases in the watershed: stormwater runoff, stormwater phosphorus concentrations, and stream erosion. Without action, the predicted phosphorus load increase reduces the likelihood that reservoir standards and beneficial uses will be met in the future.

The *Watershed Plan 2003* is a dynamic document in that regular updates and revisions are not only anticipated, but necessary for this plan to be effective. The document outlines strategies to protect and enhance water quality in the Cherry Creek Reservoir Watershed. As the name implies, the focus of the *Watershed Plan 2003* is water quality management strategies in the watershed; in-lake management strategies are not presented in this report, as they are not viable at this time.

Specifically, the *Watershed Plan 2003* is a guide that:

- Defines goals and objectives to support the water quality mission and vision for the Cherry Creek Reservoir watershed.
- Assesses reservoir and watershed health, looking at its watershed history, trends, and condition.
- Identifies key water quality issues and key studies, such as evaluation of phosphorus fate and transport issues.
- Sets forth management strategies and presents a coordinated effort and partnership plan between the Authority and land use agencies to improve water quality in the reservoir and the watershed.
- Provides local governments with management tools to facilitate informed water quality decisions.
- Identifies potential funding mechanisms to support implementation of plan recommendations and identified opportunities.
- Encourages preservation of the unique ecology of the Cherry Creek Reservoir Watershed to enhance water quality.
- Promotes informing and educating the public about the challenges and opportunities for water quality protection in the Cherry Creek Reservoir Watershed.
- Presents recommendations and opportunities for consideration to achieve water quality goals.

Many activities to support water quality improvement, such as the fate and transport of pollutants in the watershed and the reservoir dynamics that cause algae within the reservoir,

will require more information and studies. Further, even after water quality strategies are implemented, it may take years to see water quality improvement in the reservoir. Regardless, immediate ACTION is key.

ES.1 Water Quality Goals Support the Vision

The Cherry Creek Basin Water Quality Authority (Authority) consists of representatives from two counties, seven cities, a representative from the special district, and seven public representatives appointed by the governor to a board committed to preserving water quality in the Cherry Creek Reservoir Watershed, and achieving water quality goals summarized in **Table ES-1**. The Authority's mission is to "maintain beneficial uses in the Cherry Creek Reservoir by preserving its water quality." The water quality goals support the overarching Cherry Creek Reservoir watershed vision that provides the foundation for the *Watershed Plan 2003*.

"The Vision of the *Cherry Creek Reservoir Watershed Plan 2003* is to integrate watershed goals for community development, water supply, recreation, wildlife habitat and open space with the Authority's water quality mission."

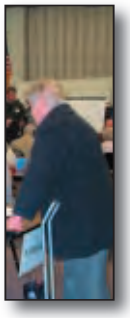
Table ES-1. Cherry Creek Reservoir Watershed Plan Goals

RESERVOIR AND WATERSHED WATER QUALITY MANAGEMENT GOALS

- Maintain and enhance beneficial uses of the reservoir.
- Achieve the 15-µg/L chlorophyll a standard in the reservoir.
- Meet the phosphorus goal for the reservoir of 40-µg/L of total phosphorus.
- Meet the evolving Cherry Creek TMAL for total phosphorus.
- Reduce sediment loads from the watershed.
- Maintain and enhance overall diversity of habitat in the watershed.
- Promote good stewardship of water resources through incentives to public and private interests.

PUBLIC INFORMATION, EDUCATION, AND OUTREACH GOALS

- Work cooperatively with other watershed groups and local agencies to promote watershed health.
- Promote public awareness and involvement in watershed management.
- Promote good stewardship of water resources through leadership, cooperation, financial support, and incentives.



ES.2 Plan Recommendations and Identified Opportunities

The *Watershed Plan 2003* outlines strategies to protect and improve water quality in the Cherry Creek Reservoir Watershed. The document will be revisited annually to track progress and update as changes will be made in the future. A wide variety of management strategies were evaluated against the vision and the water quality goals. Based on the assessment of existing and projected conditions in the Cherry Creek Reservoir Watershed and the relationship between the reservoir and its upstream watershed, the following recommendations and identified opportunities are presented for consideration to achieve water quality goals. **Table ES-2** summarizes recommendations and opportunities in two broader categories of "Reservoir and Watershed Water Quality Management Goals" and "Public Information, Education and Outreach Goals."

Table ES-2. Watershed Plan 2003 Recommendations and Opportunities

RESERVOIR AND WATERSHED WATER QUALITY MANAGEMENT GOALS	
Recommendation	**Consider various funding options to achieve a capital budget increase of $2 million to $4 million annually.**
	Opportunities: • Identify a funding champion to generate financial resources for water quality improvement. In order to secure the financial resources needed, a full time individual with sufficient time, ability, and experience is required to promote the vision, marshal and coordinate resources, steer the effort through state and federal government programs and funding sources, and help coordinate widely varied groups. • Identify and develop new funding mechanisms to meet watershed goals. Implement a variety of federal, state, local, and private funding mechanisms to meet funding goals of an additional $2 to $4 million annually. • Develop an overall business program and financing plan.

RESERVOIR AND WATERSHED WATER QUALITY MANAGEMENT GOALS	
Recommendation	**Implement the Cherry Creek Reservoir Watershed Plan 2003 as a coordinated management program.**
	In close coordination with local governments, implement a management program that will address prioritization, funding, implementation of recommendations, and identification of who does what and when. Track progress and measure benefits. **Opportunities:** • Consider integration of watershed management with source water protection and water resources management. Implement urban best management practices (BMPs) that are designed to promote recharge of the alluvium, pollutant removal, prevent erosion, control downstream flooding, and protect alluvial source water. • Explore incentives for runoff volume controls. Employ advanced techniques to reduce stormwater runoff and phosphorus loading to levels closer to predevelopment conditions. Improve detention of frequent, bank-full storm events influencing stream degradation. • Encourage land use agencies to enhance streams and preserve floodplains. In coordination with the Urban Drainage and Flood Control District (UDFCD) and local governments, preserve floodplains by providing ample flood capacity and freeboard, allowing for future aggradation and increase in riparian vegetation and roughness. Explore proactive reinforcement of natural stream systems, in conjunction with development, to avoid degradation and to create conditions to enhance water quality such as shallow, widespread flow in a well-vegetated riparian corridor. • Coordinate with land use agencies to secure information on existing development, including subdivision names, date of construction, percentage of imperviousness, and any permanent water quality BMPs. Assess correlation of development type and age to stream condition. Use land use agencies' geographic information system data to map information in the watershed. Update information as new development occurs. • Identify a land use agency to manage and serve as a repository for watershed geographic information system tools. These maps and coverages are vital to the management of the watershed and Reservoir. • Cooperate with local land use agencies to acquire access rights or property to construct improvements in privately held stream corridors.
Recommendation	**Fund, design, and construct high priority stream improvements.**
	Implement targeted stream improvements to reduce phosphorus loads. Based on stream inventory and prioritization efforts, fund, design, and construct high priority stream improvements designed to include water quality enhancement. **Opportunities:** • Due to the significant amount of erosion that is currently evident in Piney Creek, Sulphur Gulch, mainstem Cherry Creek, and other streams, streams already undergoing erosion should be addressed as soon as possible. • Proactively stabilize streams predicted to degrade as a result of increased runoff from new development before significant erosion occurs.

RESERVOIR AND WATERSHED WATER QUALITY MANAGEMENT GOALS	
	Opportunities (continued): • Consider conducting an inventory of stream conditions and prioritize improvements. Stream inventories with established protocols provide useful information for locating and prioritizing targeted stream improvements. Coordination with land use agencies on geographic information system mapping will facilitate assessment of stream conditions, maintenance of a digital photo record and assessment rankings. • Consider constructing stream enhancement retrofits in drainageways, particularly in drainageways previously stabilized with hard-lined low flow channels or other high-conveyance approaches • Seek partnerships to acquire conservation easements on stream preservation areas and floodplains to enhance water quality. Establish a buffer network along the Cherry Creek corridor to promote land conservation, protect riparian areas, and stabilize, reclaim, and enhance Cherry Creek and its tributaries.
Recommendation	**Design and construct additional pollutant reduction facilities (PRFs).**
	Continue to identify, design, and construct PRFs in the watershed on the basis of factors such as lowest cost per pound of phosphorus immobilized, most pounds removed, funding opportunities with other partners, and potential for multiple uses and benefits. **Opportunities:** • Consider retrofit of Natural Resource Conservation Service (NRCS) detention facilities with water quality features. • Promote water quality detention in existing NRCS and 100-year detention facilities. • Drop structures may be prudent upstream of selected roadcrossings to increase channel storage.
Recommendation	**Promote trading incentives and request removal of the 216-pound "Reserve Pool" cap.**
	Create trading incentives for public and private entities to implement water quality controls and other enhanced BMPs into new PRFs. Remove regulatory barriers to allow local governments and private entities to construct and implement trading projects above the 216-pound cap.
Recommendation	**Encourage all land use agencies to adopt and implement the Authority's "Stormwater Quality Requirements" stormwater policy and design criteria.**
	Opportunities: • Develop stormwater policy and criteria specifically targeted at stream stabilization design for enhanced water quality. • Consider modifying design criteria for flood detention facilities that would provide even greater water quality benefits.

RESERVOIR AND WATERSHED WATER QUALITY MANAGEMENT GOALS	
Recommendation	**Encourage local governments to work with developers to construct innovative demonstration projects.**
	Through the Authority's Phosphorus Facilitator, work with one or more developers to implement water quality controls and other innovative BMPs to advance the science and showcase creative water quality control techniques to local governments and other developers.
Recommendation	**Encourage local governments to provide developer incentives to preserve and enhance stream corridors.**
	Land dedication, real estate amenities, or reduction in tax liability are examples of incentives that could be extended to developers to preserve the stream corridor.
Recommendation	**Explore options to reduce septic system loading in Cherry Creek.**
	Septic systems located in stream preservation areas provide a direct conduit of nutrient and pathogen loads to the system and threaten source water. **Opportunities:** • Consider converting septic systems to conventional sewer system. Locate and inventory septic systems in stream preservation areas. Valley Country Club and Franktown are two areas that presently have septic systems located in stream preservation areas. An evaluation of service area issues and pollutant loads will support the need for sewer conversion and facilitate conversion priorities. • Coordinate with Tri-County Health in tracking septic systems. Permits, inspection data, and maintenance records provide useful information on the status of septic systems in the Basin. Implement education and outreach programs for owners of septic systems regarding maintenance responsibilities. • Consider alternative funding sources, such as the U.S. Army Corps of Engineers (COE) authority under 593 and incentives such as trading to reduce the number of septic systems in stream preservation areas.
Recommendation	**Promote reuse of wastewater through land application.**
	Opportunities: • Encourage dischargers to voluntarily apply wastewater to land in greenbelts to effectively irrigate and reduce nutrient loads at the same time. • Assure that land application requirements promote the reuse of treated wastewater
Recommendation	**Conduct special studies to optimize water quality improvements.**
	Special studies and research are encouraged to increase the understanding of optimum measures for water quality improvements. These studies would: - Increase the understanding of phosphorus fate and transport in the watershed and reservoir. - Better define soil-phosphorus equilibrium conditions in key locations. - Increase understanding of nutrient enrichment in the reservoir. - Identify background phosphorus sources in the headwater region. - Confirm the most effective BMP approaches to immobilize total and soluble phosphorus. - Identify industrial processes and septic systems in the watershed and quantify phosphorus loading from these sources.

PUBLIC INFORMATION, EDUCATION AND OUTREACH GOALS	
Recommendation	**Develop and implement a comprehensive public involvement plan.**
	Opportunities: • In coordination with the Cherry Creek Stewardship Partners, develop and implement a public information and outreach plan that includes the Cherry Creek Reservoir Watershed website and education and outreach materials to promote water quality enhancement efforts.
Recommendation	**Consider participation in several federally funded programs that support sustainable agricultural and habitat protection and restoration.**
	Programs such as the Conservation Reserve Program, Environmental Quality Incentives Program (EQIP), Partners for Fish and Wildlife, Wetlands Reserve Program (WRP), and Wildlife Habitat Incentives Program (WHIP) are federal programs appropriate to fund efforts in the Upper Basin. Provide incentives to local farmers and ranchers to implement these programs.
Recommendation	**Coordinate with other stormwater Phase I and II entities and efforts.**
	Seek opportunities to cost-effectively address stormwater quality issues, particularly public education and outreach and pre-and post-construction BMPs, by coordinating stormwater control activities with stormwater permittees in the Cherry Creek Basin.
Recommendation	**Collaborate with other private and public interest groups to leverage funding mechanisms to meet watershed goals.**
	Coordinate with Cherry Creek Stewardship Partners and other public and private interest groups to obtain additional funding to meet water quality goals and objectives.

ES.3 Conceptual Costs to Implement the Plan

The Authority is uniquely poised to take a strong leadership role in the process of identifying funding sources and generating additional funding to support water quality goals in the Cherry Creek Reservoir Watershed. The future funding needs of the Authority include both capital construction dollars (hard costs), and funding for administration and planning (soft costs). A preliminary assessment of the costs to implement the *Watershed Plan 2003*, including potential future capital needs, was conducted. Planning level estimates of Watershed Plan "program's" hard and soft costs for Authority projects are approximately $40 million. However, partnering and cost-sharing arrangements with other entities, which typically range from 20- to 80-percent, depending on the specific project, could lower the Authority's actual costs. Assuming a 5-year budget cycle and cost-sharing at the 50-percent level, an estimated annual budget of $4 million is needed to support implementation of the *Watershed Plan 2003*.

The *Watershed Plan 2003* is organized in a progressive fashion, stepping the reader through the following components of the strategic plan:

Chapter 1 Authority mission, *Watershed Plan 2003* vision, goals and objectives

Chapter 2 Watershed history and water quality trends

Chapter 3 Watershed analysis of existing and projected conditions in the watershed and management strategies to reduce phosphorus loads to the reservoir

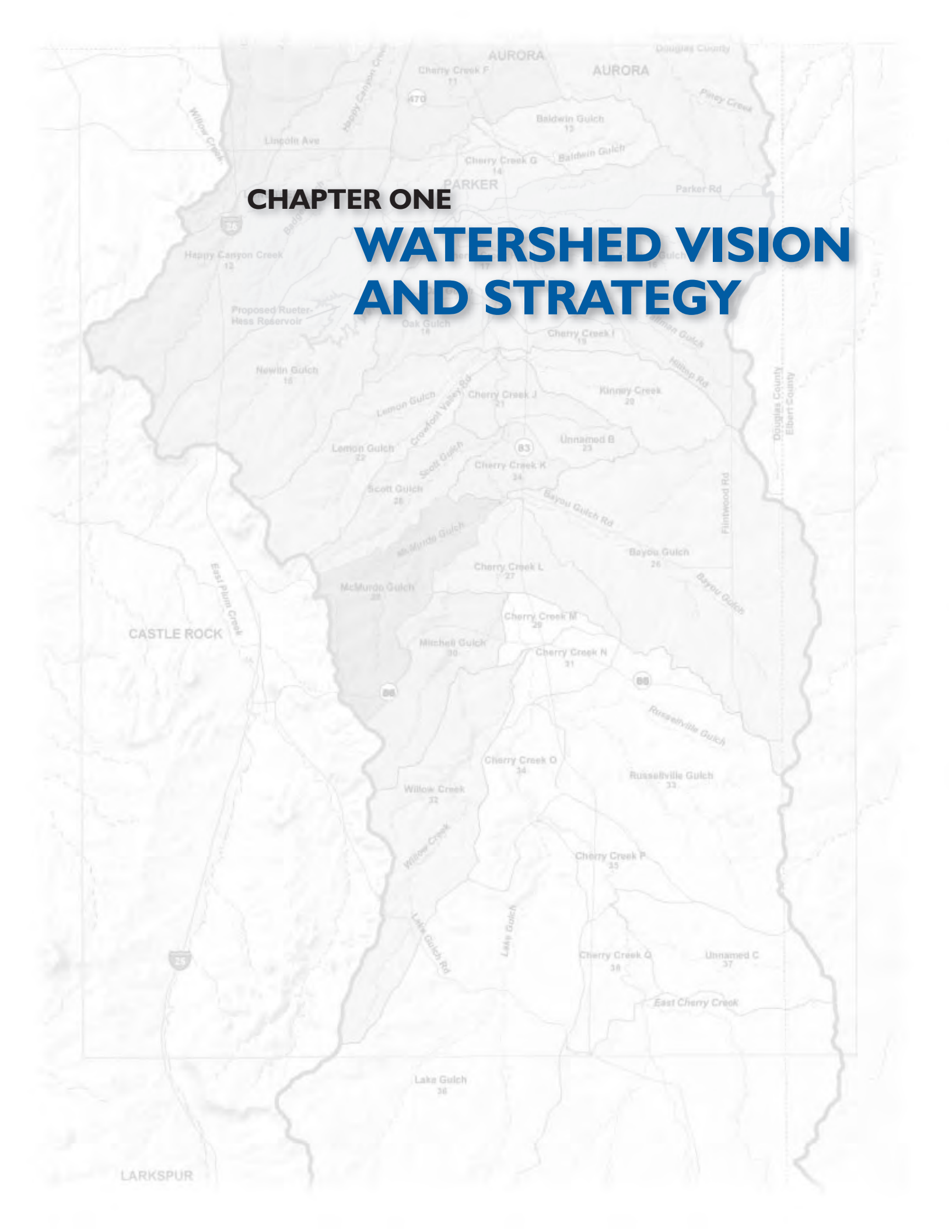
Chapter 4 Review of the Cherry Creek TMAL and Control Regulation #72 requirements

Chapter 5 Funding considerations to augment financial resources to meet water quality goals and estimated costs to implement the plan

Chapter 6 Water quality management strategies, recommendations, and identified opportunities

Chapter 7 References

A supplemental technical appendix provides supporting documentation for the watershed analysis, water/phosphorus balance scenarios, Watershed Plan programs, conceptual level costs to implement the plan, and formal comments on the July, 2003 draft *Watershed Plan 2003.*



CHAPTER ONE

WATERSHED VISION AND STRATEGY

The Cherry Creek Reservoir Watershed is one of the most studied and talked about urban watersheds in Colorado because it lies within one of the fastest growing parts of the country.

Located in the southeast portion of the Denver metropolitan area, the Cherry Creek Reservoir watershed consists of 32 subwatersheds that drain into Cherry Creek Reservoir, (**Figure 1-1**) and 386 square miles of some of the fastest growing portions of Arapahoe, Douglas, and El Paso counties.

Basin Number	Sub-Watershed Name
1	Cherry Creek Reservoir
2	Direct Flow Area #1
3	Direct Flow Area #2
4	Direct Flow Area #3
5	Shop Creek
6	Direct Flow Area #4
7	Direct Flow Area #5
8	Piney Creek
9	Cottonwood Creek
10	Lone Tree Creek
11	Happy Canyon Creek/Badger Gulch
12	Baldwin Gulch
13	Newlin Gulch
14	Direct Flow Area #6
15	Tallman Gulch
16	Sulphur Gulch
17	Lemon Gulch
18	Scott Gulch
19	Direct Flow Area #7
20	Kinney Creek
21	McMurdo Gulch
22	Direct Flow Area #8
23	Bayou/Moonshine Gulch
24	Mitchell Creek
25	Willow Creek
26	Reed Hollow Gulch
27	Upper Lake Gulch
28	Direct Flow Area #9
29	Haskell/Antelope Creek
30	West Cherry Creek
31	East Cherry Creek
32	Oak Gulch

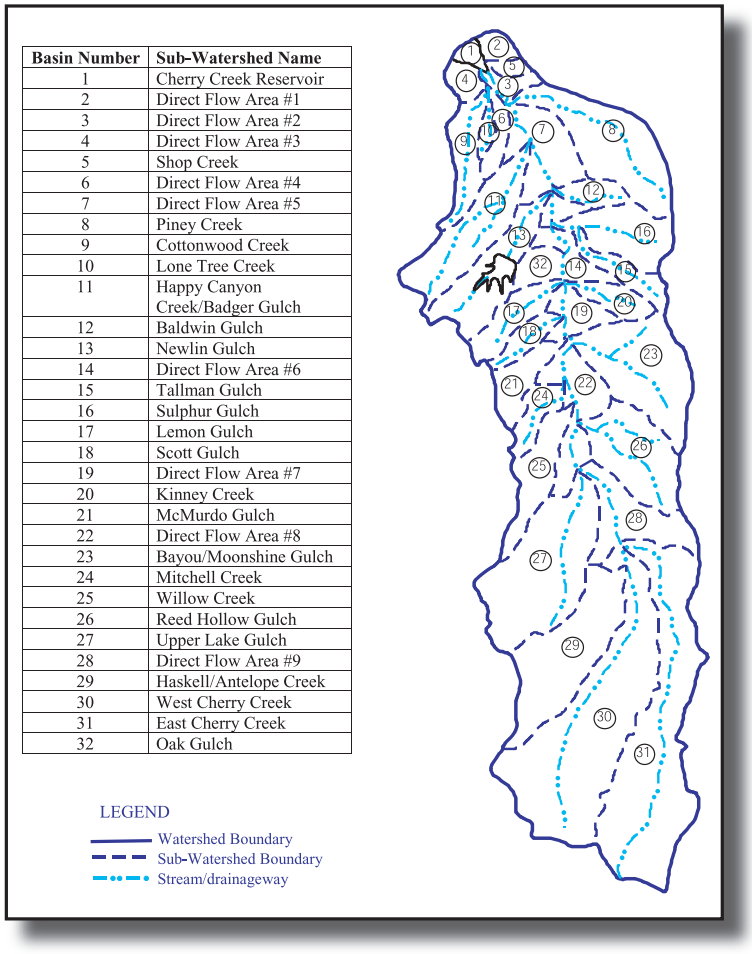


Figure 1-1. Cherry Creek Reservoir Watershed and Subwatershed Locations and Names

The 600 miles of riparian-vegetated stream corridors, the alluvial aquifer that provides water supplies to many water purveyors, and the Cherry Creek Reservoir, including its recreational amenities and fishery, provide a highly valued resource to the residents of Colorado. As early as the 1980s, citizens recognized this and took major steps to protect this resource.

In 1985, the legislature formed the Cherry Creek Basin Water Quality Authority (Authority) as the water quality management agency to "…develop and implement…plans for water quality controls for the reservoir, applicable drainage basin, waters and watershed, to achieve and maintain the water quality standards" (CRS 25-8.5-111).

The Cherry Creek Control Regulation, originally adopted by the Colorado Water Quality Control Commission (WQCC) in 1985 and updated in 2001, set the water quality standards to meet the beneficial uses of the reservoir and the basic elements of the Total Maximum Annual Load (TMAL). An in-reservoir chlorophyll a standard of 15 µg/L (July through September seasonal mean) was set with the goal of maintaining an average total phosphorus goal of 40 µg/L. The phosphorus TMAL was allocated among point and nonpoint sources in the basin at 14,270 pounds per year. This TMAL is now in the process of being reviewed in order to meet the water quality standards in the reservoir.

The *"Cherry Creek Reservoir Watershed Plan 2003"* (*Watershed Plan 2003*) offers a menu of suggested water quality management strategies and options that work towards achieving watershed goals and objectives. The *Watershed Plan 2003* builds upon prior planning studies, including the Watershed Plan 2000 (Authority, 2000) and the Cherry Creek Water Quality Management Plan (Denver Regional Council of Governments [DRCOG], 1985, 1989). The *Watershed Plan 2003* integrates science, effective management strategies, and stakeholder concerns into a concise strategic plan to protect water quality in the Cherry Creek Reservoir Watershed.

The Cherry Creek Reservoir Watershed Plan 2003 is a guide for achieving water quality goals.

The *Watershed Plan 2003* provides a guide that:

- Defines goals and objectives to support the water quality mission and vision for the Cherry Creek Reservoir Watershed.
- Assesses reservoir and watershed health - looking at its watershed history, trends, and condition.
- Identifies key water quality issues and key studies, such as evaluation of phosphorus fate and transport issues.
- Sets forth management strategies and presents a coordinated effort and partnership plan between the Authority and land use agencies to improve water quality in the reservoir and the watershed.
- Provides local governments with management tools to facilitate informed water quality decisions.

- Identifies potential funding mechanisms to support implementation of plan recommendations and identified opportunities.
- Encourages preservation of the unique ecology of the Cherry Creek Reservoir Watershed to enhance water quality.
- Promotes informing and educating the public about the challenges and opportunities for water quality protection in the Cherry Creek Reservoir Watershed.
- Presents recommendations and opportunities for consideration to achieve water quality goals.

The *Watershed Plan 2003* is organized in a progressive fashion, leading the reader through the following components of the strategic plan:

Chapter 1	Authority mission, *Watershed Plan 2003* vision, goals and objectives
Chapter 2	Watershed history and water quality trends
Chapter 3	Watershed analysis of existing and projected conditions in the watershed and management strategies to reduce phosphorus loads to the reservoir
Chapter 4	Review of the Cherry Creek TMAL and Control Regulation 72 requirements
Chapter 5	Funding considerations to augment financial resources to meet water quality goals and estimated costs to implement the plan
Chapter 6	Water quality management strategies, recommendations, and identified opportunities
Chapter 7	References

A supplemental technical appendix provides supporting documentation for the watershed analysis, water/phosphorus balance scenarios, Watershed Plan programs and conceptual level costs to implement the plan, and formal comments on the July 2003 draft *Watershed Plan 2003.*

1.1 Cherry Creek Watershed Vision

The Mission of the Authority is to maintain beneficial uses in the Cherry Creek Reservoir by preserving its water quality.

The Cherry Creek Watershed Vision provides the foundation for the *Watershed Plan 2003.*

"The Vision of the *Cherry Creek Reservoir Watershed Plan 2003* is to integrate watershed goals for community development, water supply, recreation, wildlife habitat, and open space with the Authority's water quality Mission."

1.2 Cherry Creek Reservoir Watershed Goals and Objectives

Specific goals and objectives support the Vision of the *Watershed Plan 2003*. The goals are what the Authority wants to achieve in a number of areas, and the objectives are measurable ways to achieve the goals (**Figure 1-2**).

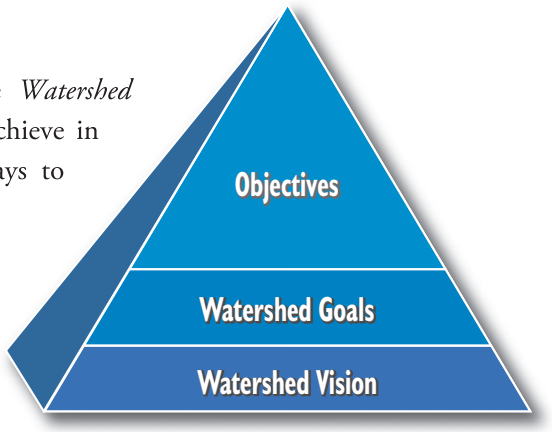


Figure 1-2. Vision Supports Goals and Objectives

The goals are consistent with statutory requirements and the Cherry Creek Control Regulation 72 (WQCC, 2001). Goals such as "achieve the 15 µg/l chlorophyll a standard" and "meet the Cherry Creek TMAL" are specific and quantifiable goals. The objectives for the Cherry Creek watershed and subwatersheds provide the actions necessary to meet the goals.

Table 1-1 summarizes reservoir and watershed water quality management goals identified by the Authority and its stakeholders during a facilitated work session and the management objectives that support the goals for the reservoir's, vulnerable watershed and subwatersheds. Due to the unique character of the Cherry Creek subwatersheds, a "one-size fits all" approach to water quality protection is not appropriate.

Table 1-1. Reservoir and Watershed Goals and Objectives

RESERVOIR AND WATERSHED WATER QUALITY MANAGEMENT	
Goals	• Maintain and enhance beneficial uses of the reservoir. • Achieve the 15-µg/L chlorophyll a standard in the reservoir. • Meet the phosphorus goal for the reservoir of 40-µg/L of total phosphorus. • Meet the evolving Cherry Creek TMAL for total phosphorus. • Reduce sediment loads from the watershed. • Maintain and enhance overall diversity of habitat in the watershed. • Promote good stewardship of water resources through incentives to public and private interests.
Objectives	1. Reduce average phosphorus loads by 2020. 2. Reduce wastewater treatment plant (WWTP) direct discharges to 0.05 mg/L phosphorus by August 1, 2004. 3. Implement minimum best management practices (BMPs) for all new development, per the Authority's "Stormwater Quality Requirements" (Authority, 2001). 4. Retrofit existing development BMPs to enhance phosphorus immobilization. 5. Promote practices that reduce phosphorus loads from new development. 6. Stabilize, reclaim, and enhance Cherry Creek and its tributaries. 7. Optimize phosphorus reduction opportunities and watershed health by implementing BMPs that exceed minimum requirements during new development. 8. Identify phosphorus sources in the headwater region and implement phosphorus reduction strategies.

Objectives (cont.)	9. Coordinate with the National Pollutant Discharge Elimination System (NPDES) stormwater Phase I and II entities and efforts. 10. Reduce septic system loads in the Cherry Creek Reservoir Watershed. 11. Promote watershed-based pollutant trading for phosphorus. 12. Promote reuse of wastewater through land application or indirect potable reuse, as applicable. 13. Implement Pollutant Reduction Facilities (PRFs). 14. Identify and develop new funding mechanisms to meet watershed goals. 15. Integrate watershed management with source water protection. 16. Implement education and outreach programs, including a website. 17. Identify background phosphorus sources in the headwater region and implement phosphorus reduction strategies. 18. Stabilize channels and streambanks where appropriate. 19. Protect groundwater recharge areas and groundwater quality by establishing protection zones. 20. Identify and promote the preservation of buffer zones for water quality. 21. Promote land conservation related to water quality. 22. Inventory stream conditions and rehabilitate problem areas. 23. Protect sensitive areas and vulnerable resources.

1.3 Public Information, Education and Outreach

By involving the public in the development of the *Watershed Plan 2003*, diverse ideas and stewardship practices were incorporated into the Plan. Public involvement is a key component in the watershed planning process. From the outset, the Authority and its Technical Advisory Committee, sought broad representation on the development of the *Watershed Plan 2003* through various public involvement and outreach activities. Formal comments to the plan are provided in the supplemental appendix.

Progress Meetings. A series of progress meetings, open to the public, served to exchange information, discuss ideas and findings, and present results.

Website. The *Watershed Plan 2003* website was created to disseminate information, report Plan progress, and solicit input. An interactive comment form was incorporated to obtain public feedback and answer questions.

Public Notices and News Releases. News about upcoming meetings and the website were placed in local papers and water and sewer bills.

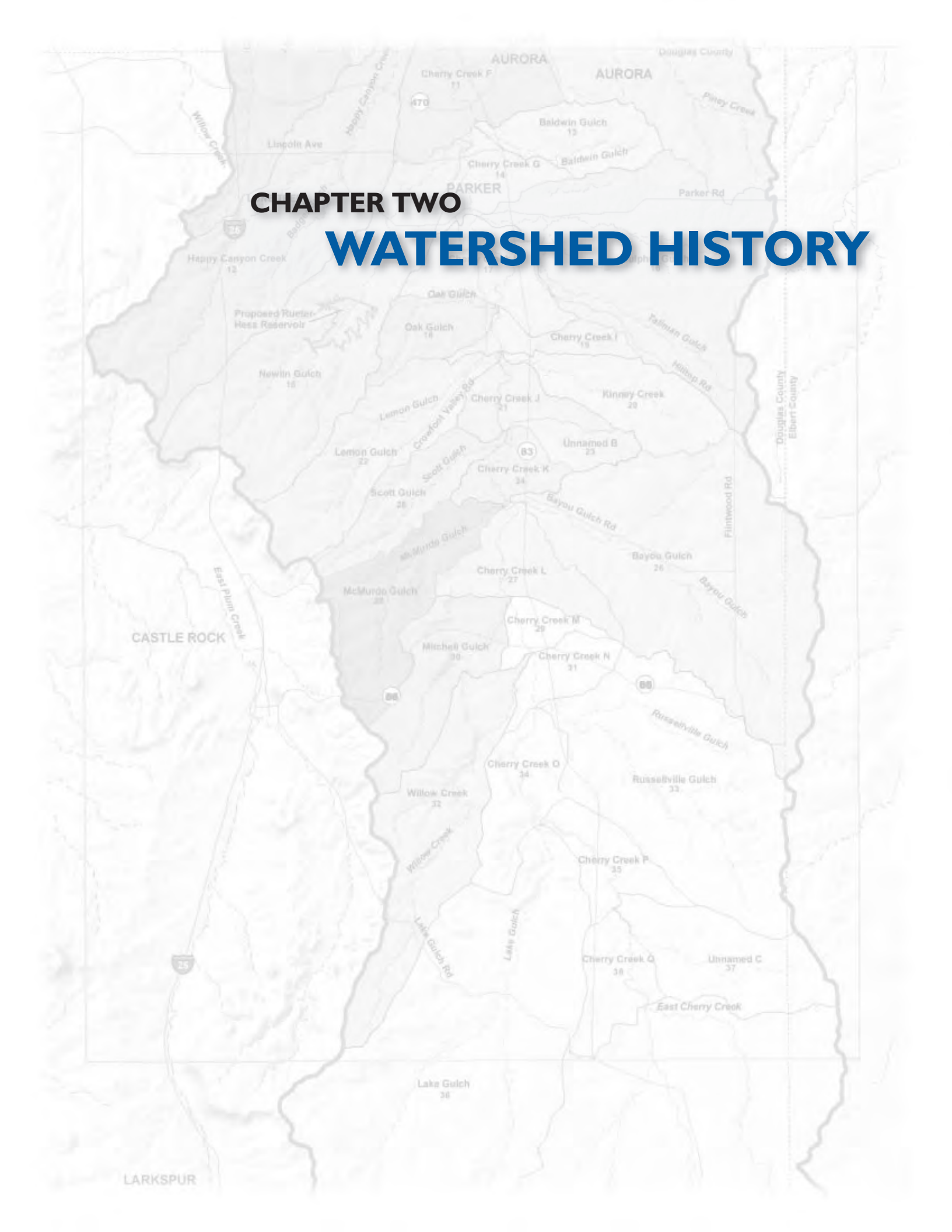
Speakers Bureau. Members of the Authority presented updates and requested feedback from local land use agencies, elected officials, and other Cherry Creek stakeholder groups, such as the Cherry Creek Stewardship Partners.

Public Open House Presentations. The Authority hosted Open House presentations at three venues in the Cherry Creek Watershed (Cherry Creek State Park, the Town of Parker, and Franktown) during July 2003 to present the draft plan, solicit input, and garner support. Comments were received by a variety of agencies, but particularly from individuals who enjoy the amenity that the reservoir and watershed provide (such as boaters, bicyclists, homeowners, and horseback riders).

Table 1-2. summarizes the plan's public information, education and outreach goals and objectives.

Table 1-2. Public Information, Education And Outreach Goals and Objectives

PUBLIC INFORMATION, EDUCATION AND OUTREACH GOALS AND OBJECTIVES	
Goals	• Work cooperatively with watershed groups and local agencies to promote holistic watershed health. • Promote public awareness and involvement in watershed management. • Promote good stewardship of water resources through leadership, cooperation, financial support, and incentives.
Objectives	1. Educate and empower local land use agencies on the appropriate implementation of enhanced BMPs for all new development, per "Stormwater Quality Requirements" (Authority, 2001). 2. Publicize practices that reduce phosphorus loads from new development. 3. Enhance Cherry Creek and its tributaries through volunteer efforts. 4. Implement education and outreach programs, including a website. 5. Coordinate education and outreach components of the NPDES stormwater Phase I and II permit with Cherry Creek entities. 6. Develop and implement a comprehensive public information/public involvement plan. 7. Encourage regional development of PRFs through cooperative arrangements. 8. Through cooperative efforts with watershed groups, identify and develop new funding mechanisms to meet watershed goals. 9. Highlight protected riparian areas, preserved buffer zones, and conservation easements through educational outreach mechanisms such as signage and kiosks located on-site at the reservoir and in the watershed. 10. In coordination with land use agencies, utilize citizen groups and organizations to inventory stream conditions and rehabilitate problem areas.



CHAPTER TWO

WATERSHED HISTORY

For nearly 20 years, the Authority has developed and implemented water quality management strategies to reduce point and nonpoint pollutant sources.

The Authority has continuously monitored water quality to determine water quality trends, seek insights on how the reservoir functions and measure the changes that may result from implementation of point source and nonpoint source control strategies. While an extensive database exists for Cherry Creek, its alluvium and the reservoir, there is a lack of certainty about the fate and transport of pollutants in the watershed and the interrelationships between phosphorus loading and reservoir dynamics that cause algae to grow in the reservoir.

2.1 Reservoir Condition and Trends

Originally built for flood control in 1957, Cherry Creek Reservoir is owned and operated by the U.S. Army Corps of Engineers (COE). The 850-acre reservoir and surrounding land was leased to the State of Colorado for use as the Cherry Creek State Recreation Area at that time. The 4,200 acre-park almost immediately received extensive recreation use, a pattern that has continued to the present day. Cherry Creek State Park, the most popular state park in Colorado, had over 1.5 million visitors in 2000. As can be seen in **Figure 2-1**, from 1990 to 2000 the park saw a 27-percent increase in park visitation (TPL, 2002). The

FOR MORE INFORMATION

"*Cherry Creek Basin Open Space Conservation and Stewardship Plan*," prepared for the Trust for Public Lands, Cherry Creek Steering Committee by ERO Resources Corp., Muller Engineering, and Computer Terrain Mapping, October 2002.

Cherry Creek State Park website, http://parks.state.co.us/

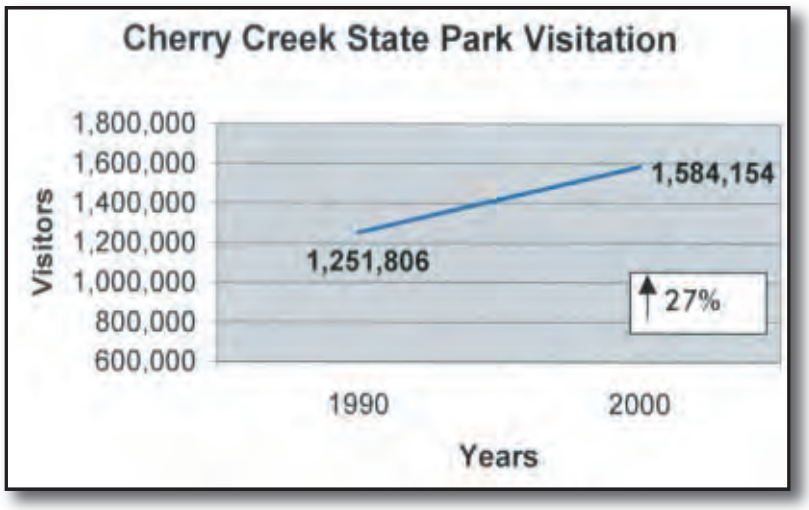


Figure 2-1. Cherry Creek State Park Visitation

reservoir and surrounding park serve as an important urban recreational and wildlife habitat site, providing opportunities for a variety of activities, including sport fishing, boating, swimming, bicycling, bird watching, horseback riding, camping, nature study, sightseeing, shooting sports, and hiking (**Figure 2-2**). The impact of recreation at the State Park on the regional economy is significant, with a capitalized economic value of recreation estimated to be in the range of $1.4 to $3.3 billion (Stratus Consulting, 2000). The reservoir is currently classified for warmwater aquatic life, recreation, water supply, and agricultural uses (Authority, 2003).

Figure 2-2. Cherry Creek Reservoir

Since 1984, water quality standards have been adopted to control eutrophication of the reservoir, the process by which a body of water becomes rich in dissolved nutrients and deficient in dissolved oxygen, through limits of phosphorus and chlorophyll a concentrations. Until 2001, the standard was 35-µg/L total phosphorus, which was modeled to produce an in-reservoir chlorophyll a level of 15 -µg/L or less. The water quality standard adopted by the Colorado WQCC in 2001 for the Cherry Creek Reservoir is 15-µg/L of chlorophyll a (July-September mean, to be met 9 out of 10 years), with an underlying total phosphorus goal of 40-µg/L, also as a July through September mean. **Table 2-1** summarizes applicable water quality standards and designated uses for the creek and reservoir.

Table 2-1. Water Quality Standards for Cherry Creek Reservoir Watershed

Waterbody	1. Water Quality Standards [1, 2]	Designated Uses [3]
Mainstem of Cherry Creek from the source of East and West Cherry Creek to the inlet of Cherry Creek Reservoir	Chlorophyll a = 15 µg/l 2. Dissolved Oxygen = 5.0 mg/l pH = 6.5- 9.0 Fecal Coliform = 200/100 ml	Aquatic Life Warm 2 Recreation 1a Water Supply 3. Agriculture
4. Cherry Creek Reservoir	Chlorophyll a = 15 µg/l 5. Dissolved Oxygen = 5.0 mg/l pH = 6.5- 9.0 Fecal Coliform = 200/100 ml 6. Phosphorus = 40 mg/l goal	Aquatic Life Warm 1 Recreation 1a Water Supply Agriculture

[1] All values obtained from CDPHE Water Quality Control Commission Regulation No. 38, *Classifications and Numeric Standards South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin.*

[2] Standards for all other constituents can be found in the aforementioned regulation.

[3] For definitions of designated uses refer to CDPHE Water Quality Control Commission Regulation No. 31, *The Basic Standards and Methodologies for Surface Water.*

FOR MORE INFORMATION

"Cherry Creek Reservoir 2002 Annual Aquatic Biological and Nutrient Monitoring Study," prepared by Chadwick Ecological Consultants for the Authority, March 2003.

"2002 Annual Report of Activities," prepared by Chadwick Ecological Consultants for the Authority, March 2003.

The 1985 TMAL of 14,270 pounds per year total phosphorus loads remains in effect, but as a "phased TMAL" for the reservoir (Authority, 2003) until additional studies support the modeling required for developing a different TMAL. Additional studies to update the phased TMAL are under way; however, in the meantime, water quality control measures are being implemented throughout the watershed.

Although some water quality data is available from the early 1980s, a more complete data record begins in 1987 with the Authority's annual monitoring program. Chadwick Ecological Consultants, Inc. (CEC) has conducted aquatic biological and nutrient analyses on Cherry Creek Reservoir and selected tributaries since 1994. Currently, ten sites are being sampled - three sites in Cherry Creek Reservoir, six sites on tributary streams, and one site on the mainstem of Cherry Creek downstream of the reservoir. (**Figure 2-3**).

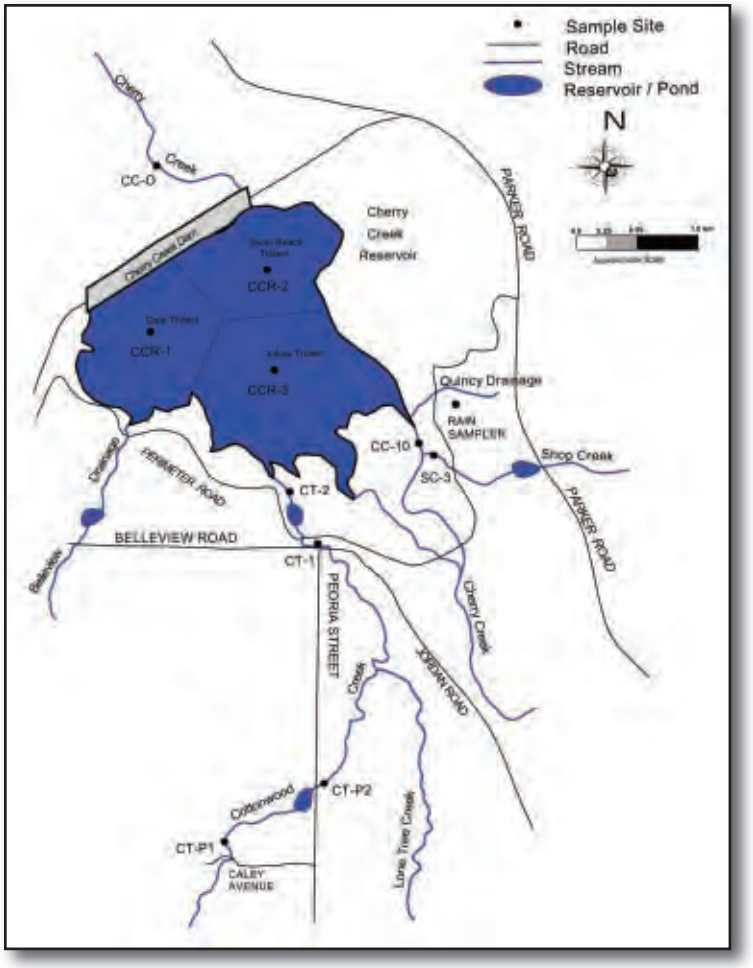


Figure 2-3. Sampling Sites on and near Reservoir

Reservoir health and quality is measured as a function of transparency (Secchi depth), phytoplankton density, chlorophyll a levels, temperature, dissolved oxygen concentration, total phosphorus concentration, total nitrogen concentration, and inflow. Historical data demonstrates that increases and decreases in inflow have led to a corresponding increase in

phosphorus load to the reservoir (**Figure 2-4**). The recent 2002 drought demonstrates this occurrence, showing a decrease in phosphorus loads resulting in a decrease in runoff from the watershed. This indicates that runoff control is a critical water quality control measure.

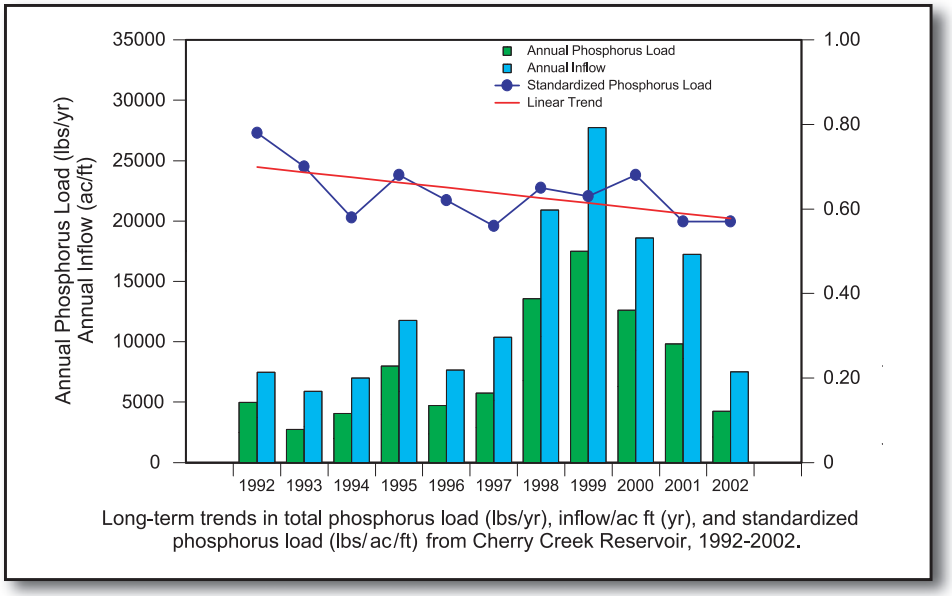


Figure 2-4. Increase in Phosphorus Loads to the Reservoir

General Water Quality trends. Over the past decade, concentrations of total phosphorus have exhibited a slight upward trend in Cherry Creek just upstream of the reservoir, and chlorophyll a concentrations in the reservoir have not met the standard since 1995. Both constituents exceed water quality standards and/or goals. However, the evolving phased TMAL of 14,270 pounds has not been exceeded. The following sub-sections provide more detail on water quality trends.

Chlorophyll a trends. The July through September mean chlorophyll a concentrations have met the standard of 15-µg/L only four out of the past 16 years. Since 1987 there has been a slight increasing trend in the July through September mean concentration (**Figure 2-5**). The

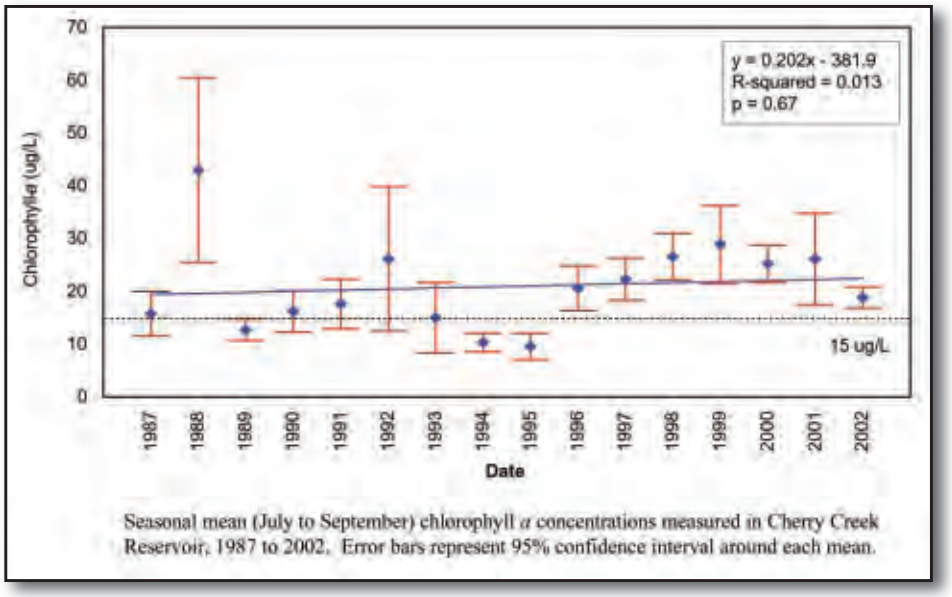


Figure 2-5. Chlorophyll a Trends

July through September mean chlorophyll a concentration in Cherry Creek Reservoir was 18.8-µg/L in 2002. Prior to that the first year that the 15-µg/L standard was met was in 1995 (Authority, 2003) (**Table 2-2**).

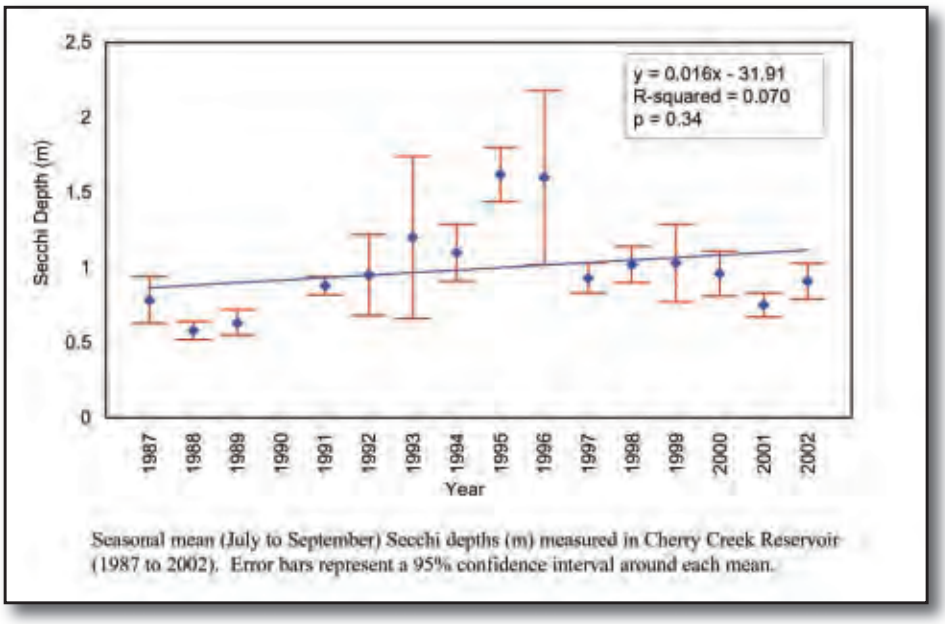
Table 2-2. Reservoir Water Quality Summary

Water quality and total phosphorus loads data for Cherry Creek Reservoir, July-September 1992-2002. **Bold** indicates value meets the respective standard, goal, or TMAL value.

Year	Chlorophyll a (µg/L)	Secchi Depth (m)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Annual Phosphorus Load (lbs/yr)*	Annual Inflow (ac/ft)*	Standardized Phosphorus Load (lbs/ac-ft)
1992	17.0	0.9	66	970	**5,857**	7,474	0.78
1993	**14.4**	1.2	62	826	**4,110**	5,905	0.70
1994	**10.0**	1.1	59	1,144	**4,049**	7,001	0.58
1995	**9.4**	1.6	48	913	**7,972**	11,781	0.68
1996	20.5	1.0	62	944	**4,715**	7,644	0.62
1997	22.3	1.0	96	1,120	**5,761**	10,362	0.56
1998	26.5	1.0	89	880	**13,577**	20,903	0.65
1999	28.9	1.0	81	753	17,471	27,739	0.63
2000	25.2	1.0	81	802	**12,593**	18,610	0.68
2001	26.1	0.75	87	757	**9,837**	17,250	0.57
2002	18.8	0.9	74	858	**4,246**	7,498	0.57
10-Year Mean	19.9	1.1	73	906	8,199	12,924	0.64
Median	20.5	1.0	74	880	5,857	10,362	0.63

* Stream, alluvium, and precipitation

Transparency (Secchi Depth) trends. The highest transparency is generally observed in the reservoir in late June-early July, and the lowest measured in late spring and early fall. The July through September mean has been averaging approximately 1.0 meter. In general, seasonal mean transparency depths increased from 1987 to 1996, then decreased from 1996 to 2002 (**Figure 2-6**).



Seasonal mean (July to September) Secchi depths (m) measured in Cherry Creek Reservoir (1987 to 2002). Error bars represent a 95% confidence interval around each mean.

Figure 2-6. Reservoir Transparency

Total phosphorus concentration trends in Cherry Creek Reservoir tributaries just upstream of reservoir. The phosphorus goal in Cherry Creek Reservoir is 40-µg/L. Since 1994, the Authority has measured upstream tributaries to evaluate the phosphorus loads

contributed to the reservoir annually. Analyses have been performed on data from the mainstem and two tributaries at Cherry Creek Reservoir - Cherry Creek (CC-10), Shop Creek (SC-3), and Cottonwood Creek (CT-2) - to determine long-term trends in total and dissolved phosphorus concentrations over time. Over the past 8-year period, mean phosphorus concentration was highest at Site CC-10 (232-µg/L) and lowest at Site CT-2 (101-µg/L). Concentrations of total phosphorus exhibited significant increasing trends over time at Site CC-10 (**Figure 2-7**). The observed downward trend at the Cottonwood Creek

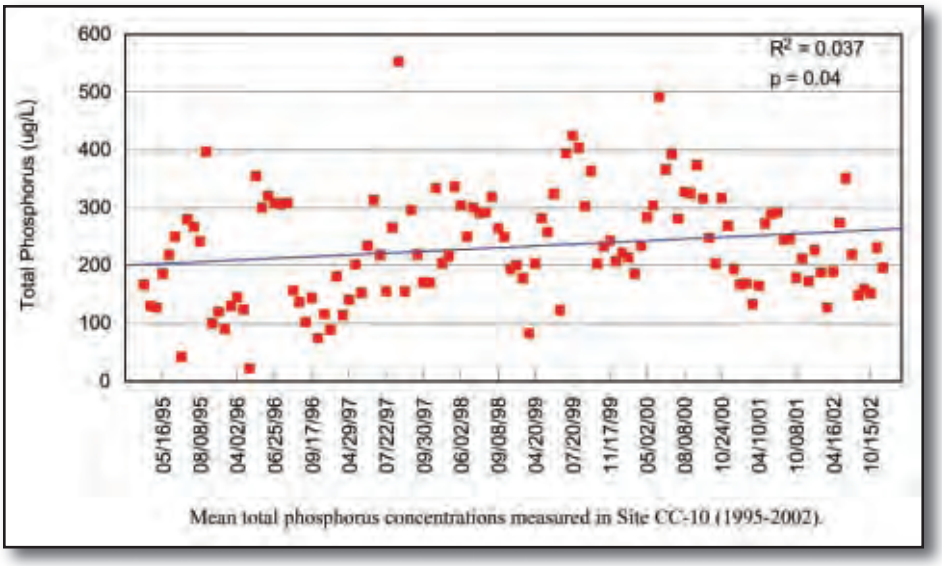


Figure 2-7. Total Phosphorus Concentrations Upstream of Reservoir

Site (CT-2) may be an indication of the increasing effectiveness of the Cottonwood Creek PRF, installed in 1996 by the Authority (**Figure 2-8**) (Authority, 2003). At all three sites there is a distinct seasonal pattern in phosphorus concentrations – higher in summer and lower in winter.

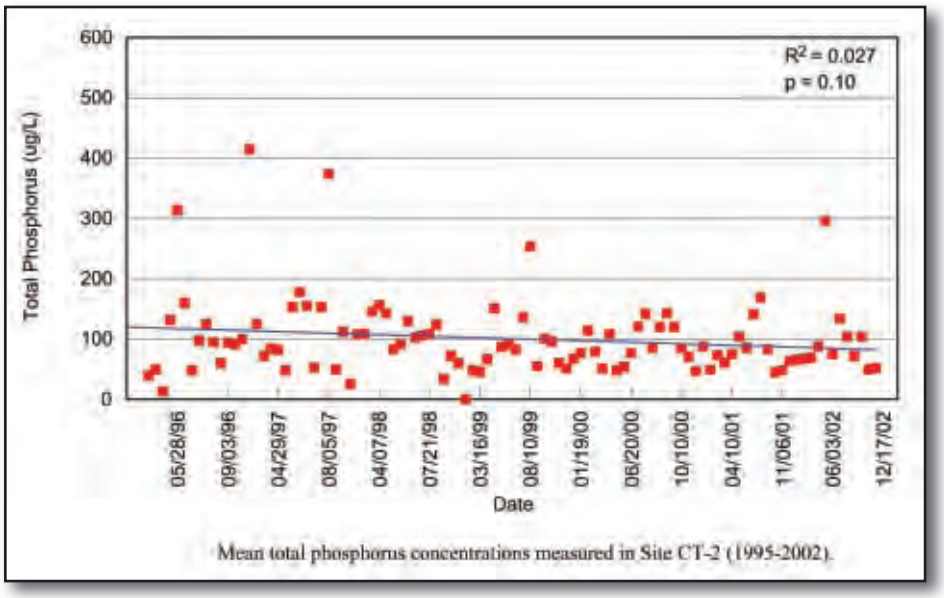


Figure 2-8. Total Phosphorus Concentrations at Cottonwood Creek Upstream of Reservoir

Total phosphorus trends in Cherry Creek Reservoir. Routine monitoring data collected since 1987 indicates a generally increasing trend in July through September mean concentration of total phosphorus (**Figure 2-9**). However, there appears to be a decreasing

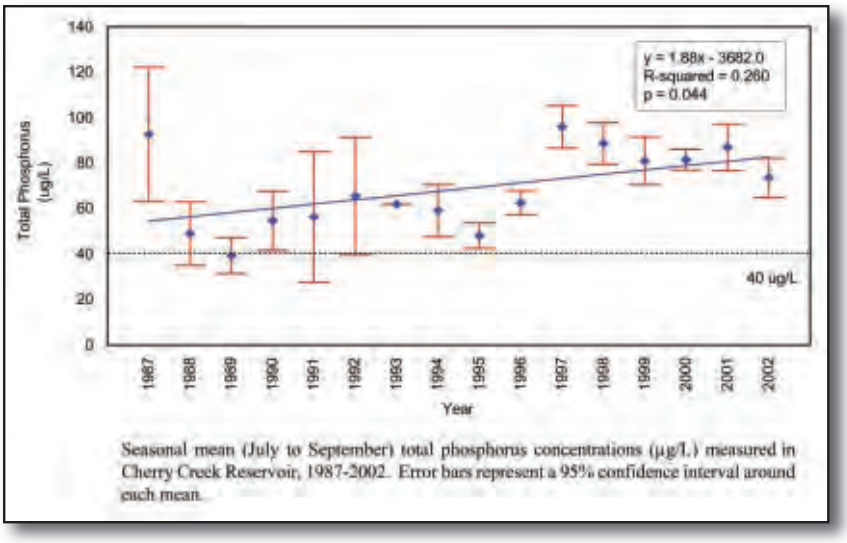


Figure 2-9. Total Phosphorus Trends in Cherry Creek Reservoir

trend in July through September mean total phosphorus concentration over the past 6 years (**Table 2-2**) (Authority, 2003), which could relate to effective PRFs, BMPs and low flows. The phosphorus goal of 40-µg/L has not been met since 1989.

Phosphorus Loading. The 2002 phosphorus loading mass-balance schematic is shown in **Figure 2-10**. Phosphorus loading from the tributaries to the reservoir - Cherry Creek,

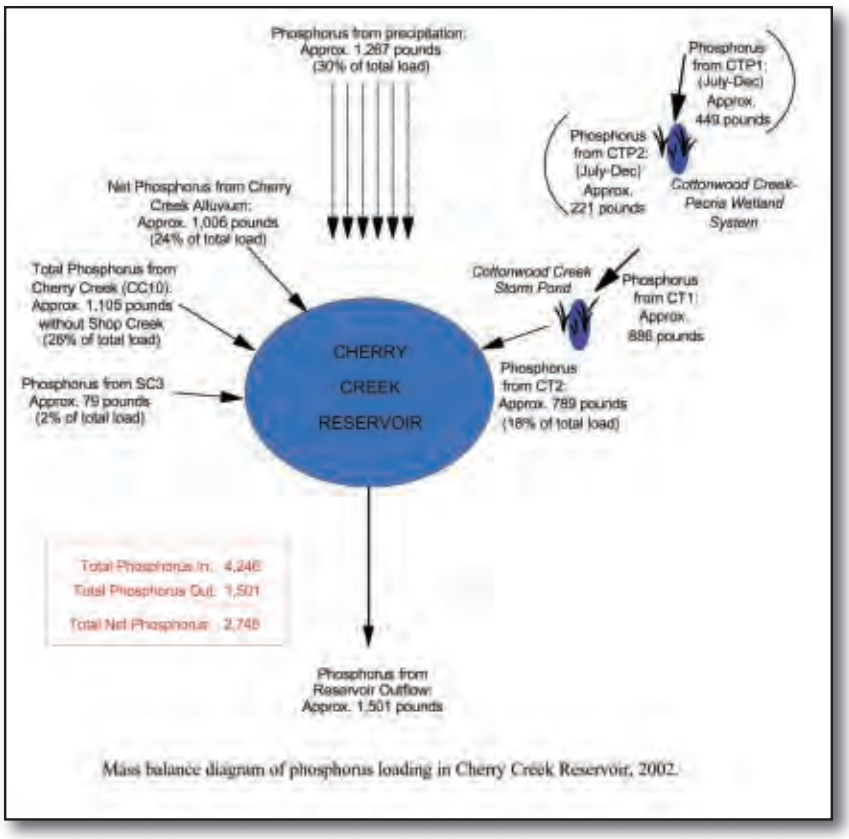


Figure 2-10. Cherry Creek Phosphorus Loading Mass-Balance Schematic (2002)

Cottonwood Creek, Shop Creek, and the Cherry Creek alluvium - was estimated at 2,979 pounds for 2002. Phosphorus loading from precipitation was 1,267 pounds or 30-percent of the 2002 load to the reservoir, for a total phosphorus load to the reservoir of 4,246 pounds, well below the 14,270 pound TMAL. Phosphorus loads peaked in 1999 with a total of 17,471 pounds, the only year on record when the TMAL was exceeded. This peak load was directly related to the peak inflows of 27,239 acre-feet (ac-ft) estimated for that year, over twice the long-term average inflow. A reduction in phosphorus loading was observed over the past 3 years due, in part, to a 73-percent decrease in inflow from 1999 to 2002 (Authority, 2003).

2.2 Watershed Condition

The Cherry Creek Reservoir Watershed includes approximately 245,500 acres. Cherry Creek, with its own alluvial aquifer, is the major surface water stream within the basin. Since Cherry Creek and the alluvial aquifer are hydraulically connected, changes in water table elevation can change this creek from a losing stream to a gaining stream and vice versa. Although water flows continuously through the aquifer, surface flows in Cherry Creek are intermittent. Many other tributaries only have visible flows after local storm events (Authority, 2000).

2.2.1 Stream and Alluvial Monitoring

Since 1994, the Authority has conducted baseline surface water and groundwater quality data collection within the watershed for a number of water quality parameters, such as phosphorus species, nitrogen species, sulfate, and chloride. The study reach spans from Castlewood Canyon to the entrance to Cherry Creek Reservoir (**Figure 2-11**). Based on data collected over the past 8 years, the following trends have been noted (Halepaska, 2003):

FOR MORE INFORMATION

"2002 Annual Report, Baseline Water Quality Data Collection Study for the Upper Cherry Creek Basin," prepared for the Authority by John C. Halepaska and Associates, Inc., April 2003.

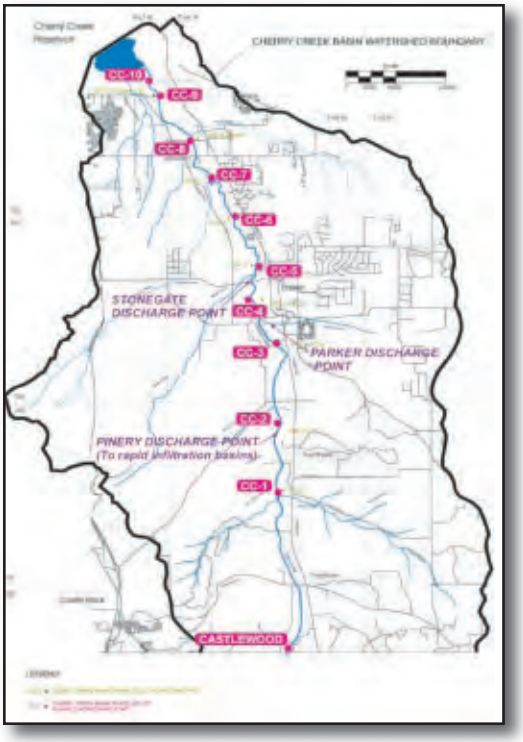


Figure 2-11. Surface and Groundwater Monitoring Points

- For the period of record, both dissolved phosphorus and total phosphorus concentrations increased in response to storm events throughout the urbanized portion of the study reach. Data collected to date indicate that

phosphorus concentrations show a slight upward trend over time at the downstream end of the study reach, near the reservoir (**Figure 2-12**).

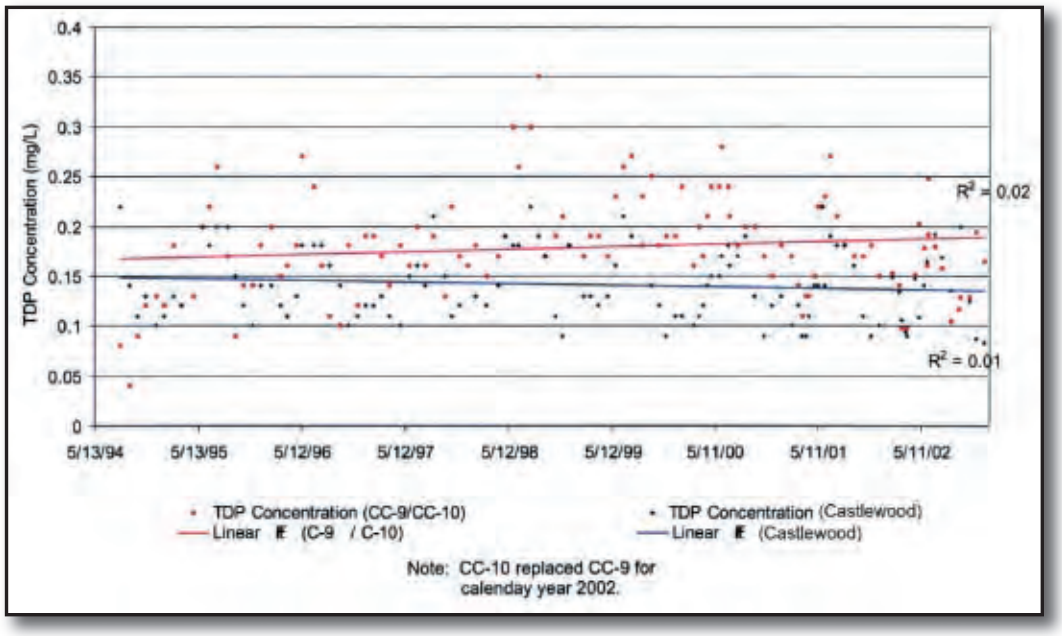


Figure 2-12. Total Dissolved Phosphorus Concentrations Near The Reservoir

- During the past year, the cumulative phosphorus loading to the reservoir from the mainstem of Cherry Creek is approximately 20 percent of the TMAL to the reservoir, as measured at CC-10. The 2002 load measured at CC-10 is lower than the 2001 phosphorus loading to the reservoir, 2,916 pounds compared to 4,813 pounds (**Figure 2-12**).

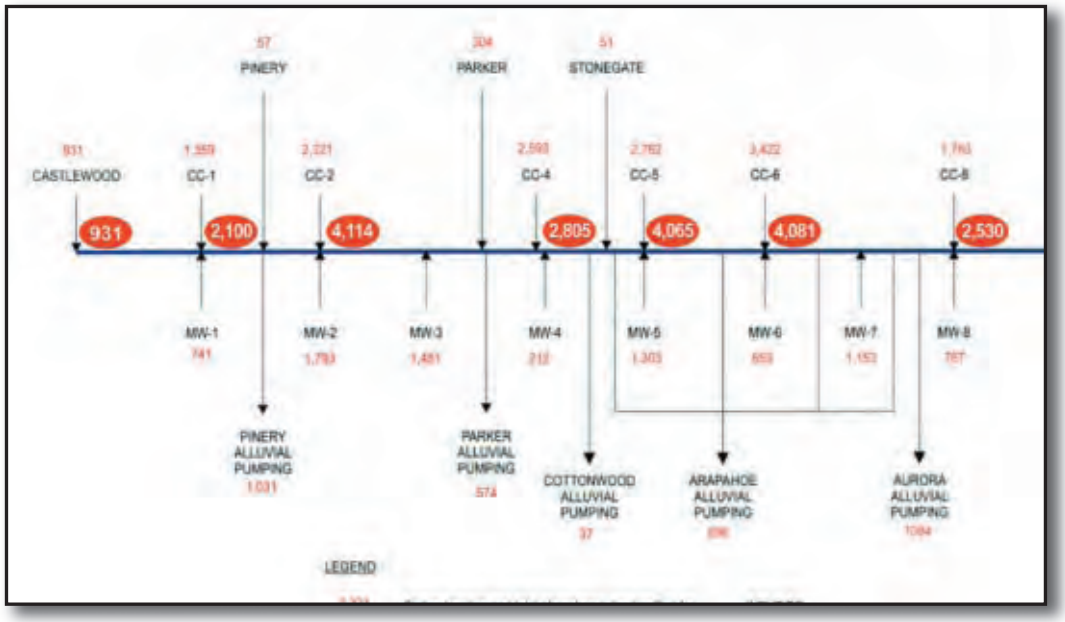


Figure 2-13. 2002 Phosphorus Loads Along Cherry Creek

- Nonpoint sources contribute the bulk of phosphorus loading to the reservoir from the mainstem of Cherry Creek at this time. The source is principally related to flow with some attendant increases from average concentrations of phosphorus.
- Point source discharges from advanced wastewater treatment (AWT) plants currently

represent approximately 7-percent of the total phosphorus load input in the study reach in 2002. These loadings will increase in the future as a result of growth in the watershed but will be mitigated through AWTs designed to limit discharges to 0.05 mg/L. Point source discharges, however, are important since most of the phosphorus is in a dissolved form, therefore, more readily available for nutrient growth.

- Municipal alluvial pumping removes over eight times the amount of phosphorus that is input through municipal wastewater discharges. However, there is a corresponding increase in phosphorus from urban storm runoff from development that is served by the municipal Wastewater Treatment Facilities (WWTFs).
- Nitrate-nitrogen concentrations fluctuated throughout 2002 and were generally higher in the alluvium than in surface water. It appears that a large portion of the nitrate-nitrogen concentration in the groundwater system is from nonpoint sources, such as agricultural uses and leachfield discharges (Authority, 2003) (**Figure 2-14**). There was a net decrease in nitrate-nitrogen loads from the upstream end of the study reach to the downstream end of the study reach in the alluvial groundwater in 2002.

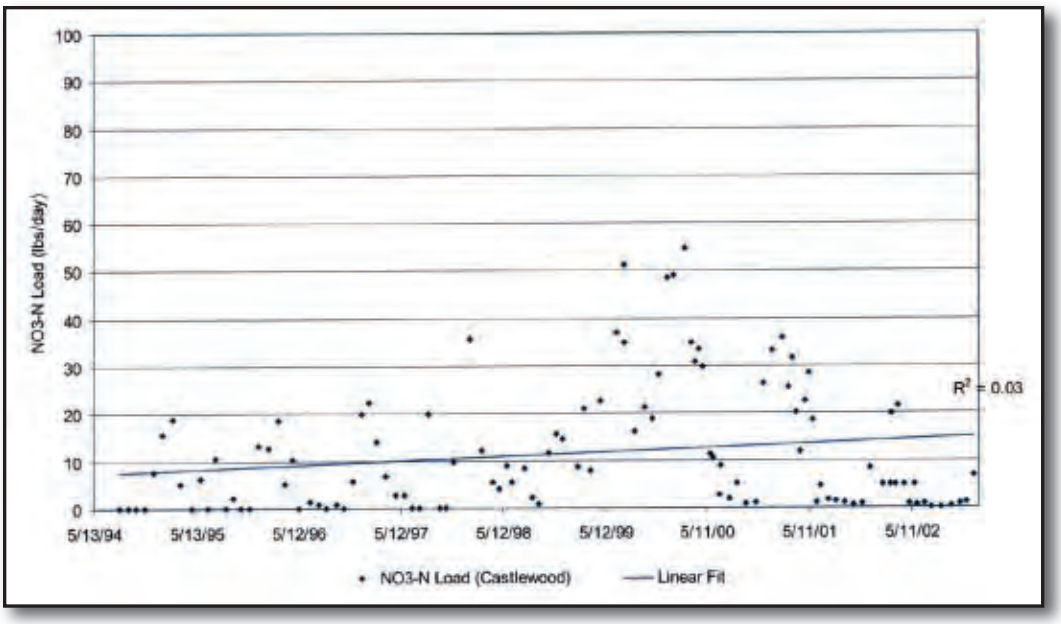


Figure 2-14. Nitrogen Concentration from Nonpoint Sources

- Increased levels of chloride and sulfate were observed in surface waters in the vicinity of direct discharges. Concentrations of chloride and sulfate are below the drinking water standard, but sulfate concentrations approach the standard just upstream of Cherry Creek Reservoir (Authority, 2003).

2.2.2 Cherry Creek Stream Stability

Stream stability has a direct connection to water quality enhancement, particularly since phosphorus-laden sediments are a source of phosphorus loads to the reservoir. A recent major drainageway planning study along the Cherry Creek Corridor (Corridor) was conducted by the Urban Drainage and Flood Control District (UDFCD, 2002). Based on a reach-by-reach evaluation of the stream morphology in the Corridor, Cherry Creek is experiencing significant areas of instability. Areas of headcutting, aggradation, degradation,

and lateral instability are all apparent within the study reach. These factors result in increased sediment and phosphorus loads to the reservoir.

FOR MORE INFORMATION

"Cherry Creek Reservoir – Reservoir to Scott Road, Major Drainageway Planning Study Alternative Evaluation Report," prepared for the UDFCD by URS Corporation, December 2002.

The bed slope ranges between 0.0024 to 0.0064 feet per foot (ft/ft). Based on the channel stability analysis, a channel grade of approximately 0.0022 ft/ft will offer a stable vertical condition for most channel areas. The stream stabilization and water quality features of the UDFCD plan include the following improvements:

- Floodplain stabilization, habitat enhancement, and creation of wetland areas by constructing structural grade controls and providing stream/floodplain corridors.
- Enhancement of braided stream characteristics.
- Lateral bank stabilization using buried rip-rap with soil and vegetation.
- Sediment and phosphorus load reductions utilizing a strategically located sediment trap facility.
- Channel restoration and corridor management efforts to reduce erosion.

These stabilization measures mimic a "natural" stream system, which help to manage stormwater quality and achieve other watershed goals such as restoration of riparian areas, wildlife habitat and preservation of open space.

2.2.3 Land Use

The northern portion of the watershed has been urbanizing over the past 25 years, especially in the subbasins immediately adjacent to the reservoir. Developed land uses include high to moderate density suburban residential areas, large lot subdivisions, commercial and light industrial parks, and office buildings. Traditional agricultural and agribusiness uses are still present, but mostly in the southern portion of the watershed (Authority, 2003).

2.2.4 Impervious Cover

Based on projected land use, the overall percent imperviousness within the northern portions of the Cherry Creek Reservoir Watershed between Castlewood Canyon and Cherry Creek Reservoir is expected to increase to 19-percent by the year 2020 (UDFCD, 2002). Impervious cover is important because it is a function of runoff potential and pollutant loading. The majority of the impervious cover for subwatersheds north of Lincoln Avenue are greater than for the entire basin, ranging from 20-percent to 50-percent. The majority of the watershed, approximately 80-percent, is projected to remain undeveloped and rural. To date, most of the development has occurred in the northern part of the watershed, primarily in the City of Aurora, City of Centennial, Arapahoe County, and the Town of Parker (UDFCD, 2002).

Subwatershed Classification. Subwatershed category classifications, such as that developed

by the Center for Watershed Protection (1998), serve as tools for water resource protection in the Cherry Creek Reservoir Watershed. **Table 2-3** summarizes a host of subwatershed categories that are pertinent to the Cherry Creek Reservoir Watershed.

Table 2-3. Subwatershed Categories in the Cherry Creek Reservoir Watershed

SUBWATERSHED CLASSIFICATION	DESCRIPTION
Sensitive Stream	Less than 10 percent imperviousness, rated as high quality for fish, macroinvertebrates, or habitat indicators. May be warm or cold water system.
Impacted Stream	Subwatershed has 10-percent to 25-percent impervious cover, and monitoring indicates a decline in the physical, chemical, or biological indicators.
Restorable Stream	Subwatershed classified as impacted or non-supporting that has sufficient retrofit potential to make a meaningful improvement in the basin and pollutant loading of the stream.
Urban Lake	Subwatershed drains to natural or man-made lake that is subject to degradation (watershed to lake area ratio of 200 to 1 or less)
Aquifer Protection	Subwatershed has strong surface water-groundwater interaction and groundwater is a primary source of potable drinking water.

"Sensitive streams" are generally found in the rural, southern portion of the watershed with low impervious cover; "impacted streams" are typical of what is observed in the urbanized portion, (or greater impervious cover) of the watershed. The "restorable stream" classification is given for those subwatersheds that have potential for improving the watershed and pollutant loading of the stream by stabilizing is streambanks and channels, augmenting riparian areas, controlling hydrologic regime, and reducing urban pollutants. Water quality management strategies identified by the Authority and other watershed programs are geared towards protecting "sensitive stream" subwatersheds and shifting subwatersheds from an "impacted stream" status to a "restored" condition.

The "urban lake" classification is given to those direct flow areas and subwatersheds that drain into the Cherry Creek Reservoir. Finally, the "aquifer protection" classification is appropriate to this watershed because water purveyors rely on the Cherry Creek alluvium and non-tributary aquifers for drinking water supplies.

2.3 WATER SUPPLIES

Municipal water sources in the Cherry Creek Watershed come from the alluvial (tributary) and deep, non-tributary aquifers, as well as surface water storage imported to the watershed, but not from Cherry Creek Reservoir itself. A new raw water storage facility, Parker Water and Sanitation District's Reuter-Hess Reservoir, is also being evaluated as a supply of water.

There are six principal municipal water supply entities in the Cherry Creek Watershed that utilize Cherry Creek alluvial aquifer wells. These entities include Arapahoe County Water and Wastewater Authority, City of Aurora, Cottonwood Water and Sanitation District (CWSD), Parker Water and Sanitation District, East Cherry Creek Valley Water and Sanitation District, and the Pinery Water and Sanitation District.

The alluvial water that is pumped from the Cherry Creek alluvial aquifer by the municipal water entities is replaced by effluent treated to advanced levels (AWT), which is 4 to 10 times lower in phosphorus concentrations than the water removed during alluvial pumping. Increases in the historic pumping pattern in the alluvium are likely to alter Cherry Creek in various segments from a gaining to a losing stream (Authority, 2000). In 2002, municipal pumping from alluvial aquifers ranged from a low of about 3,500 ac-ft to over 7,500 ac-ft annually, with an average around 5,400 ac-ft. Pumping from the alluvium reduces runoff volume and phosphorus loads delivered to the reservoir; both of which can affect reservoir water quality (Authority, 2000).

2.4 Point Source Discharges

The point source dischargers within the Cherry Creek Watershed are those WWTFs that provide centralized wastewater treatment service. Currently, there are six WWTFs authorized in the watershed that provide tertiary treatment and either directly discharge the treated water or land apply the reclaimed water within the basin. Additional WWTFs, including new land application facilities within the basin, would require authorization and an appropriate wasteload allocation from the Authority.

FOR MORE INFORMATION

"Watershed Plan 2000 – Cherry Creek Watershed, Colorado," prepared for the Authority by Brown and Caldwell, 2000.

The Cherry Creek Phase I TMAL allocates the annual phosphorus contributions among the various sources in the watershed as shown in **Table 2-4**.

Table 2-4. Total Maximum Annual Load

ALLOCATION TYPE	TOTAL PHOSPHORUS POUNDS PER YEAR
Non-point and regulated stormwater sources	10,290 pounds
Background sources	1,170 pounds
Wastewater facility sources (including Reserve Pool and Phosphorus Bank)	2,310 pounds
Industrial process wastewater sources	50 pounds
Individual sewage disposal systems	450 pounds
TOTAL MAXIMUM ANNUAL PHOSPHORUS LOAD	**14,270 pounds**

The Cherry Creek Control Regulation specifically allocates a point source load of 2,310 pounds per year among the WWTFs and provides a maximum allocation of phosphorus that each point source may discharge annually. Those allocations, which are summerized in **Table 2-5**, are as follows:

Table 2-5. Annual Allocations of Phosphorus by WWTF

FACILITY	POUNDS PER YEAR (TP)
Arapahoe County Water and Wastewater Authority/Cottonwood	402
Denver Southeast Suburban Water and Sanitation District	304
Inverness Water and Sanitation District	129
Meridian Metropolitan District	113
Parker Water and Sanitation District	533
Stonegate Center Metropolitan District	161
Semi-urban areas	236
Subtotal	1928
Reserve Pool	216
Phosophorus Bank	216
TOTAL	**2,310**

In the Cherry Creek Watershed, WWTFs provide for a very high level of phosphorus removal and treatment using either secondary treatment followed by land application or AWT followed by land application or direct discharge. The Cherry Creek Control Regulation requires that by August 1, 2004 all discharges must meet an effluent concentration of 0.05 mg/l TP and their annual wasteload allocations for their discharges.

Pursuant to the Cherry Creek Control Regulation, dischargers may increase their annual phosphorus allocation through a number of means - acquisition of phosphorus credits from the Reserve Pool, creation of trade credits from the Phosphorus Bank, temporary transfers, or allocations from the semi-urban areas. Each modification to a WWTF's wasteload allocation must be approved by the Authority, which constitutes final approval. The point source may discharge pursuant to its increased wasteload allocation upon completing any necessary modifications to its discharge permit or reuse authorization. To keep this plan updated, the Authority will periodically incorporate such revised wasteload allocations into this plan.

The service areas and populations for each WWTF were evaluated by the Water Quality Control Commission during the adoption of the TMAL. Specifically, the wasteload allocations were based upon design capacity of the WWTFs to serve the projected population for 2007 to 2010. Service areas for each of the WWTFs included in the supplemental technical appendix. Each WWTF's service area - the wastewater utility service area, clean water planning area, and regional envelope - may be modified upon approval of the WWTF's Wastewater Utility Plan or amendments approved by the Authority and DRCOG. This plan shall be updated periodically to incorporate revised service areas.

The Authority reviews all WWTF site applications for new, updated, upgraded, and expanded WWTFs and new lift stations within the watershed for consistency with the effluent limitations set forth in the TMAL and the Control Regulation. The release of untreated wastewater compromises water quality, and in 1997 and 2001, two sanitary sewers transmitting wastewater from the watershed, Aurora and Havana Water and Sanitation District, had sewer overflows that impacted water quality and caused the closure of Cherry Creek State Park Swim Beach. In 2001, the Authority developed emergency response plan criteria that require wastewater facility design and plans to minimize the risk and

water quality impacts caused by sewer overflows. The Authority adopted the Cherry Creek Reservoir Watershed Emergency Response Criteria on March 28, 2002 (Authority 2003). In the first year of implementation of the Emergency Response Criteria, the Authority found many submittals consistent with the criteria and approved them for construction.

While there are no new WWTFs proposed in the watershed, it is likely that new development will continue to be served by existing districts in proximity to development. Septic systems will likely be utilized in more rural areas upstream of Franktown.

2.5 Stormwater Discharges

The Authority's "Cherry Creek Stormwater Quality Requirements" describes minimum BMP requirements for implementation by all land use agencies. Moreover, under the federally mandated NPDES Stormwater Phase I and II programs, many of the land use agencies that are part of the Authority are required to implement and enforce a water quality component to their Municipal Separate Storm Sewer System (MS4). In 2002, the Authority surveyed MS4s in the Cherry Creek Basin to document the status of Erosion and Sediment Control and Water Quality (ESC/WQ) BMP programs to control stormwater runoff. The survey confirmed that all the land use agencies in the Cherry Creek Basin have ESC/WQ BMP programs in place and are implementing these programs through engineers, inspectors, and other support personnel (Authority, 2003). There has also been a cooperative effort to plan and build regional stormwater improvements in the area near the reservoir, including water quality improvements. Participating agencies include Arapahoe County, the Town of Parker, the City of Aurora, Greenwood Village, Douglas County, the Town of Castle Rock, and City of Centennial. Except for Aurora, which has a Phase I NPDES permit, all of these designated entities have recently submitted applications for NPDES Stormwater Phase II permits that describe stormwater programs, or minimum control measures, developed to address program goals and requirements in the following areas:

FOR MORE INFORMATION

Clean Water Act - 40 CFR 122.26, WQCC Stormwater Regulation – Colorado Regulation CCR 61, and Cherry Creek Control Regulation 72.

- Public Education and Outreach
- Public Participation/Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Stormwater Runoff Control
- Post-construction Stormwater Management
- Pollution Prevention/Good Housekeeping of Municipal Operations

As part of the stormwater regulation, designated entities within the Cherry Creek Basin are required to meet a more aggressive implementation schedule for the minimum control measures. Phase II permitees in the watershed have developed ad-hoc working groups to coordinate on Phase II stormwater program implementation to avoid duplication and save money. The City of Aurora has recently renewed its first permit term for its Stormwater Phase I permit.

A suite of nonpoint source control fact sheets, *The BMP Series*, will complement the public education and outreach components on stormwater runoff impacts in the Cherry

Creek Watershed. *The BMP Series* is being developed by the Authority as part of an (Environmental Protection Agency (EPA) 319 Grant to provide education and outreach materials to the public and private sector, including the residents of the Cherry Creek Basin, developers, contractors, engineers, and land use agencies.

2.6 Other Nonpoint Sources

Approximately 80-percent of the watershed remains rural and undeveloped. While the primary nonpoint sources are attributable to background sources and urban stormwater runoff, other nonpoint sources in the watershed include agricultural runoff, septic systems and gravel mining.

Agricultural Activities. The upper portion of the watershed is generally rural with large residential lots and small ranches, stables, and agribusinesses. In some areas, cattle and horses graze next to drainages, resulting in over-grazing, erosion, and water quality concerns. Nutrients (nitrates and phosphorus), bacteria, and pathogens are the primary constituents of concern. Historically and statutorily, the Authority has not addressed agricultural activities in rural areas and has relied on other federal agencies, such as the Natural Resource Conservation Service (NRCS), to work with the agricultural community to implement voluntary control measures for reducing agricultural nonpoint source loading in the Cherry Creek Basin.

Septic Systems. The primary water quality issues associated with septic systems is the cumulative amount of phosphorus and nitrogen species reaching water bodies, and the high threat of pathogenic bacteria contamination of groundwater (EPA, 1977). Cumulative phosphorus and nitrogen loading from septic systems can be a significant nonpoint nutrient contributor in urbanized watersheds (DRCOG, 1999). An earlier study conducted in the Cherry Creek Watershed (Halepaska, 1999) suggested septic systems from upland areas may not contribute significant loads to stream preservation areas, while septic systems along tributaries and in the stream preservation areas can contribute significant loads to Cherry Creek and its alluvium. Issues have been raised regarding potential water quality impacts from septic systems and the adequacy of current efforts to minimize such impacts in some portions of the Cherry Creek Watershed, including the Franktown Planning Area (approximately 100 septic systems) and Valley Country Club (approximately 20 septic systems). In these areas, septic systems are located in the environmentally sensitive Cherry Creek alluvium. Historically, the Authority has restricted installation of septic systems in the Cherry Creek Watershed and does not allow for construction of septic systems in stream preservation areas due to water quality impacts (Authority, 2000).

Gravel Mining. Gravel mining operations are present in the Cherry Creek Watershed. These activities result in additional point and nonpoint source contributions of phosphorus that are released from soils during mining in the Cherry Creek Watershed. Because of the impact these operations potentially have in Cherry Creek, the TMAL includes "Industrial Process Wastewater," as a wasteload allocation that is regulated in the Control Regulation to address phosphorus loads produced by mining operations.

2.7 Pollutant Reduction Facilities

The Authority has constructed and is operating, maintaining, and monitoring several PRFs in the immediate vicinity of the Cherry Creek Reservoir. Baseline BMPs are the first line of defense for water quality management of new development. PRFs further increase the level of treatment above baseline BMPs and provide additional water quality protection in a subwatershed. Shop Creek (1990), East Side Shade Shelter (1996), Quincy Outfall (1996), and Cottonwood Creek (1996) were the first PRFs constructed by the Authority in the Cherry Creek Watershed. These initial PRFs are the Authority's Historic Trade Projects and comprise 216-pounds in the Phosphorus Bank approved by the WQCC in 2001. The Authority has also constructed the Tower Loop/Dixon Grove project along the northeast part of the reservoir and the Cottonwood Creek/Peoria Street extended detention basin. Other projects are in preliminary and final design phases. (**Figure 2-15**).

East Side Shade Shelter PRF. This shoreline stabilization project is located immediately adjacent to popular access areas for fishing and picnics. Rock toe, willow plantings and bio-logs provide water quality enhancement of approximately 15 pounds per year by controlling erosion.

Quincy Drainage PRF. This vegetated infiltration basin captures runoff from over 530-acres upstream. Native grasses and riparian vegetation uptake nutrient laden baseflow and stormflows captured behind the berm that serves as a bike path. Phosphorus reductions are approximately 150 pounds annually.

Shop Creek PRF. Retention pond followed by a series of seven wetland ponds removes approximately 250 pounds of phosphorus annually from the 725-acre subbasin.

Cottonwood Creek PRF. This PRF slows storm runoff and baseflows while reducing phosphorus loads from a 7,500-acre drainage area. Annual phosphorus removals are typically over 800 pounds per year.

Figure 2-15. Original PRFs (Historic Trade Projects) Constructed by the Authority

Cottonwood Creek Water Quality Improvements. Water quality improvements are also being implemented in the Lower Cottonwood Creek basin. The Cottonwood/Peoria Street Water Quality Detention Pond was completed in May 2002 to reduce sediment migration from streambank erosion. The proposed Lower Cottonwood Creek stream reclamation project is located in the southwest part of the Park downstream of the Cottonwood/Peoria

Street Pond. The focus of this project is to reduce streambank erosion and reclaim 7,700 linear feet of the channel and floodplain to allow regularly occurring floods to become connected to the floodplain, allowing filtration and/or infiltration of runoff. This project is under design, and construction will begin in the Fall 2003 (**Figure 2-16**). This project is expected to immobilize 300 to 600 pounds of phosphorus annually at a cost of $300 to $600 per pound of phosphorus reduced.

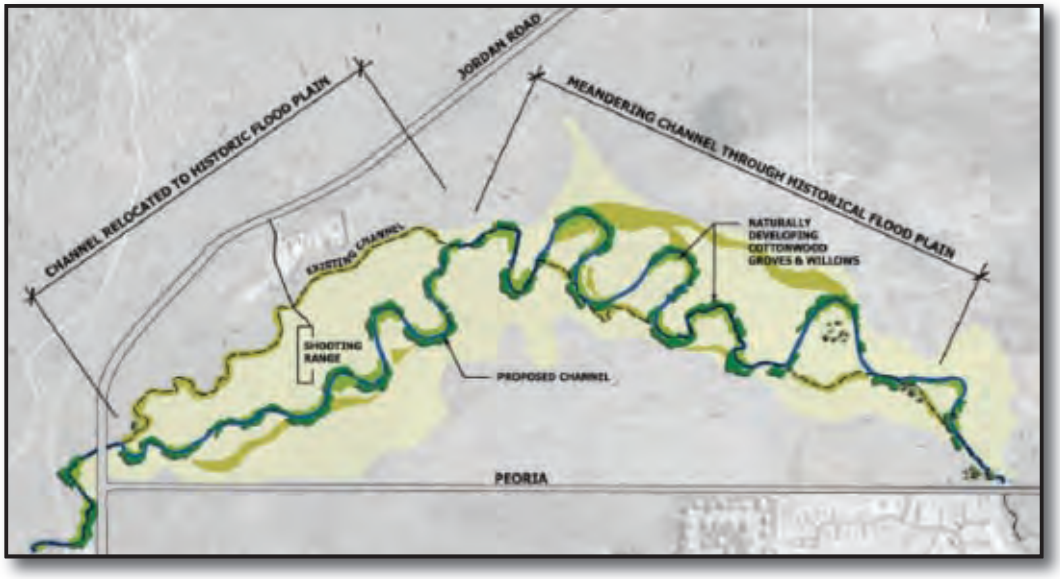


Figure 2-16. Lower Cottonwood Creek Stream Reclamation PRF

Bowtie Property Acquisition. The Authority also recently partnered with UDFCD, TPL, City of Centennial and Arapahoe County to purchase the Bowtie Property adjacent to Cherry Creek State Park at the confluence of Piney Creek and Cherry Creek. The property will be the future site of a 10.5-acre wetland PRF, expected to immobilize 235 pounds of phosphorus at an annual cost of $400 per pound (**Figure 2-17**). Water rights were also acquired as part of the Bowtie project. The total yield of the two wells, one shallow tributary and the other a deep bedrock aquifer, is estimated at 52-acre feet per year. Potential use of this water is subject to several legal proceedings, including change of use and plan for augmentation.

Figure 2-17. Bowtie Wetlands PRF

Cherry Creek State Park Wetlands. Design concepts are under way to improve flow distribution in the existing riparian corridor and delta upstream of the reservoir (**Figure 2-18**). As proposed, this project will enhance existing wetland treatment processes along Cherry Creek and reduce phosphorus in baseflows and storm runoff through settling, soil filtration, and wetland treatment. Phosphorus removal is estimated to be 600 to 1,200

pounds on a long-term annual average basis (Authority, 2003). Project costs are expected to be $1.26 million.

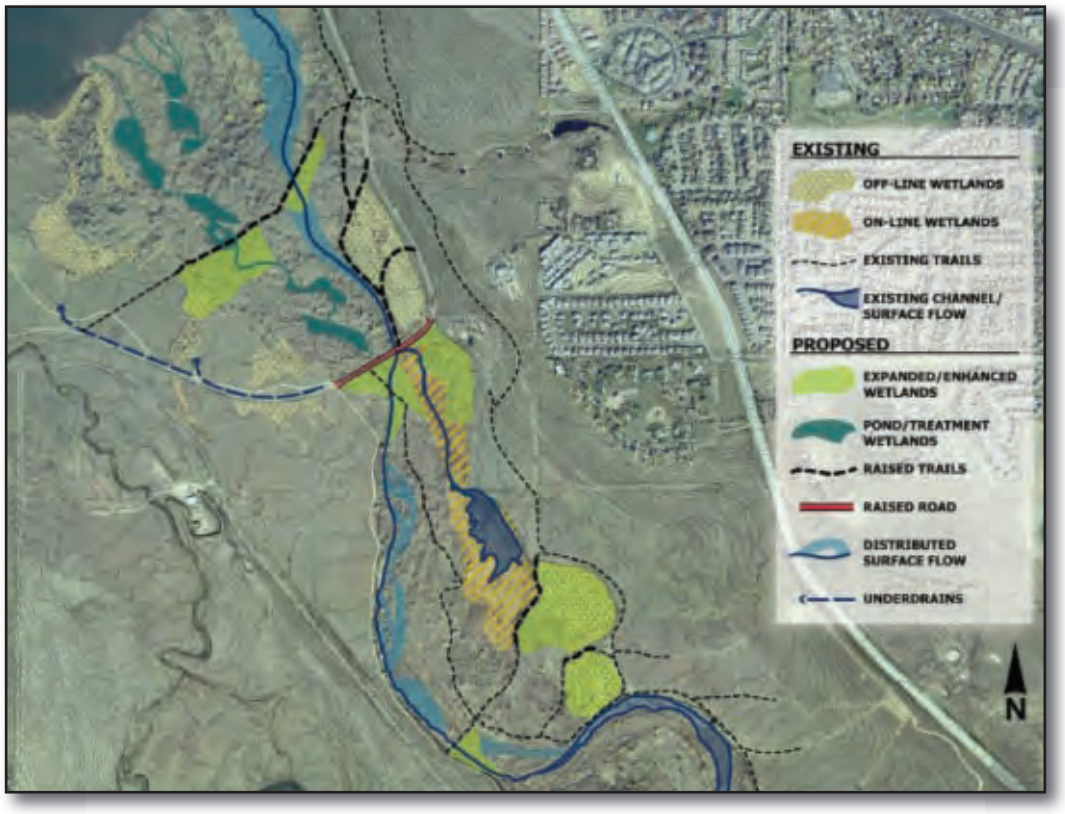


Figure 2-18. Cherry Creek State Park Wetlands

2.8 Watershed-Based Trading

Trading is the exchange of pollutant allocations or reduction credits between sources within a watershed to meet water quality requirements (EPA, 2003). In 1996 the Authority began developing a watershed-based trading program, recognizing:

FOR MORE INFORMATION

"Cherry Creek Basin Water Quality Authority Trading Program Guidelines," Authority, 2003.

- Innovative strategies to meet water quality requirements
- Incentives to encourage and facilitate the construction of nonpoint source control projects, thereby reducing phosphorus loads to the reservoir
- Methods for dischargers to increase their wasteload allocations and meet permit requirements.

In Summer 2003, the Authority revised the Trading Program Guidelines to comply with 2001 modifications to the Cherry Creek Control Regulation. The trading program allows applicants to receive, in allocated form, or purchase/lease, a total of 432 pounds of phosphorus for new or increased phosphorus wasteload allocations from two distinct sources:

(1) 216 pounds from the Reserve Pool (new trade projects) in exchange for phosphorus loading reductions from nonpoint source control projects built by the applicant or third parties.

(2) 216 pounds stored in the Phosphorus Bank from credits acquired from the Authority's historic trading projects. Applicants can purchase or lease a portion of these credits from the Authority.

A trade ratio is applied to the pounds of phosphorus removed by a trade project to determine the pounds of credit. The minimum trade ratio is 2:1, so that for every 2 pounds of dissolved phosphorus removed by a project, there is no more than 1 pound of credit available (Authority, 2003). Monitoring of trading projects provides additional information on project effectiveness. Trades between nonpoint sources and point sources have a trade ratio of 2:1 or greater, ensuring that trading provides a net water quality benefit.

2.9 Watershed Management Structure

In order to meet the established water quality standards and to preserve the beneficial uses of the reservoir, the Authority, comprised of elected officials and governor- appointed representatives within the Cherry Creek Watershed, has made the commitment to implement water quality management strategies in the watershed. These strategies complement the development and implementation of the phosphorus TMAL and support comprehensive water quality improvements in the Cherry Creek Basin.

Following 2001 legislation (CRS 25-8.5-101), the Authority Board was reconstituted to include the following 17 members:

- Two Counties (Arapahoe and Douglas)
- Seven Municipalities (City of Aurora, Town of Castle Rock, City of Centennial, Town of Foxfield, City of Greenwood Village, City of Lone Tree, and Town of Parker)
- One member representing the seven special districts (Arapahoe Water and Wastewater Authority, Cottonwood Water and Sanitation District, Inverness Water and Sanitation District, Meridian Metropolitan District, Parker Water and Sanitation District, Pinery Water and Sanitation District, and Stonegate Village Metropolitan District)
- Seven citizens representing various environmental and economic interests, appointed by the governor

The legislation requires the Authority to submit a new Water Quality Control Plan within 2 years (2003) and spend at least 60-percent of the authorized revenues on the construction and maintenance of PRFs. The Authority continues to implement the intent of the legislation and Control Regulation within the constraints of funding limitations.

Since 1985 the Authority has:

- Conducted extensive water quality monitoring of Cherry Creek, its tributaries, the alluvium, and the reservoir
- Developed a three-step approach to controlling phosphorus through control of erosion during construction, baseline BMPs to control pollutants in urban runoff, and PRFs that go beyond BMPs
- Adopted stormwater quality regulations that land agencies have used to implement, monitor, and enforce construction erosion control and baseline BMPs that control stormwater pollution

- Coordinated with land use agencies on appropriate water quality requirements for pre- and post-construction BMPs for developed areas
- Reviewed site applications for WWTFs and lift stations, wastewater utility plans, and land use and development applications and implemented measures to reduce potential impacts to water quality
- Planned, constructed and monitored the performance of a number of PRFs in the basin
- Developed a 3-year Capital Improvement Project (CIP) plan (**Table 2-6**)
- Implemented an operations and maintenance plan to insure PRFs continue to serve their purpose
- Developed information and education programs

Table 2-6. 2003 CIP Plan

31 Oct 02	PROJECT BUDGET								
Project Number	**Project Title**	**Capital**[1]	**Land**	**Water**	**Total**	**O&M**	**Authority Portion**	**Budget 2002**	**Residual PRF Costs**
CCB-1	CCSP Wetlands	$1,260,000	$ -	$325,000	$ 1,585,000	$ 26,000	100%	$ 45,000	$ 1,540,000
CCB-6.1	Piney Creek SBS - Project 1[4]	$ 118,000	$ -	$ -	$ 118,000	$ -	100%	$ 118,000	$ -
CCB-12	Bowtie Property PRF	$ 826,000	$300,000	$ 63,000	$ 1,189,000	$ 6,400	100%	$ 350,000	$ 839,000
CCB-12.1	Expanded Bowtie Project	$ 235,000	$200,000	$ 80,000	$ 515,000	$ 7,000	100%	$ -	$ 515,000
CCB-13	Cottonwood Stream Bank Restoration[3]	$1,033,000	$ -	$ -	$ 1,033,000	$ 15,000	93%	$ 354,000	$ 628,738
CCB-14	Belleview Open Water Wetlands	$ 210,000	$ -	$ -	$ 210,000	$ 2,000	100%	$ -	$ 210,000
CCB-16	Stream Corridor Preservation[2]	$ -	$100,000	$ -	$ 100,000	$ -	100%	$ -	$ 100,000
CCB-11	Advanced Water Treatment Plant	$4,593,000			$ 4,593,000	$ 69,000	100%	$ -	$ 4,593,000
CCB-15	Surface Water Reuse at Cherry Creek Vista[5]	$ 50,000	$ -	$ -	$ -	$ -	100%	$ -	$ 50,000
	Operations and Maintenance 1. Restore Cottonwood Wetlands 2. Future O&M								
	TOTALS	$8,325,000	$600,000	$468,000	***$ 9,343,000***	***$ 125,400***		***$ 867,000***	***$ 8,475,738***

NOTES:
1 Includes engineering, administration, and contingency
2 Specific project not identified. Budget based on available funds.
3 WQCD 319 Grant provides $76,467. Project includes enhancements not identified in Watershed Plan 2000
4 Project budget is for CCBWQA portion of project.
5 Suggested contribution of Authority. All other project costs borne by developer.

2.10 Cherry Creek Stakeholders

The Cherry Creek Watershed is comprised of interested stakeholders, including a group of private, local, state, and federal entities committed to finding ways to reduce phosphorus and aid in the implementation of the phosphorus TMAL, while preserving the viability and lifestyle of the watershed. Stakeholders include engineers, water specialists, attorneys, scientists, fisheries experts, local elected officials, recreationists, and members of the public. The following organizations have taken an active role in the Cherry Creek Basin water quality issues and shaped the water quality management strategies:

- Authority Members/Agencies
- Cherry Creek Stewardship Partners
- Special Districts
- CDPHE Water Quality Control Division

- Cherry Creek State Park
- DRCOG
- UDFCD
- Tri-County Health Department
- COE
- EPA
- TPL
- Great Outdoors Colorado

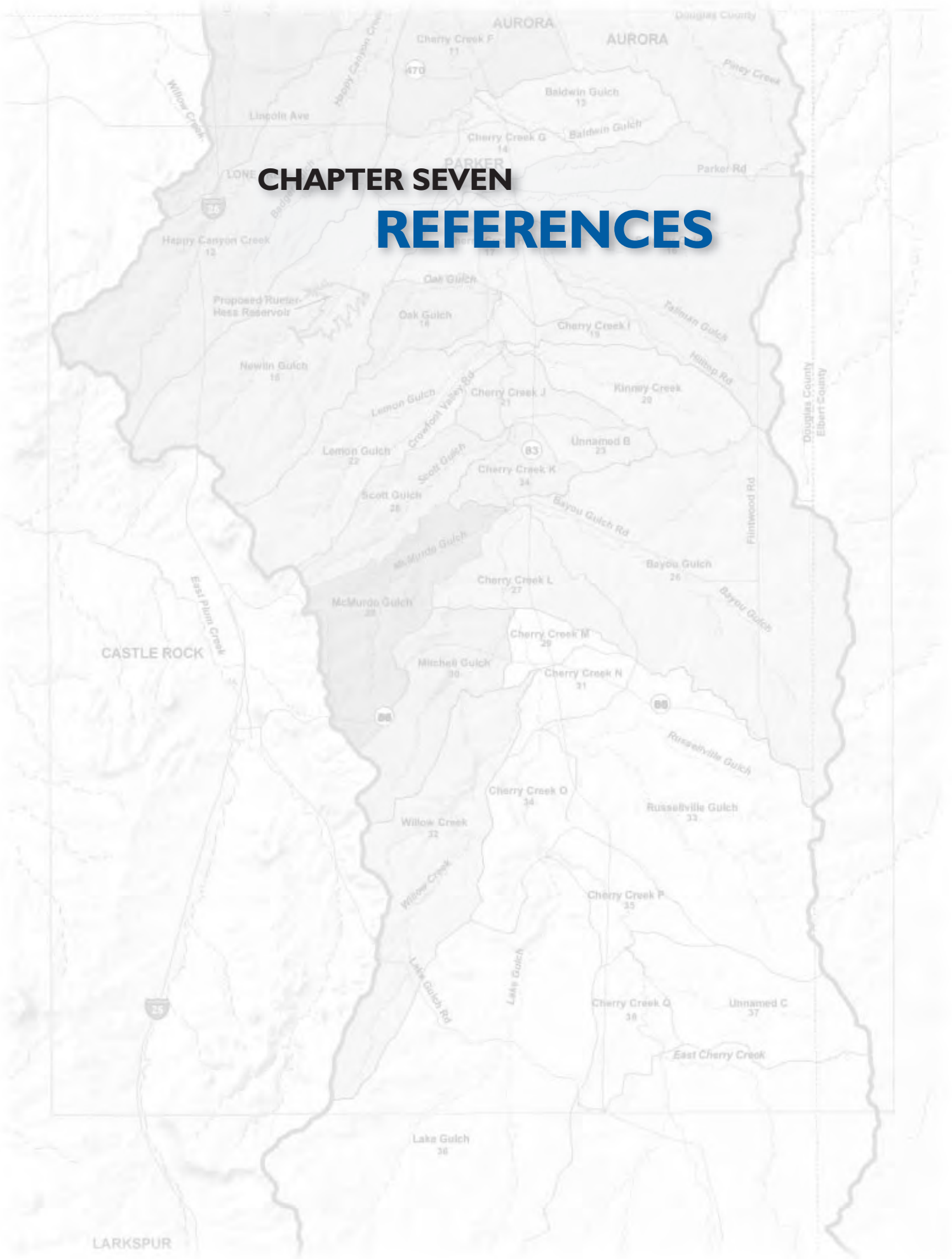
2.11 Other Watershed Programs

There are numerous other ongoing Cherry Creek Watershed programs that support the water quality partnerships, coordination, and collaborative efforts between the Authority and local land use agencies. These programs involve:

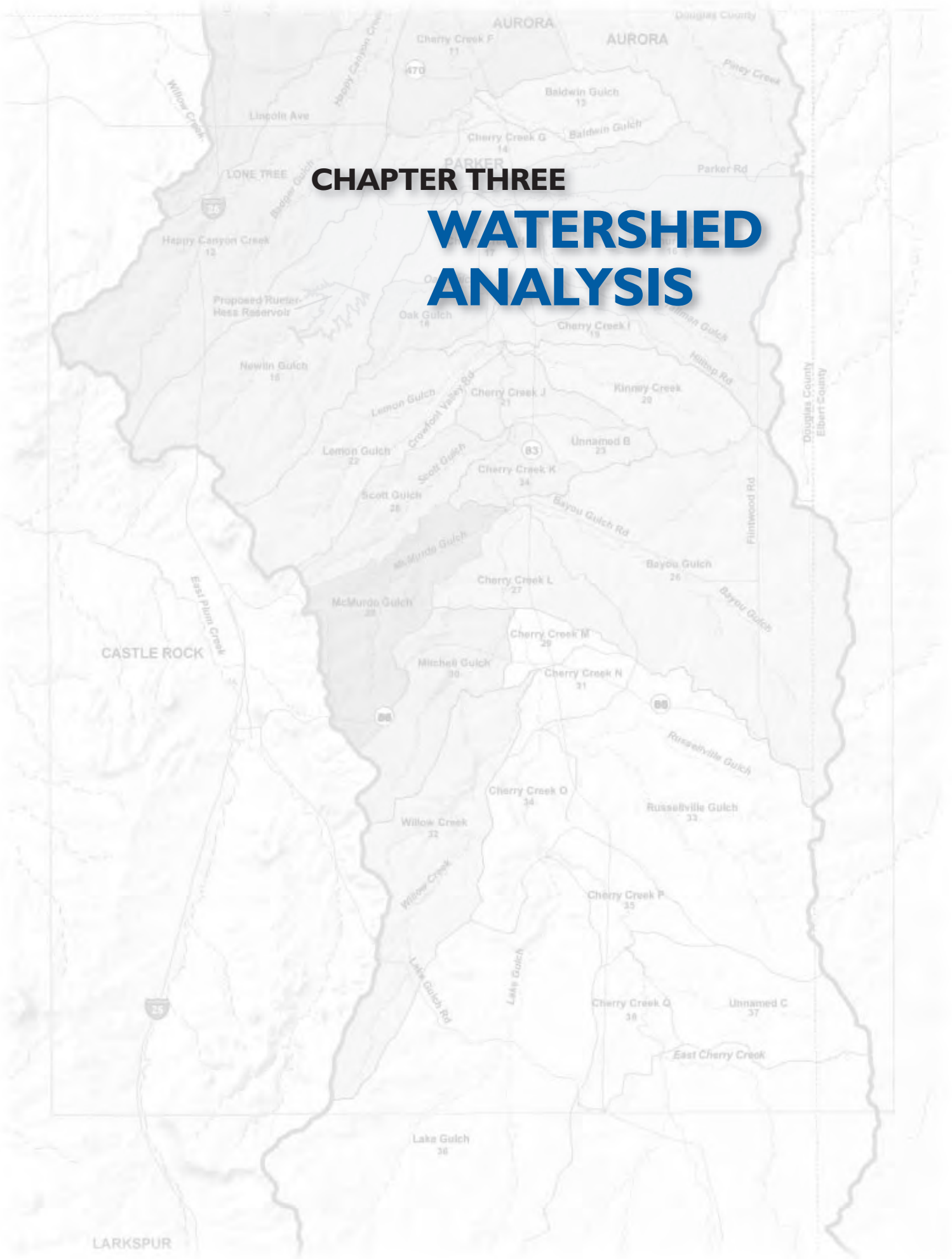
- Implementation of the Authority's "Stormwater Quality Requirements" and minimum BMPs to improve water quality
- Implementation and compliance with Phase II NPDES permit requirements to address stormwater quality of urban runoff
- Adoption of floodplain ordinances that preserve, protect, and enhance the multi-use functionality of floodplains in the Cherry Creek Watershed.
- Adoption of setback or buffer ordinances that promote protection of environmentally sensitive areas in the Cherry Creek Watershed.
- Financial support and implementation of subwatershed master drainageway plans, outfall system plans and major drainageway plans, to stabilize streambank and enhance water quality in Cherry Creek drainages

CHAPTER SEVEN

REFERENCES



Author	Date	Title	Summary
American Water Works Association (AWWA) Research Foundation	1991	Effective Watershed Management for Surface Water Supplies	Resource for assisting water utility managers and local governments in developing effective watershed protection programs for their surface water supplies.
Aquatic Solutions, LLC and Muller Engineering Company, Inc.	November 2000	Experimental Evaluation of the Eutrophication Potential to Standley Lake of Raw, Settled, and Filtered Church Ditch Storm Water	Study and modeling of eutrophication potential when mixing stormwater into Standley Lake.
Brown and Caldwell	October 1997	Water Quality Management Strategy	Excerpts from the 1997 version of the Authority Requirements, specifically addressing implementation of baseline BMPs to control erosion.
Brown and Caldwell	October 1, 1999	Cherry Creek Reservoir Watershed Storm Drainage Quality Plan	Provides a basis to implement structural practices called pollutant reduction facilities (PRF) that reduce external phosphorus loads into Cherry Creek Reservoir.
Brown and Caldwell	June 2002	Summary of Requirements for Compliance with WQCC Control Regulation 72, State Statutes 25-8.5-101 Et. Seq., and Compliance Schedule	Summarizes sections in the Control Regulation and State Statutes requiring action on the part of the Authority.
Brown and Caldwell	October 31, 2002	Summary of Pollutant Reduction Facilities 2003 Capital Improvement Program	Three-year CIP recommendations to the Board.
BRW and WRC	July 1985	Feasibility Study for the Cherry Creek Basin Drainageway	Provides results of a feasibility analysis to identify drainage improvement options for the reach of Cherry Creek from Arapahoe Road to the Douglas County line.
Center for Watershed Protection (CWP)	October 1998	Rapid Watershed Planning Handbook: A Comprehensive Guide for Managing Urbanizing Watersheds	Comprehensive manual for watershed planning which provides insights to watershed planning and case studies from other national watershed plans.
Cherry Creek Basin Water Quality Authority (CCBWQA)	1989	Cherry Creek Basin Water Quality Management Master Plan	Update on Authority activities, wasteload allocation for discharges, allowed phosphorus discharges, effluent limits, control of nonpoint sources, and water quality monitoring.
Cherry Creek Basin Water Quality Authority (CCBWQA)	June 2000	Watershed Plan 2000	Provides information on a watershed approach for Reservoir protection, the phosphorus and chlorophyll a standards, the Cherry Creek TMDL, and projects necessary to achieve objectives.
Cherry Creek Basin Water Quality Authority (CCBWQA)	January 17, 2002	Restated and Amended Bylaws of the Cherry Creek Basin Water Quality Authority	As stated in document title.



CHAPTER THREE

WATERSHED ANALYSIS

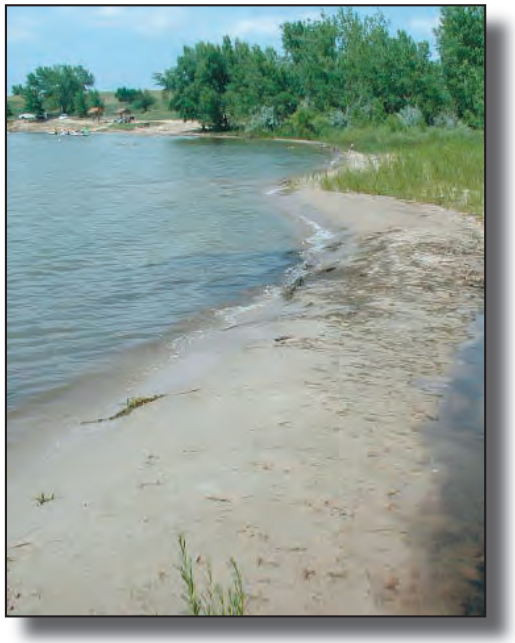
The Cherry Creek Reservoir Watershed Plan is a dynamic document that utilizes scientifically-sound tools to assess the watershed and formulate management strategies.

This section explores the relationship between the reservoir and its upstream watershed and recommends a series of management measures to reduce watershed impacts and help protect reservoir beneficial uses.

3.1 Existing and Projected Conditions in the Watershed

Building on the foundation of the Authority's monitoring program and other water quality activities, and incorporating the findings of UDFCD's *Cherry Creek Corridor Plan* (UDFCD, 2002), and The Trust for Public Land's *Cherry Creek Basin Open Space Conservation and Stewardship Plan* (TPL, 2002), an evaluation of the Cherry Creek Watershed was conducted.

The Authority's mission is to protect beneficial uses of Cherry Creek Reservoir (WQCC, 2001). The water quality of the reservoir is affected by the quantity and quality of inflows from the watershed. Generally speaking, given time, the lower the pollutant loads flowing to the reservoir for a given quantity of inflow (i.e., concentration as pounds of phosphorus per acre-foot of runoff), the higher the likelihood that water quality in the reservoir will be protected (NALMS, 2001). Reservoir response to pollutant loading takes time, both with regard to impairment from excessive loading and improvement as a result of decreased loading; gradual changes over perhaps a 10 or 15 year period may be more typical than monthly or annual responses to loads.



Water quality in Cherry Creek Reservoir is influenced by what happens in the upstream watershed.

A number of watershed pollutants can affect the quality of a water body like Cherry Creek Reservoir, such as sediment, nutrients, metals, bacteria, petroleum products, and other chemicals. Of the pollutants flowing into the reservoir from the upstream watershed, termed "external loading," phosphorus is

of special concern, since it has been identified as a critical nutrient leading to algal growth (DRCOG, 1985). Algal growth, if excessive, can impair reservoir uses and can lead to a cycle of decay, reduction of oxygen in the bottom of the reservoir, and release of additional phosphorus from bottom sediments.

Phosphorus released from reservoir bottom sediments is termed "internal loading." A variety of control methods are oriented toward reducing internal loading; however, this plan focuses on the control of external phosphorus loading from the watershed and does not address management of internal loading.

As discussed in Chapter 2, the reservoir is not consistently meeting chlorophyll a standards given the phosphorus loading that has actually been occurring over the last number of years. While there is uncertainty regarding the level of loading that will enable the chlorophyll a standard to be more consistently achieved, allowing watershed loading to increase above current levels will reduce the likelihood that the reservoir will meet standards in future. If anything, reducing loads below current levels may be necessary. This will be further explored in a phased TMAL approach, discussed in Chapter 4.

The objective of the watershed analysis is to assess whether watershed phosphorus loading is expected to decrease, stay the same, or increase in the future and, if it is projected to increase, to identify management strategies that can be considered to control the primary sources of phosphorus and manage loading, if possible, to levels below current conditions.

3.1.1 Phosphorus in the Watershed

Phosphorus is present throughout the Cherry Creek Watershed. Significant concentrations of phosphorus have been measured in surface baseflows and storm runoff, in alluvial groundwater, in watershed soils and stream bed sediments, and in the precipitation that falls on the reservoir and watershed (CCBWQA, 2001). In addition, phosphorus is likely present in dryfall (airborne dust) that falls on the lake and watershed, although phosphorus in dryfall is not specifically monitored by the Authority. **Figure 3-1** indicates typical total phosphorus concentrations measured by the Authority in the watershed.

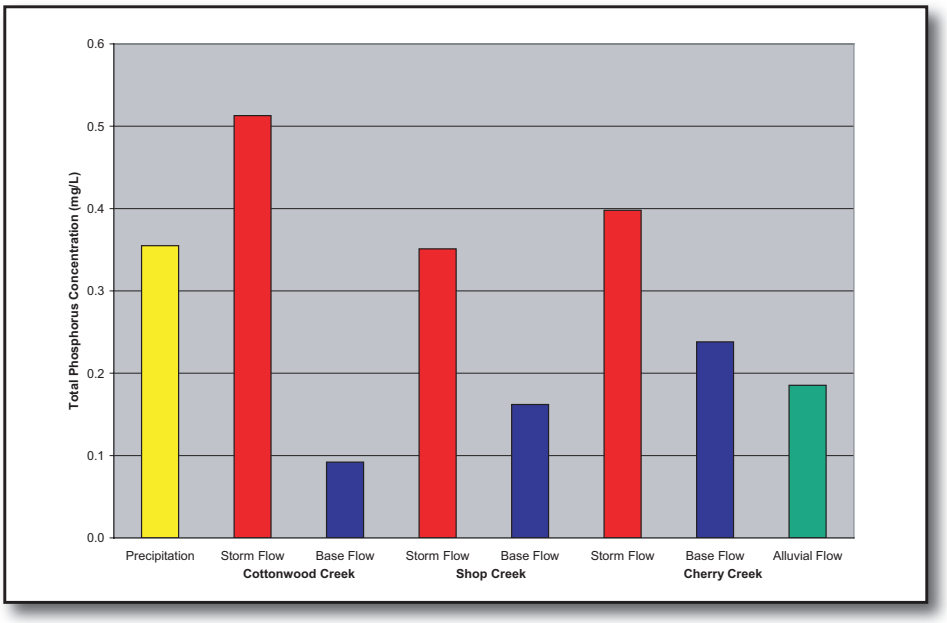


Figure 3-1. Total Phosphorus Concentrations

Cherry Creek alluvial and baseflow concentrations are similar throughout the watershed, whether upstream near Castlewood Canyon or downstream near the reservoir. Since not much urbanization is found in the upstream portion of the watershed, this illustrates that significant sources of phosphorus exist apart from urban effects.

Soluble and Particulate Forms of Phosphorus - Phosphorus can exist in the water column in a dissolved form, termed soluble phosphorus, or be adsorbed onto fine sediment particles that are borne by the water or precipitate into insoluble forms, called particulate phosphorus. Sediment-bound and particulate phosphorus can later be released in a soluble form into the water column, especially under anoxic, or low dissolved oxygen, conditions, that may exist at the bottom of a reservoir. Equilibrium conditions between soil particles and the water column influence actual concentrations of phosphorus in soluble and particulate forms (EPA, 1991).

It is the soluble, not the particulate, form of phosphorus that has been shown to correlate directly to algal productivity, but particulate phosphorus can contain a stored form of the nutrient that can be released under certain conditions like a timed-release fertilizer (Westminster, Northglenn, Thornton, 2000).

Laboratory testing for total phosphorus reflects both particulate and soluble forms of the nutrient, using an acid to strip off sediment-bound phosphorus. A variety of tests reflect soluble phosphorus concentrations in various chemical forms, including tests for dissolved phosphorus, ortho-phosphorus, and soluble reactive phosphorus.

Soluble and particulate forms of phosphorus can be found to some degree in most types of inflows to the reservoir. Stormwater runoff, with its high sediment concentrations, contains significant particulate forms of phosphorus. Groundwater, treatment plant effluent, and clear-weather baseflows typically have a higher proportion of soluble phosphorus (CCBWQA, 2001).

Phosphorus Transport and Delivery - Only a small percentage of the potential phosphorus supply in the watershed is currently mobilized and delivered to the reservoir. If typical phosphorus concentrations measured by the Authority are applied to the whole watershed, over 200,000 pounds of total phosphorus are present in the annual precipitation that falls on the watershed and as much as 2,000,000 pounds of phosphorus may exist within the top 16th of an inch of soil in the watershed (CCBWQA, 2001). Any condition that adds to surface runoff and erosion, or improves conveyance of flow and sediment toward the reservoir, adds to the total phosphorus load in the watershed.

Cherry Creek's Absorption of Runoff and Phosphorus - Stormwater runoff volume measured in Cherry Creek at the reservoir appears to be lower than expected given the size of the watershed and the amount of urbanized area within it. For instance, the Cottonwood Creek watershed has less than 4% of the total area of Cherry Creek (14 square miles compared to 379 square miles) and less than 18% of the impervious area (3.2 square miles compared to 18.3 square miles), yet storm runoff measured by the Authority in Cherry Creek and Cottonwood Creek is comparable, with Cottonwood Creek producing roughly half of the stormwater peak discharges and volumes of Cherry Creek (CCBWQA, 2003). It appears that infiltration processes are significant in the Cherry Creek Watershed and

that a relatively high capacity to absorb runoff and phosphorus is currently working in the reservoir's favor to keep external loads below what could be the case with less absorption.

Where erosion rates are small and infiltration of rainfall and runoff on land surfaces and in the stream network is high, watershed phosphorus loading tends to be low. Conditions that slow down velocities of runoff and increase the contact area with the soil, such as the conditions that are found in wide, well vegetated stream channels, promote infiltration. The presence of a large alluvial deposit under the Cherry Creek corridor and groundwater pumping from this alluvium encourages this effect. Stream channels may also reduce phosphorus concentrations in stormwater runoff via physical, biological and chemical processes that occur in the wetland plant communities and soil substrates along watercourses. Runoff that infiltrates into the Cherry Creek alluvium reflects generally lower phosphorus concentrations than surface stormwater flows (approximately 0.2 mg/l compared to 0.4 mg/l).

Healthy stream systems can reduce sediment and phosphorus loads in urban stormwater through filtering, infiltration, and wetland processes.

Infiltration processes evident in the Cherry Creek Watershed are vulnerable to impacts, however. If stream degradation creates deeper, narrower channels or if natural drainageways are lined with concrete low flow channels, both of which decrease infiltration and vegetative filtering, then greater phosphorus loads may be delivered to the reservoir.

Existing processes in the watershed that naturally absorb runoff and phosphorus are vulnerable to negative impacts.

Therefore, while source controls, such as avoiding over-fertilization and managing animal wastes, are important, maintaining infiltration and absorption processes in the watershed and stream system is also critical. The objective is to leave the phosphorus upstream in the watershed and make it difficult for it to be delivered to the reservoir. Stormwater management techniques that control urban stormwater runoff volume and promote groundwater recharge will come closer to matching predevelopment hydrology and will reduce watershed phosphorus loading.

3.1.2 Urbanization Effects

Erosion, stream degradation, and phosphorus loading are evident both in urban and non-urban portions of the watershed. Measured phosphorus concentrations in the upper reach of Cherry Creek near Castlewood Canyon, where little development has occurred, are similar to concentrations near the reservoir, downstream of urbanized areas. However, urbanization has been shown to influence water quality in several ways, some positive and some negative.

Some aspects of urbanization serve to reduce phosphorus loading. Urbanization tends to stabilize land surfaces and reduce erosion rates once construction is finished, by covering soil with lawn, landscaping, buildings, and pavement. Airborne dust can diminish. Increased runoff and baseflows can create hydrology favorable for the establishment of wetland and riparian vegetation in stream corridors.

However, data show that, overall, urbanization tends to increase stormwater runoff and phosphorus loading (CWP, 1998 and UDFCD, 1999). With urbanization, rainfall runs off roofs and pavement (less infiltration), accumulating and flowing downstream at greater peak rates, velocities, frequency, and volume than before.

With urbanization, rainfall runs off roofs and pavement and flows downstream at greater peak rates, velocities, frequency, and volume than before.

Phosphorus concentrations in urban stormwater runoff tend to be higher than concentrations in non-urban areas (0.65 mg/l compared to 0.40 mg/l based on monitoring by the Urban Drainage and Flood Control District (UDFCD, 1999)). Loads are calculated as the product of runoff volume and concentration, and, since urban runoff volumes can be 5 to 10 times greater than for non-urban land uses, urbanized phosphorus loads can be an

order of magnitude greater than under pre-development conditions. Authority monitoring data for Shop Creek, Cottonwood Creek, and Cherry Creek confirm this trend toward higher phosphorus loading (for a given area) associated with greater urbanization.

Increased runoff can also lead to stream degradation by throwing a stream's equilibrium out of balance and causing it to erode and flatten its gradient to compensate for the extra runoff (Simons and Senturk, 1977). Stream degradation is evident in portions of Cherry Creek and its tributaries, much of it associated with urban effects.

Impact of Stream Degradation - Stream degradation tends to mobilize and transport significant quantities of sediment and particulate phosphorus that is bound to streambed and bank soils. In this way, eroding streams can become a significant source of phosphorus loading, independent from and in addition to phosphorus generated from watershed surfaces.

Degradation impairs channel vegetation and wildlife habitat (CWP, 1998) and tends to lower the water table in stream overbanks, drying up riparian vegetation and weakening the overbank's ability to convey floodwaters without erosion. Stream degradation concentrates flood flows in the channel deepened by erosion and inhibits wide, shallow flow conditions that typify a healthy, functional floodplain. The velocity and erosive power of the concentrated flow may be two or three times greater than in a natural floodplain, further exacerbating erosion.

Degradation can increase sediment and phosphorus loads, concentrate flood flows in incised channels, impair channel vegetation and wildlife habitat, lower the water table, and dry up riparian vegetation.

Incised channels with exposed banks offer less vegetative filtering and infiltration than a healthy natural stream and tend to convey more runoff and phosphorus downstream to the reservoir. Thus, degrading channels can impact the water quality of Cherry Creek Reservoir by becoming sources of sediment-bound phosphorus through bed and bank erosion, by conveying more runoff and associated phosphorus loads downstream to the reservoir, and by impairing the ability of streams to immobilize phosphorus.

Threshold Levels of Urbanization - A variety of factors influence the propensity of a stream system to undergo significant degradation. These factors include the increase in runoff

from urbanization and the period of time the stream is subjected to higher flow rates from urbanization. The greater the upstream imperviousness and the older the development, other factors being equal, the greater the likelihood and severity of stream degradation. Degradation in this case refers to not only erosion, but to the general physical, biological, and chemical aspects of stream health. A number of researchers have investigated the relationship between watershed imperviousness and stream degradation and have concluded that stream impacts can result from impervious levels of 10% or less (less than one-quarter of a watershed being developed) (CWP, 1998).

Existing and Future Urbanization in the Cherry Creek Watershed - Land use information from the Trust for Public Land's Cherry Creek Basin Open Space Conservation and Stewardship Plan was evaluated. This information was used to determine the influence of existing and projected levels of urbanization in the Cherry Creek Watershed on stream health and reservoir quality. This reference compiled a spatial distribution of several types of land uses in the watershed for the years 2000 and 2020 based on information generated by DRCOG. This information was also used as the basis of peak flow estimation in UDFCD's Cherry Creek Corridor Plan. The increase in future urbanization is illustrated in **Figures 3-2 and 3-3** (following pages) by the greater areas with gray coloration.

Figure 3-4 indicates the level of urbanization in the upper Cherry Creek Watershed upstream of the reservoir in 2000 and 2020, according to the Stewardship Plan's land use information. Urbanization is also shown for the northern portion of the watershed between Castlewood Canyon and the reservoir. This northern portion comprises 55% of the total area upstream of the reservoir and represents the portion of the watershed most subject to urbanization.

According to the data, the northern portion of the watershed between Castlewood Canyon and the Reservoir had an imperviousness of 9% in 2000 and is expected to more than double to 19% by 2020. Mixed-urban land uses, the most dense category, in the northern area are expected to increase from 9% to 32% of the area from 2000 to 2020 and total

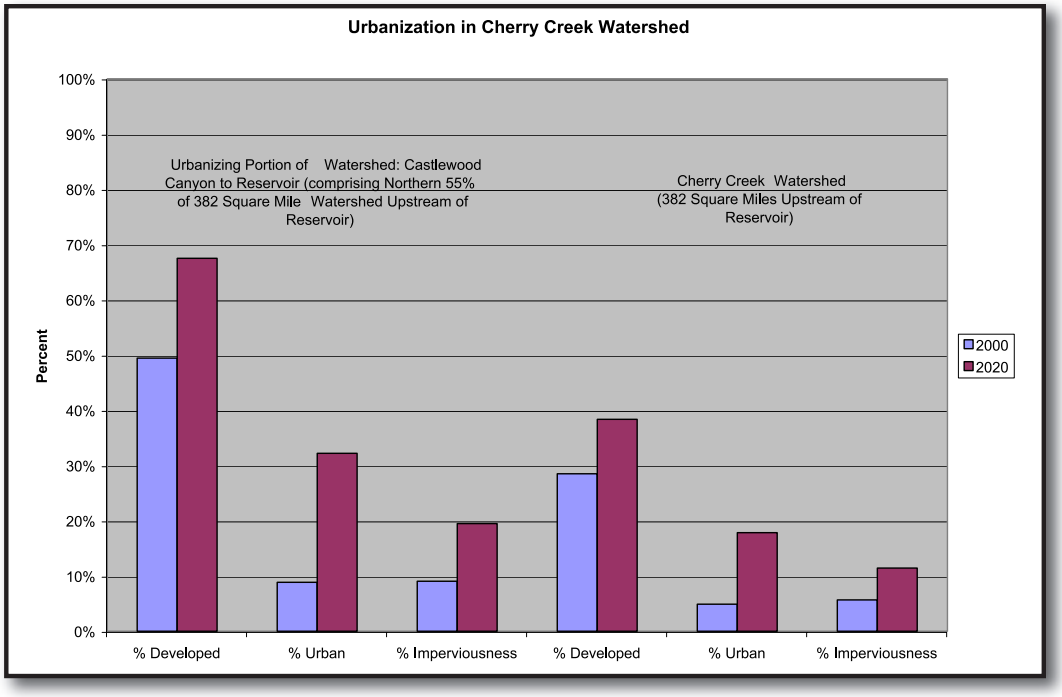


Figure 3-4. Urbanization in Cherry Creek Watershed

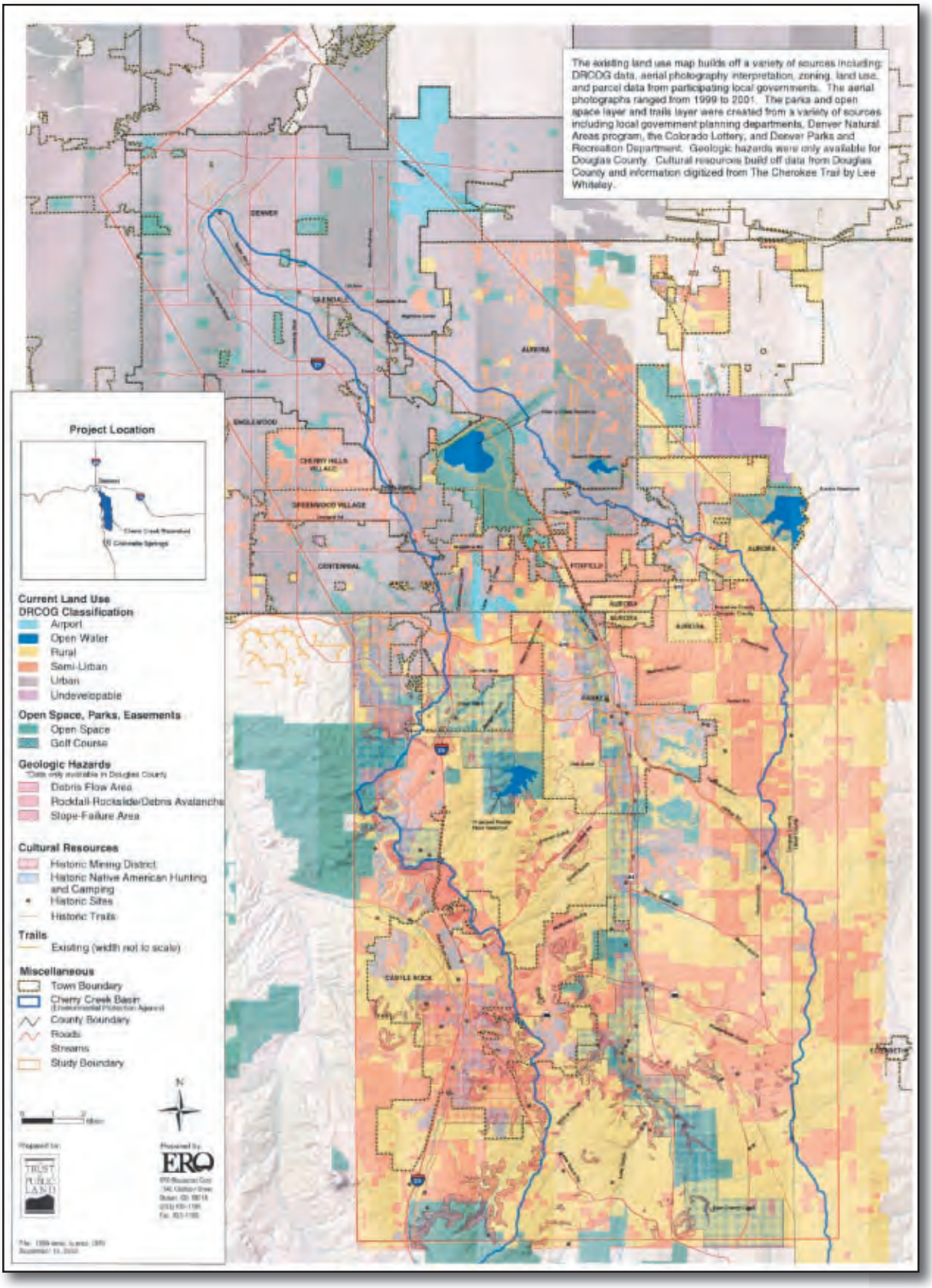


Figure 3-2. Year 2000 Land Use

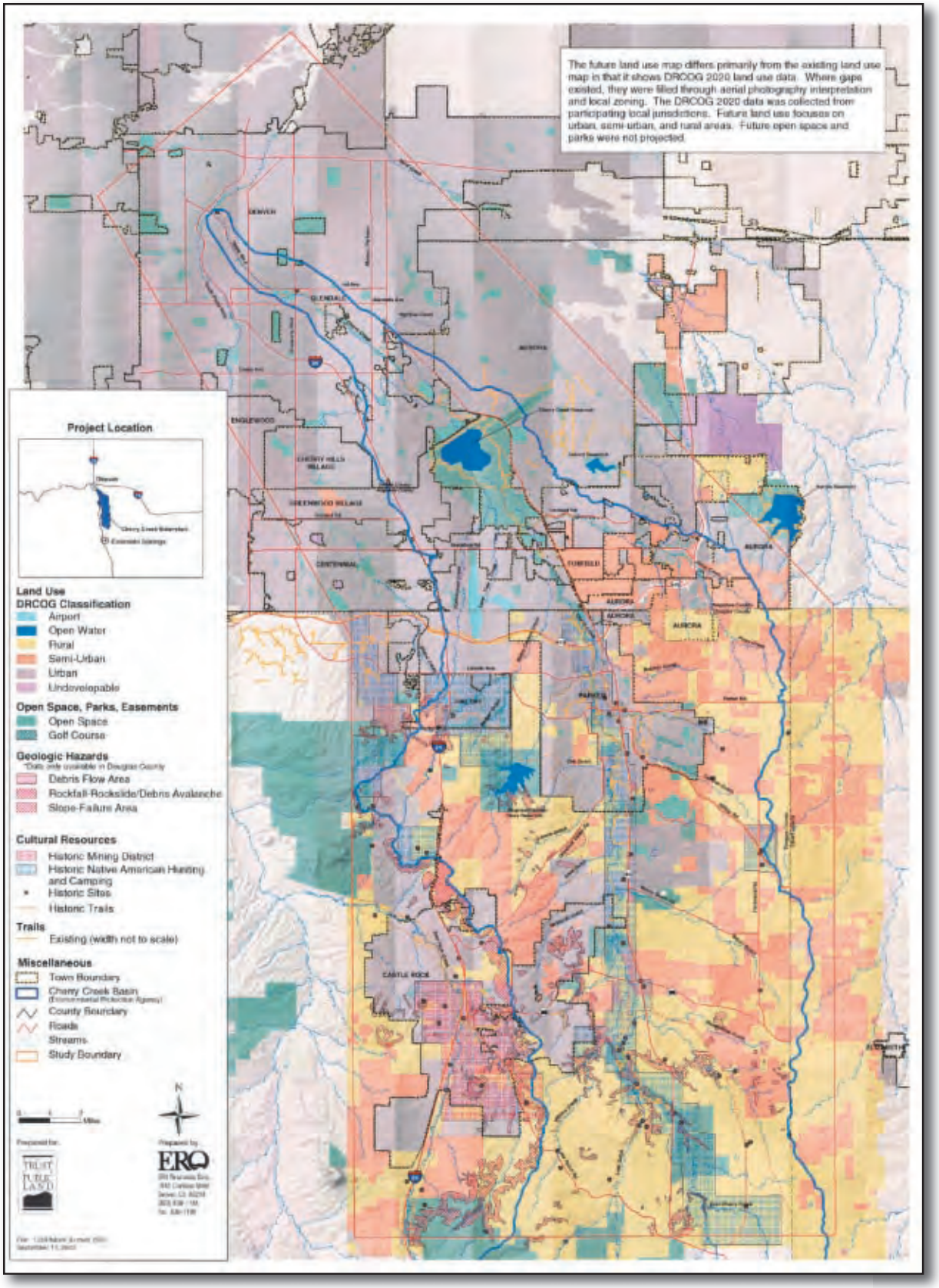


Figure 3-3. Year 2020 Land Use

development is anticipated to grow from 49% to 68% on an area basis. These urbanization increases can have significant impacts on the reservoir water quality and beneficial uses if mitigation measures are not implemented.

Potential Storm Runoff Loads - **Figures 3-5, 3-6, and 3-7** (following pages), reproduced from the Stewardship Plan, depict modeled storm runoff volumes in the watershed for three different time periods and development conditions. Baseflows and alluvial flows are not shown in the modeled volumes, nor are reductions in storm runoff due to stream infiltration, so the storm runoff estimates reflect only part of the reservoir loading picture. However, storm runoff is a significant part of watershed phosphorus loading and the estimates show that stormwater loading is increasing. A comparison of the three figures shows how potential storm runoff volumes are growing progressively greater with time (depicted by the southward spread of darker blue colors) as urbanization moves southward in the watershed (TPL, 2002).

Potential Storm Phosphorus Loads - **Figures 3-8, 3-9, and 3-10** (following pages) depict estimated total phosphorus loads associated with storm runoff and are also reproduced from the Stewardship Plan. The increasing spread of red (signifying higher phosphorus loading rates) shown on the three figures shows how storm-related phosphorus is growing progressively greater with time as urbanization moves southward (TPL, 2002). Currently required water quality best management practices implemented in newly developing areas will moderate, but not fully mitigate, the increase in stormwater phosphorus loading shown in **Figures 3-8, 3-9, and 3-10**.

Urbanization's Influence on Subwatershed Management - The Stewardship Plan categorized and prioritized 39 subwatersheds based on the results of the stormwater runoff modeling described above. The categories and their management implications are reproduced in **Table 3-1**. The resulting subwatershed map is shown in **Figure 3-11** (following pages). **Table 3-2** lists the subwatersheds in each of the four management categories in order of priority, based on anticipated increase and overall magnitude of stormwater runoff in 2020 (TPL, 2002).

For the purposes of this study, the year 2000 and 2020 land use and stormwater runoff modeling from the Stewardship Plan was applied to the 414 finely divided subwatersheds created to conduct the detailed hydrology of the Corridor Plan. The subwatersheds are depicted in **Figure 3-12** (following pages).

Table 3-1. Subwatershed Categories and Management Implications

Category	Map Color	Increase in Runoff from 1963 to 2000	Increase in Runoff from 1963 to 2000	Management Implications
1	Red-orange	Low	High	These subwatersheds are about to be impacted for the first time by increased runoff from development, starting a cycle of harmfull degradation. An opportunity exists to proactively stabilize these drainageways prior to significant degradation, reducing costs and preserving healthy stream systems.
2	Purple	High	High	These subwatersheds have already experienced increased runoff from urbanization and will continue to undergo further increases in the future. It is critical that these streams be stabilized quickly to reduce degradation impacts.
3	Grey	High	Low	These subwatersheds have already experienced increased runoff from urbanization, but are not expected to undergo much of a further increase in the future. Chances are, stabilization programs have already been undertaken in these areas, but it is important to follow these through to completion.
4	Green	Low	Low	These subwatersheds have not experienced increased runoff from urbanization and are not expected to undergo much of an increase in the near future. However, it is important that other potential impacts, such as poor grazing practices, be inventoried and controlled. Also, urbanization beyond the limits shown for 2020 will likely affect some of these subwatersheds.

Table 3-2. Cherry Creek Subwatershed Priorities

Watershed ID Number	Watershed Name	Total Run-off in 2020 acre-ft/year	% Increase 2000 to 2020	Priority Index
Category One				
28	McMurdo Gulch	826	581%	100
12	Happy Canyon Creek	1545	175%	56
18	Oak Gulch	372	640%	50
25	Scott Gulch	268	581%	32
22	Lemon Gulch	328	213%	15
17	Cherry Creek H	344	158%	11
27	Cherry Creek L	158	302%	10
26	Bayou Gulch	567	45%	5
32	Willow Creek	266	82%	5
20	Kinney Creek	193	44%	2
13	Baldwin Gulch	108	62%	1
Category Two				
8	Cottonwood Creek	2180	81%	37
11	Cherry Creek F	773	177%	28
30	Mitchell Gulch	466	133%	13
10	Cherry Creek E	444	130%	12
24	Cherry Creek K	222	249%	12
16	Sulphur Gulch	812	51%	9
15	Newlin Gulch	1157	33%	8
21	Cherry Creek J	216	154%	7
9	Piney Creek	1102	25%	6
14	Cherry Creek G	274	59%	3
23	Unnamed B	185	70%	3
19	Cherry Creek I	108	117%	3
7	Cherry Creek D	239	44%	2
Category Three				
2	Cherry Creek B	1004	11%	2
3	Goldsmith Gulch	1532	7%	2
4	Cherry Creek C (Lake)	1322	2%	1
6	Shop Creek	122	6%	0
5	Unnamed A	107	5%	0
1	Cherry Creek A	1227	0%	0
Category Four				
29	Cherry Creek M	45	26%	0
31	Cherry Creek N	39	11%	0
33	Russellville Gulch	231	0%	0
34	Cherry Creek O	37	0%	0
35	Cherry Creek P	40	0%	0
36	Lake Gulch	260	0%	0
37	Unnamed C	92	0%	0
38	Cherry Creek Q	45	0%	0
39	Upper Cherry Creek	857	0%	0

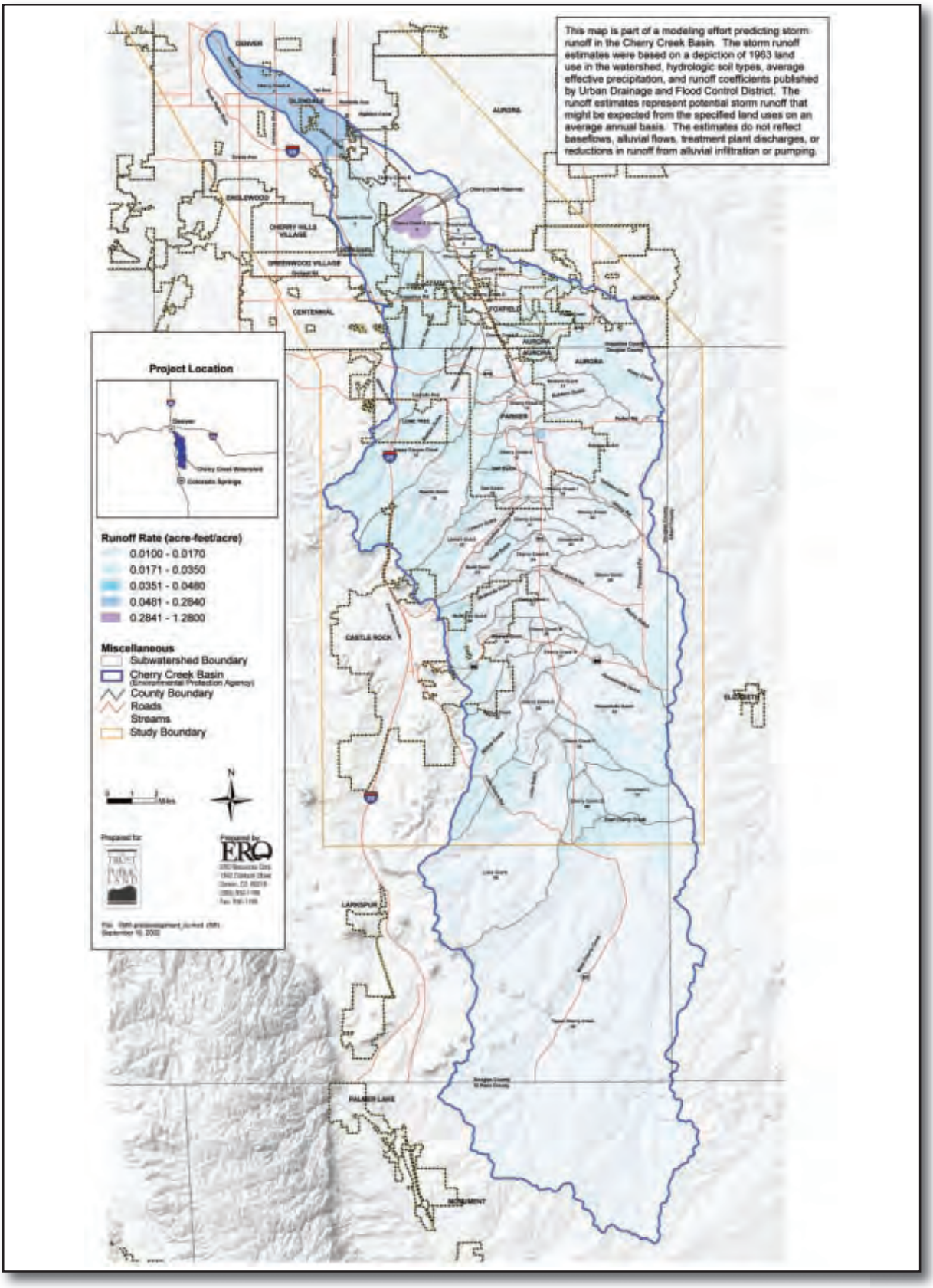


Figure 3-5. Estimated Storm Runoff for 1963 Development Conditions

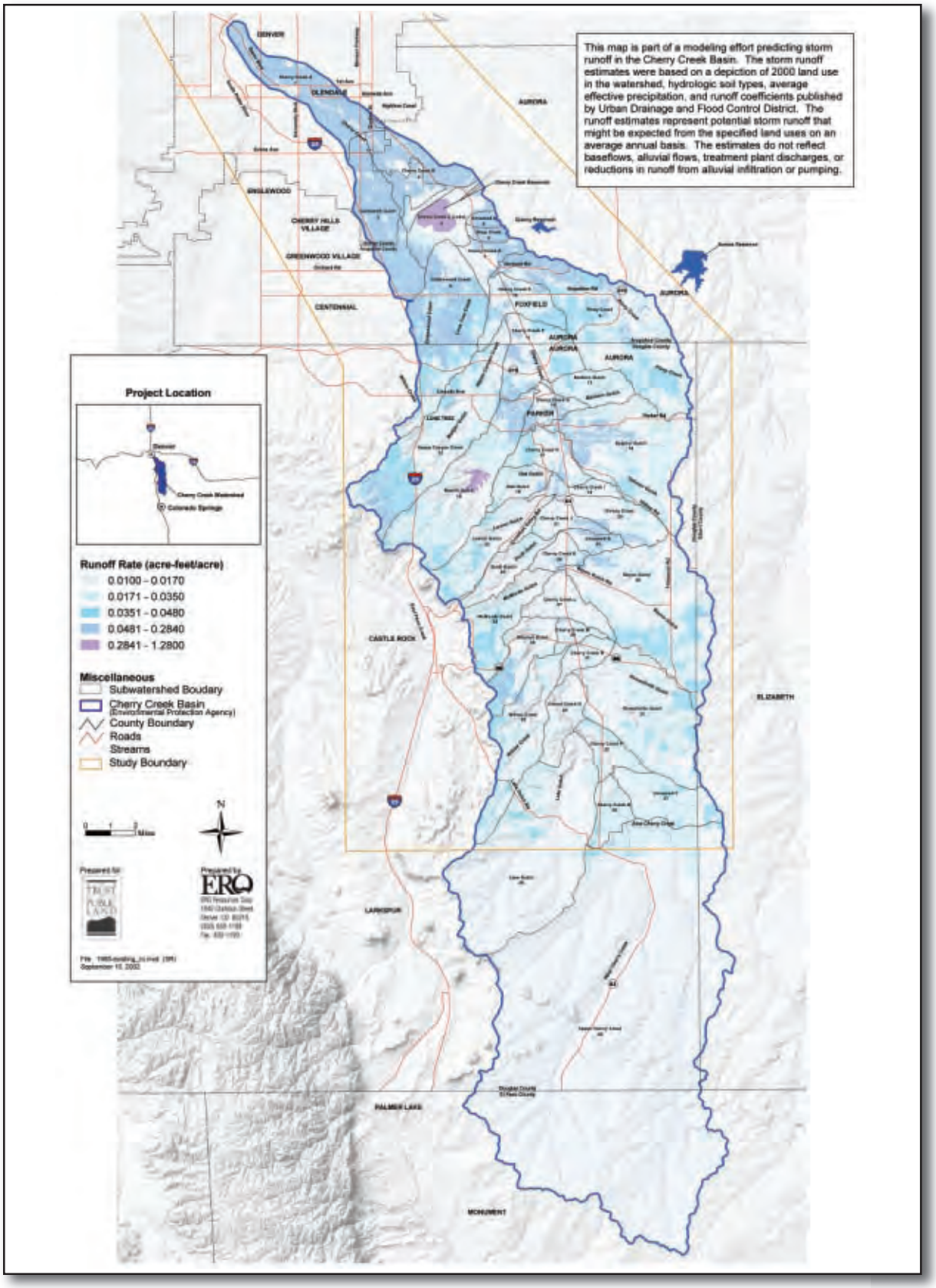


Figure 3-6. Estimated Storm Runoff for 2000 Development Conditions

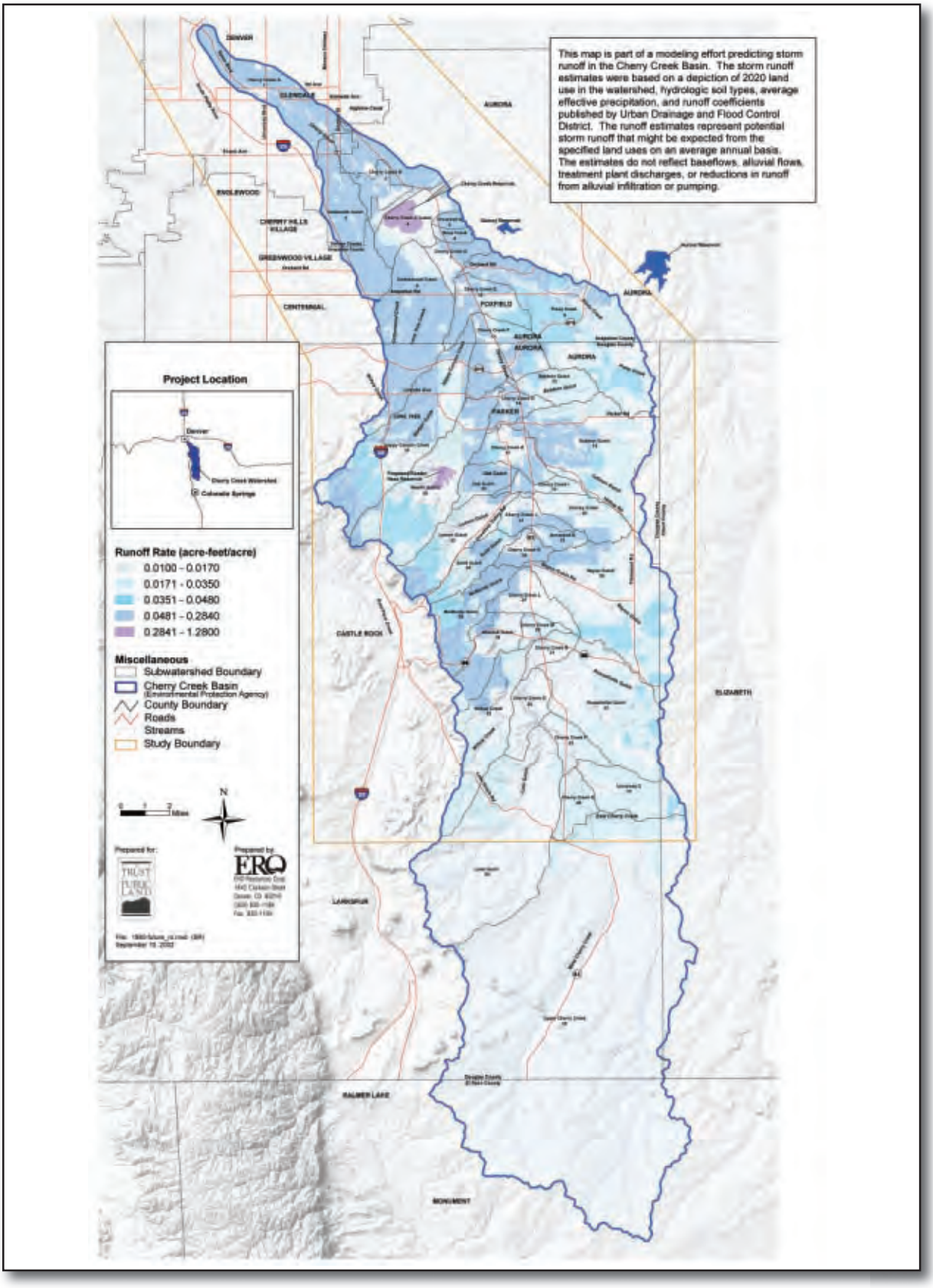


Figure 3-7. Estimated Storm Runoff for 2020 Development Conditions

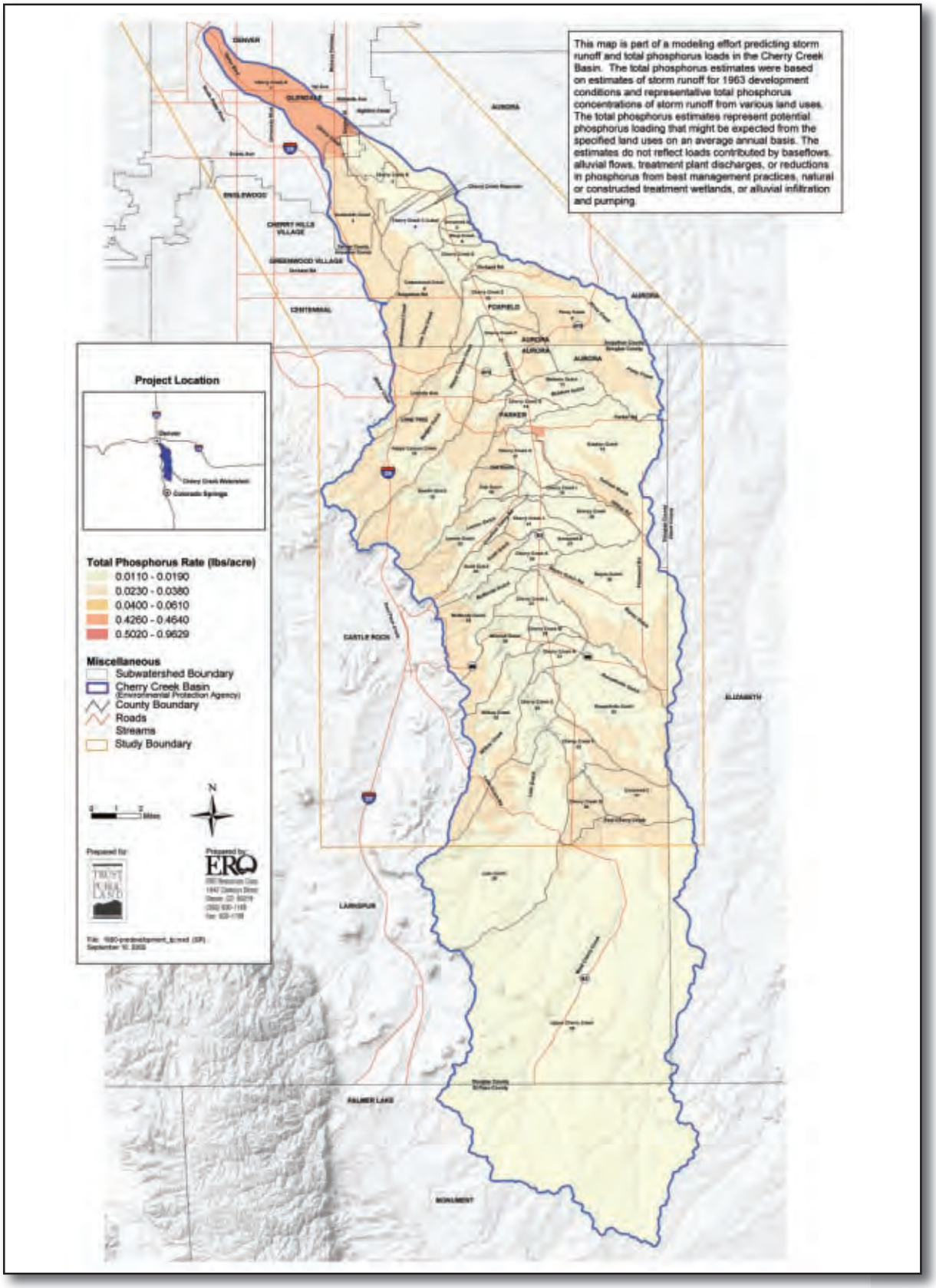


Figure 3-8. Estimated Total Phosphorus Loads From Storm Runoff for 1963 Development Conditions

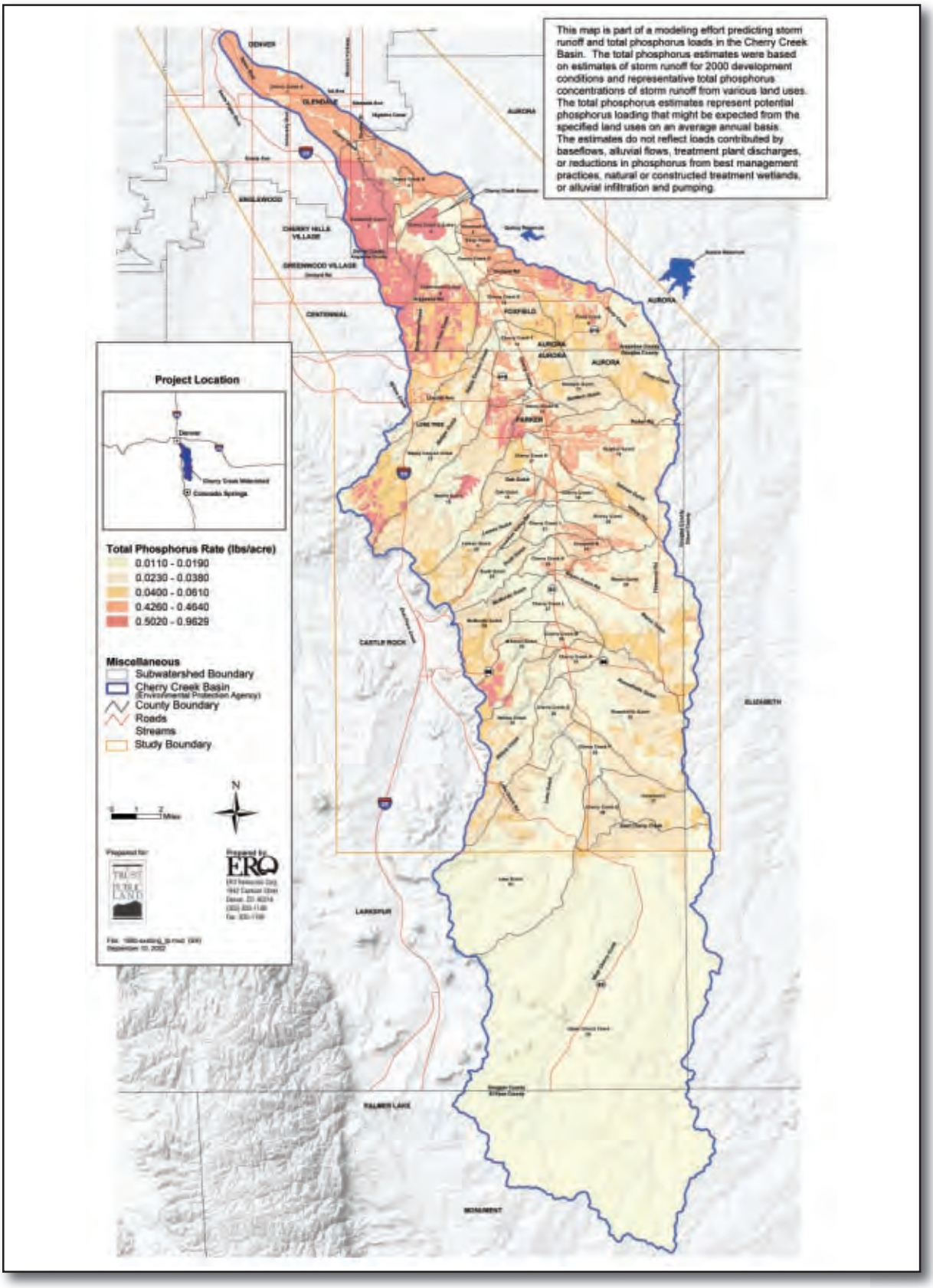


Figure 3-9. Estimated Total Phosphorus Loads from Storm Runoff for 2000 Development Conditions

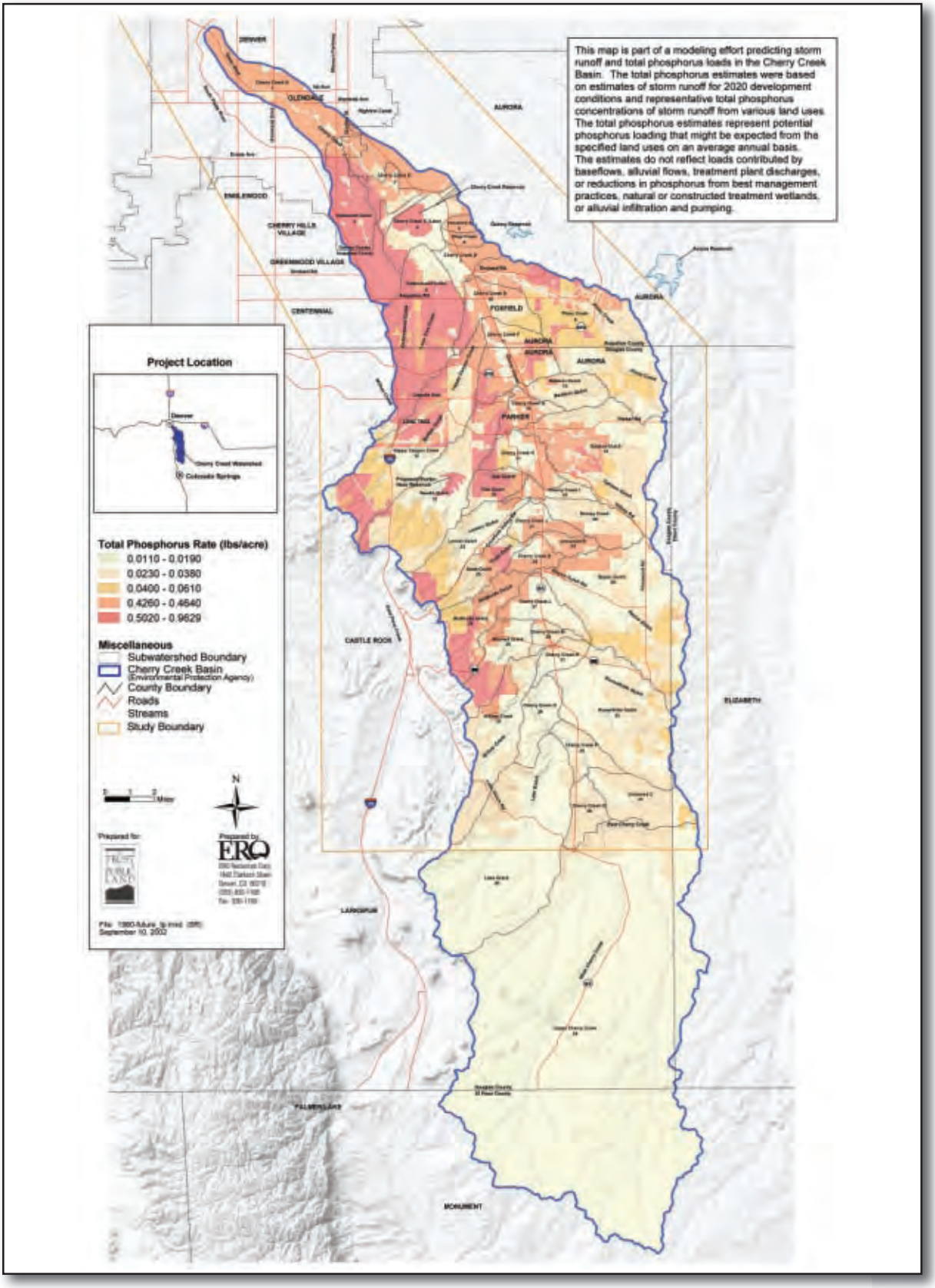


Figure 3-10. Estimated Total Phosphorus Loads from Storm Runoff for 2020 Development Conditions

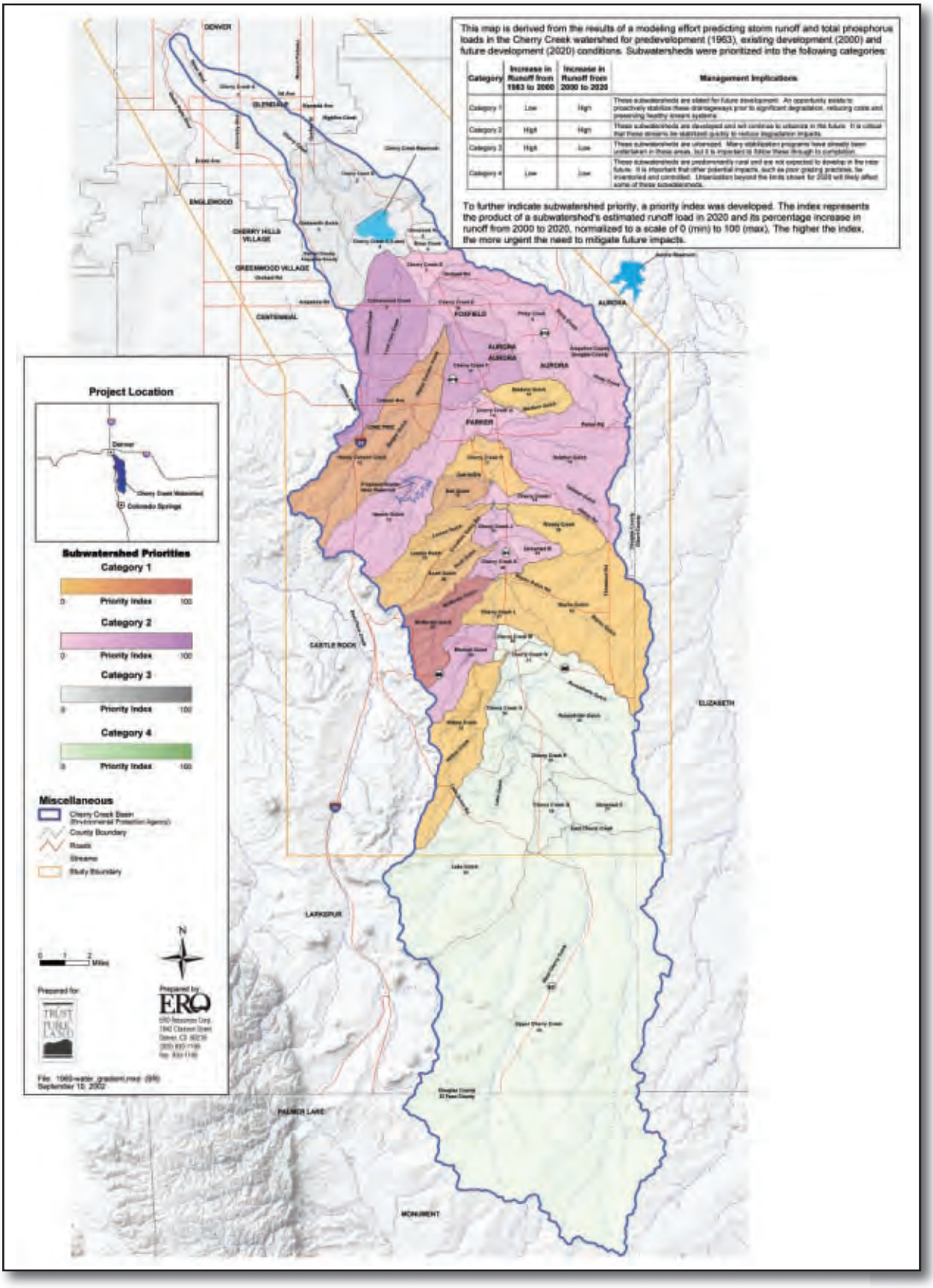


Figure 3-11. Major Subwatershed Prioritization

The same categorization shown in **Table 3-1** was modeled using the Corridor Plan subwatersheds. The resulting map, **Figure 3-13** (following pages), indicates in a more detailed manner the areas of the Cherry Creek Watershed that are influenced by existing and future urbanization. This information is also useful in establishing priority watersheds for implementation of mitigation measures.

3.1.3 The Cherry Creek Stream Network

A network of major drainageways in the upper Cherry Creek Watershed was identified. The resulting length of the stream network evaluated in the Cherry Creek Watershed totals 618 miles. This length was divided into individual segment lengths for each subwatershed shown in **Figure 3-12.** The density of this stream network averages 1.6 miles per square mile of watershed.

Potential Storm Runoff in the Cherry Creek Stream Network - Storm runoff estimates for each finely divided subwatershed were added together in the stream network to determine total stormwater runoff in each stream segment for 1963, 2000, and 2020 development conditions. **Figures 3-14 and 3-15** (following pages) illustrate the potential storm runoff volumes for mainstem Cherry Creek and its tributaries, respectively.

The major drainageway network in the Cherry Creek watershed encompasses over 600 miles of streams

A review of **Figures 3-14 and 3-15** illustrates the relative magnitude of potential storm runoff at various points in the stream network in 1963, 2000, and 2020. Streams impacted to date by increased storm runoff, indicated in green, include Cottonwood Creek, Piney Creek, and Sulphur Gulch. These and a number of additional streams are projected to be impacted through 2020, shown in red.

The percent increase in potential storm runoff volume from 1963 to 2000, from 2000 to 2020, and from 1963 to 2020 was calculated. **Figures 3-16, 3-17, and 3-18** (following pages) depict this information graphically along the Cherry Creek stream network. Urbanization in the Cherry Creek Watershed is estimated to increase storm runoff as much as 2000 percent in some streams. The greater the percent increase in runoff, the higher the potential for stream degradation, and the greater the need for stabilization improvements.

Table 3-3 summarizes potential storm runoff totals for Shop Creek, Cottonwood Creek, and mainstem Cherry Creek. The totals compare favorably with Authority monitoring results for Shop Creek and Cottonwood Creek for estimated storm flows exceeding base

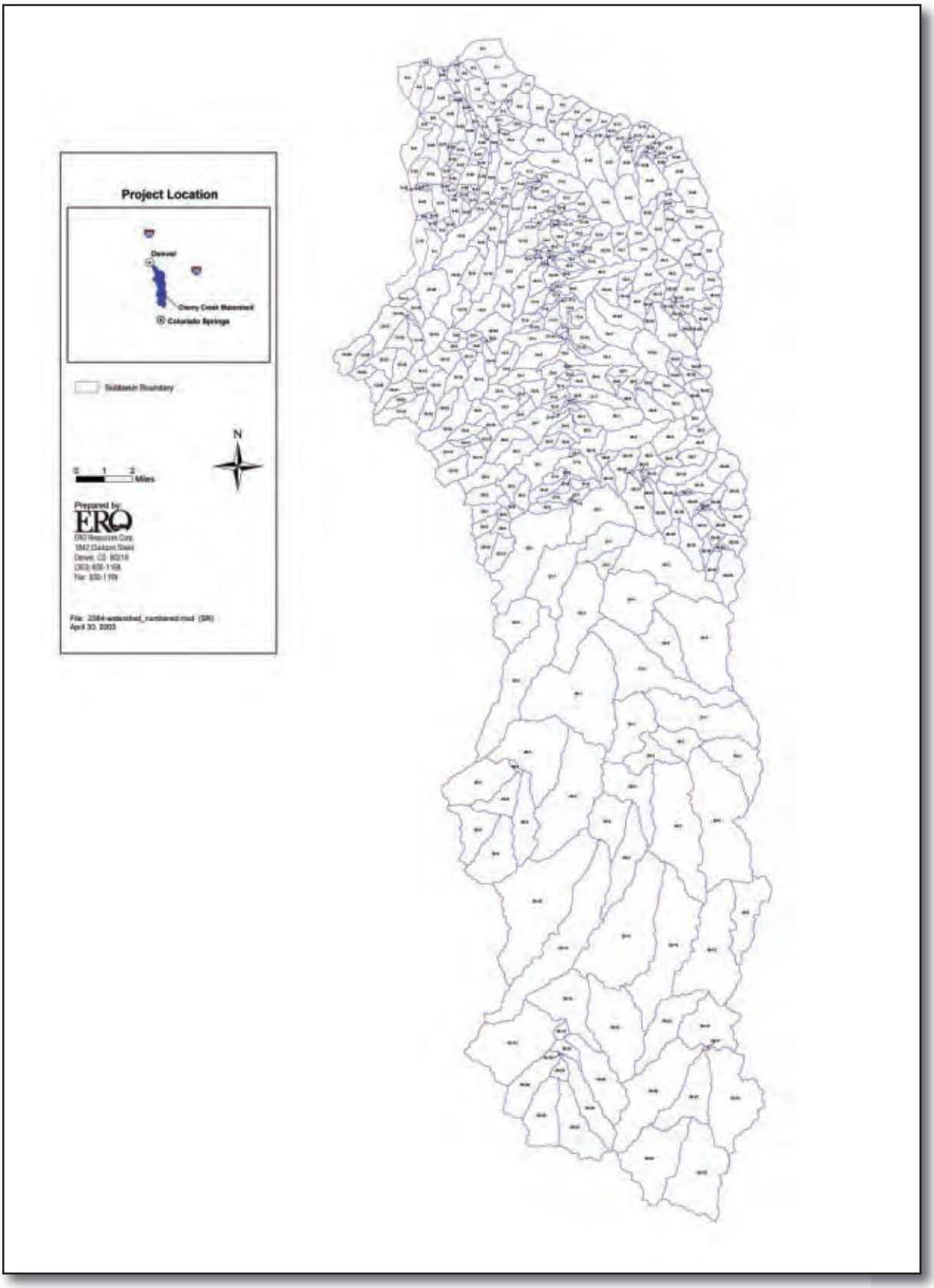


Figure 3-12. Subbasin Boundaries

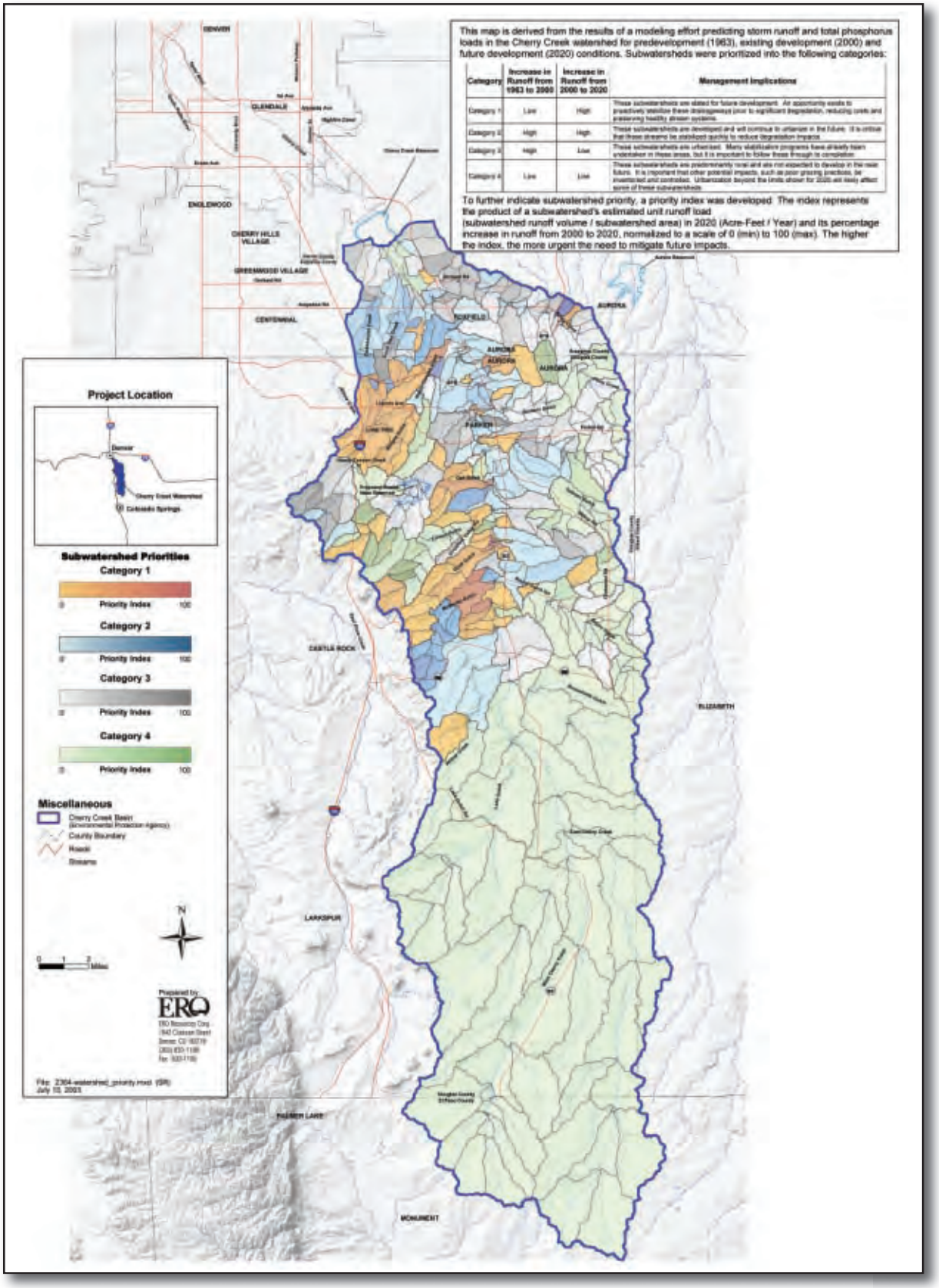


Figure 3-13. Subwatershed Prioritization

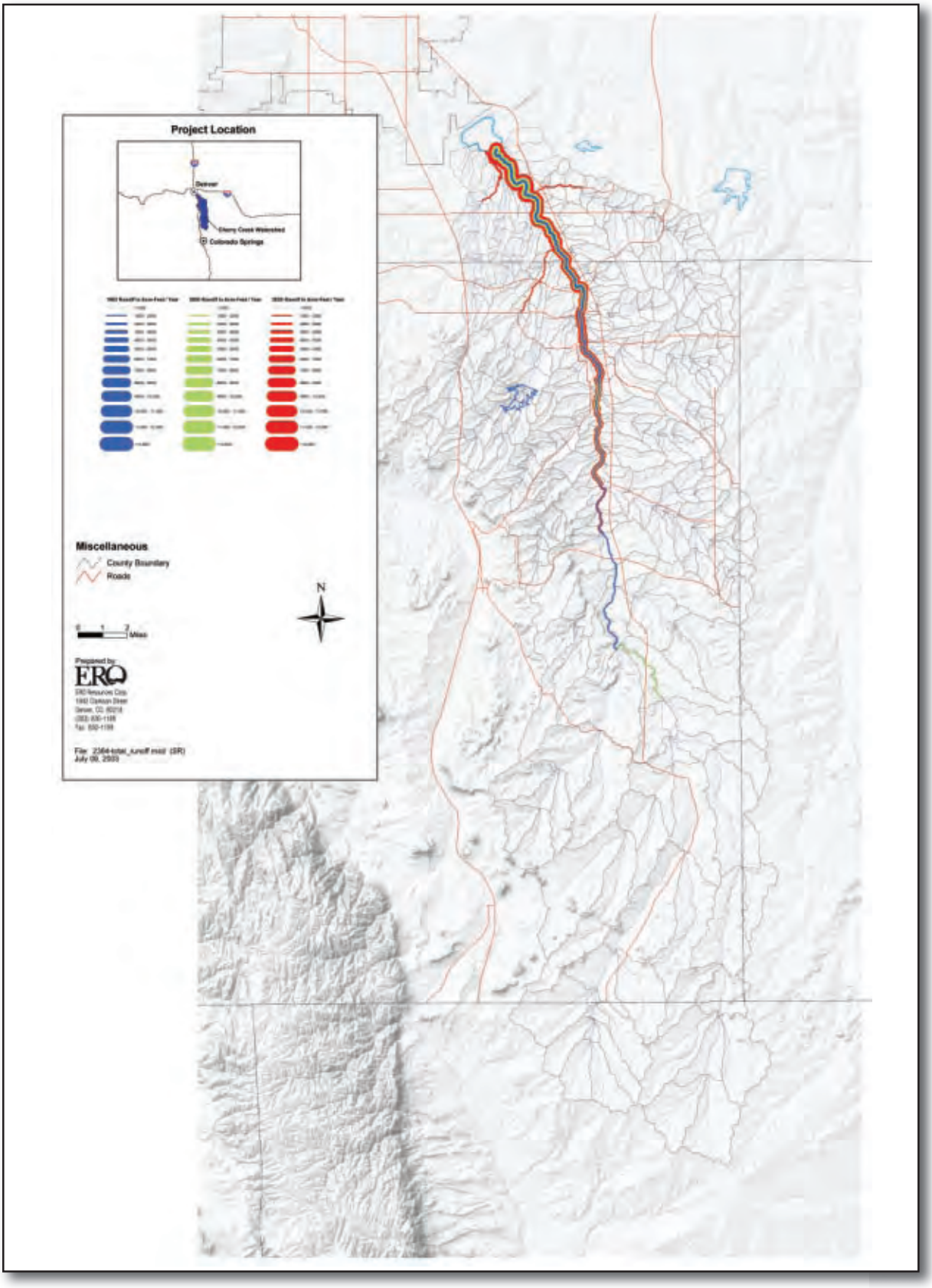


Figure 3-14. Estimated Stormwater Runoff for Cherry Creek Mainstem

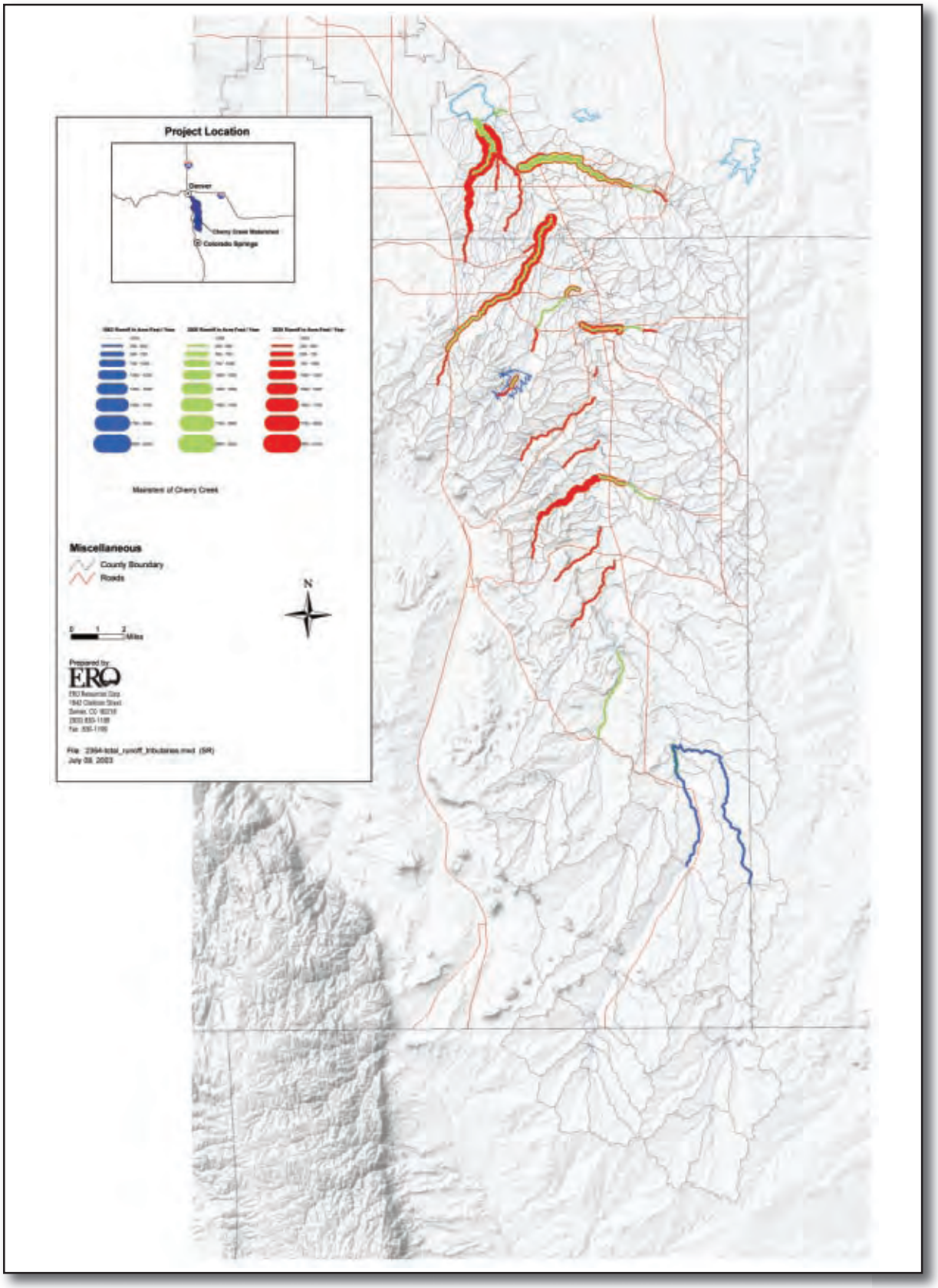


Figure 3-15. Estimated Stormwater Runoff for Cherry Creek Tributaries

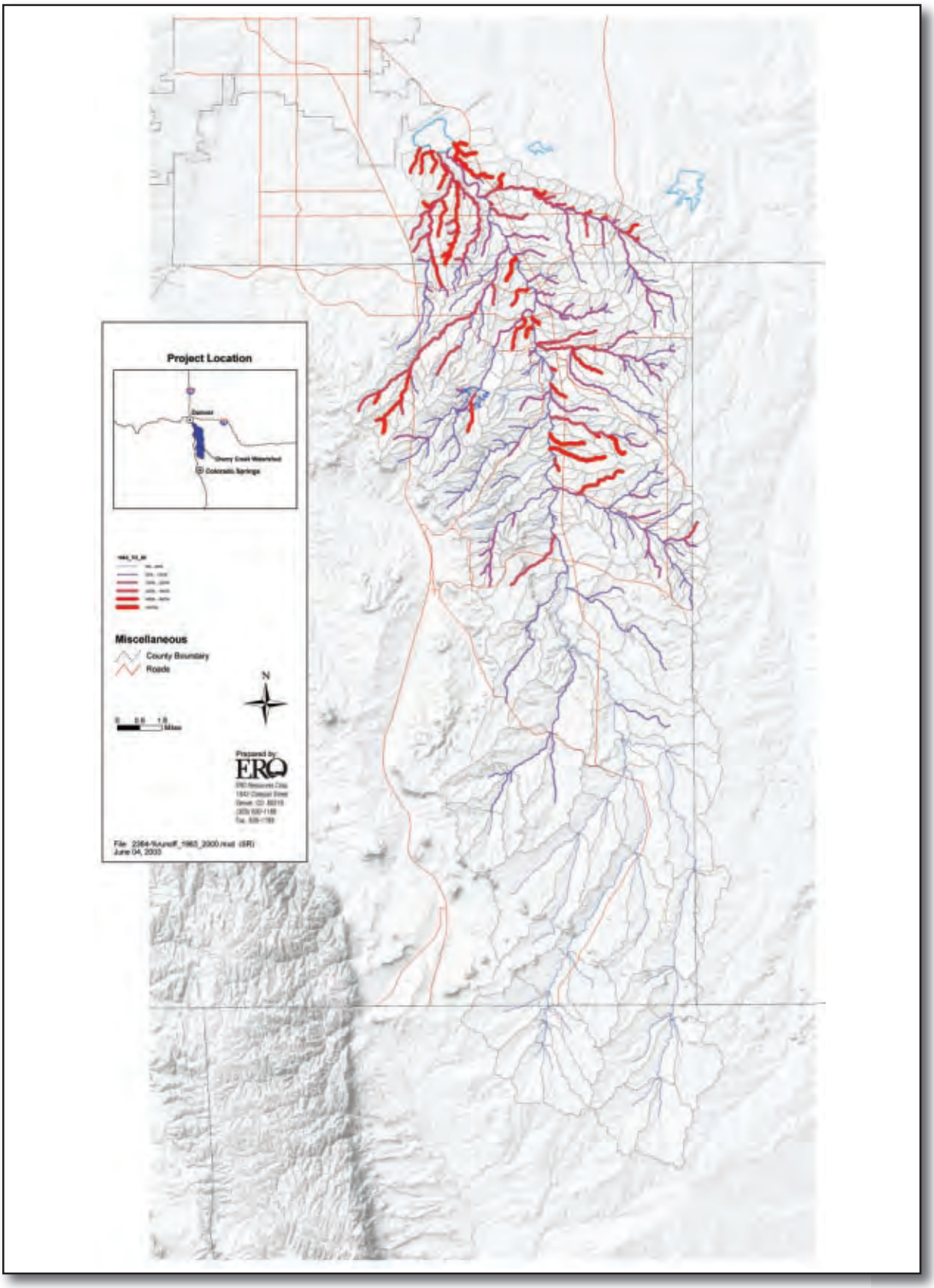


Figure 3-16. Estimated Percent Increase in Storm Runoff 1963 - 2000

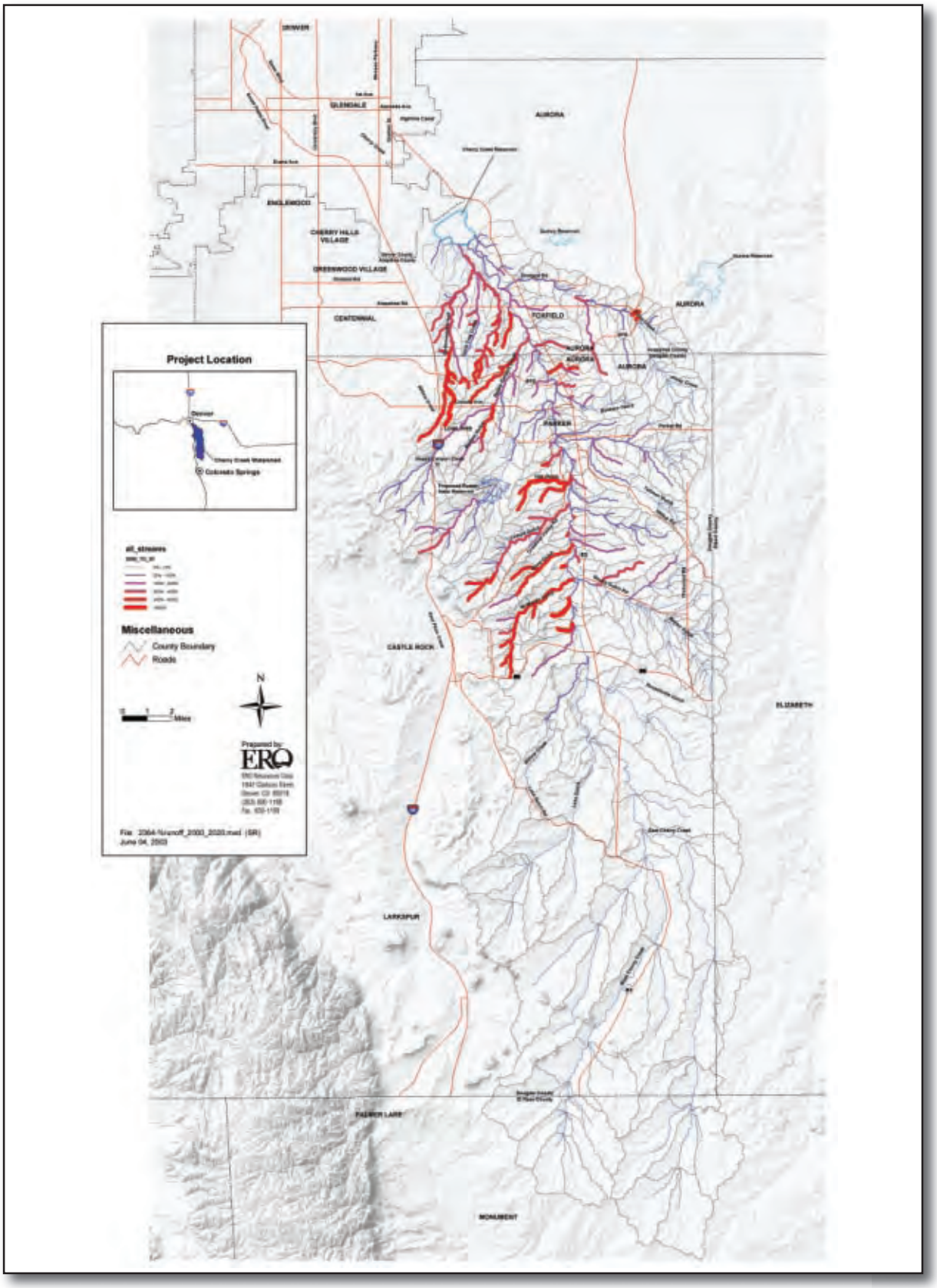


Figure 3-17. Estimated Percent Increase in Storm Runoff 2000 - 2020

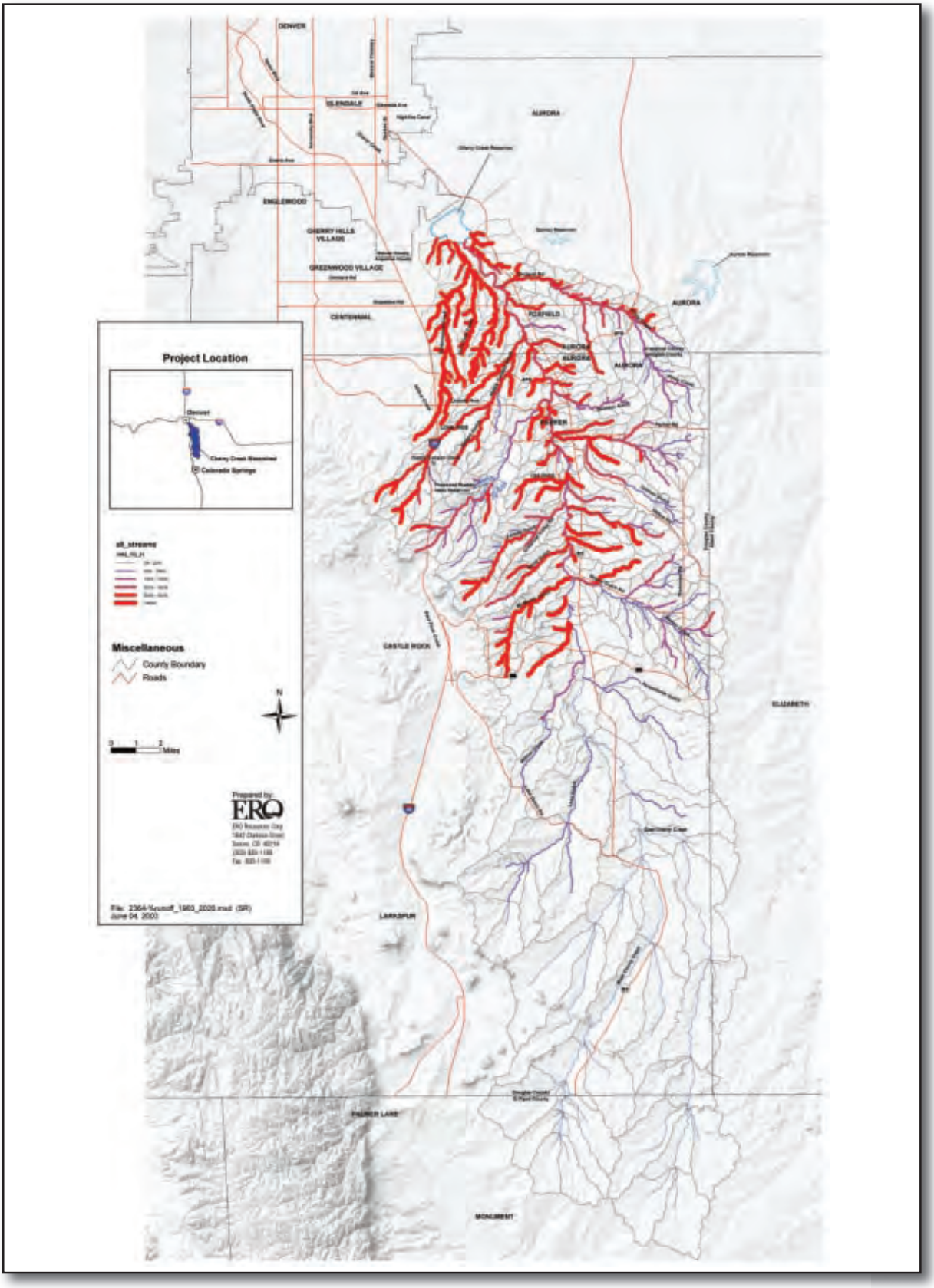


Figure 3-18. Estimated Percent Increase in Storm Runoff 1963 - 2020

flow conditions, but are about four times higher for Cherry Creek than monitored storm flows (CCBWQA, 2003). This is believed to be evidence of significant stream infiltration within the Cherry Creek stream network, indicative of the watershed's absorption of storm runoff and phosphorus.

Table 3-3. Potential Stormwater Runoff in Cherry Creek Watershed

Creek	Potential Stormwater Runoff (AF/YR) 2000	2020	Area (SQ MI)	Potential Stormwater Runoff as Percent of Average Precipitation 2000	2020
South Cherry Creek (upstream of Castlewood Canyon)	1,400	1,400	170	1.0%	1.0%
North Cherry Creek (Castlewood Canyon to Reservoir)	4,800	10,600	209	2.9%	6.3%
Total Cherry Creek	6,200	12,000	379	2.0%	4.0%
Shop Creek	110	130	0.9	16%	18%
Cottonwood Creek	720	2,100	14	6%	18%

Assessment of Stream Conditions in the Cherry Creek Watershed - A cursory field reconnaissance was conducted to assess current stream conditions in the Cherry Creek Watershed. A variety of conditions were found, from severe erosion problems to fully stabilized stream reaches. In addition, many non-impacted, stable stream segments were observed, particularly in areas undisturbed by increased flows and other urban impacts.

To characterize the range of observed stream conditions and relate stream characteristics to water quality impacts and management strategies, a stream rating system was developed. The rating system is illustrated in **Figure 3-19** (following pages). Five different stream classifications are shown, together with illustrative photos. The classifications range from streams creating water quality impairment due to deep incision, flow concentration, and severe erosion (rating = 1); to channels that are stable but concentrate flows and offer no water quality treatment (rating = 3); to streams providing favorable water quality treatment via wide, shallow, slow flow conditions, infiltration, vegetative filtering, and wetland processes (rating = 5).

From a management perspective, it appears that the further right on **Figure 3-19**, the better, with the best condition represented by the 5 classification. Additional data collection and analysis may be able to provide confirmation of this intuitive conclusion. In most urbanized areas of the Cherry Creek Watershed, the prevalent stream character varies from 1 to 4. Given the increased runoff from urbanization, there is an opportunity to encourage more Class 5 streams in newly developing areas.

The prevalent use of concrete-lined low flow channels in the developed portions of the watershed produces a negative water quality effect. Concrete low flow channels concentrate runoff, discourage infiltration, and convey soluble and particulate phosphorus downstream toward the reservoir.

Figure 3-20 (following pages) illustrates existing degradation impacts to the mainstem Cherry Creek corridor, including channel incision, decreased wetted width and infiltration, loss of overbank vegetation, increased flow velocities and conveyance efficiency, lowered

water table, tributary impacts, and infrastructure issues. These impacts, although in their beginning stages, could create serious water quality consequences if not controlled quickly and effectively.

Best Management Practices - The Authority and its member jurisdictions have adopted requirements for the use of water quality BMPs within newly developing areas of the watershed. These are patterned after BMPs described in UDFCD's Volume 3 Criteria Manual (UDFCD, 1999), although applied specifically to the Cherry Creek Watershed.

In addition to construction erosion control, the primary permanent BMP recommended is the provision of water quality capture volume detention facilities in new areas of development. The Volume 3 manual indicates that, if properly designed, such facilities are expected to reduce stormwater phosphorus loads from upstream developing areas by approximately 40- to 50% or more below uncontrolled urban phosphorus loads, although extended detention basins, the most prevalent BMPs, do not in themselves control urban increases in storm runoff volume.

Volume 3 encourages the practice of minimizing directly connected impervious areas to reduce peak rates and volumes of stormwater runoff. As discussed earlier, controlling the increase in stormwater runoff from newly developing areas could help to mitigate stream degradation impacts and increased urban phosphorus loading.

Several initiatives are under way in the watershed to promote stormwater runoff controls and other innovative BMPs. The Cherry Creek Stewardship Partners have undertaken the preparation of a water quality report highlighting some of these techniques. The Authority's upcoming Phosphorus Facilitator work will seek to encourage implementation of enhanced BMPs within several new development sites and create demonstration projects to advance the science.

Stream Stabilization Policy and Design Criteria - Stormwater design policy and criteria related to stream stabilization has a bearing on water quality. As described above, a variety of stream stabilization practices were observed in the developed portions of the watershed, some favorable to the goals of reservoir water quality and some unfavorable. Favorable practices provide stable, well vegetated channels that promote wide, shallow flow with significant infiltration and filtering. Unfavorable practices result in unstabilized, eroding streams and drainageways with hard-lined low flow channels that directly convey phosphorus downstream toward the reservoir. Opportunities exist to create more consistent design criteria for stream stabilization to promote enhanced water quality effectiveness.

Timing of stream stabilization also affects water quality. The need for a stream stabilization project is often recognized only after significant degradation occurs. Then the project needs to be budgeted for, designed, and finally constructed. During the time between the initial stages of erosion and final construction, typically, large quantities of sediment and phosphorus can move downstream. Stabilization costs in such cases can be substantial and improvements may tend to fix in place a deeper, narrower channel cross-section than existed prior to degradation. An alternate approach seeks to implement stream stabilization improvements proactively, before degradation grows severe. In this way, stream improvement costs, sediment and phosphorus loads, and disruption of habitat can be reduced.

Potential Stream Stabilization Costs - Figure 3-21 reflects potential costs associated with stream stabilization in the Cherry Creek Watershed under a variety of management approaches. The costs shown are approximate, order-of-magnitude estimates, based on a series of assumptions documented in the appendix. The magnitude of cost is less important than the relative differences in cost from various management scenarios.

Case 1 illustrates potential costs associated with stabilizing streams that are or will be impacted by the development that has already occurred in the watershed as of 2000, assuming streams within development sites have been taken care of as development occurred and improvements downstream of development sites are implemented after degradation has occurred. Case 2 illustrates the same approach for streams impacted by year 2020 development.

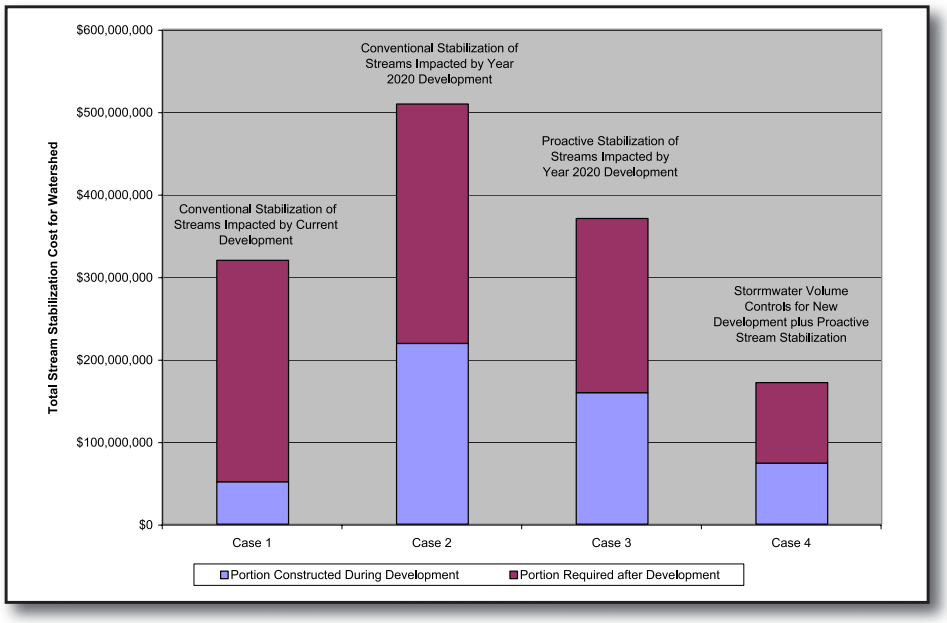


Figure 3-21. Stream Stabilization Costs

Case 3 reflects the potential cost savings associated with implementing a comprehensive program of proactive stream stabilization in the Cherry Creek Watershed. Case 4 shows the effect of adopting stormwater volume controls in newly developing areas of the watershed at levels that match predevelopment hydrology, together with proactive stream reinforcement improvements. The resulting cost savings from the strategy (over $100 million), as well as the reduction in sediment and phosphorus loading and impacts to the stream habitat, would be substantial.

Stream Inventory - To more accurately understand the current status of the stream network in the Cherry Creek Watershed and assess the need for and cost of stream improvements, undertaking a comprehensive stream inventory would be of value. The inventory would provide a logical basis for selecting streams that need stabilization sooner, rather than later. **Figure 3-22** provides an example illustrating the kind of information that could be observed and documented in a GIS format. Such a format could indicate information regarding stream baseflows, channel vegetation, existing erosion, current stream improvements, and non-urban impacts. Digital photos of the stream could be added as "hot-links" to allow users to click on an icon and pull up representative photos. A draft of a possible inventory form is included in the appendix.

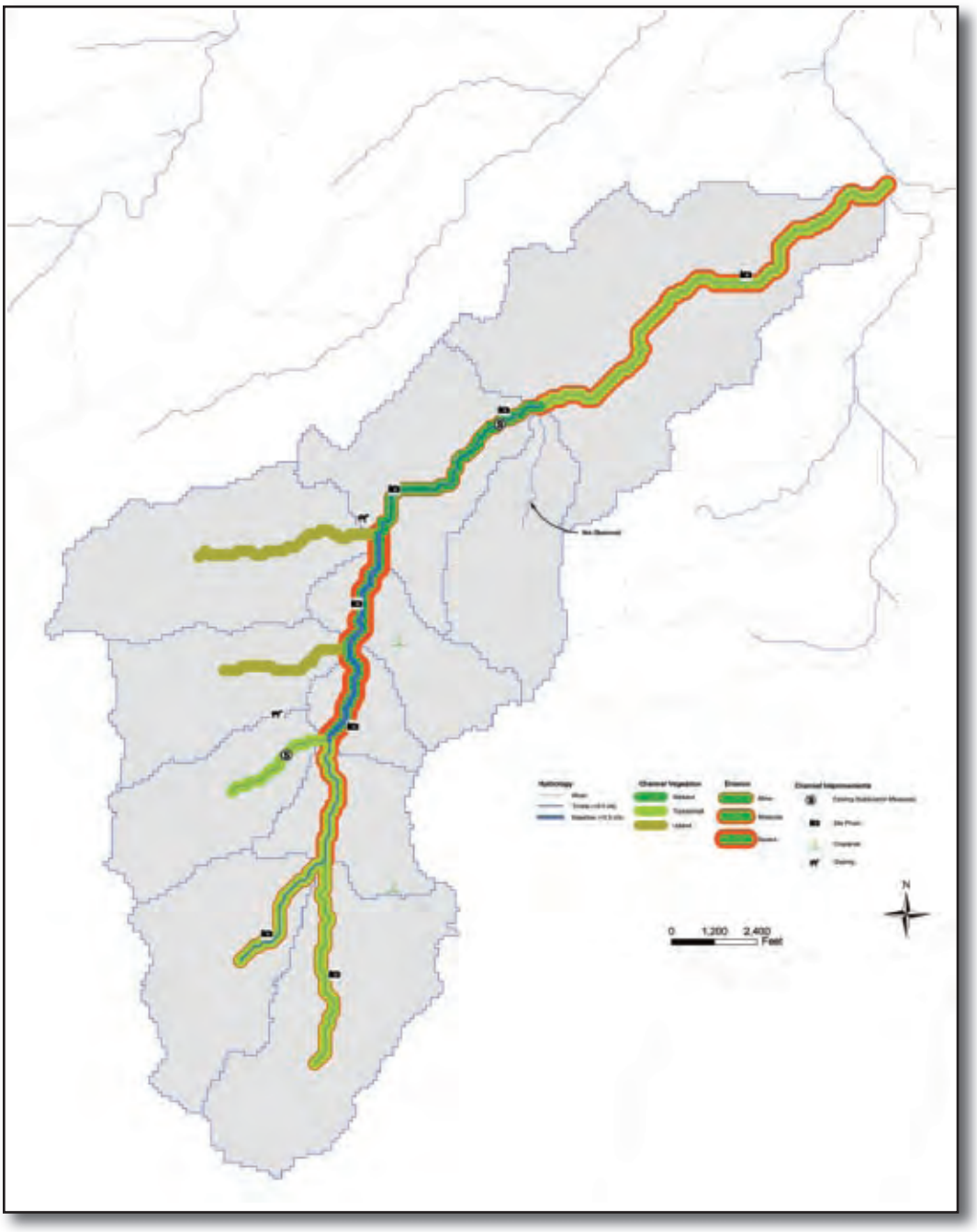


Figure 3-22. Example Stream Inspection Inventory Map

Flood Detention Policy and Design Criteria - Drainage criteria for flood detention, usually addressing the 10- and 100-year storms, may present an opportunity for water quality enhancement. Controlling these large, infrequent events, even if water quality capture volume detention is added, does not control some of the frequent, 1- to 2-year, bank-full storm event discharges that tend to degrade stream channels. Since most floodplains are regulated for 100-year future development discharges without factoring in most on-site detention facilities, it may possible to create criteria that could more effectively control frequent storm events and reduce degradation impacts, perhaps without exceeding the equivalent of the 100-year volume. It may even be possible to develop design criteria to allow retrofitting existing 100-year detention facilities with outlet structures more favorable for water quality.

Water and Phosphorus Balance in the Watershed - **Figure 3-23** (following page) was developed as part of the Stewardship Plan as a generalized illustration of potential interactions of water and phosphorus in the Cherry Creek Watershed for year 2000 conditions (TPL, 2002). In a sense, this illustration could serve as a starting point for a detailed watershed TMAL analysis. The figure was developed from limited available information; additional monitoring and research is necessary to more accurately understand these relationships and the fate and transport of phosphorus in the watershed. In addition, a similar analysis is needed to depict soluble phosphorus interactions and loading to the reservoir.

The figure seeks to illustrate the "big picture" of water and phosphorus movement in the watershed and attempts to depict some of the complex surface water/groundwater interactions occurring in the watershed. The year 2000 conditions model illustrates some of the runoff and phosphorus absorption that is believed to occur in the watershed through in-stream infiltration and treatment.

The water and phosphorus balance shown in **Figure 3-23** was revised to reflect two "alternate futures" scenarios. One scenario, based on current loading trends and assuming no improvement in current BMP technology and implementation, is generally unfavorable. The second scenario is favorable, based on a more aggressive, proactive managment strategy. The unfavorable scenario shows phosphorus loading increasing to the reservoir by more than 500% while the favorable scenario reflects a slight decrease in phosphorus loading compared to current conditions (TPL, 2002), even without major PRF projects (PRF projects would then decrease loading below current conditions).

The higher loading of the unfavorable scenario is due to increased stormwater runoff and associated phosphorus loading, increased particulate phosphorus loading from stream degradation in urban and non-urban areas, and a lessened capacity for natural stream infiltration and treatment, also due to stream degradation. The reduced loading of the favorable scenario is based primarily on stormwater volume practices for new development, matching predevelopment levels of runoff, and a proactive, comprehensive stream restoration/reclamation effort to create class 4 and 5 water quality treatment streams throughout the watershed.

The point of the alternate futures comparison is to highlight some of the extremes in potential reservoir loading based on different management strategies. The comparison also illustrates that future phosphorus loads can be managed to significantly reduce impacts from future urbanization.

Impacts from Septic Systems, Point Sources, and Non-urban Sources – Other sources that impact reservoir water quality are septic systems, point sources, and non-urban sources. Over 100 septic systems are located in the stream preservation area of Cherry Creek. These septic systems provide a more direct conduit of pollutant loads such as phosphorus and nitrogen species and pathogens to Cherry Creek. The Authority has not supported installation of septic systems in the Cherry Creek Watershed and does not support construction of septic systems in stream preservation areas due to potential water quality impacts (CCBWQA, 2000).

Chapter 2 discussed treatment standards and phosphorus loads associated with wastewater treatment plant discharges. In general, phosphorus concentrations from point sources are low relative to ambient conditions in Cherry Creek.

In addition to urban impacts, a number of other potential sources of phosphorus loading to the reservoir exist in the watershed. These include activities related to animal waste management, crop management, and grazing along stream corridors. A number of federally-funded programs that support sustainable agriculture and habitat protection and restoration are available to farmers, ranchers, and landowners, including the following:

Conservation Reserve Program - This program provides funding for a 10-15 year period to landowners for converting highly erodible cropland or environmentally sensitive land to permanent vegetative cover. It is available to any individual or agency owning or operating private croplands.

Environmental Quality Incentives Program - This program provides incentive payments and cost sharing for conservation practices designed to reduce nonpoint source pollution, reduce emissions, reduce erosion and sedimentation, and promote habitat conservation for at-risk species. It is available to anyone engaged in agricultural production.

Partners for Fish and Wildlife - This program provides technical and financial assistance to private landowners to restore wetlands and other fish and wildlife habitats on their land. It is available to any private landowner owning lands with potential for restoration to its original habitat.

Wetlands Reserve Program - This program provides compensation for the restoration of agricultural lands to wetlands. It is available to any landowner with land that is restorable to wetland conditions.

Wildlife Habitat Incentives Program - This program provides cost-sharing and technical assistance to improve wildlife habitat, including upland, wetland, and riparian habitats and threatened and endangered species habitats. It is available to any landowner, although participation in the Conservation Reserve Program, Wetlands Reserve Program, or other similar programs renders the land ineligible.

Trading Program - Incentives for further nonpoint source reductions via trading could be provided as well as removing barriers limiting trading in the Basin and encouraging implementation of water quality improvements in a cost-effective manner. There is a significant opportunity to provide incentives for nonpoint source reductions from septic systems via the trading program. Trading credits could be provided to the entity that facilitated conversion of the septic systems to conventional wastewater treatment. Because of the water quality impacts of septic systems, the Cherry Creek phosphorus TMAL, and the water supply uses of the Cherry Creek alluvium, it is important to evaluate this conversion expeditiously. An incentive program, like trading, will provide the key to move septic system conversion forward and reduce phosphorus loads from Cherry Creek.

3.2 Strengths, Weaknesses, Opportunities and Threats

Table 3-4 provides a summary of strengths, weaknesses, opportunities, and threats (SWOT) in the Cherry Creek Watershed. This information is foundational to the management plan recommendations discussed in Section 3.3 and elaborated on in Chapter 6.

Table 3-4. Strengths, Weaknesses, Opportunities and Threats Summary

Weaknesses	Strengths
Presence of phosphorus sources in watershed far surpassing current loading to reservoir. Susceptability of stream network to degradation as a result of increased runoff from urbanization. Lack of substantial implementation of stormwater volume controls beyond currently accepted BMP practices. Stream stabilization practices, such as constructing concrete low-flow channels, that inhibit infiltration and increase conveyance of phosphorus downstream toward the reservoir. Allowing stream degradation to grow to significant proportions prior to stabilization work. Lack of public access to much of Cherry Creek stream network, which is located mostly on private property, inhibiting access for maintenance operations. Difficult to address stream degradation that may occur downstream of developing areas	Cherry Creek watershed and stream network shows evidence of capacity to infiltrate and absorb some amount of runoff and phosphorus. It is still relatively early in the watershed's urbanization process, so that degradation effects are still not fully developed. A cursory field recconnaissance showed that much of the stream network within areas of existing development has been stabilized to some degree. Demonstration projects exist to showcase ability of stream stabilization projects to also enhance water quality. Consideration of stormwater runoff controls and other advanced BMP concepts has been high among TAC and local government staff. Evidence that proactive stream stabilization measures are cost-effective Efforts by Authority, TPL, and local governments to acquire open space tracts in stream corridors
Threats	**Opportunities**
Increased stormwater runoff and phosphorus loading from urbanization. Significant additional urbanization is anticipated through the year 2020. Degradation of Cherry Creek and tributary stream network due to increased runoff, adding particulate sources of phosphorus, reducing infiltration and vegetative filtering, increasing conveyance of phosphorus downstream toward reservoir, lowering water table, and drying out overbank vegetation.	Promotion of stormwater runoff controls and other advanced BMPs in newly developing areas. Recognition and preservation of natural water quality enhancement function of mainstem Cherry Creek corridor. Design and construction of stream stabilization improvements that provide significant in-stream water quality enhancement. Proactive stream reinforcement and stabilization in advance of significant degradation. Consideration of detention design criteria that provides greater focus on more frequent storm events, reducing degradation effects and enhancing water quality.

3.3 Conclusions and Recommendations

This chapter has focused on current and projected phosphorus loading to Cherry Creek Reservoir from its upstream watershed. The watershed analysis has led to several conclusions.

1. Without additional mitigation measures, overall phosphorus loading from the watershed is projected to increase in the future due to the following factors:

    - The available supply of phosphorus in the upstream watershed - in the precipitation that falls on the watershed, within the watershed soils, and in other sources - is large, and any condition that increases erosion or runoff will increase phosphorus loading to the reservoir.
    - Urbanization in the watershed is projected to increase.
    - Unless controlled in a manner that goes beyond current BMPs, stormwater runoff will increase as urbanization increases.
    - Stormwater phosphorus concentrations are projected to increase and, although required BMPs are intended to moderate this increase, current BMP practices allow increases in stormwater volume and phosphorus loading over predevelopment conditions.
    - Stream degradation is expected to increase along with increases in runoff, delivering additional sediment and adsorbed phosphorus toward the reservoir.
    - Stormwater infiltration in Cherry Creek and tributary corridors is projected to decrease as degradation narrows and deepens channel sections and as stabilization projects tend to reduce overbank infiltration. Reduced stormwater infiltration will increase the delivery of runoff and phosphorus to the reservoir.

2. The reservoir has not been consistently meeting chlorophyll a standards given current levels of phosphorus loading, therefore, increased phosphorus loading will reduce the likelihood that the reservoir will meet chlorophyll a standards in the future.

3. The recommended management plan is aimed at reducing or eliminating future increases in phosphorus loading from the watershed and, if confirmed that it is necessary to preserve beneficial uses in the reservoir, to reduce future loading below current levels.

4. An initiative is recommended within newly developing areas to work toward attaining runoff and phosphorus loading that is similar to pre-development levels. Collaboration with local land use agencies in the area enhanced stormwater management, runoff volume control and recharge methods, and stream reclamation (to create class 5 streams) is viewed as one of the most beneficial and cost effective strategies the Authority can take to reduce future phosphorus loading to the reservoir.

5. An aggressive, two-prong stream improvement program is recommended to control channel degradation impacts in the watershed and reduce related phosphorus loading to the reservoir. Streams that have already experienced degradation are to be identified

through a comprehensive inventory process (a draft protocol is shown in the appendix) and stabilized as soon as possible. Such stabilization would tend to reduce current loads.

Streams that are stable today, but expected to be impacted from projected increases in urban runoff are recommended to be stabilized proactively, in conjunction with increased runoff. Proactive stabilization costs less and yields reduced phosphorus loads compared to allowing degradation to occur prior to implementing stabilization measures. Proactive stabilization would tend to keep future loads from increasing.

A draft prioritization order for both types of stream stabilization projects is shown in **Table 3-1**, although this will be revised as necessary based on the results of the stream inventory. It will be important to acquire access rights, easements or open space tracts along stream corridors to enable the improvements to be made. All stream improvements are recommended to promote stormwater quality treatment by reducing velocities and increasing overbank flow width, infiltration, and vegetative filtering.

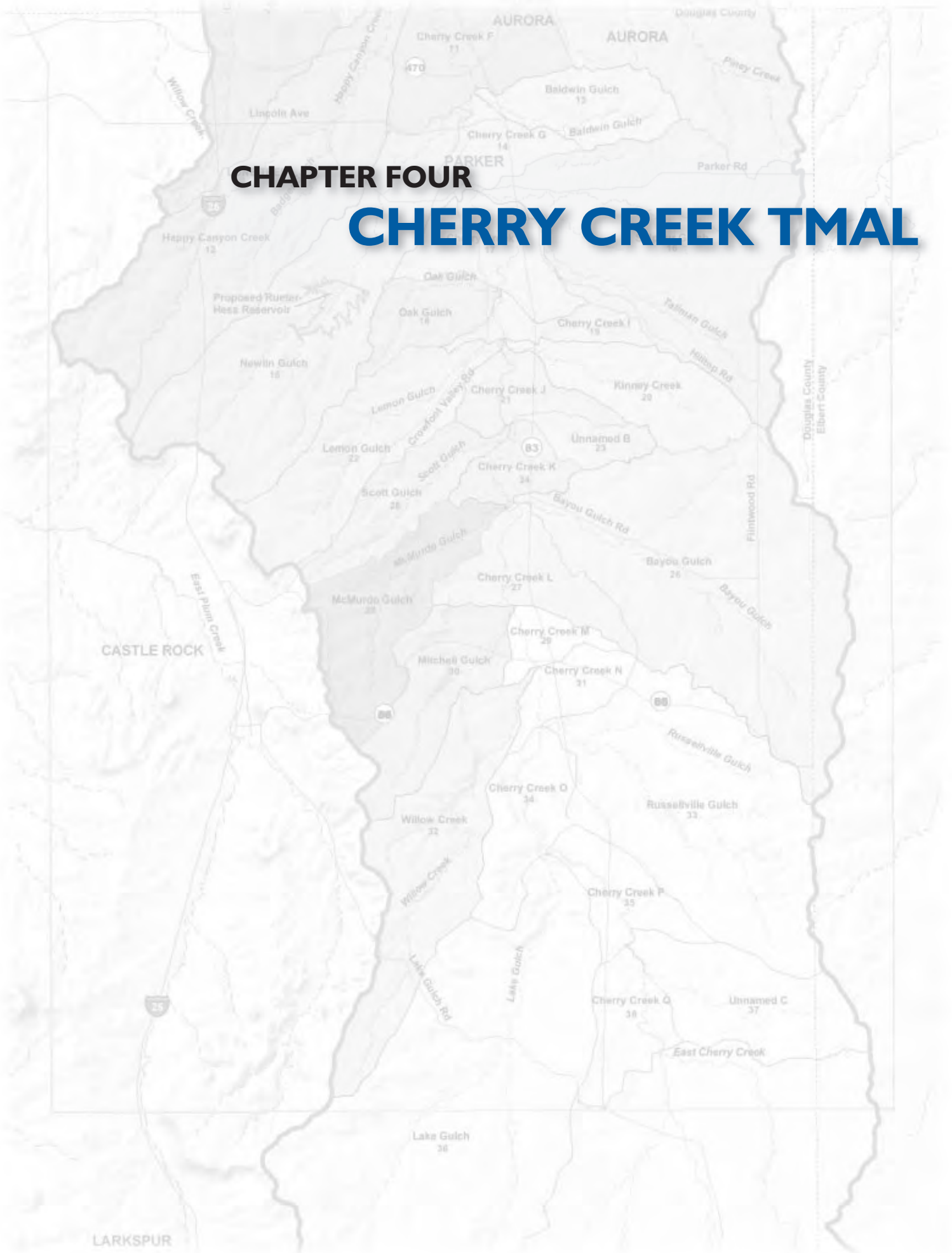
6. While enhanced new development BMPs and proactive stream stabilization will focus on controlling future increases in watershed phosphorus loads, addressing existing stream erosion and implementing other pollutant reduction facilities (PRFs) are recommended to reduce watershed phosphorus loads below current levels. It is anticipated that some of the runoff volume controls and recharge methods implemented in newly developing areas could be retrofitted in existing urban areas, especially in conjunction with some of the existing 100-year detention facilities in the watershed. Opportunities also exist to reduce phosphorus loading from septic systems located within the Cherry Creek alluvium and livestock operations located along streams in the watershed.

7. Further work on understanding the fate and transport of phosphorus in the watershed is recommended, including defining an accurate water/phosphorus balance for both total and soluble forms of the nutrient. **Figure 3-19** represents a starting point for this effort. Also, it is critical to ascertain the levels of total phosphorus loading, soluble phosphorus loading, and water inflows (considering residence time effects) that will enable the reservoir to consistently achieve chlorophyll a standards.

Management recommendations associated with the watershed analysis are elaborated on in Chapter 6, along with recommendations associated with funding, public involvement, and other issues. An initial draft of a funding program to work toward implementing these recommendations is shown in the supplemental appendix. The draft funding program covers the next several years of implementation and reflects costs that are expected to be shared with local land use agencies and other entities.

In order to make progress on the watershed recommendations, a coordinated implementation program will be necessary. It is anticipated that much of the program will be undertaken in close collaboration with member local governments, and that the program will be managed through the Technical Advisory Committee, either by the committee as a whole or through a subcommittee.

The implementation program will address prioritization, funding, scoping, and execution of the recommendations, and will need to identify who does what and when. Especially important will be developing systems to track progress and measure benefits.



CHAPTER FOUR

CHERRY CREEK TMAL

In September of 2000, the WQCC adopted a phased TMAL for total phosphorus for Cherry Creek Reservoir.

A phased TMAL recognizes that the TMAL has elements of uncertainty which need further monitoring and evaluation and, thereafter, the TMAL may be refined (See, *EPA, Guidance for Water Quality Based Decisions, 1991).* However, a phased TMAL requires implementation of the controls and management strategies designed to improve the water quality. EPA characterizes a phased TMAL as an appropriate mechanism for water quality control. Further, the WQCC recognized the importance of the phased TMAL process that allows for the adoption of both point source and nonpoint source requirements that will provide protection for the reservoir while studies of contributing problems to reservoir quality continue, and if necessary, additional control programs are formulated (WQCC, 2000).

Review of the TMAL by various entities, such as EPA and the WQCC, has revealed that the current allocations are not attaining water quality standards or protecting current designated uses. The WQCC recognizes that this situation requires the necessary controls be identified that will attain the applicable standards and protect the uses. The identification of the necessary controls will require considerably more investigation and evaluation before the Control Regulation can be revised to reflect these changes. The WQCC recognizes that until additional investigations are completed, a new TMAL cannot be calculated. The Phase I TMAL will implement further controls on point sources, stormwater, and nonpoint sources while sufficient information on the phosphorus loadings to the watershed and reservoir are developed to support revision of the TMAL (WQCC, 2000).

The TMAL for total phosphorus by sources is based on the following formula:

Cherry Creek TMAL =

Nonpoint and Regulated Stormwater Sources + Background Sources + Wastewater Facility Sources + Industrial Process Wastewater Sources + Individual Sewage Disposal Systems + Margin of Safety

The current TMAL phosphorus poundage allocations are distributed among the sources as shown in **Table 4-1**:

Table 4-1. Cherry Creek TMAL

ALLOCATION TYPE	TOTAL PHOSPHORUS (LBS/YR)
Nonpoint and Regulated Stormwater Sources	10,290
Background Sources	1,170
Wastewater Facility Sources (including Reserve Pool, Phosphorus Bank, and Semi-Urban Areas)	2,310
Industrial Process Wastewater Sources	50
Individual Sewage Disposal System Sources	450
TMAL	**14,270**

As shown, over 72-percent of the load is allocated to nonpoint and regulated stormwater sources. The annual point source wasteload allocation of phosphorus in the Cherry Creek Watershed is limited to 2,310 pounds per year, or 16-percent of the TMAL. The wasteload allocations for each WWTF were based on a maximum effluent concentration of 0.05 mg/L total phosphorus, near term (2007-2010) hydraulic capacity needs, and near term population and employment levels estimated in the Metro Vision Plan (DRCOG,

Table 4-2. Summary of Phosphorus Wasteload Allocations

CHERRY CREEK BASIN POINT SOURCE ALLOCATION	
Facility	(lbs/yr)
Arapahoe Water and Wastewater Authority/Cottonwood Water and Sanitation District	402
Pinery Water and Sanitation District	304
Inverness Water and Sanitation District	129
Parker Water and Sanitation District	533
Meridian Water and Sanitation District	113
Stonegate Village Water and Sanitation District	161
Subtotal	**1,642**
Semi-Urban Areas	236
Reserve Pool	216
Phosphorus Bank	216
Total Wasteload Allocation	**2,310**

2000). **Table 4-2** summarizes the wasteload allocated to each of the WWTFs, semi-urban areas which as they develop may be provided centralized wastewater service, the Reserve Pool, and the Phosphorus Bank (WQCC, 2001). While treated wastewater flows have increased at each WWTF, treatment facilities have consistently instituted new processes or changed their chemical additives and dosages to reduce phosphorus concentrations (Authority, 2000).

Continued water quality monitoring, specific modeling, and special investigative studies are required as part of the process and continued development of the phased TMAL. The Control Regulation mandates that the Authority undertake certain activities and studies for 2003, 2004, and 2005 (**Table 4-3**). The WQCC requested that these water quality activities be implemented, as funding allows.

Table 4-3. Summary of Future Activities to Revise the TMAL - Years 1-3

YEAR ONE
Construction of nonpoint source control projects
Reservoir nutrient enhancement studies
Further development of event mean concentration for stormwater flows
Identification of industrial process wastewater sources and associated phosphorus loading
YEAR TWO
Construction of nonpoint source control projects
Evaluation of phosphorus removal effectiveness of nonpoint source control structures
Monitoring of shallow alluvial ground water loading in tributaries
Quantification of individual sewage disposal system phosphorus loading
YEAR THREE
Construction of nonpoint source control projects to reduce phosphorus loading to the maximum extent practicable
Implementation of lower phosphorus effluent limits
Characterization of watershed hydrology to establish reference condition for evaluation of phosphorus loading
Depth profiling of nutrient content in ground water
Revised calculations of background sources, industrial process wastewater sources, and septic system sources of phosphorus contributions
Revision of control regulation TMAL for next triennial review

From: 5 CCR 1002-72.3 (4) (a)-(c)

Table 4-4 summarizes the status of Authority activities identified in the Control Regulation. (following pages)

Table 4-4 Control Regulation Review and Status

Control Regulation Requirement	Description	Status	Comments	Action Item(s)
72.3 Phase I TMAL Phosphorus Load Allocations		Continuous process	See below	See below.
72.3 (4) Future activities to attain TMAL[1]				
(a)(1): Construct non-point source control projects	1.Cottonwood Creek at Peoria Pond	Completed 2002	Items 2 and 3 are currently in design phases; Item 2 scheduled to begin construction Fall 2003	• Continue with 2004 CIP
	2.Cottonwood Creek Stabilization	Design and construction		
	3.Cherry Creek SP Wetlands	Design		
(a)(2): Conduct reservoir nutrient studies		In progress	Study funded with EPA 319 grant and Authority match dollars	• Work with WQCD
(a)(3): Develop event mean concentrations for storm flows		No action taken	How to fund studies?	• Work with WQCD to address requirements and funding
(a)(4): Quantify soil and GW background phosphorus levels		WQCD developed scope	Partial study funded with EPA 319 grant dollars and Authority match	• Work with WQCD to address requirements
(a)(5): Identify industrial process WW sources and associated phosphorus loading; Identify and quantify septic system phosphorus loading		No action taken	Septic systems identified in Franktown and Valley Country Club area	• Identify scope and direct investigation
72.4 WWTF Load Allocations/ Limitations				
72.4(2): Wasteload allocation	Annual WW load among WWTFs limited to 2,310 lbs/yr (excluding industrial waste)	Loads reported by dischargers in their DMR submitted to WQCD; Loads below allocation		• Provide results in Annual Report (See 72.9)
72.4(4) Effluent concentration	Attain phosphorus effluent concentration of 0.05 mg/l by August 2004			• Identify dischargers unable to meet objective by Aug. 2004 • Support loans for WWTFs to improve phosphorus removals • Continue studies of fate and transport to better characterize the wastewater loadings and effects on Reservoir
72.4(5): Discharger request for a compliance schedule	Discharger must notify Authority and request comments	Site applications and wastewater utility plans evaluated to meet water quality requirements; Recommendations to TAC	TAC recommends to Board for action	• Continue current process • No compliance schedules requested, if so, would include in Annual Report. (see 72.9)

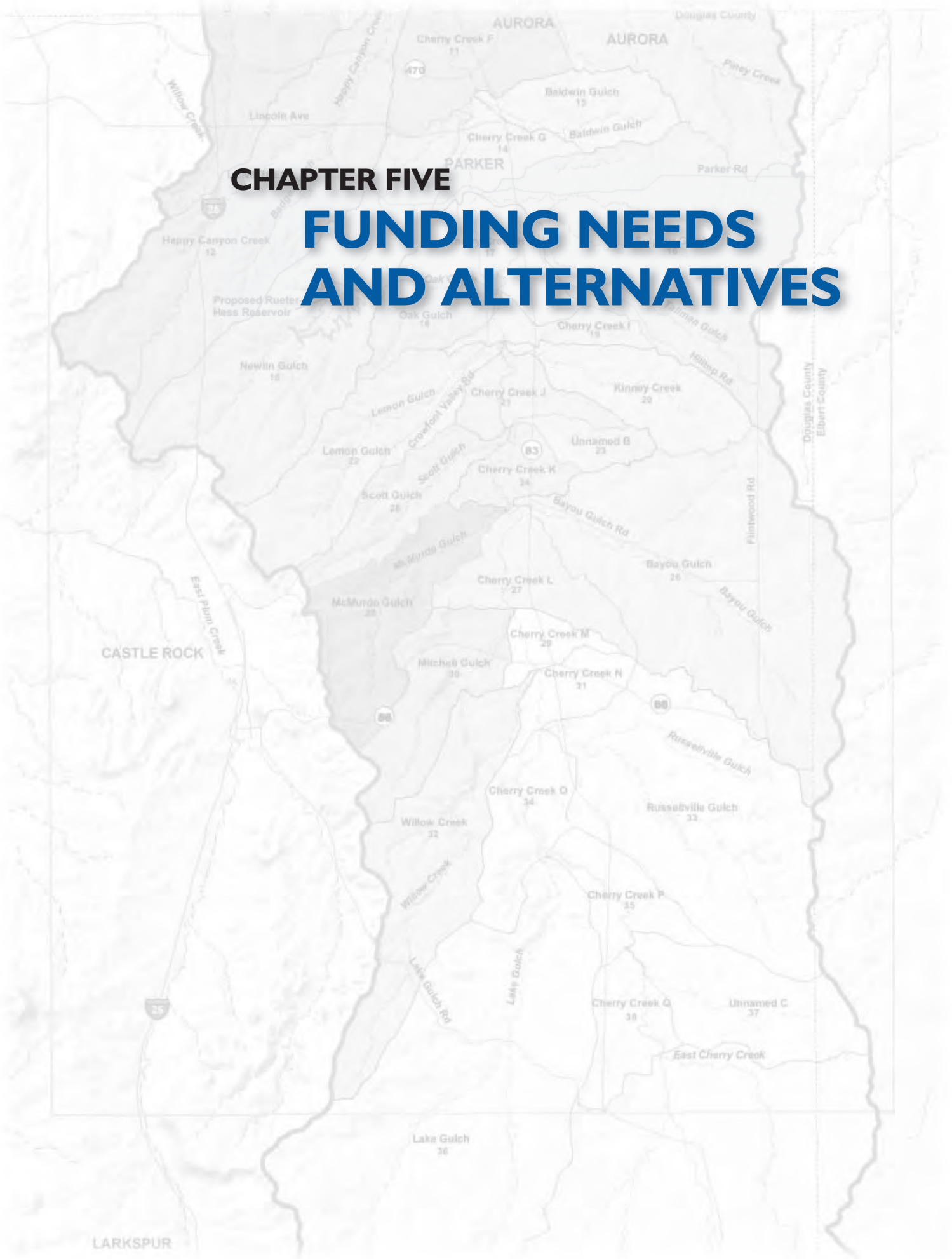
[1] Year One activities discussed in summary table. Additional requirements for Years Two and Three will be addressed during subsequent report updates.

Control Regulation Requirement	Description	Status	Comments	Action Item(s)
72.4(6): Wasteload Allocation for Semi-urban areas		None pending	Requirements would be identified in WUP or site applications	• Identify activities in Annual Report (see 72.9)
72.4(7): Determine monthly and annual quantity of phosphorus discharged		Included with discharger's DMR submitted to WQCD	WQCD reviews DMR from discharger	
72.4(8): Additional prohibitions and precautionary measures	Control of other point sources	No action taken		• Evaluate and prioritize activities for future consideration. • Work with WQCD to identify additional prohibitions and precautionary measures
72.5 Point Source Wasteload Allocation Modifications				
72.5 (1): Temporary Transfer of Phosphorus Allocation		None Pending	Include activities with Annual Report (see 72.9)	• Include any potential activities with Annual Report (see 72.9)
72.5(2) Reserve Pool	For expanded or new wasteload allocations	Three possible applications for credits pending	Board considering reserving portion for lease only for emergency conditions and retiring remainder. New guidelines adopted by Board, July 2003	• Authority and WQCD review trading application s • Identify activities in Annual Report • Request the WQCC to remove the 216 - pound cap on trading
72.5(3) Trading Program	Trading allowed for certain nonpoint source projects	Trading Guidelines have been drafted and received Authority approval Application submitted by: Parker Water & Sanitation Dristrict and Arapahoe Water and WW Authority		• Implement Trading Guidelines via trading applications
72.5(3)(I): Maintain Phosphorus Bank	Approved phosphorus trade credits are tracked. Credits are available for expanded or new wasteload allocations	Trading Guidelines have been drafted and received Authority approval; No credits have been banked; Four projects in progress	Trading Guidelines approved by WQCD	• Establish accounting system for tracking banked credits
Section 72.6	Nonpoint Source Nutrient Controls			
72.6(1)(a): Nonpoint Source BMP	Recommends that Authority Members adopt and implement nutrient control measures	The Authority reviews development submittals for compliance with the criteria Authority budgeted, scoped, and advertised for Phosphorus Facilitator in 2003	Authority requirements for control measures is completed, but has not been adopted by all land use agencies Phosphorus facilitator to investigate and report on low impact development techniques	• Request all Authority members to adopt and implement appropriate control measures

Control Regulation Requirement	Description	Status	Comments	Action Item(s)
72.6(1)(c): List of Prioritized CIP Projects	Identify, prioritize, and update list of effective and cost-efficient projects	3-year CIP implemented in 2003	Original project list was submitted 9/2001 as required by the control regulation	• Review updated project list for 2004 planning and budget
72.6(1)(d): O&M provided for nonpoint source projects and oversight		O&M costs included in prioritized CIP list. O&M activities for Cottonwood Pond included in 2003 CIP	Updated list in progress. Consultant designing Cottonwood O&M improvements	• Refine O&M requirements. • Define O&M procedures for each project. • Budget for oversight in the future and determine how Authority will provide oversight
72.6(2): Public Information and Education	Develop program with focus on known nonpoint water quality impairments; Consult with WQCD; To be implemented by 6-1-2002	319 Grant education program in progress Authority participates in Cherry Creek Stewardship Partners and has contributed to CCSP interpretative signage	Possible partnership with COE upgrade of visitor center WQCD can provide personnel and funding assistance 319 Information and Education program meets schedule requirements	• Implement 319 Grant Program • Identify other Education and Public Information requirements • Form TAC subcommittee
72.6(5): Floodplain Preservation	Recognizes protection of floodplains, etc. through acquisition and conservation as nonpoint control measures	Purchase of Bowtie property adjacent to CCSP completed	Cherry Creek Corridor master plan update (in progress), may identify other priority properties	• Pursue other acquisitions and conservation measures
Section 72.7 Stormwater Permit Requirements (Addressed by Local Jurisdictions)				
Section 72.8	Nutrient Monitoring			
72.8(1): Nutrient monitoring by Wastewater Dischargers				• No action required
72.8(2): Authority develop and implement Monitoring Program	Watershed and Reservoir water quality monitoring required	Monitoring plan completed and monitoring is completed Prepared and submitted Annual Aquatic Biological and Nutrient Monitoring Report		• Report on annual monitoring program
72.8(3): Authority consults with WQCD on Monitoring Program	Evaluate nutrient sources/transport Characterize nutrient load reductions Document attainment standards	Completed	WQCD approved monitoring program	• Continue coordinating with WQCD on future programs

Control Regulation Requirement	Description	Status	Comments	Action Item(s)
72.8(4): Authority consult with WQCD on Special Studies	72.8(4)(a): Feasibility study of nutrient removal: point sources 72.8(4)(a): Qualification of effectiveness of removal strategies: non point sources 72.8(4)(b): Quantification of control structure effectiveness 72.8(4)(c): Other studies to support phased TMAL	Discussions with WQCD in progress under leadership of TAC Chairman	Requires that data be collected under 72.8(4) WQCD or others may fund some special studies	• Continue coordinating with WQCD on requirements and report to TAC
72.8(5): Uses of monitoring data	Determine nutrient fate and transport Calculate annual nutrient loads Document compliance with standards Analyze long-term trends in Reservoir and the Watershed Calibrate WQ models for next phase	Some monitoring data collection in progress	Requires that data be collected under 72.8(4)	• No action required at this time
Section 72.9	Reporting			
72.9(1): Annual Report Submittal		Submitted 2002 Annual Report in March 2003		• Compile information for 2003 Annual Report due in March 2004
72.9(1)(a): Wastewater Facility Controls	Monthly and annual loads Permit violations Approved Site Applications Reduction in nutrient load effectiveness	Submitted 2002 Annual Report in March 2003 and included information	Monthly loads not previously included and annual loads not reported in 2001	• Compile information for 2003 Annual Report due in March 2004
72.9(1)(b): Nonpoint Source Controls	Sediment and erosion control permit, inspection, and enforcement actions Construction BMPs inspection and enforcement actions Permanent BMP construction, inspection, and maintenance actions Flood control facilities retrofitting, inspection and maintenance actions Effectiveness in reducing nutrient loads Funding/monitoring of nonpoint projects Public information and education actions	Authority reviews land use applications for compliance Design of two PRF's began in 2003 Completion of Cottonwood/Peoria St. in 2002	Requires additional input from local jurisdictions Cherry Creek Corridor master plan update (in progress) may identify other priority properties	• Work with local jurisdictions to compile information for Annual Report.

Control Regulation Requirement	Description	Status	Comments	Action Item(s)
72.9(1)(c): Riparian and Wetlands Protection	Protection, enhancement, and restoration actions	Authority approved participation in Piney Creek stream stabilization, Bowtie property acquisition, and Cherry Creek Corridor Major Drainageway Study Compiled information for 2002 Annual Report and was delivered in March 2003	Cherry Creek Corridor master plan update (in progress) may identify other priority properties	• Continue participation in multi-party watershed protection plans • Compile information for 2003 Annual Report due in March 2004
72.9(1)(d): Wasteload Allocation	Temporary transfer and Reserve Pool actions	See 72.5(3)	See 72.5(3)	See 72.5(3)
72.9(1)(e): Trading Program	Point and nonpoint source actions	See 72.5(3)	See 72.5(3)	See 72.5(3)
Annual Report Content	Monitoring data Point and nonpoint source loadings Status of compliance with discharge permits Recommendations on new or proposed expansion of treatment facilities Recommendations for improving water quality	2002 report delivered in March 2003 Included information in Annual Report Worked with local jurisdictions to compile information for Annual Report	Some information not previously reported	• Include information in Annual Report due in March 2004 • Work with local jurisdictions to compile information for Annual Report
Evidence or agreements	Financing of nonpoint source projects Implementation of permit Adoption/Implementa-tion of BMPs Demonstrate reasonable progress towards control of point and non-point sources of phosphorus	2002 report provided in March 2003 Included information in Annual Report	Some information not previously reported	• Include information in Annual Report due in March 2004



CHAPTER FIVE

FUNDING NEEDS AND ALTERNATIVES

Water quality improvement in the Cherry Creek Reservoir Watershed is dependent on reliable and adequate financial resources to address water quality needs.

Since the anticipated financial resources to address water quality improvements in the Cherry Creek Reservoir Watershed exceed the Authority's budget, the Authority must pursue additional funding sources to implement water quality management strategies and to construct, operate, and maintain PRFs. This section discusses ways to finance a water quality management program for the Cherry Creek Reservoir Watershed, including a number of potential funding sources, and introduces a business plan concept that would provide a roadmap for additional acquisition of financial resources.

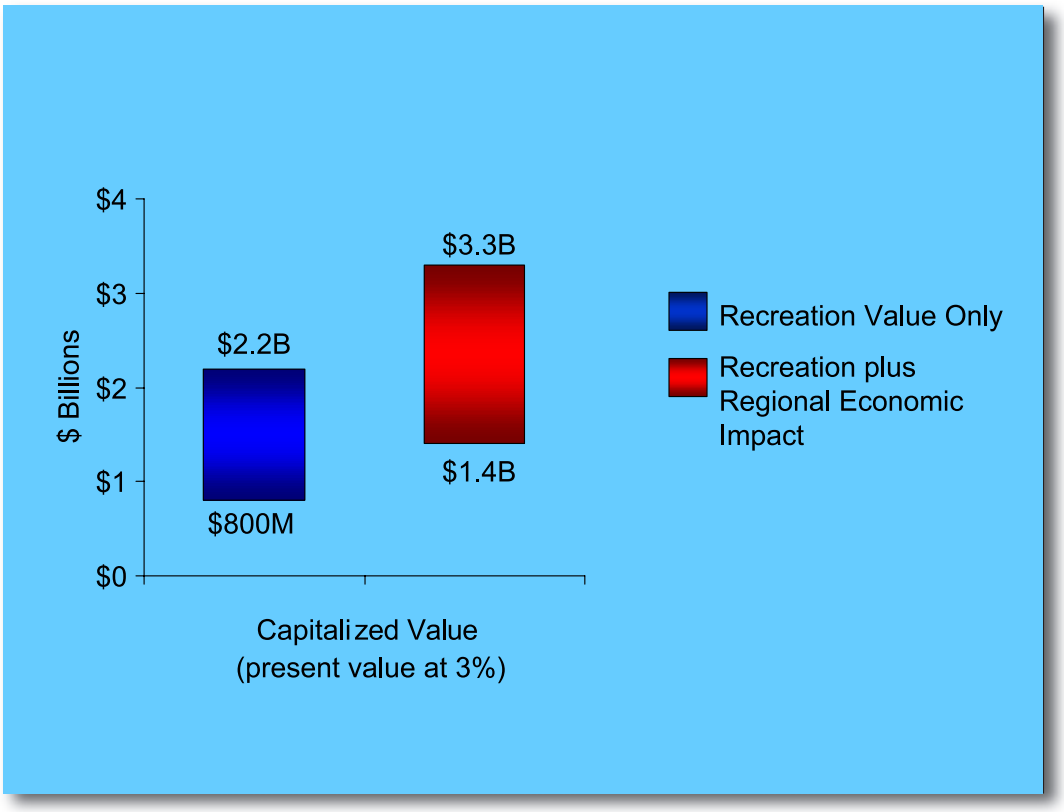
There are significant opportunities to work collaboratively with various local governments, nonprofit organizations, and business entities. This collaboration can establish the Cherry Creek Watershed as an example of how cooperation can find the balance between preserving unique and beautiful resources and supporting profitable development.

Continued work with other partners in the watershed and its environs will further reveal the potential for leveraging funding opportunities. There are many forces presently at work within and around the Cherry Creek Watershed, creating potential synergy for decisive and positive action. Consider the following:

- Local governments have expressed a desire to protect and enhance both the creek and the reservoir by signing a Cherry Creek Regional Agreement, as can be seen in the supplemental technical appendix, that lays the foundation for a healthy Cherry Creek Watershed.
- Cherry Creek Stewardship Partners and other nonprofit groups have an extensively planned program that has direct relation to conservation and preservation of the unique aspects of the watershed and reservoir.
- More and more Denver Metropolitan area residents are utilizing the reservoir, which is considered the urban jewel of metropolitan Denver.
- The COE is interested in investing in programs to enhance the reservoir, and assisting with solutions for water quality problems in the watershed.

- The capitalized economic value of recreation at the Cherry Creek State Park is estimated to be between $800 million and $2.2 billion; $1.5 billion of this amount is for water-based activity (**Figure 5-1**) (Stratus Consulting, 2000).

Figure 5-1. Economic Value of Cherry Creek State Park



- The Authority has received national recognition and been lauded for its water quality-trading program.
- Douglas County has recently initiated a significant open space program that includes the headwaters of the Cherry Creek Watershed, and may offer opportunities for preservation and conservation easements.
- Projected growth within the Douglas County watershed area of Cherry Creek is one of the highest in the nation and is expected to have high quality residential and commercial developments.
- The National Association of Local Government Environmental Professionals has identified the Cherry Creek Watershed as one of it's five partners areas to develop Smart Growth for Clean Water "Study Strategies to Improve Water Quality" (Smart Growth for Clean Water Partnership).

5.1 Funding Concepts

The Authority's 2003 budget is $1.4 million. About $880,000 is tax-based directed to the Authority's General Fund and $560,000 is fee-based directed to the Authority's Enterprise Fund. Current capital expenditures are about $1 million annually, with wide swings, historically.

The future funding needs of the Authority include both nonstructural approaches and capital construction dollars (hard costs) and funding for administration and planning (soft costs). There is a provision in the enabling legislation mandating a 60:40 split between hard and soft costs, respectively. While any funding increase is welcome, the primary need of the Authority is to secure additional funding for capital construction of PRFs and other water quality management strategies.

A preliminary assessment of the potential future capital construction need was conducted. Within the range of possible outcomes of other actions, the most likely outcome involves a combination of local government actions and Authority construction, and a capital budget increase of about $2 million to $4 million annually or a total of $3.4 to $5.4 million. This capital budget range balanced the actual potential to raise funds through more conventional short-term means with demand for monies for hard costs.

Who Should Pay?

Many philosophical discussions arise over who should share in the costs of reducing phosphorus and other actions that must be taken to meet water quality criteria for the reservoir. Among those being considered are:

- Reservoir recreation users - Recreational users are the most direct beneficiaries of the clean water within the reservoir and the primary reason for phosphorus reduction is to make the reservoir more attractive to reservoir recreational users.
- Watershed property owners – They may be contributing to the increase in phosphorus above background levels.
- Denver residents – They benefit from improved stream water quality in Cherry Creek, not to mention flood control protection, due to the pollutant retention properties of the reservoir.
- All metropolitan residents - The economic benefit of the reservoir to all in the metropolitan area has been evaluated and documented at over $1 billion annually.

On balance, it seems that each party benefits from maintaining the reservoir's water quality and has a role in generating revenue to support programs that reduce the actual pollution load.

5.2 Funding Sources and Opportunities

The Authority is in a unique position to take a strong leadership role in the process of identifying funding sources and generating additional funding. The selection of a grant manager will greatly increase the Authority's ability to realize its full funding potential. Funding responsibilities require focus and a nearly full-time effort that should be compensated. However, that effort would generate funds many times the annual salary of such an individual or team.

Evaluation criteria are typically employed in a funding study to assess each method of primary or secondary funding. Potential criteria might include:

- Financial impact on citizens and businesses

- Equity and public acceptance
- Revenue sufficiency
- Timeliness and the process required for implementation
- The costs of development, implementation, and upkeep
- Consistency with capital project and program needs

Several broad categories of fund sources were considered - enhancing existing sources, and finding additional government, private, and miscellaneous sources.

Enhancing Existing Sources

There are currently several major sources of funding: property taxes, Park user fees, and other fees and charges. Each of these primary sources can be increased, and some substantially. If each is increased to meet the legislative ceiling, the additional revenue could approach $1.5 million dollars.

1. Ad Valorem tax revenues are limited both by general Colorado law and by the enabling legislation. The Authority enabling legislation limits ad valorem taxes to 0.5 mil. Due to the Taxpayers Bill of Rights (TABOR) limitations, the current mil rate is 0.36 and generates about $800,000. There are two actions that can be taken to increase this amount.

   First, the current mil rate can be increased to the legislative ceiling of 0.5 mil. This could generate an additional $300,000-$400,000 annually. It would require a vote by the electorate to raise the mil rate above the TABOR ceiling. There is speculation in several quarters that both the time and the message for such a TABOR election on Cherry Creek may be right.

   Second, if the current mil rate was raised above the 0.5 mil ceiling, it could generate an additional $400,000 annually. However, this would require a legislative amendment to eliminate the 0.5 mil ceiling.

2. Recreation Fees are limited by enabling legislation to the amount that would be raised if the Reservoir user fee were $3 per user per year. Currently the revenue raised is only $120,000. The current approach allows walk-in users to enter free and motor vehicles to pay a basic charge per automobile, not per person, similar to state park's funding programs.

   Park use is estimated at 1.5 million users per year. Assuming that some proportion of these users use the reservoir more than once per year, the potential revenue to be collected is probably in the range of $500,000 per year.

3. Other Fees are collected as a surcharge to wastewater bills ($70,000/year) and building permit fees ($225,000/year) and are based on economic analysis. An updated analysis of these fees should be done with the idea of increasing their bases, which includes many factors such as construction and development activities and wastewater-related phosphorus generation. No estimate can be made on the potential increase in these fees until this analysis is done.

4. Special Assessment Districts consist of specially calculated fees authorized by the Cherry Creek enabling legislation, based on the direct and special benefit received by a paying

property. This funding source is similar to charges levied on a property owner from a sanitary district when sewer service is made available in a neighborhood previously on septic systems. In that case, the basis of the charge is often road frontage. The basis for PRF construction should be primarily pollutant-related. For example, new capital construction could be paid for, totally or partially, by a calculated assessment against all properties where runoffs drain through and are treated by the "facility." It might be that the basis of the assessment is an estimate of pounds of phosphorus generated by each property calculated simply through the Event Mean Concentration and volume of runoff estimates. It would be necessary to insure that these properties do, in fact, receive both direct and special benefit from the PRF to which they drain.

5. El Paso and Elbert Counties are within the Cherry Creek Watershed and may be included in the mil levy and other funding mechanisms. This would require a legislative amendment. A preliminary analysis of the amount of revenue that would be raised versus costs for a legislative amendment would need to evaluated.

6. Urban Drainage and Flood Control District boundaries currently extend partially into northern Douglas County, but do not cover the entire Cherry Creek Watershed. An immediate source of funding, which would require a UDFCD concurrence and a vote of the Cherry Creek electors, would extend the UDFCD boundaries to coincide with the Cherry Creek Watershed boundaries. Independent of this boundary concept, UDFCD funding should be maximized each year through both the Authority's program and those of participating local governments by formalizing coordination between local governments on priority projects in the Cherry Creek Basin.

Federal Sources

The Authority currently attempts to take advantage of various government sources either directly or indirectly through nonprofit organizations. Current direct revenues include a current 319 Grant from EPA and COE management of the reservoir. Additional sources might include:

1. Corps of Engineers. An aggressive approach by the Authority to work with the COE on watershed improvements is expected to result in new sources of funding opportunities as well as the potential for larger capital construction dollars. Ideas include:
   - Consideration of the COE continuing authorities such as the Section 1135 program for modification of older existing Corps flood control structures for environmental purposes and the Section 206 program for aquatic ecosystem restoration. For smaller projects, these programs can expedite the process so that construction can begin in as little as 18 months.
   - Working out a modified reservoir management approach wherein the Corps helps to fund phosphorus reduction efforts based on a renewed economic analysis of the benefits of recreation. This approach would be dependent on, amongst other things, resolving potential dam safety concerns.
   - Developing a whole new Corps of Engineers project for construction of PRFs on the basis of a net positive benefit-cost analysis. This would be funded under the Water Resources Development Act (WRDA), but could conceivably be a lengthy process to work through. This approach may open up opportunities for a multi-agency effort between the COE, NRCS, and EPA.

2. Other Federal Sources. There are a number of sources of federal dollars and federal assistance that have been used by other entities to provide revenue or consulting, thus freeing up revenue for other uses, in support of watershed activities. These sources include: Federal Emergency Management Association (FEMA), Federal Highway Administration (FHWA), Housing Urban Development (HUD), NRCS, EPA, Bureau of Reclamation (BUREC), COE, National Park Service (NPS), U.S. Fish and Wildlife Service (USFWS), and USGS. Each one of these agencies needs to be investigated for potentially eligible local programs and situations. Many of the programs are state-administered.

   The Authority is aware of many of these programs and has received several grants. For example, among the awards is the EPA Section 319 grant, which has supported construction of portions of the lower Cottonwood Creek project ($188,467) and information/education programs, such as the acclaimed "*The BMP Series*" fact sheets, that focus on the education and promotion of best management practices for controlling nonpoint pollution sources in the Cherry Creek basin. The grants are awarded and administered by the Colorado Department of Public Health and Environment's (CDPHE) WQCD as part of the Nonpoint Source Management Program.

Just a few examples of other federal funding sources that illustrate funding potential are highlighted below.

- The FHWA, under the TEA-21 program, has mandatory set asides for wetlands protection and stream restoration, often in conjunction with roadway construction.

- EPA has new Watershed Initiative Grants, for which Cherry Creek is a likely candidate (see http://www.epa.gov/region8/community_resources/grants/grantmedia/grantwater.html).

- FEMA has a new program for pre-flooding mitigation, including stream stabilization and riparian corridor activities. The "Federal Commons" website is the best place to begin the search (http://www.cfda.gov/federalcommons) if flooding is an issue.

Local Sources

Local governments have access to many of the same funding sources as the Authority as well as others, since they have land use control. If a local government has a stormwater utility fee (Denver, Aurora, Parker and Castle Rock have fees, and Arapahoe and Douglas Counties are considering such fees), there is a menu of multiple options to pay for their program focus, such as channel protection and erosion control, as well as to supplement the Authority.

1. Denver floodplain surcharge. While the primary focus of the Authority's program is water quality, it must be remembered that the reservoir provides flood protection for land near the creek downstream, and that those properties protected receive a direct and special benefit. The Denver stormwater utility might want to consider assessing a floodplain surcharge, similar to Boulder's, to help defray the flood control-related costs of reservoir operation.

2. Stormwater utility fees. General stormwater utility fees for local governments, such as that assessed in the Town of Parker, could be collected throughout the watershed as a watershed-specific surcharge to handle the cost of extra services and needs of the watershed's TMAL requirement. This fee would be presented as a cost of developing and living in the watershed.

3. Capital Recovery Fees and Charges. In a manner similar to the Authority's ability to develop special assessment districts, local governments can do the same to defray costs of multi-user capital construction to handle pollution and runoff volume increases related to new development. There are other capital recovery fees potentially available to the Authority, such as a stormwater or surface water "tap" fee, latecomer charge, system development charge, or impact fee.

4. Bonds and Loans. Inherent in the enabling legislation is the ability to obtain revenue through bonding. This can be in the form of either general fund or revenue bonds. In addition, the Authority may obtain funds through the state revolving loan fund. The Authority evaluated funding options through the Colorado Water and Power Authority Revolving Loan Program in 2001. While funding opportunities were limited based on the Authority's current funding level and source of revenues, it would be worthwhile to re-explore these funding options, particularly if the Authority's revenue increases as planned.

5. Watershed-based Trading Program Upgrades/ Banking Programs. The Cherry creek watershed-based trading program is a model for the rest of the country. Pounds of phosphorus immobilized provide an environmental benefit and are considered "currency". This program should be maximized or modified to increase the revenue such a program can generate.

6. Other Fees and Charges. There are other fees and charges that could be assessed to match either the impact of a particular property on the reservoir or the cost it imposes on a local program by virtue of inspection needs (e.g., erosion control or BMP inspection). There are also plan review fees and urban hotspot fees. Another fee is charging for the use of regional facilities by single property owners, termed a fee in lieu of a charge commensurate with the level of use.

Private Sources and Miscellaneous Ideas

1. Nonprofit organizations. Significant support can be obtained through partnerships with nonprofit organizations for the "soft side" of phosphorus reduction and watershed protection. They can be a source of labor, funding, and support. Some local governments have actually formed partnerships with local nonprofit groups, assisting them in obtaining grants and leveraging local funds through them.

   Additionally, nonprofit organizations have access to private grant funds that are unavailable to local governments. The Rivernetwork provides a good starting place to look at potential grant funding beyond that which is already known to the local organizations (http://www.rivernetwork.org/library/libnetdirnonprofit.cfm).

   Individual organizations with programs directly involved with Cherry Creek can serve as doorways to other national organizations:

Greenway Preservation Trust - http://www.greenwayfoundation.org/ -The Greenway Foundation is the nonprofit organization that initiated the resurrection of the South Platte River and its surrounding area from a virtual cesspool to a place of environmental and recreational pride for the citizens of the Greater Denver area. The Greenway Foundation can play a vital role in constructing trails in the Cherry Creek riparian zone. An initial goal for the Trust has been set at $5 million with a target date of 2004.

Cherry Creek Stewardship Partners - http://cherry-creek.org/index.htm -The Cherry Creek Stewardship Partners is an informal association of a broad range of stakeholders interested in promoting effective stewardship of the Cherry Creek Watershed. Partners emerged from the first Cherry Creek Watershed forum, held in the fall of 1999. They bring together representatives from the land use jurisdictions, the state and federal resource management agencies, conservation, recreation, and historic preservation groups, and the business community. The Partners host an annual conference on Cherry Creek, and are spearheading a Smart Growth for Clean Water initiative and the Cherry Creek Basin Legacy project.

Colorado Watershed Network - http://www.coloradowatershed.org/ - The group's mission is to achieve healthy watersheds throughout the state of Colorado through the development, support, and implementation of volunteer monitoring, local collaborative initiatives, sound stewardship, and educational activities. Through the River Watch Program, they work in a partnership with the Colorado Division of Wildlife and with voluntary stewards to monitor water quality and other indicators of watershed health and utilize this high quality data to educate citizens and inform decision makers about the condition of Colorado's waters.

2. Corporate foundations or sponsorship. Corporations provide numerous ways to raise money. They offer internships, sponsorship of events, donations, foundation grants, and donations in return for product placement. For example, Adopt-a-Stormdrain uses a unique approach to assisting in local fundraising through linking corporate sponsors' use of their logos on signage throughout the reservoir in exchange for placement of their logos on those signs resulting in public association of their corporation with environmental causes.

   For example, the reservoir could be named by a corporation in a manner similar to a stadium, or "reservoir memberships" could be sold at various levels (platinum, gold, silver) in exchange for recognition and special events.

   Enabling the Cherry Creek Watershed independently to receive charitable corporate gifts would require either the creation of a foundation with IRS status as a nonprofit organization, or entering into a relationship with a community foundation that can accept and manage contributions on behalf of the reservoir.

   Most corporations have a public affairs officer who handles such requests initially, or web sites can provide the relevant information. Obviously, connection with top corporate management best insures cooperation and involvement.

3. Endowments. Once the project can accept charitable contributions, an endowment fund can be established with donations from individuals, businesses, and other foundations. Interest from the endowment will then support project administrative costs and eventually, as the endowment continues to grow, may support programs and staff. The endowment principal typically is not spent; it is maintained as a permanent legacy. This funding option is dependent on the project receiving contributions from the community. Although an uncertain funding source, the public may prefer to contribute dollars to improve the water quality of the reservoir, rather than be subject to a mandatory tax.

4. Boat tags or Reservoir memberships. Requiring special boater registration tags or stickers is another direct way to raise revenue from those individuals that benefit from the reservoir and pollute more than normal lake users. This concept could be expanded into a reservoir membership program similar to a health club or public pool.

5. Fundraising Events. Fundraising events are an excellent way to draw new supporters for Cherry Creek and the reservoir and gain visibility for the project's work. Special events can also provide the project with an additional source of income to supplement and diversify the budget. Examples of some possible fund raising events include auctions, benefits, concerts, dinners, festivals, guided tours, and races. Event planning is an ongoing process and should involve individuals from the community to share in the work of developing the event.

6. Cherry Creek Automobile License Plates. A special license plate could be developed and is legal in Colorado, either generally or for special events. These could be created and offered to residents; the revenue would supplement the project budget. They are typically sold at a premium of about $25 over the normal plate cost.

7. Concessions. With the support of the Colorado State Parks, the Authority could develop concession stands in the park. The revenues would be used for reservoir preservation, while the stand would provide a needed service to reservoir users and also serve as a point to disseminate education material.

8. Check-off on other bills. Already available in Colorado is the ability, through checking a box on a current utility bill, to donate a certain amount of money to watershed organizations such as the Authority or a related nonprofit foundation. However, many causes are already competing for these same check-off funds.

5.3 Business Plan

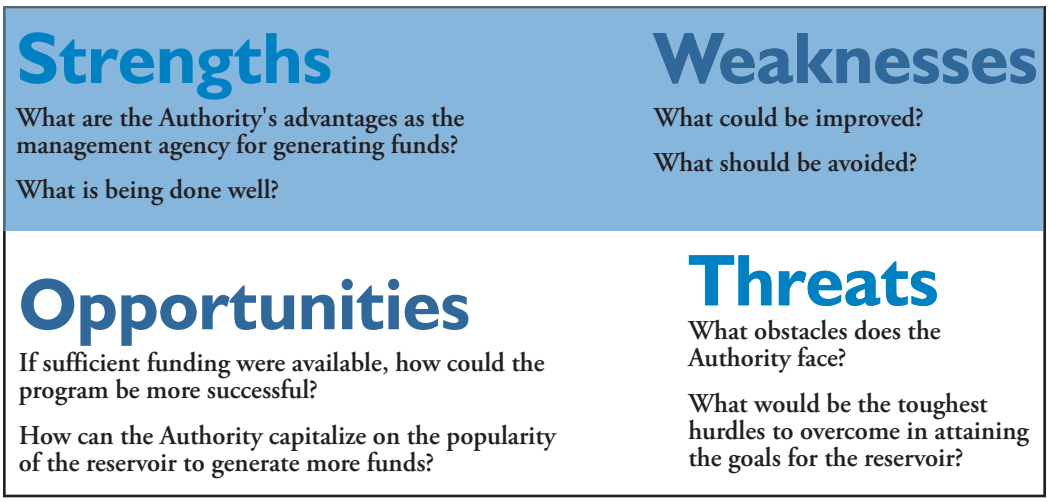
Local governments, special districts and other nonprofit organizations must think and operate like businesses. Therefore, the development of a business program and financing plan makes excellent sense for the Authority as it comes to terms with revenues and expenses. This plan would include the following elements:

1. Mission and Vision. Clarification of the vision and mission of the organization and adoption of objectives reflective of its authority is the key starting place. Both the mission and the vision of the Authority will change and evolve as forces external to the Authority come into play on a watershed-wide basis.

2. Current Business Description. The business plan should include descriptions of the current programs, budgets, manpower, and other aspects of the organization. This information is important for new board members, and especially for potential partners, donors, and stakeholders. The description should include an organizational chart, pro-forma budget and balance sheets, and a summary of legal authority and limitations.

3. Future and Trends. An assessment of the current players (i.e., board members, agencies, and collaborators), their future goals and objectives, and future trends and external forces (e.g., future compliance issues, COE program changes and budgets, and economic growth) should be done to help insure that any future direction aligns with the forces impacting the Authority.

4. SWOT (Strengths, Weaknesses, Opportunities, and Threats) Analysis. The SWOT Analysis is an effective method of identifying strengths and weaknesses, and examining the opportunities and threats faced. Often, an analysis using the SWOT framework will reveal helpful changes to be made. An example of questions posed in the SWOT analysis for Authority Funding options can be seen below.



5. Balanced Scorecard. The balanced scorecard is a *management system,* not only a measurement system, that enables organizations to clarify their vision and strategy and translate them into action. It provides feedback for both the internal business processes and external outcomes in order to continuously improve strategic performance and results. When fully deployed, the balanced scorecard transforms strategic planning from an academic exercise into the nerve center of an enterprise. For example, the City of Charlotte Stormwater Program has used it to plan and guide program transformation for the last several years with good results. It is specifically applicable to government organizations due to its wide focus beyond profitability. Only a simplified version of the balanced scorecard is suggested for the Authority.

   The process develops a set of metrics and tracking based on outcome-based measures of effectiveness in the following areas:

   - Customer Satisfaction – To be successful, how should the Authority be perceived by its "customers" (reservoir users, Park users, regulators, local governments, State Parks, the COE, etc.).

- Financial – To be viable and successful, how should the Authority generate and spend funds?

- Administration – What internal and external administrative processes are vital to the success of the organization?

- Program Growth and Change – Given the drivers and forces for change, how does the Authority best plan and organize to grow and adapt?

The culmination of the process is both a plan and a process to manage the plan. The plan sets goals and objectives in each key mission and support area and normally sets program priorities for a 5-year period in detail, and for 10 or even 20 years in less detail. Costs and resource needs are developed in sufficient detail to determine real potential for success.

It is important to define, and limit as necessary, the scope of the plan to those goals and objectives that the Authority wants to accomplish. The plan can be both project and program oriented and should involve collaborative and cooperative projects and programs.

6. Financial. Once the basic program is laid out and costs/resources determined, the financial analysis looks at how the program can be carried out and resourced. There is a feedback loop to step 5 to change the program on the basis of available funding. The end result is a rate structure and funding analysis that determines primary and secondary funding methods, sets rates, and details activities necessary to explore options that will generate funds.

5.4 Summary of Funding Recommendations

Water quality improvement in the Cherry Creek Reservoir Watershed is dependent on financial resources to address water quality needs. Generating additional funding will be a challenge, nonetheless, continued work with other partners in the watershed and its environs will leverage existing funds and provide new funding opportunities. For the Authority to achieve its funding goals, the following recommendations and opportunities are provided:

- Secure the services of a grant manager with sufficient time, ability, and experience to generate vision, marshal and coordinate resources, steer the effort through state and federal government programs and funding sources, and help coordinate widely varied groups.

- Work collaboratively with federal, state, and local governments; nonprofit organizations; and business entities to establish funding goals.
- Develop an overall business program and financing plan ("business plan"). Identify and fund budgetary priorities.

- Implement the business program and financial plan to achieve a capital budget increase of $2 million to $4 million annually. Consider generating funding from some of the

suggested sources identified in this section.

- Consider and evaluate the option of increases from existing sources. Examples include:

  - Approach electors to increase the current mil rate to the legislative ceiling of 0.5 mil or higher.

  - Assess recreational fees from all who use the park, for each use.

  - Fee increases for wastewater surcharges and building permits that include the rational nexus of construction and wastewater-related input.

  - Form special assessment districts to fund PRFs, totally or in part, by a calculated assessment against all properties where runoffs drain through a subwatershed, are treated by the PRF, and receive direct and special benefit from the PRF.

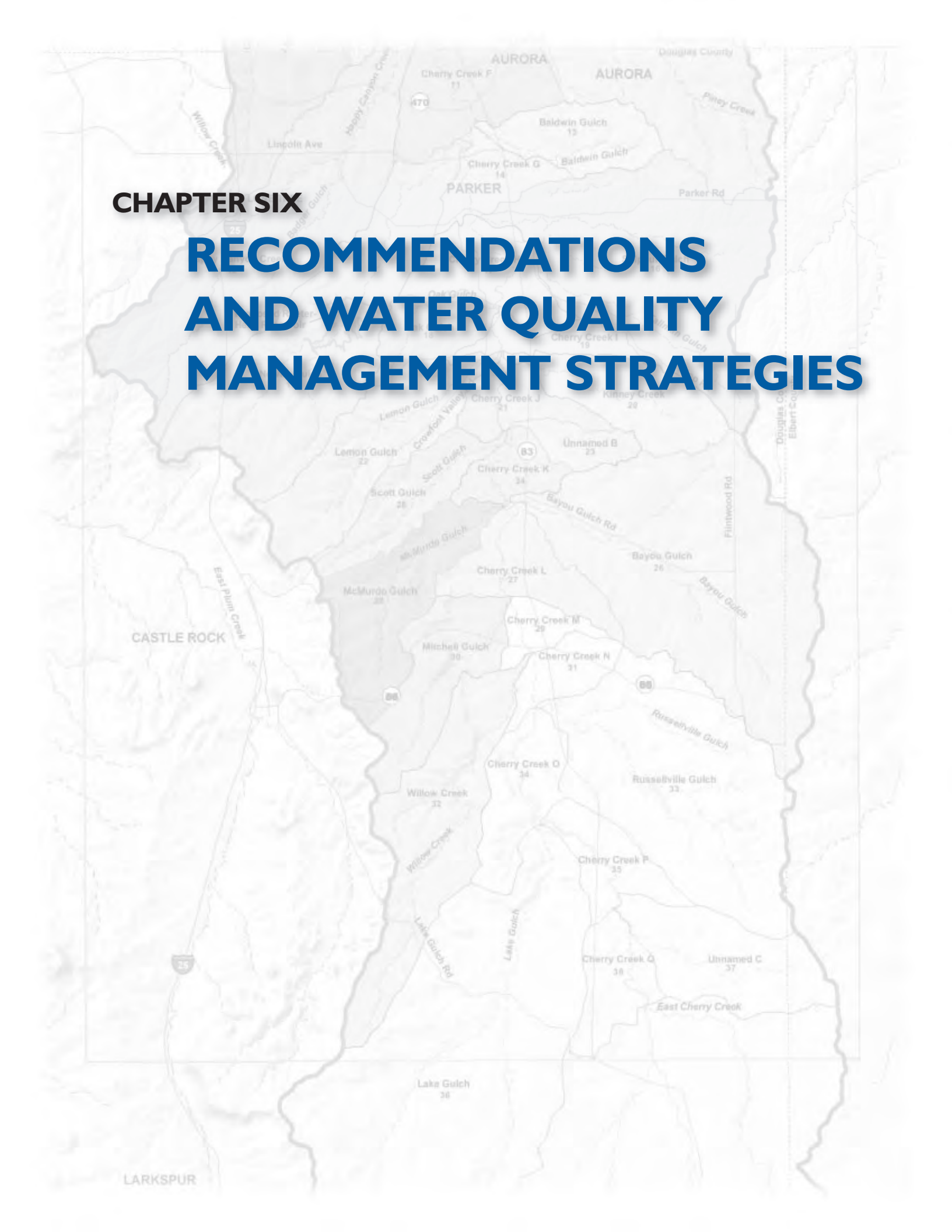
  - Assess portions of El Paso and Elbert counties located within the Cherry Creek Watershed in the mil levy and other funding mechanisms as appropriate.

  - Broaden UDFCD boundaries within the Cherry Creek Watershed.

- Consider implementing additional funding from federal, state, and local sources described above. Examples include COE, FHWA (TEA-21), WRDA, and bonds/loans.

- Evaluate opportunities to generate funds from private sources. A subset of examples described above includes nonprofit organizations, corporate sponsorships, and endowments.

- Engage the Greenway Preservation Trust to promote water quality and corridor improvements along Cherry Creek.



CHAPTER SIX

RECOMMENDATIONS AND WATER QUALITY MANAGEMENT STRATEGIES

The *Cherry Creek Reservoir Watershed Plan 2003* is a living document that can be easily updated as priorities change and recommendations are implemented.

A wide variety of management strategies were evaluated against the Mission, vision and the water quality goals and objectives outlined in Section 1. Based on the assessment of existing and projected conditions in the Cherry Creek Reservoir Watershed and the relationship between the reservoir and its upstream watershed, the following actions are recommended.

Table 6-1 summarizes recommendations and opportunities in two broader categories of "Reservoir and Watershed Water Quality Management Goals" and "Public Information, Education and Outreach Goals."

Table 6-1. Watershed Plan 2003 Recommendations and Opportunities

RESERVOIR AND WATERSHED WATER QUALITY MANAGEMENT GOALS	
Recommendation	**Consider various funding options to achieve a capital budget increase of $2 million to $4 million annually.**
	Opportunities: • Identify a funding champion to generate financial resources for water quality improvement. In order to secure the financial resources needed, a full time individual with sufficient time, ability, and experience is required to promote the vision, marshal and coordinate resources, steer the effort through state and federal government programs and funding sources, and help coordinate widely varied groups. • Identify and develop new funding mechanisms to meet watershed goals. Implement a variety of federal, state, local, and private funding mechanisms to meet funding goals of an additional $2 to $4 million annually. • Develop an overall business program and financing plan.

RESERVOIR AND WATERSHED WATER QUALITY MANAGEMENT GOALS	
Recommendation	**Implement the Cherry Creek Reservoir Watershed Plan 2003 as a coordinated management program.**
	In close coordination with local governments, implement a management program that will address prioritization, funding, implementation of recommendations, and identification of who does what and when. Track progress and measure benefits. **Opportunities:** • Consider integration of watershed management with source water protection and water resources management. Implement urban best management practices (BMPs) that are designed to promote recharge of the alluvium, pollutant removal, prevent erosion, control downstream flooding, and protect alluvial source water. • Explore incentives for runoff volume controls. Employ advanced techniques to reduce stormwater runoff and phosphorus loading to levels closer to predevelopment conditions. Improve detention of frequent, bank-full storm events influencing stream degradation. • Encourage land use agencies to enhance streams and preserve floodplains. In coordination with the Urban Drainage and Flood Control District (UDFCD) and local governments, preserve floodplains by providing ample flood capacity and freeboard, allowing for future aggradation and increase in riparian vegetation and roughness. Explore proactive reinforcement of natural stream systems, in conjunction with development, to avoid degradation and to create conditions to enhance water quality such as shallow, widespread flow in a well-vegetated riparian corridor. • Coordinate with land use agencies to secure information on existing development, including subdivision names, date of construction, percentage of imperviousness, and any permanent water quality BMPs. Assess correlation of development type and age to stream condition. Use land use agencies' geographic information system data to map information in the watershed. Update information as new development occurs. • Identify a land use agency to manage and serve as a repository for watershed geographic information system tools. These maps and coverages are vital to the management of the watershed and Reservoir. • Cooperate with local land use agencies to acquire access rights or property to construct improvements in privately held stream corridors.
Recommendation	**Fund, design, and construct high priority stream improvements.**
	Implement targeted stream improvements to reduce phosphorus loads. Based on stream inventory and prioritization efforts, fund, design, and construct high priority stream improvements designed to include water quality enhancement. **Opportunities:** • Due to the significant amount of erosion that is currently evident in Piney Creek, Sulphur Gulch, mainstem Cherry Creek, and other streams, streams already undergoing erosion should be addressed as soon as possible. • Proactively stabilize streams predicted to degrade as a result of increased runoff from new development before significant erosion occurs.

RESERVOIR AND WATERSHED WATER QUALITY MANAGEMENT GOALS	
	Opportunities (continued): • Consider conducting an inventory of stream conditions and prioritize improvements. Stream inventories with established protocols provide useful information for locating and prioritizing targeted stream improvements. Coordination with land use agencies on geographic information system mapping will facilitate assessment of stream conditions, maintenance of a digital photo record and assessment rankings. • Consider constructing stream enhancement retrofits in drainageways, particularly in drainageways previously stabilized with hard-lined low flow channels or other high-conveyance approaches • Seek partnerships to acquire conservation easements on stream preservation areas and floodplains to enhance water quality. Establish a buffer network along the Cherry Creek corridor to promote land conservation, protect riparian areas, and stabilize, reclaim, and enhance Cherry Creek and its tributaries.
Recommendation	**Design and construct additional pollutant reduction facilities (PRFs).**
	Continue to identify, design, and construct PRFs in the watershed on the basis of factors such as lowest cost per pound of phosphorus immobilized, most pounds removed, funding opportunities with other partners, and potential for multiple uses and benefits. **Opportunities:** • Consider retrofit of Natural Resource Conservation Service (NRCS) detention facilities with water quality features. • Promote water quality detention in existing NRCS and 100-year detention facilities. • Drop structures may be prudent upstream of selected roadcrossings to increase channel storage.
Recommendation	**Promote trading incentives and request removal of the 216-pound "Reserve Pool" cap.**
	Create trading incentives for public and private entities to implement water quality controls and other enhanced BMPs into new PRFs. Remove regulatory barriers to allow local governments and private entities to construct and implement trading projects above the 216-pound cap.
Recommendation	**Encourage all land use agencies to adopt and implement the Authority's "Stormwater Quality Requirements" stormwater policy and design criteria.**
	Opportunities: • Develop stormwater policy and criteria specifically targeted at stream stabilization design for enhanced water quality. • Consider modifying design criteria for flood detention facilities that would provide even greater water quality benefits.

RESERVOIR AND WATERSHED WATER QUALITY MANAGEMENT GOALS	
Recommendation	**Encourage local governments to work with developers to construct innovative demonstration projects.**
	Through the Authority's Phosphorus Facilitator, work with one or more developers to implement water quality controls and other innovative BMPs to advance the science and showcase creative water quality control techniques to local governments and other developers.
Recommendation	**Encourage local governments to provide developer incentives to preserve and enhance stream corridors.**
	Land dedication, real estate amenities, or reduction in tax liability are examples of incentives that could be extended to developers to preserve the stream corridor.
Recommendation	**Explore options to reduce septic system loading in Cherry Creek.**
	Septic systems located in stream preservation areas provide a direct conduit of nutrient and pathogen loads to the system and threaten source water. **Opportunities:** • Consider converting septic systems to conventional sewer system. Locate and inventory septic systems in stream preservation areas. Valley Country Club and Franktown are two areas that presently have septic systems located in stream preservation areas. An evaluation of service area issues and pollutant loads will support the need for sewer conversion and facilitate conversion priorities. • Coordinate with Tri-County Health in tracking septic systems. Permits, inspection data, and maintenance records provide useful information on the status of septic systems in the Basin. Implement education and outreach programs for owners of septic systems regarding maintenance responsibilities. • Consider alternative funding sources, such as the U.S. Army Corps of Engineers (COE) authority under 593 and incentives such as trading to reduce the number of septic systems in stream preservation areas.
Recommendation	**Promote reuse of wastewater through land application.**
	Opportunities: • Encourage dischargers to voluntarily apply wastewater to land in greenbelts to effectively irrigate and reduce nutrient loads at the same time. • Assure that land application requirements promote the reuse of treated wastewater
Recommendation	**Conduct special studies to optimize water quality improvements.**
	Special studies and research are encouraged to increase the understanding of optimum measures for water quality improvements. These studies would: - Increase the understanding of phosphorus fate and transport in the watershed and reservoir. - Better define soil-phosphorus equilibrium conditions in key locations. - Increase understanding of nutrient enrichment in the reservoir. - Identify background phosphorus sources in the headwater region. - Confirm the most effective BMP approaches to immobilize total and soluble phosphorus. - Identify industrial processes and septic systems in the watershed and quantify phosphorus loading from these sources.

PUBLIC INFORMATION, EDUCATION AND OUTREACH GOALS	
Recommendation	**Develop and implement a comprehensive public involvement plan.**
	Opportunities: • In coordination with the Cherry Creek Stewardship Partners, develop and implement a public information and outreach plan that includes the Cherry Creek Reservoir Watershed website and education and outreach materials to promote water quality enhancement efforts.
Recommendation	**Consider participation in several federally funded programs that support sustainable agricultural and habitat protection and restoration.**
	Programs such as the Conservation Reserve Program, Environmental Quality Incentives Program (EQIP), Partners for Fish and Wildlife, Wetlands Reserve Program (WRP), and Wildlife Habitat Incentives Program (WHIP) are federal programs appropriate to fund efforts in the Upper Basin. Provide incentives to local farmers and ranchers to implement these programs.
Recommendation	**Coordinate with other stormwater Phase I and II entities and efforts.**
	Seek opportunities to cost-effectively address stormwater quality issues, particularly public education and outreach and pre-and post-construction BMPs, by coordinating stormwater control activities with stormwater permittees in the Cherry Creek Basin.
Recommendation	**Collaborate with other private and public interest groups to leverage funding mechanisms to meet watershed goals.**
	Coordinate with Cherry Creek Stewardship Partners and other public and private interest groups to obtain additional funding to meet water quality goals and objectives.

Author	Date	Title	Summary
Cherry Creek Basin Water Quality Authority (CCBWQA)	March 2003	2002 Annual Report of Activities by the Cherry Creek Basin Water Quality Authority	Annual report of CCBWQA activities, in accordance with the Control Regulation.
Cherry Creek Basin Water Quality Authority (CCBWQA)	March 2003 (a)	Cherry Creek Reservoir 2002 Annual Aquatic Biological and Nutrient Monitoring Study (in conjunction with Chadwick Ecological Consultants, Inc.)	Accumulative data report and summary of Reservoir monitoring.
Denver Regional Council of Governments (DRCOG)	1984	Cherry Creek Reservoir Clean Lakes Study	Discusses the present and future water quality conditions of Cherry Creek Reservoir, with emphasis on eutrophication, phosphorus and chlorophyll a.
Denver Regional Council of Governments (DRCOG)	February 1985	Cherry Creek Basin Master Plan- Control Option Cost Analysis	Analysis of costs for selected point and nonpoint source controls for phosphorus removal from wastewater and stormwater runoff within the Cherry Creek Basin.
Denver Regional Council of Governments (DRCOG)	May 1985	Cherry Creek Basin Master Plan- Volume 1: Costs of Wastewater Treatment Options; Volume 2: Costs and Water Rights Impacts of Selected Point Source Treatment Alternatives; Volume 3: Costs of Nonpoint Control Options	As stated in title.
Denver Regional Council of Governments (DRCOG)	1985, 1989	Cherry Creek Basin Water Quality Management Master Plan	Defines point, nonpoint, and in-reservoir phosphorus control strategies necessary to protect Cherry Creek Reservoir water quality.
Denver Regional Council of Governments (DRCOG)	Janurary 7, 1999	Individual Sewage Disposal Systems: Colorado Issues Review and Task Force Recommendations	Deals with on-site waste disposal practices, implications to water quality and characterization of the issue of accumulative loading of nutrients to surface and groundwater from on –site septic systems.
Denver Regional Council of Governments (DRCOG)	Revised December 2000	Metro Vision 2020 Clean Water Plan- Wastewater Utility Plan Process	Provides necessary information, direction and process to utility departments, consultants, planners or wastewater managers that need to produce or update a wastewater utility plan.
Halespaska, John C. & Associates, Inc.	October 1998	Final Report Evaluation of Water Quality Impacts from Leach Fields in the Upper Cherry Creek Basin (Project No. 5548a)	Evaluation of potential impacts of septic systems in tributaries to Cherry Creek.

Author	Date	Title	Summary
Halespaska, John C. & Associates, Inc.	May 2003	2002 Annual Report, Baseline Water Quality Data Collection Study for the Upper Cherry Creek Basin	Data report and summary of surface and groundwater monitoring along Cherry Creek from Castlewood Canyon to the Reservoir.
North American Lake Management Society (NALMS)	2001	Managing Lakes and Reservoirs	Basic limnological reference material.
Simons and Sentürk	1977	Sediment Transport Technology, Water Resources Publications, Fort Collins, CO	Basic reference for sediment transport text
State of Colorado	2001	Colorado Revised Statutes (CRS) 25-8.5-101, Legislative Declaration; 25-8.5-111, Powers of Authority- General and Financial	25-8.5-101: Defines the purpose of the Cherry Creek Basin Water Quality Authority. 25-8.5-111: Defines the power of the Cherry Creek Basin Water Quality Authority.
Stratus Consulting	August 2, 2000	Preliminary Evaluation of Recreational Value Provided by Cherry Creek State Park	Provides a cursory investigation into the likely order of magnitude of the total value of recreation at Cherry Creek State Park.
Trust for Public Land (TPL)	October 2002	Cherry Creek Basin Open Space Conservation and Stewardship Plan	Plan evaluates current and future land uses, identifies vulnerable sub-basins in Cherry Creek and promotes conservation, preservation, and Smart Growth for Clean Water concepts to enhance water quality in the Cherry Creek Basin.
U.S. Army Corps of Engineers	Unknown	Colorado Service Office Aquatic Ecosystem Restoration, Section 206: General Information Study	Summaries of various Corp programs for water resource projects.
U.S. Environmental Protection Agency (EPA)	1977	State and Areawide Waste Treatment Management Plants	
U.S. Environmental Protection Agency (EPA)	1991	Technical Resource Document Batch-Type Procedures for Estimating Soil Adsorption of Chemical (EPA Document number: EPA 530 SW-87 006-F)	
U.S. Environmental Protection Agency (EPA)	1991	Guidance for Water Quality Based Decisions: The TMDL Process	Provides guidance to help State water quality program managers understand the application of TMDLs within the water quality-based approach to establish pollution control limits for waters not meeting water quality standards.
U.S. Environmental Protection Agency (EPA)	1994	Urbanization and Water Quality	Provides information on causes of nonpoint source pollution and the design and implementation of programs to control this pollution.

Author	Date	Title	Summary
U.S. Environmental Protection Agency (EPA)	January 13, 2003	Final Water Quality Trading Policy	Provide guidance to states and tribes on how trading can occur under the Clean Water Act and its implementing regulations.
Urban Drainage and Flood Control District (UDFCD)	September 1999	Urban Storm Drainage Criteria Manual, Volume 1	Provide guidance for planning and design of drainageway channels and hydraulic structures.
Urban Drainage and Flood Control District (UDFCD)	September 1999	Urban Storm Drainage Criteria Manual, Volume 3: Best Management Practices	Provides guidance for the selection and design of stormwater quality best management practices.
Urban Drainage and Flood Control District (UDFCD)	December 2002	Cherry Creek Corridor-Reservoir to Scott Road, Major Drainageway Planning Study, Alternative Evaluation Report	Master drainageway planning study for the Cherry Creek Corridor that provides a roadmap for drainage and water quality improvement in the Cherry Creek Corridor.
Water Environment Research Foundation (WERF)	2000	Phosphorus Credit Trading in the Cherry Creek Basin: An Innovative Approach to Achieving Water Quality Benefits	Provides documentation of development and implementation of the Authority's Trading Program, highlighting scientific, economic, and institutional conditions in the watershed community.
Water Quality Control Division (WQCD)	1996	Status of Water Quality in Colorado (CDPHE)	Assesses and reports on the quality of Colorado's waters to satisfy requirements from Section 305(b) of the Clean Water Act.
Water Quality Control Commission (WQCC)	2000, Revised September 2001	Cherry Creek Control Regulation No. 72, 5 CCR 1002-72	This regulation is based on a state-local partnership in controlling total phosphorus and provides the basis for state actions in protecting Cherry Creek Reservoir's water quality.