# 2015 Annual Report on Activities
# Cherry Creek Basin
# Water Quality Authority

**Cherry Creek Basin Water Quality Authority**
Chuck Reid, Manager
CliftonLarsonAllen LLP
8390 E. Crescent Parkway, Suite 500
Greenwood Village, CO 80111
Phone: 303-779-4525
Email: chuck.reid@cliftonlarsonallen.com

**Thank you to Board and TAC Members for their leadership this year.**

| Board Members | TAC Members |
|---|---|
| Stephanie Piko | Rick Goncalves |
| Tom Bishop | Jim Dederick |
| John McCarty | Steve Miller |
| Nancy Sharpe | Jill Piatt-Kemper |
| David Weaver | David Van Dellen |
| Brad Pierce | Lanae Raymond |
| George Teal | Ann Woods |
| Susan Squyer | John Cotton |
| Joshua Rivero | Jacob James |
| Heather Beasley | Rich Borchardt |
| Roger Kilgore | Max Grimes |
| Myrna Poticha | Casey Davenhill |
| Alan Vajda | Elaine Hassinger |
| Christopher Lewis | Tim Metzger |
| Ron Weidmann | Tim Rose |
| John Woodling | Bahman Hatami |

# TABLE OF CONTENTS

TABLE OF CONTENTS ..... i
LIST OF FIGURES ..... iv
LIST OF TABLES ..... v
LIST OF MAPS ..... v
CONTROL REGULATION 72 REPORTING REQUIREMENTS CHECKLIST ..... vii
LIST OF ACRONYMS AND ABBREVIATIONS ..... ix
Executive Summary ..... ES-1
1 The Authority ..... 1-1
1.1 Regulatory History of Chlorophyll α Standards and Implementation ..... 1-2
1.2 Financial Matters ..... 1-5
1.3 Authority Website ..... 1-6
2 Description of Cherry Creek Reservoir Watershed ..... 2-1
2.1 Basinwide Coordination on Water Quality ..... 2-3
2.2 Cherry Creek Reservoir Model ..... 2-4
2.3 Public Information and Education by Authority and Partners ..... 2-5
3 Point Sources ..... 3-1
3.1 Limits and Data Summary Requirements for Phosphorus and Nitrogen ..... 3-5
3.2 Monthly Phosphorus Concentrations ..... 3-8
3.3 Monthly Nitrogen Concentrations ..... 3-10
3.4 Permit Compliance ..... 3-11
3.5 Permit Renewal Timing and Process ..... 3-11
3.6 Other Point Source Discharge Permits in the Watershed ..... 3-14
3.7 Graywater Control ..... 3-17
3.8 Onsite Wastewater Treatment Systems ..... 3-18
3.9 Authority's Role in Site Application Process ..... 3-20
3.9.1 Approved Site Applications ..... 3-21
3.10 Effectiveness in Reducing Nutrient Concentrations ..... 3-23
4 Regulated Stormwater Source Controls ..... 4-1
4.1 Cherry Creek MS4 General Permit Renewal Process ..... 4-4
4.2 Sediment and Erosion Control Permits ..... 4-4
4.3 Adoption and Implementation of BMPs by Local Governments ..... 4-4
4.4 Construction BMPs ..... 4-4
4.5 Post-Construction BMPs ..... 4-5
4.6 Flood Control Facilities Retrofitting, Inspection, and Maintenance Actions ..... 4-6

4.7 Effectiveness in Reducing Phosphorus Concentrations ..... 4-8
4.8 Funding of Regulated Stormwater Projects ..... 4-11
4.9 Monitoring of Regulated Stormwater Projects ..... 4-12
4.10 Public Information and Education Actions of MS4s ..... 4-12
5 Other Nonpoint Sources ..... 5-1
5.1 Update list of PRFs Implemented ..... 5-1
5.2 Overview of PRFs to Date ..... 5-5
5.3 2015 Pollutant Reduction Facilities (PRF) Activities ..... 5-7
5.3.1 Cherry Creek at Arapahoe Road Stream Reclamation, Reach 5 ..... 5-7
5.3.2 Cherry Creek Stream Reclamation at Norton Farms Open Space ..... 5-8
5.3.3 Piney Creek Stream Reclamation – Reaches 6 (Ranches) & 7 (Liverpool) ..... 5-8
5.3.4 Cherry Creek Stream Stabilization at Hess Road ..... 5-9
5.4 Floodplain Preservation/Conservation Easements ..... 5-10
5.5 Monitoring of PRFs ..... 5-10
5.6 PRF Effectiveness in Reducing Phosphorus Concentrations ..... 5-12
5.6.1 Cottonwood Creek Peoria Pond ..... 5-14
5.6.2 Cottonwood Creek Reclamation and Perimeter Pond ..... 5-15
5.6.3 McMurdo Gulch Stream Reclamation ..... 5-16
5.6.4 Piney Creek Sediment Study ..... 5-17
5.7 Funding of PRFs and Nonpoint Source Projects ..... 5-18
5.8 Annual Inspection of PRFs ..... 5-19
6 Riparian and Wetlands Protection ..... 6-1
6.1 Riparian and Wetlands in the Cherry Creek Basin ..... 6-1
6.2 Regulatory Protection ..... 6-3
6.3 Land Development Activities ..... 6-4
6.4 Protection, Enhancement, and Restoration Actions ..... 6-4
7 Monitoring ..... 7-1
7.1 Sampling and Analysis Plan ..... 7-1
7.1.1 Purpose ..... 7-1
7.1.2 Sampling Program Objectives ..... 7-2
7.2 Sampling Sites ..... 7-3
7.2.1 2015 Reservoir Water Quality ..... 7-7
7.3 2015 Reservoir Inflows – Outflows and Total Phosphorus Loads ..... 7-14
7.4 Reservoir Management Strategy ..... 7-17
7.5 2014 Phytoplankton and Cyanotoxins ..... 7-17
7.6 Long-Term Phytoplankton ..... 7-19

7.7 Water Quality in Cherry Creek from a Watershed Perspective ..... 7-20
7.7.1 Nutrients ..... 7-21
7.8 Proposed Modifications to Monitoring Program ..... 7-24
7.8.1 Installation of New Monitoring Well #7b ..... 7-24
8 Watershed Plan Implementation ..... 8-1
8.1 Strategic Planning Meeting ..... 8-2
8.2 Implementation of Watershed Plan in 2015 ..... 8-3
References ..... R-1

## LIST OF FIGURES


Figure 1-1: Estimated 2016 Revenues ..... 1-5
Figure 2-1: Priority Projects to Stabilize Piney Creek ..... 2-3
Figure 3-1: 2015 Source Total Phosphorus monthly concentrations ..... 3-9
Figure 3-2: 2015 Point Total inorganic Nitrogen Monthly Concentrations ..... 3-11
Figure 4-1: Number of Land Use and Development Applications that the Authority has Received Annually Since March 1997 ..... 4-10
Figure 4-2: Distribution of Land Use for the Referrals Received in 2015 ..... 4-11
Figure 5-1: Percentage of Funding Paid by Authority for PRF Projects ..... 5-5
Figure 5-2: PRF Categories, 1989-2015 ..... 5-5
Figure 5-3: Base Flow Total Phosphorus Concentrations for Cottonwood Creek, 1996-2015 ..... 5-11
Figure 5-4: Storm Flow Total Nitrogen Concentrations for Cottonwood Creek, 1996-2015 ..... 5-12
Figure 5-5: Storm Flow Total Phosphorus Concentrations for Cottonwood Creek, 1996-2015 ..... 5-13
Figure 5-6: Storm Flow Total Nitrogen Concentrations for Cottonwood Creek, 1999-2015 ..... 5-13
Figure 6-1: Cherry Creek Ecological Park Wetlands ..... 6-8
Figure 7-1: Concentration of chlorophyll α (µg/L) in Cherry Creek Reservoir, 2015 WY. ..... 7-8
Figure 7-2: Seasonal mean (July through September) concentrations of chlorophyll a (µg/L) measured in Cherry Creek Reservoir, 1987 to 2015. ..... 7-9
Figure 7-3: Soluble Reactive Phosphorus and Chlorophyll a Concentrations Measured in Cherry Creek Reservoir, 2015 WY ..... 7-10
Figure 7-4: Dissolved Inorganic Nitrogen and Chlorophyll a Concentrations Measured in Cherry Creek Reservoir, 2015 WY ..... 7-10
Figure 7-5: Seasonal mean (July through September) total phosphorus concentrations (µg/L) measured in Cherry Creek Reservoir, 1987 to 2015 ..... 7-11
Figure 7-6: Seasonal mean (July through September) total nitrogen concentrations (µg/L) measured in Cherry Creek Reservoir, 1992 to 2015 ..... 7-12
Figure 7-7: Daily mean temperature (°C) recorded at depth for CCR-2 based on 15-minute interval data collected by temperature loggers, with USACE inflow in 2015 ..... 7-13
Figure 7-8: Dissolved oxygen (mg/L) recorded at depth during routine monitoring at CCR-2 during the 2015 WY ..... 7-14
Figure 7-9: Percent relative biovolume of algal groups for each routine photic zone composite sample collected in Cherry Creek Reservoir, 2015 CY ..... 7-19
Figure 7-10: Algal biovolume of major taxonomic groups in the photic zone composite samples in Cherry Creek Reservoir from 2011 through 2015, by CY ..... 7-20
Figure 7-11: Total Phosphorus Concentration Measured at Cherry Creek Surface Water Stations, Castlewood, CC-1, CC-4, and CC-9 ..... 7-21
Figure 7-12: Nitrate Concentration Measured at Surface Water Stations Castlewood, CC-1, CC-4, and CC-9 ..... 7-22
Figure 7-13: Chloride Concentration Measured at Surface Water Stations Castlewood, CC-1, CC-4, and CC-9 ..... 7-23
Figure 7-14: Sulfate Concentration Measured at Surface Water Stations Castlewood, CC-1, CC-4, and CC-9 ..... 7-24

## LIST OF TABLES

Table 1-1: Authority Board Members ..... 1-4
Table 1-2: Authority TAC Members ..... 1-4
Table 1-3: New and Updated Reference Documents ..... 1-6
Table 3-1: Cherry Creek Watershed Wastewater Facilities and Permit Expiration Dates ..... 3-1
Table 3-2: Regulation 72 Discharge Limits for Phosphorus ..... 3-5
Table 3-3: Summary of Total Phosphorus PERMIT Limits and Data 2015 ..... 3-6
Table 3-4: Summary of Total Inorganic Nitrogen Permit Limits and Data 2015 ..... 3-7
Table 3-5: 2015 Point Source Phosphorus Monthly Concentration ..... 3-8
Table 3-6: 2015 Point Source Total Inorganic Nitrogen ..... 3-10
Table 3-7: Workplan Schedule for Renewal of General and Individual Permits – Sewage Systems Sectors ..... 3-12
Table 3-8: Workplan Schedule For Renewal of General and Individual Permits – Construction, Commerce, and Industry Sector ..... 3-13
Table 3-9: Types and Numbers of Active CDPS Permits Within the Watershed in 2015 ..... 3-15
Table 3-10: Total Phosphorus Concentration Ranges reported in 2015 by other PERMITTED POINT source dischargers in the cherry creek basin ..... 3-17
Table 4-1: Summary of Stormwater Permit, Inspection, and Enforcement Actions in 2015 ..... 4-6
Table 5-1: CCBWQA Summary of Recommended Pollutant Reduction Facilities 2015-2025 Budget Projections ($1000) ..... 5-3
Table 5-2: CCBWQA Summary of Recommended Pollutant Reduction Facilities 2015-2025 Budget Projections ($1000) ..... 5-4
Table 5-3: Historical flow-weighted total phosphorus, total nitrogen, and total suspended solids concentrations upstream and downstream of the Cottonwood Creek – Peoria Pond, 2002 to 2015 WY ..... 5-15
Table 5-4: Historical total phosphorus, total nitrogen, and total suspended solids concentrations upstream and downstream of the Cottonwood Creek Perimeter Pond, 1997 to 2015 WY. ..... 5-16
Table 5-5: Average Concentrations of Total Phosphorus, Total Nitrogen, and Total Suspended Solids upstream and Downstream of McMurdo Gulch Stream Reclamation, 2015 ..... 5-17
Table 5-6: Piney Creek Summary of Lab Results ..... 5-18
Table 5-7: 2015 Annual Inspection Report of PRFs at Cherry Creek State Park ..... 5-20
Table 7-1: Reservoir Sampling Parameters and Frequency ..... 7-5
Table 7-2: Stream and Groundwater Sampling Parameters and Frequency ..... 7-6
Table 7-3: Normalized Phosphorus Loads, Exports, and Flow-Weighted Phosphorus Concentrations for Cherry Creek Reservoir, 1992 to 2015 ..... 7-16

## LIST OF MAPS

Section
Map 1-1: Entities Within the Cherry Creek Reservoir Watershed Boundaries ..... 1
Map 2-1: Cherry Creek Reservoir Watershed Boundaries ..... 2
Map 3-1: Locations of Wastewater Treatment Facilities Outfalls ..... 3

Map 3-3: Onsite Wastewater Treatment Systems....3
Map 4-1: Standard and Non-Standard Municipal Separate Storm Sewer Systems....4
Map 4-2: Land Use Development Applications Reviewed by Authority, 2015....4
Map 5-1: Pollutant Reduction Facility (PRF) Sites Located Throughout the Cherry Creek Watershed....5
Map 6-1: U.S. Fish and Wildlife Service National Wetlands Inventory of Wetlands and Waters of the U.S. in the Cherry Creek Basin....6
Map 7-1: Sampling Sites on Cherry Creek Reservior, Surface Water Monitoring Site, and Alluvial Groundwater Sites....7

## CONTROL REGULATION 72 REPORTING REQUIREMENTS CHECKLIST

This report is being submitted to both the Colorado Water Quality Control Commission and the Water Quality Control Division on or before March 31, 2016, in fulfillment of the reporting requirements of Regulation No. 72 – Cherry Creek Reservoir Control Regulation (Regulation 72). The following list shows where the reporting requirements of the Cherry Creek Reservoir Control Regulation can be found in this report. Reporting information includes all requirements of Regulation 72, effective November 30, 2012.

**Cross Reference between Regulation 72 Reporting Requirements and Annual Report Section**


**Reservoir/Watershed**

Public information and education by Authority and Partners (§72.6(2)) ..... 2.2

**Point Source Controls** (§72.9(1)(a) & §72.9(1)(e)) ..... 3

Phosphorus concentrations (§72.9(1)(a)) ..... 3.1,3.2

Permit violations (§72.9(1)(a)) ..... 3.4

Approved site applications (§72.9(1)(a)) ..... 3.9

Effectiveness in reducing nutrient concentrations (§72.9(1)(a)) ..... 3.10

**Regulated Stormwater Controls** (§72.9(1)(b) & (§72.9(1)(e)) ..... 4

Sediment and erosion control permit, inspection, and enforcement actions (§72.9(1)(b)) ..... 4.2

Construction BMPs inspection and enforcement actions (§72.9(1)(b)) ..... 4.4

Permanent BMPs construction, inspection, and maintenance actions (§72.9(1)(b)) ..... 4.5

Flood control facilities retrofitting, inspection, and maintenance actions (§72.9(1)(b)) ..... 4.6

Effectiveness in reducing phosphorus concentration (§72.9(1)(b)) ..... 4.7

Funding of nonpoint source control projects (§72.9(1)(b)) ..... 4.8

Monitoring of nonpoint source control projects (§72.9(1)(b)) ..... 4.9

Public information and education actions of MS4s (§72.9(1)(b)) ..... 4.10

**Nonpoint Source Controls** (§72.9(1)(c) & (§72.9(1)(e)) ..... 5

Updated list of PRFs implemented (§72.3). ..... 5.1

Floodplain preservation/conservation easements (§72.6(6)) ..... 5.3

Effectiveness in reducing phosphorus concentration (§72.9(1)(c)) ..... 5.6

Funding of PRFs (§72.9(1)(c)) ..... 5.7

Monitoring of PRFs (§72.9(1)(c)) ..... 5.5

**Riparian and Wetlands Protection** (§72.9(1)(d)) ..... 6

Protection, enhancement, and restoration actions (§72.9(1)(d)) ..... 6.1

**Water Quality Monitoring** (§72.9(1)(e)) ..... 7

Reservoir water quality and inflow volumes (§72.8.1) ..... 7.2, 7.3

Alluvial water quality (§72.8.2) ..... Appendix

Surface water quality (§72.8.2(a)) ..... 7.7

Point sources (§72.8.1) ..... 3

PRF monitoring (inflow and outflow nutrient concentrations) (§72.8.2(b)) ..... 5.5

Proposed modifications to monitoring program (§72.8.3) ..... 7.8

**Program Effectiveness** (§72.9(2) & §72.9(1)(e)) ..... 3.10, 4.7, 5.5

Status of compliance with discharge limits and conditions ..... 3.4
Recommendations on new/proposed expansion of facilities (§72.9(1)e) ..... 5.1
Updated list of planned PRFs with implementation schedule (§72.6.1c) ..... 5.1, 5.2
Recommendations for improving water quality (§72.9(1)e) ..... 8
Proposed special water quality investigative studies (§72.8.4) ..... 8
Financing of nonpoint source projects (§72.9(2)) ..... 5.6
Regulated stormwater permit requirements (§72.9(2)) ..... 4.2, 4.4, 4.5
Adoption and implementation of BMPs by local governments (§72.9(2)) ..... 4.3
Reduction of phosphorus concentrations into the reservoir by the MEP (§72.9(2)) ..... 7.2

**PREPARED BY:**

Leonard Rice Engineers, Inc.
William P. Ruzzo, P.E., L.L.C.
GEI Consultants, Inc.
JRS Engineering Consultant LLC
Cherry Creek Land Use Agencies and Utilities
Cherry Creek Stewardship Partners

**Photo Credits:** Chris Muller, Jojo La, Jessica DiToro, Katie Fendel, Jim Swanson, Casey Davenhill, SEMSWA, Cherry Creek Partners, Craig Wolf, Joli Sajban

## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| 2015 Annual Report | 2015 Annual Report on Activities |
| ac-ft | Acre-feet |
| ACWWA | Arapahoe County Water & Wastewater Authority |
| Authority | Cherry Creek Basin Water Quality Authority |
| BMP | Best Management Practice |
| Board | Board of Directors of Cherry Creek Basin Water Quality Authority |
| CCR | Colorado Code of Regulations |
| CCSP | Cherry Creek State Park |
| CDOT | Colorado Department of Transportation |
| CDPHE | Colorado Department of Public Health and Environment |
| CDPS | Colorado Discharge Permit System |
| CIP | Capital Improvement Project |
| COE | U.S. Army Corps of Engineers |
| Commission | Colorado Water Quality Control Commission |
| CPW | Colorado Parks and Wildlife |
| C.R.S. | Colorado Revised Statutes |
| CSU | Colorado State University |
| DESC | Drainage, Erosion, and Sediment Control |
| Division | Colorado Water Quality Control Division |
| DOC | Dissolved Organic Carbon |
| DOLA | Dog Off-Leash Area |
| DMR | Discharge Monitoring Report |
| ECHO | Enforcement & Compliance History Online |
| EDB | Extended Detention Basin |
| EPA | U.S. Environmental Protection Agency |
| ESCP | Erosion and Sediment Control Plan |
| GESC | Grading, Erosion, and Sediment Control |
| lbs/yr | Pounds per Year |
| LID | Low Impact Development |
| µg/L | Micrograms per Liter |
| m | Meter |
| mg/kg | Milligrams per Kilogram (dry weight) |
| mg/L | Milligrams per Liter |

| | |
|---|---|
| MGD | Million Gallons per Day |
| MEP | Maximum Extent Practicable |
| MS4 | Municipal Separate Storm Sewer System |
| MWAT | Maximum Weekly Average Temperature |
| NOA | Notice of Authorization |
| O&M | Operation and Maintenance |
| OWTS | Onsite Wastewater Treatment Systems |
| Partners | Cherry Creek Stewardship Partners |
| PCWRA | Plum Creek Water Reclamation Authority |
| PJMD | Parker Jordan Metropolitan District |
| PWSD | Parker Water and Sanitation District |
| PRF | Pollutant Reduction Facility |
| Regulation 31 | The Basic Standards and Methodologies for Surface Water (5 CCR 1002-31) |
| Regulation 38 | Classifications and Numeric Standards for South Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin (5 CCR 1002-38) |
| Regulation 61 | Colorado Discharge Permit System Regulations (5 CCR 1002-61) |
| Regulation 72 | Cherry Creek Reservoir Control Regulation (5 CCR 1002-72) |
| Regulation 85 | Nutrients Management and Control Regulation (5 CCR 1002-85) |
| SBR | Sequencing Batch Reactor |
| SEMSWA | Southeast Metro Stormwater Authority |
| SRP | Soluble Reactive Phosphorus |
| TAC | Technical Advisory Committee-Cherry Creek Basin Water Quality Authority |
| TCHD | Tri-County Health Department |
| TDP | Total Dissolved Phosphorus |
| TDS | Total Dissolved Solids |
| TIN | Total Inorganic Nitrogen |
| TMAL | Total Maximum Annual Load |
| TN | Total Nitrogen |
| TOC | Total Organic Carbon |
| TP | Total Phosphorus |
| TSS | Total Suspended Solids |
| UDFCD | Urban Drainage and Flood Control District |
| USGS | U.S. Geological Survey |
| WWTF | Wastewater Treatment Facility |
| WY | Water Year |

# Executive Summary

**The Authority's focus is protecting, preserving, and enhancing beneficial uses and water quality needed to support the beneficial uses in Cherry Creek Reservoir and Cherry Creek watershed.**

**The 2015 Annual Report on Activities gives a status report on activities and reviews progress made by the Authority toward achieving water quality standards in 2015. This Annual Report on Activities is submitted in fulfillment of the Authority's obligation to report annually to the Colorado Water Quality Control Commission and Water Quality Control Division.**

# Authority's Statutory & Regulatory Basis

**Statute (Colorado Revised Statutes 25-8.5-101 *et seq.*)**

**The Authority was formally created in 1988 by the Colorado State Legislature to benefit the basin's inhabitants and landowners by preserving water quality in Cherry Creek and Cherry Creek Reservoir, and to benefit the people of the state of Colorado by preserving waters for recreation, fisheries, water supplies, and other beneficial uses. The statute provides the Authority with broad powers under its enabling statute; these powers allow the Authority to implement water quality protective measures beyond those prescribed in Regulation 72.**

**Regulation 72**

**The Cherry Creek Reservoir Control Regulation (Regulation 72) was originally adopted in 1984 to further protect the beneficial uses and the water quality of the Reservoir. Over time, the focus of the regulation has changed from phosphorus to both phosphorus and nitrogen. Regulation 72 requires actions to reduce nutrient inflows to Cherry Creek Reservoir, including phosphorus effluent limits, requirements for regulated nonpoint sources, and educational and voluntary efforts directed at nonregulated nonpoint sources.**

**Regulation 38**

**State water quality standards for Cherry Creek basin are found in Regulation 38, last amended in 2015.**

2015

In 2015 the Commission adopted total phosphorus and chlorophyll α standards for various waters within the watershed, including the mainstem of Cherry Creek, tributaries, and lakes and reservoirs, but only for waters that are located upstream of basin wastewater treatment facilities. The Commission made no changes to the existing site-specific chlorophyll α standard for Cherry Creek Reservoir itself.

# Reservoir and Watershed

**The Cherry Creek watershed is one of the most important and prominent components of the Denver metropolitan area. Cherry Creek meets the South Platte River in the heart of Denver and connects communities in Denver, Arapahoe, and Douglas Counties. Cherry Creek Dam was constructed and the Reservoir was created in 1948, to protect downstream areas from floods such as the 1933 flood, in which eight lives were lost and numerous buildings in Denver were destroyed. Cherry Creek State Park, Colorado's first state park was created in 1959. Today it is one of Colorado's busiest, with approximately 1.7 million visitors from July 2014 to June 2015.**

**Land use within the watershed varies from highly rural in the upper watershed to dense residential in the lower watershed and around the reservoir. The watershed is the source of nutrients to the reservoir, which impacts algal growth in the reservoir.**

- The Authority is a sponsor of the Denver Metropolitan Regional Science Fair. In 2015, the Cherry Creek Basin Water Quality Award was presented to Charles Wehner-Ortega for his erosion control project.
- In June 2015, the Partners involved environmental law professionals from the American Bar Association in a water quality and macroinvertebrate identification session at /Cherry Creek in conjunction with the STEM Institute from the Auraria campus.

2015

**The Authority's Vision is water quality in Cherry Creek Reservoir and watershed that optimizes beneficial uses for the public.**

**The Authority works together with its member entities to implement nutrient controls in the reservoir. Education is also an important key to achieving water quality protection; the Cherry Creek Stewardship Partners (Partners) help the Authority fulfill its Regulation 72 public education functions.**

# Reservoir Model

**In 2013, the Cherry Creek Reservoir Model effort was initiated to better understand the complex relationships among the biotic and abiotic components of the reservoir. The model will be used to further evaluate the potential effects of alternative management strategies, both within the reservoir and the watershed, to meet beneficial uses and numeric standards.**

## Questions Model Could Be Used To Answer

- **Are there ways we can enhance our protection and improvement of beneficial uses?**
- **Can we control the impacts of internal loading on chlorophyll α values and on beneficial uses?**
- **Would changes to the destratification system operation impact the beneficial uses?**
- **Would further reduction of watershed nutrient loads enhance our protection and improvement of beneficial uses and achievement of the standard?**

2015

## 2015 Model Progress

- **Completion of Temperature Calibration – January 2015**
- **Completion of Water-Quality Calibration – June 2015**
- **Completion of Model Sensitivity Analyses – July 2015**
- **Submittal of Task 3 Tech Memo – July 2015**
- **Completion of Peer Review Sessions – June-October 2015**

# Point Sources

## Wastewater Treatment Facilities

**There are currently six permitted major wastewater treatment facilities that discharge to waters in the Cherry Creek basin:**

- **Stonegate Village Metropolitan District**
- **Pinery Water & Sanitation District**
- **Parker Water & Sanitation District**
- **Arapahoe County Water & Wastewater Authority**
- **Meridian Metropolitan District**
- **Plum Creek Water Reclamation Authority**

2015

### Graywater

In response to the 2013 legislation to allow graywater use in Colorado, the Commission adopted a Graywater Control Regulation (Regulation 86) on May 11, 2015. The use of graywater for irrigation could potentially contribute additional nutrients to the basin. Regulation 86 allows these concerns to be addressed. Each local city, city and county, or county can decide whether or not to allow graywater use within its jurisdiction via the adoption of a resolution or ordinance, and could include needed protections. In 2015, the Authority participated in the public meeting process and attended stakeholder meetings to assess potential impacts to the basin.

One point source discharger, Plum Creek Water Reclamation Authority, is located outside the watershed but applies some of its treated effluent in the basin. The wastewater treatment facilities in the basin provide all phosphorus removal by using advanced wastewater treatment processes followed by land application or direct discharge. Some of the wastewater treatment facilities also remove total inorganic nitrogen to meet permit limits.

## Other Point Sources

There were 31 active permit certifications under general permits for other permitted point sources in 2015 (not including stormwater construction permits). The Authority has identified the need to include phosphorus discharge limits in some of these general permits as they are renewed, consistent with Regulation 72 requirements.

# Point Sources, Cont'd.

2015

- Point Source Controls: All six wastewater treatment facilities in the basin met their discharge limits for total phosphorus and total inorganic nitrogen (where applicable) in 2015. All of the dischargers were consistently below the flow weighted concentrations of phosphorus concentration goal for inflows to the reservoir.

- Other Point Source Discharges: The Authority reviewed the general permits that are typically used in the basin, and found that most have phosphorus requirements consistent with Regulation 72. However, recommendations were made regarding the need for phosphorus limits in three general permits when they are renewed are discussed above in Section 3.5.

- Graywater Control: Graywater could contribute nutrients to the Cherry Creek basin. Regulation 86 allows the local jurisdictions to address this.

- Approved Site Applications: In 2015, the Authority received five site applications for review and comment. The Authority recommended conditional approvals for four of the five applications. The fifth application was approved, and site-specific recommendations were developed for it.

# Stormwater Control

**The Colorado Department of Public Health and Environment is still in the process of renewing the Cherry Creek Basin (COR080000) and Standard (COR090000) MS4 permits. No date has been given yet for when the final permits will be issued. There are eight permittees covered by the general MS4 permit, and one MS4 with an individual MS4 permit, the City of Aurora. There are 11 non-standard MS4s permitted within the Cherry Creek Basin (COR070000). See full list on page 4 – 1.**

**Public education and outreach, stormwater runoff controls, and construction and post-construct best management practices were required for these permits. All MS4s in the watershed have adopted stormwater regulations setting requirements for construction and post-construction best management practices for new and redevelopment projects within their jurisdictions that are consistent with Regulation 72 requirements.**

# Stormwater Control, Cont'd.

## MS4 Permit Renewal

The Authority participated in the public meeting process for the MS4 General and Standard permit renewal, attended stakeholder meetings, and made comments during the public notice process.

## Stormwater Permits

There were over 11,000 inspections of construction and permanent best management practices by basin MS4s in 2015.

## Land Use Referrals

The number of land use referrals received by the Authority rose from approximately 150 in 2014 to 198 in 2015. The most referrals were received from the Town of Parker. The Authority took no exception to most projects that were received, indicating strong stormwater regulations and implementations by Members. For the projects for which the Authority took exception, the Authority worked with the land use agency and engineering consultants to recommend improved stormwater controls and compliance with Regulation 72.

## Public Information and Education

Numerous education programs and opportunities were offered in 2015 from the various MS4s. Aurora Water's Water World Program continued to offer free water presentations and field trips for grades pre-K to high school. Meridian Metropolitan District launched a kid's interactive webpage with educational water games. Parker Water and Sanitation District offered tours of their renewable water system infrastructure. Arapahoe County SPLASH has continued participating in community outreach to educate the public about stormwater.

# Nonpoint Sources

**Nonpoint source stormwater controls consist of Pollutant Reduction Facilities (PRF) constructed by the Authority and others. In 2015, PRFs included stream stabilization and reclamation, boat ramp and shoreline stabilization and reclamation, and installation of monitoring wells and meteorological stations, amongst others. The Authority must spend 60% of its annual budget on design, construction, operation, and maintenance of PRFs. The Authority has completed 23 PRF projects in the basin since 1989, more than $13 million, and has several specific PRF projects in the 10-year plan. PRFs aim to help reduce the nutrient loading on the Cherry Creek Reservoir to help achieve the chlorophyll α standard.**

2015

- PRF: The Cherry Creek at Arapahoe Road Stream Reclamation (Reach 5) project is underway and scheduled to be completed in spring 2016.
- PRF: The Town of Parker requested Authority funding assistance in 2012 for the Cherry Creek Stream Reclamation at Norton Farm Open. Design is complete and construction is expected to begin in January 2016 and completed in spring 2016.
- PRF: The Piney Creek Stream Reclamation – Reaches 6 (Ranches) and 7 (Liverpool) phase I design is completed and construction is scheduled to begin in January of 2016 and to be completed in spring of 2016.
- PRF: The Town of Parker requested Authority funding assistance in 2011 for the Cherry Creek Stream Stabilization at Hess Road project. This project was completed in spring of 2015, eliminating an estimated 72 pounds of phosphorus per year from being transported downstream from the Cherry Creek at Hess Road site.
- 10-Year CIP: A summary of recommended PRFs (10-year CIP) for 2016-2025 was released.
- PRF Monitoring: The Cottonwood Creek Stream Reclamation Project, which is paired with two wetland detention systems (PRFs), continues to be effective in reducing the total phosphorus load and suspended solids entering Cherry Creek Reservoir; although it shows mixed results in terms reducing total nitrogen concentrations.
- PRF Annual Inspections: In 2015, PRF Inspections occurred within Cherry Creek State Park on July 28$^{th}$ and 30$^{th}$. All PRFs were performing as designed, but some routine, rehabilitative, and restorative maintenance activities are recommended and planned for 2016.

# Riparian and Wetlands

**Riparian areas and wetlands are protected in the Cherry Creek basin by Regulation 72 as Stream Preservation Areas, providing special standards and procedures for land disturbances in riparian or wetland area. Regulation 72 requires additional BMPs for all land disturbances within a Stream Preservation Area, including both construction and post-construction best management practices. Wetlands and riparian areas are also federal-protected as Waters of the United States under section 404 of the Clean Water Act. The U.S. Fish and Wildlife Service National Wetlands Inventory has mapped approximately 4,398 acres of wetlands/riparian areas in the Cherry Creek Basin.**

2015

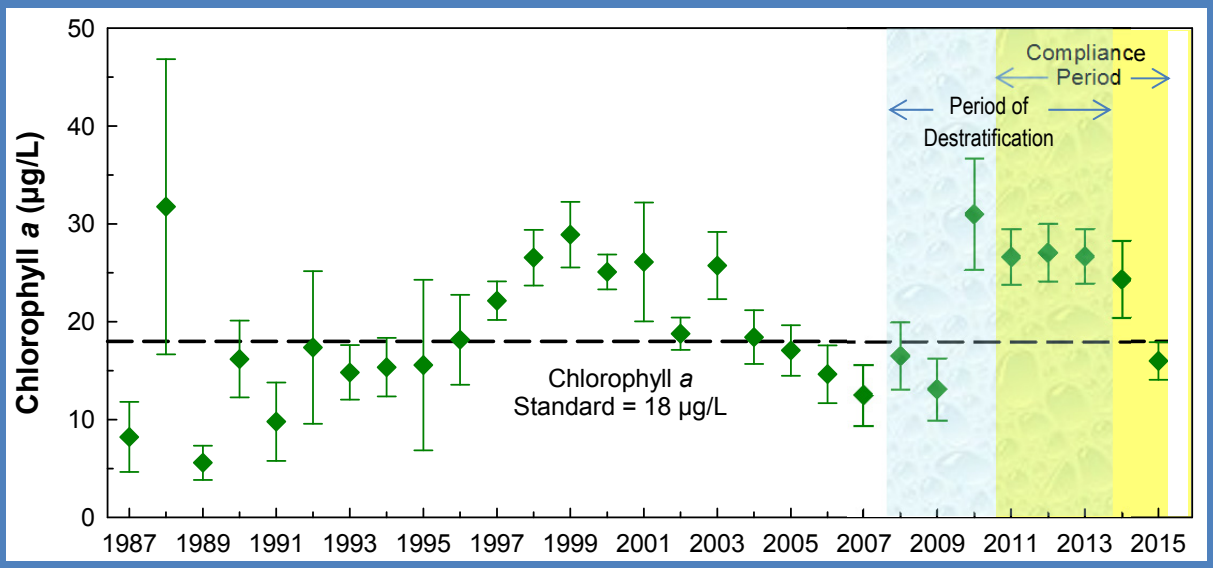
- Land Development Activities: In 2015, the Authority reviewed 13 land development activities that occurred in a Stream Preservation Area and provided comments to the land use agency.
- Cherry Creek Ecological Park Project: The area was severely eroded resulting in lateral channel migration. In 2013 the Authority and its partners implemented a natural bio-engineering approach to connect the streambed to the overbanks. The Authority conducted site visits in 2015 to assess the impact the restoration has on wetlands in the park. Approximately 1.4 acres of wetlands were created as a result of the drop structures completed in 2013.
- 2015 Grand Award for Engineering Excellence was given to the Cherry Creek at Eco Park project, brought to life by twelve partners and four funding agencies, including the Authority.

# Monitoring

**In 2015, the Authority updated the Sampling and Analysis Plan and the Quality Assurance Project Plan. These plans include long-term monitoring of nutrient levels in the reservoir and its tributaries, precipitation, groundwater, and chlorophyll α levels within the reservoir. Monitoring efforts focus on reservoir and tributary water quality, inflows and outflow, loads and export, surface and groundwater quality in the watershed, and PRF effectiveness.**

2015

- Chlorophyll α: The reservoir attained the site-specific chlorophyll α standard of 18 µg/ L during the growing season. The reservoir remains out of compliance with the allowable exceedance frequency. 2015 was the first out of five consecutive years that the standard was achieved.
- Destratification System: From 2008-2013, the Authority operated the reservoir destratification system to increase aeration to control nuisance algal growth. During this time, the destratification system was unable to completely mix oxygenated water all the way to the bottom of the reservoir; however, the system did create more uniform conditions in the reservoir, mixing bioavailable nutrients from the bottom, facilitating algal growth. The chlorophyll α concentration in the reservoir exceeded the water quality standard 4 out of the 6 years that the destratification system was operated.
- Exceedances of the chlorophyll α standard occurred in 1988, from 1997-2003, and again from 2010-2014. The standard was met in all other years. The Authority is completing its reservoir model, and anticipates its effort may shed light on the mechanisms that affect chlorophyll α concentrations.
- It is noted that after one full year (2009) of the operation of the destratification system the reservoir was out of compliance from 2010 through 2014. After one year (2014) where the destratification system was not operated the reservoir was once again in compliance (2015).

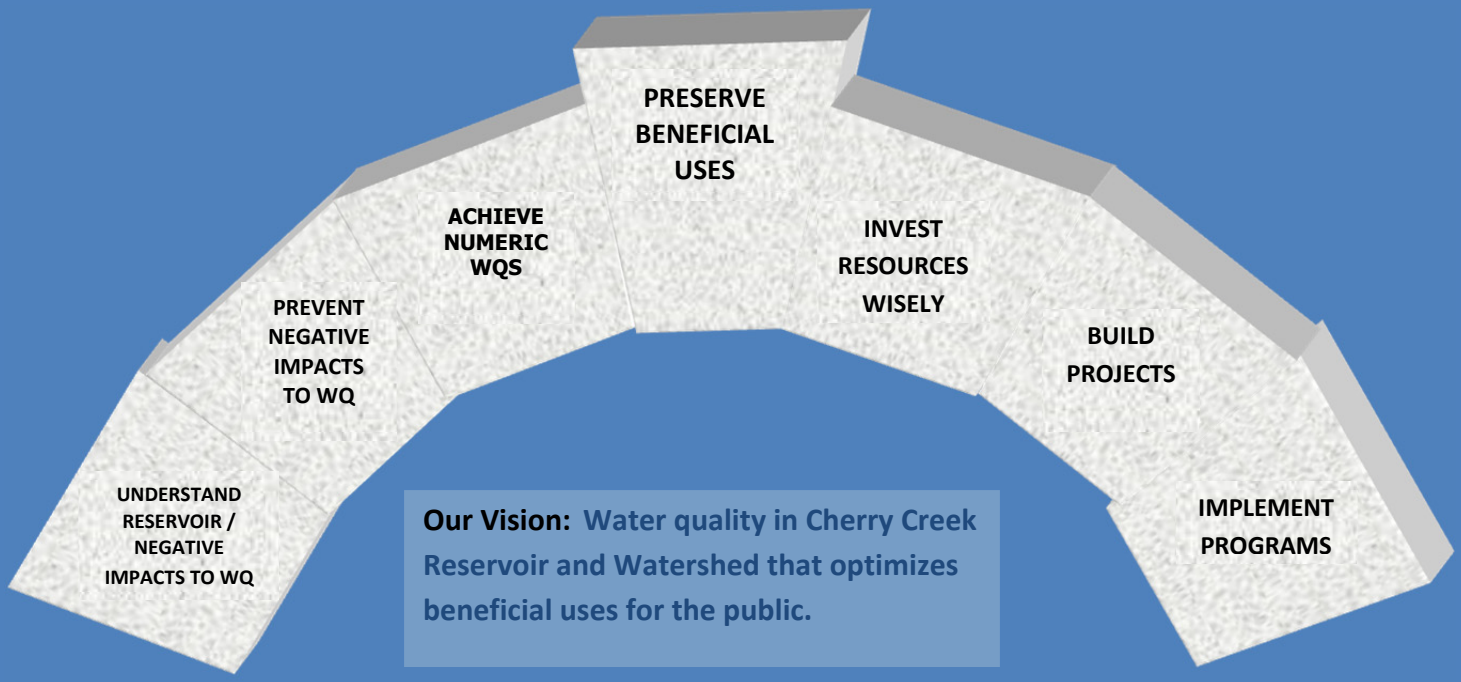


# Monitoring, Cont'd.

2015

- Nutrients: Cherry Creek Reservoir continued to experience internal nutrient loading which released soluble reactive phosphorus (SRP) and dissolved inorganic nitrogen (DIN) from the sediment into the water column. This loading occurred from approximately mid-May though early August and was facilitated by the low dissolved oxygen concentrations near the water/sediment interface. SRP concentrations at the water sediment interface peaked in June to as high as 275 µg/L while the reservoir was stratified; however, a storm event in late June caused the reservoir to mix. SRP concentrations were then more evenly distributed through the water column. The TIN concentration decreased during this event but returned to stratified concentrations by the following sampling event. The reservoir re-stratified in July. Internal loading decreased substantially again in August when Cherry Creek Reservoir slowly became more mixed.
- Phytoplankton and Cyanotoxins: During the spring through fall of 2015, the reservoir experienced two events of increased chlorophyll α concentrations. The first occurred in late May when Cryptophytes were the most abundant phytoplankton. The second event of hightened chlorophyll α occurred at the end of the year where diatoms were dominant in late September and chlorophytes in mid-November, and cryptophytes in early November. These algae are considered beneficial in terms of a food source for zooplankton and fish, and posed no risk to recreational contact.
- Temperature and Dissolved Oxygen: Cherry Creek Reservoir was in attainment of both the acute (DM = 29.5°C) and chronic (MWAT = 26.3°C) Warm Water lakes and reservoirs temperature standards for the summer months. Cherry Creek Reservoir experienced 95 days of thermally stratified conditions in 2015 beginning in early May. This value is greater than the mean number of 24 days Cherry Creek Reservoir was thermally stratified when the destratification system was in operation.

# Watershed Implementation




**Our Vision:** **Water quality in Cherry Creek Reservoir and Watershed that optimizes beneficial uses for the public.**

## Watershed Plan

**The Watershed Plan serves as a living document to define the pathways to meeting all of our goals and reaching our long-term vision. The 'preservation of beneficial uses' is the 'keystone' of the Authority's goals, as all of the other goals are there to support the 'preservation of beneficial uses'.**

2015

## Strategic Planning

A strategic planning workshop was held on August 6th with participants from the Board, the TAC, and the Authority. The focus was on "Existing Authority Programs and Drivers" (Regulation 72 vs the Statute). The goal of the meeting was to identify future projects of the highest priority to pursue in the upcoming year including:

- Finish and apply the reservoir model;
- Complete the watershed model immediately after the reservoir model and use it as a tool to determine how to implement the reservoir model's recommendations;
- Identify any needed changes to our capital project process, to incorporate findings from the items above; and
- Greater public outreach about the Authority and what we do.

# Watershed Implementation, Cont'd.

- **Monitoring Program: In 2015, both the reservoir and the watershed monitoring programs were evaluated, and an updated Sampling and Analysis Plan/Quality Assurance Project was developed.**

- **MS4 Permit Support: The Authority participated in the review and development of the basin's Cherry Creek MS4 permit, which is in the process of being revised.**

- **Reservoir Model: The model was calibrated, validated, and peer reviewed. The Authority is currently discussing several recommendations to modify some of the model's components. Management scenarios are also currently being evaluated for use in the model in 2016.**

- **Stream Reclamation Projects: The Authority focused in 2015 on five stream reclamation projects upstream of the State Park.**

- **Partnering: The Authority is partnering with UDFCD, SEMSWA, Douglas County, the City of Aurora, and the Town of Parker to more effectively use its funding and resources. Examples of projects include partnering with the City of Aurora on the Piney Creek stream reclamation project, and the Town of Parker on the Norton Farms Open Space and Hess Road stream reclamation projects.**

- **Education: The Authority partnered with the Cherry Creek Stewardship Partners to provide photo and written documentation of the progress of the Cherry Creek Ecological Park project in developing and expanding the wetlands in the area. In 2015 a wetlands map was created to compare to the pre-project 2012 imagery.**

# 1 THE AUTHORITY

The Cherry Creek Basin Water Quality Authority (Authority) was formally created in 1988 by the Colorado State Legislature by statute (see Colorado Revised Statues (C.R.S.) 25-8.5-101 *et seq*.). The Authority was created as a quasi-municipal corporation and political subdivision of the state, and was provided with specific powers (see box below). The Authority is tasked with improving, protecting, and preserving the water quality of Cherry Creek and Cherry Creek Reservoir and preserving waters for recreation, fisheries, water supplies, and other beneficial uses.

The Legislature established the Authority to benefit the inhabitants and landowners within the basin by preserving water quality in both Cherry Creek and Cherry Creek Reservoir, and to benefit the people of the State of Colorado by preserving waters for recreation, fisheries, water supplies, and other beneficial uses. The Authority develops water quality management strategies to: (1) minimize point, nonpoint, and regulated stormwater pollutant source nutrient contributions; (2) implement pollutant reduction programs; and (3) monitor water quality to evaluate progress. Together, these strategies create an effective water quality management approach.

**PARTIAL LIST OF GENERAL STATUTORY POWERS OF THE AUTHORITY (C.R.S. 25-8.5-111)**

- "Develop and implement, with such revisions as become necessary in light of changing conditions, plans for water quality controls for the reservoir, applicable drainage basin, waters, and watershed, to achieve and maintain the water quality standards"
- "Conduct pilot studies and other studies that may be appropriate for the development of potential water quality control solutions"
- "Develop and implement programs to provide credits, incentives, and rewards within the Cherry Creek basin plan for water quality control projects"
- "Recommend the maximum loads of pollutants allowable to maintain the water quality standards"
- "Recommend erosion control and urban runoff control standards and conduct educational programs regarding such controls in the basin"
- "Recommend septic system maintenance programs"
- "Acquire, lease, rent, manage, operate, construct, and maintain water quality control facilities or improvements for drainage, nonpoint sources, or runoff within or without the Authority boundaries"

(In addition, the Authority has contractual, administrative and financial powers.)

## 1.1 Regulatory History of Chlorophyll α Standards and Implementation

**1982**

- A Clean Lakes Study of Cherry Creek Reservoir identified phosphorus as the major nutrient causing algal productivity, potentially leading to eutrophication with negative impacts to beneficial uses.

**1984**

- The Colorado Water Quality Control Commission (Commission) first adopted a water quality standard for the reservoir in 1984. The following year, the Commission adopted a control regulation (Regulation 72, Cherry Creek Reservoir Control Regulation) to provide a mechanism for protecting the quality of Cherry Creek Reservoir using a model based upon 1982 hydrologic conditions.

**1990**

- In 1990/1991, the Commission established a Total Maximum Annual Load (TMAL) of total phosphorus (TP) that could enter the reservoir and still maintain the phosphorus standard and established a total phosphorus limit for dischargers of 0.05 milligrams per liter (mg/L), the lowest level found to be technically attainable.

**2000**

- The Commission adopted a new standard for the protection of Cherry Creek Reservoir in 2000. This standard, a maximum of 15 micrograms per liter (µg/L) of chlorophyll α during the growing season from July to September, with a phosphorus goal of 40 µg/L, was determined to be protective of the uses of the reservoir. An amended control regulation to implement the new water quality standard and protect the designated uses was adopted the following year, based on a phased TMAL approach.

**2009**

- Based on 13 studies completed under the phased TMAL, the Authority recommended, and the Commission adopted, a revised water quality standard (seasonal mean chlorophyll α of 18 µg/L). The standard was chosen to protect the reservoir uses to the maximum degree practical, recognizing present uncertainty as to the chlorophyll α level that will prove to be attainable over time. Changes to Regulation 72 made in 2009 included establishment of a concentration-based nutrient management approach, removal of all TMAL-related components, an effluent limit of 0.2 mg/L total phosphorus for drinking water plant discharges, and establishment of a 3-tiered system for stormwater quality control measures for new development and redevelopment.

**2012**

- The Comission adopted amendments to Regulation 72 regarding stormwater permit requirements based on recent studies and information, to help improve the effectiveness of the Regulation 72 stormwater program. The changes provided consistency between state and federal stormwater requirements in Regulation 72 and Regulation 61 Colorado Discharge Permit System Regulation .

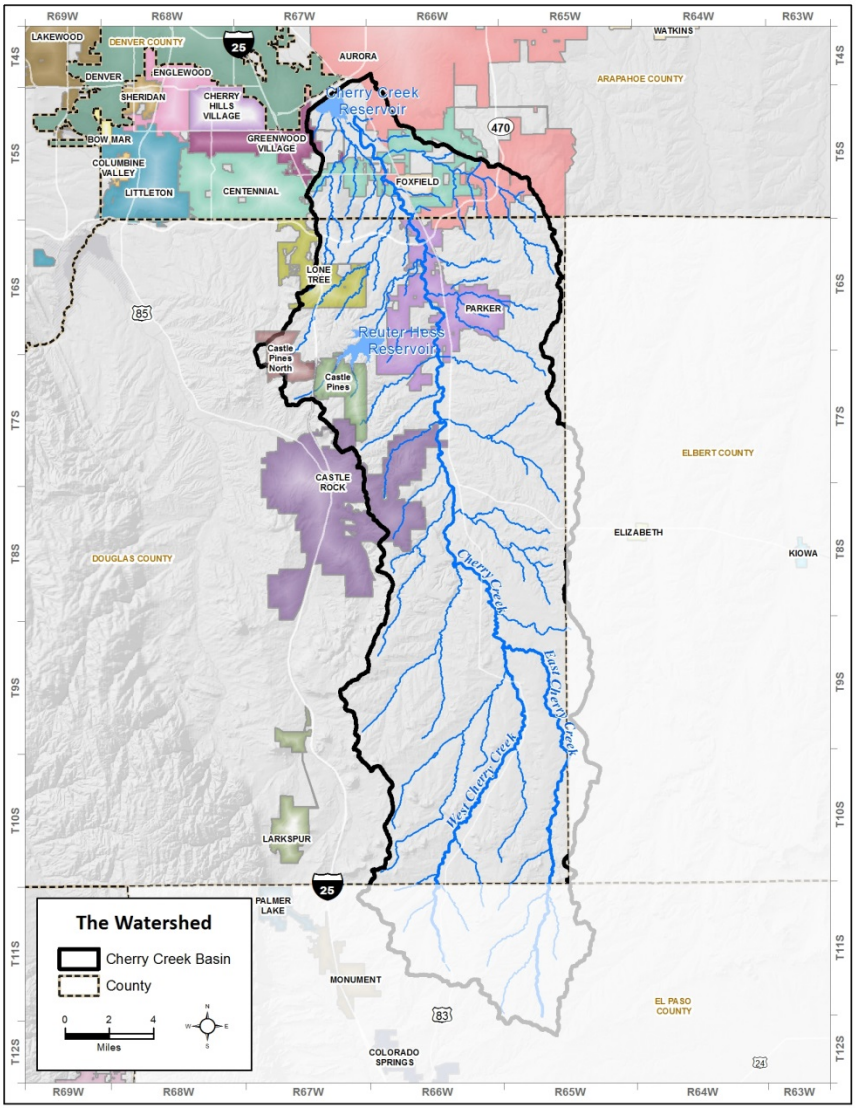
**2015**

- The Commission adopted a total phosphorus standard of 170 µg/L and a chlorophyll α standard of 150 mg/m$^2$ for the mainstream of Cherry Creek above Cherry Creek Reservoir, all tributaries to Cherry Creek, and Cottonwood Creek and all its tributaries. Total phosphorus and chlorophyll α standards only apply upstream of wastewater treatment plant facilities in the basin: Stonegate Village Metro District, Pinery W&WWD, Parker W&SD, and Arapahoe County W&WW Authority. Other lakes and reservoirs larger than 25 acres surface area in the Cherry Creek basin above Cherry Creek Reservoir were assigned a chlorophyll α of 20 µg/L and a total phophorus standard of 83 µg/L. The Commission made no changes to the existing chlorophyll α standard in Cherry Creek Reservoir.

## *Today's Authority*

C.R.S. 25-8.5-105 defines the Authority's membership. Authority members are defined as follows:

- Douglas and Arapahoe shall each have one member (El Paso and Elbert Counties are not included in the statutory definition of the Authority boundaries);
- Each municipality that has property within the Authority's boundaries shall have one member;
- The special districts that own and operate wastewater treatment services in the Cherry Creek basin shall collectively be represented by a single member of the Authority;
- A total of seven members shall be appointed by the governor to represent sports persons, recreational users, and concerned citizens.




**MAP 1 – 1: ENTITIES WITHIN THE CHERRY CREEK RESERVOIR WATERSHED BOUNDARIES**

There are currently two counties and eight municipalities within the boundaries; however, not all have appointed Board members. Of the Governor's appointees, at least two are to be from sporting or recreational organizations that have members who use the reservoir; at least two from citizen or environmental organizations interested in preserving water quality with members who use the reservoir or reside in the basin; and at least three must have professional backgrounds in or professional training regarding water quality issues.

**TABLE 1-1: AUTHORITY BOARD MEMBERS**

| Entity Type | Maximum Number of Members | Current Number of Members |
|---|---|---|
| County<br>(Arapahoe, Douglas) | 2 | 2 |
| Municipality<br>(Aurora, Castle Pines, Castle Rock, Centennial, Foxfield, Greenwood Village, Lone Tree, Parker) | 8 | 6* |
| Special Districts (one member represents all water and wastewater service district providers) | 1 | 1 |
| Appointed by the Governor | 7 | 6 |
| Total Members of Authority Board | 18 | 15 |

*Castle Pines and Foxfield have vacancies

## Board and TAC

The Authority has a Board of Directors (Board) and a Technical Advisory Committee (TAC). According to the statute, each Authority member (other than the Governor's appointees) shall appoint a representative and two alternates to serve on the Board (C.R.S. 25-8.5-106(2)). The Authority's bylaws state that county, municipal, and special district members may each appoint one representative to serve on the TAC, and the Board can appoint other individuals who represent educational or public interest groups, and/or local governments that are not members of the Authority, and have an interest in stormwater drainage and water quality within the Cherry Creek basin to the TAC.

The role of the TAC is to consider and report to the Board on matters of a scientific or technical nature. Under the bylaws, possible roles may include assistance with technical and scientific matters, development and submission of referral comments, review and provision of comments/recommendations on 401 certifications and 404 permit applications, and review and provision of comments/recommendations on local government decisions including rezoning, subdivisions, special projects, new rules and regulations, and other duties.

The current makeup of the Board and TAC are shown in Table 1-1 and Table 1-2; note that the Towns of Castle Pines and Foxfield municipality positions are currently vacant.

**TABLE 1-2: AUTHORITY TAC MEMBERS**

| Entity Type | Number of Members |
|---|---|
| County (Arapahoe and Douglas) | 2 |
| Municipality<br>(Aurora, Castle Rock, Centennial, Greenwood Village, Lone Tree, and Parker) | 6 |
| Special Districts | 1 |
| Board-appointed (TAC Chair, SEMSWA, Partners, USACOE, CPW, TCHD, CDOT, and UDFCD) | 7 |
| Total Members of TAC | 16 |

## 1.2 Financial Matters

The Authority levies property taxes (one-half mill) on all taxable property within the Authority's boundaries (C.R.S. 25-8.5-111(p)). The Statute also allows the Authority to establish rates, tolls, fees, charges, and penalties for functions, services, facilities, and Authority programs. The total annual revenue from these sources shall not exceed 30 percent of the annual Authority budget. Agricultural lands are exempt from the collection of these fees. Current development fees include $60 per single family residence and $0.04 per square foot of impervious area in commercial and multi-family developments. Wastewater fees are $0.25 per 1,000 gallons of treated wastewater discharged in the Cherry Creek basin.

The Authority also receives user fees from Cherry Creek State Park visitors. These fees are subject to review and approval by the Colorado Parks and Wildlife Board and add an additional $3 on annual passes and $1 on single-day passes. The relative percentages of the projected revenues for 2016 are shown in Figure 1-1 below.

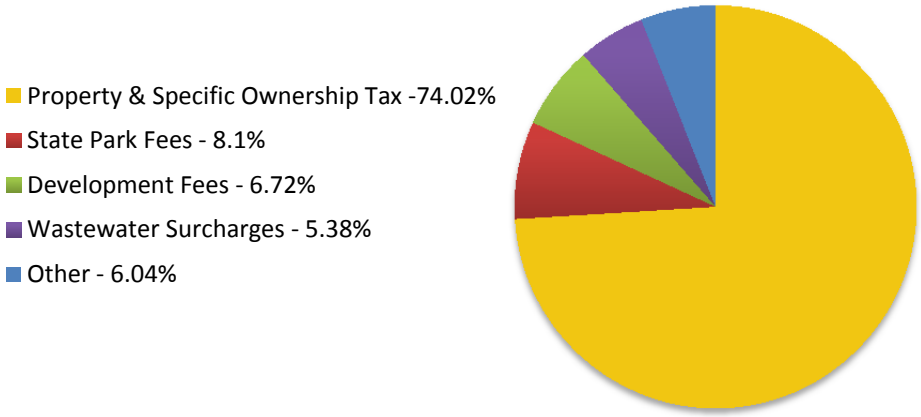



**FIGURE 1-1: ESTIMATED 2016 REVENUES**

The 2015 budget included about $2.3 million in revenues: about $1.55 million from property taxes, $175,000 from State Park user fees, $150,000 from building permit fees, $120,000 from wastewater surcharges, and the rest from miscellaneous income and a one-time payment ($18,180) from the City of Centennial for previously-collected development fees.

The Authority's 2016 budgeted expenditures are approximately $2.2 million. Expenditures and revenues are often not matched each calendar year because implementation and timing of project costs for the capital improvement program can vary significantly from year to year. The statute mandates that the Authority spend at least 60% of the annual authorized revenues on the construction and maintenance of Pollutant Reduction Facilities (PRFs). The remaining 40% is allocated towards monitoring, special studies, planning documents, technical reports or memoranda, and administrative costs. Because expenditures and revenues are not matched each calendar year, the Authority interprets the 60/40 split referenced above as a multi-year mandate and does not account for this in any one year. In 2015, the Authority met this mandate as part of the Reservoir Model costs which met the criteria for designation as a capital expense.

## 1.3 Authority Website

In 2015, the Authority added several documents to its website that serve as references for the status of water quality in Cherry Creek Reservoir. The Authority's website provides a list of members of both the Board and TAC, the Authority by-laws, past and current reports, and various maps. A variety of resources are available, providing information on funding, regulatory basis for the organization, and archives of past reports. Board and TAC meeting agendas and information about those meetings can be found under the Meetings tab. Both Board and TAC meeting packets are posted for the entire year. Under the Projects tab, one can find current, pending, and completed projects in the Cherry Creek basin. Table 1-3 shows new and updated reference documents that can be found on the Authority's website.

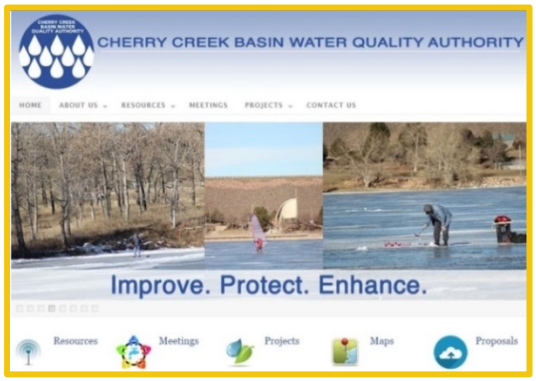
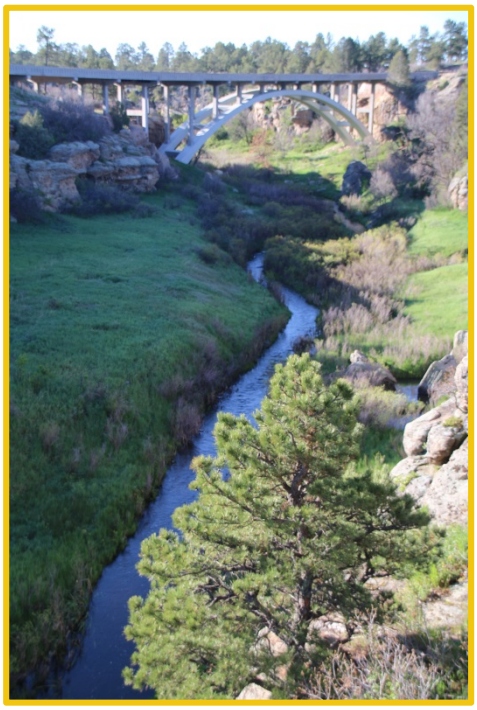



**TABLE 1-3: NEW AND UPDATED REFERENCE DOCUMENTS**

| |
|---|
| Cherry Creek Basin Water Quality Authority Watershed Plan (Chapter 7 Annual Action Plans, updated in 2015)<br>(Multi-year plan for watershed management) |
| 2015 Annual Report of Activities by the Cherry Creek Basin Water Quality Authority<br>(Update on activities completed by the Authority in 2014, submitted to Commission in March 2015) |
| 2015 Annual Inspection of Pollutant Reduction Facilities (PRFs)<br>(Inspection of PRFs constructed by the Authority to assess whether PRFs are functioning as designed and to identify routine, restorative, and rehabilitative maintenance needs) |
| 2016 - 2025 Ten-Year Capital Improvement Projects (CIP) Plan<br>(Summary of potential pollutant reduction facilities) |
| Monthly CIP Status Reports to Board<br>(Summary of 2015 progress on capital improvement projects, updated twice each month) |
| 2016 Annual Reservoir Monitoring Report. Water Year Aquatic Biological and Nutrient Monitoring Study and Cottonwood Creek Pollutant Reduction Facilities Monitoring. GEI Consultants, Inc. |

The Authority has continued to consolidate and maintain its environmental and water quality data in a relational database management system, made available through a password–protected website. The CCBWQA Data Portal is located at the following address: http://www.ccbwqportal.org. The website is used by members of the Authority, consultants, and outside entities for data evaluation and review. In the 2015, the system was updated with a more user friendly interface and new story-telling graphics that provide meaningful information about the watershed to a wider audience. The database was queried to respond to the Colorado Department of Public Health and Environment (CDPHE) data call for the 2015 Rulemaking Hearing.

## 2 DESCRIPTION OF CHERRY CREEK RESERVOIR WATERSHED



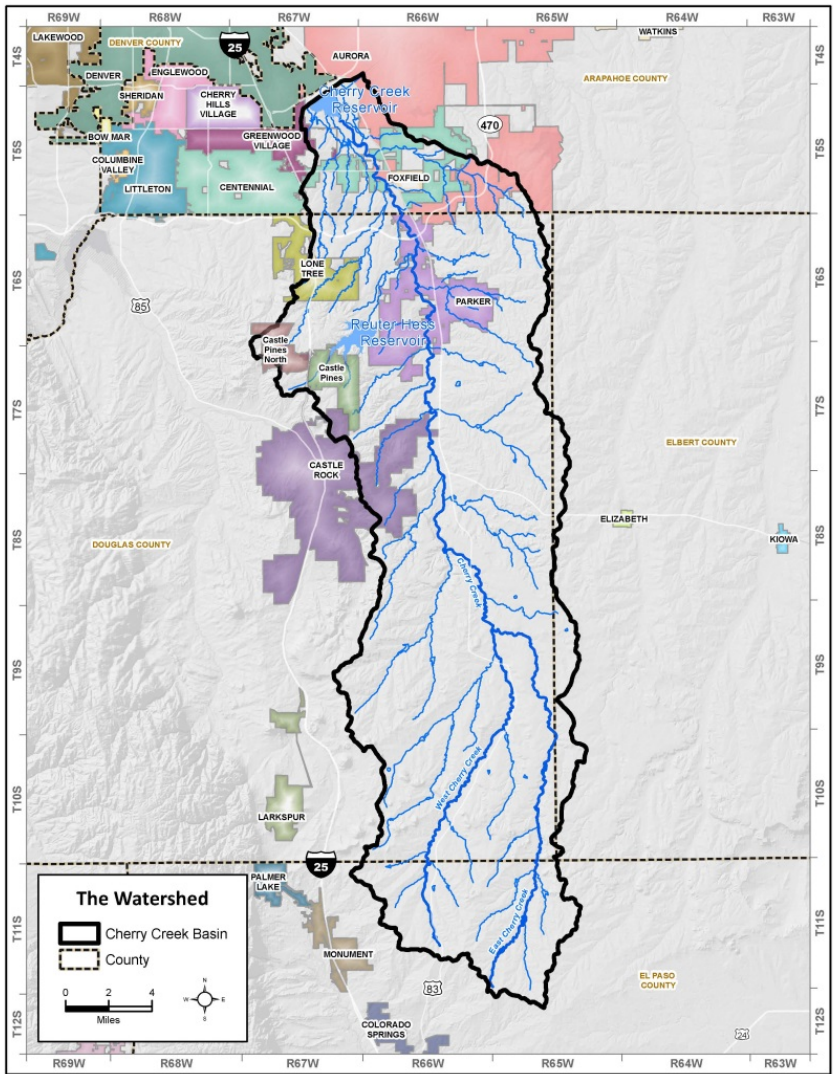
The Cherry Creek watershed is one of the most important and prominent components of the Denver metropolitan area. Cherry Creek meets the South Platte River in the heart of Denver and connects communities in Denver, Arapahoe, and Douglas Counties. The creek has been used for hundreds of years by Native Americans, trappers, traders, and settlers, and much of the land was used for agriculture, especially during the late 1800s through the 1930s. Landmarks and reminders of the watershed's rich history can still be readily found throughout the watershed and within the state parks and agricultural operations. One such site is Castlewood Dam, located in Castlewood Canyon State Park in the upper watershed. The dam was originally built in response to Cherry Creek flooding Denver in 1864. Castlewood Dam was first built in 1890, and then failed in 1892. It was then rebuilt, and failed again in 1933, bursting after several days of torrential rain. The flood was the worst in Colorado's recorded history at that time, destroying a great number of buildings in Denver, including the Rocky Mountain News building, the Methodist Church, and City Hall. Eight Denver residents lost their lives along with a great number of livestock.

Following this dam failure, Cherry Creek Dam was constructed and Cherry Creek Reservoir was created in 1948, to protect downstream areas from floods as had been experienced in the past. The reservoir is owned and operated by the U.S. Army Corps of Engineers (COE) and has a surface area of approximately 852 acres. This infrastructure was successful in reducing damages during the 1965 Denver flood by storing flows in the creek upstream of the reservoir.

In 1959, recreational demands on the reservoir from the growing urban population led to the creation of the Cherry Creek State Recreation Area, which became Colorado's first state park. Today the park is one of Colorado's busiest. The Park had approximately 1.7 million visitors from July 2014 to June 2015.

## *Boundaries of the Authority*

The Authority's defining legislation defines the boundaries of the Authority as being limited to Arapahoe and Douglas Counties. About 386 square miles of land and 600 miles of riparian stream corridors are encompassed within the Authority boundaries. Land use varies from highly rural in the upper watershed to dense residential in the lower watershed and around the reservoir.




**MAP 2-1: CHERRY CREEK RESERVOIR WATERSHED BOUNDARIES**

Note that the Cherry Creek Reservoir Control Regulation defines the boundaries of the watershed to also include lands within El Paso and Elbert Counties:

*"all lands that drain into the following: (a) the mainstream of Cherry Creek, from the source of East and West Cherry Creek to the inlet of Cherry Creek Reservoir (Segment 1), including alluvial groundwater; (b) Cherry Creek Reservoir (Segment 2), including alluvial groundwater; (c) all tributaries to Cherry Creek, including wetlands and alluvial groundwater, from the sources of East and West Cherry Creeks (parts of Segment 4); and all lakes and reservoirs in the Cherry Creek Reservoir watershed (Segment 5, in part)".*

## 2.1 Basinwide Coordination on Water Quality

The Authority members also partner with others to address water quality issues within the Cherry Creek basin. For example, Major Drainageway Plans (MDP) and Outfall System Plans (OSP) coordinated through the Urban Drainage and Flood Control District (UDFCD) plan for regional detention and water quality for tributaries on a basinwide basis. Each plan includes funding and input from the municipalities and/or counties included in the study area. Many master plans for tributaries to the Cherry Creek basin have recently been completed. For example, in February 2012 the Piney Creek Major Drainageway Plan - Conceptual Design Report was completed, which identified improvement projects for the entire Piney Creek drainage basin. The plan's participants were UDFCD, SEMSWA, Douglas County, and the City of Aurora. Due to loss of property, risk to the public (particularly in the City of Centennial), a geomorphic study was completed December 22, 2014. This study identified three priority projects to stabilize Piney Creek. The project partners, the Authority, UDFCD, and SEMSWA, are still investigating funding options with the goal of completing construction by 2018.

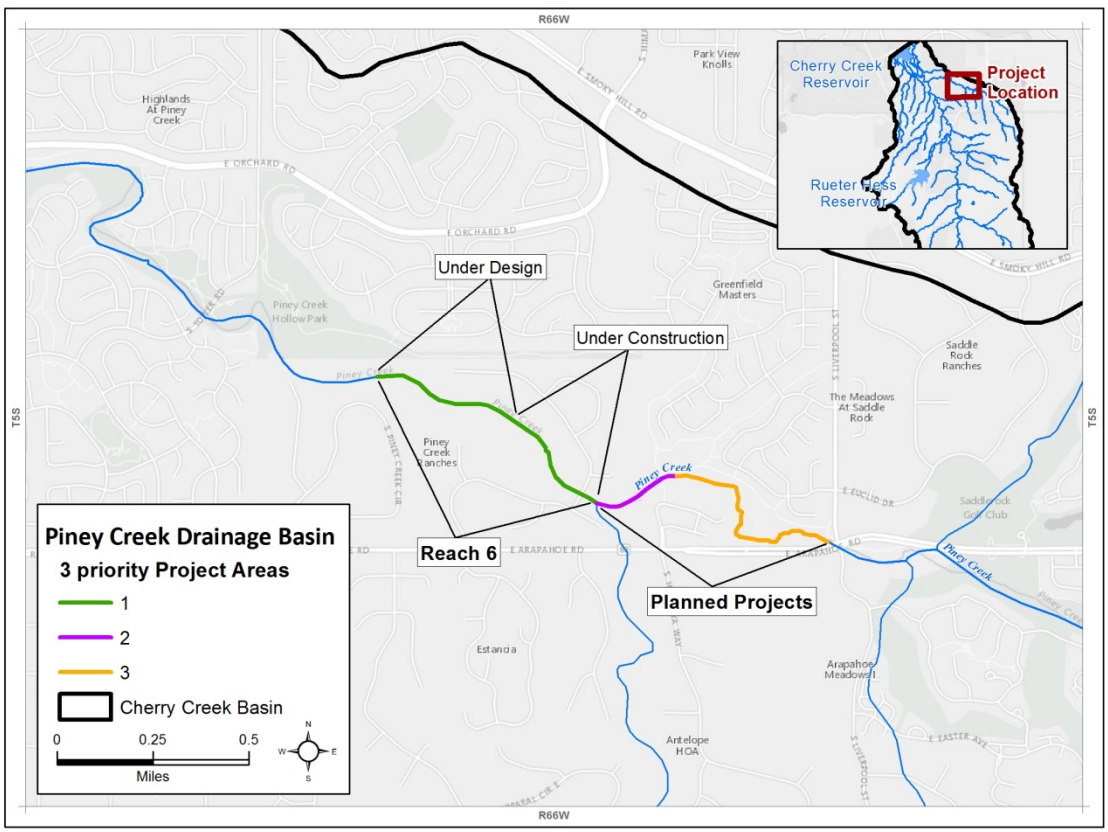
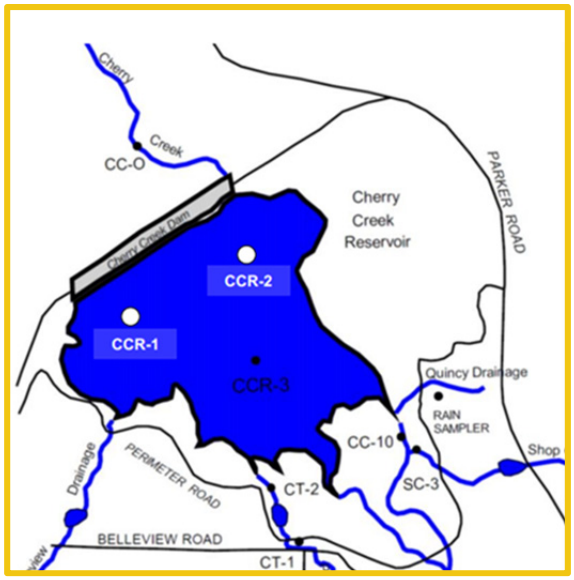



**FIGURE 2-1: PRIORITY PROJECTS TO STABILIZE PINEY CREEK**

A new MDP for Sulfur Gulch, sponsored by the Town of Parker and UDFCD, is starting in 2016. An update to the Cherry Creek MDP is scheduled for 2017; to date, identified sponsors include SEMSWA, Parker, and Douglas County.

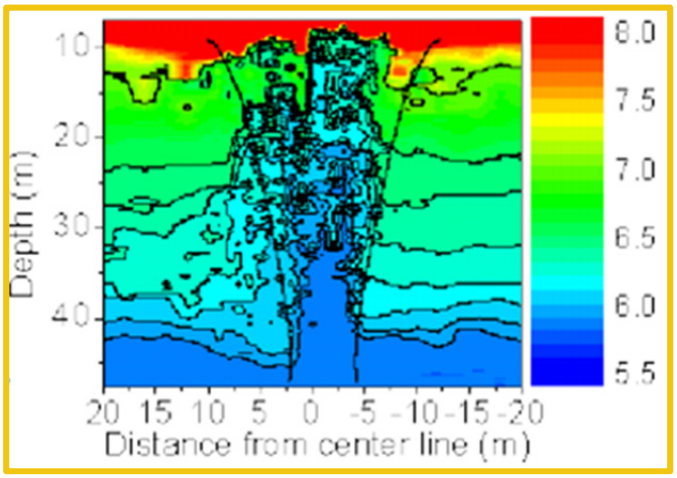
## 2.2 Cherry Creek Reservoir Model




In 2014, a comprehensive reservoir water quality model was initiated to better understand complex relationships among the biotic and abiotic components of the reservoir. The model will be used to further evaluate water quality and ecological conditions of the reservoir under different hydrologic scenarios, and to evaluate the potential effects of alternative management strategies, both within the reservoir and the watershed, to meet beneficial uses and numeric standards. The model will also help to better understand the mechanisms behind changes in chlorophyll α concentrations, especially in recent years.

The Reservoir Model could help the CCBWQA answer questions, such as the following:

1) Are we protecting and improving the beneficial uses?
2) What are the impacts of internal loading on chlorophyll α values and on beneficial uses?
3) Would changes to the destratification system operations impact the beneficial uses?
4) Would additional watershed management activities help achieve the standard?




The current status of model tasks is below:

TASK 1. DATA ACQUISITION AND ANALYSIS (Completed)

TASK 2. MODEL SELECTION (Completed; CE-QUAL-W2 was chosen.)

TASK 3. MODEL DEVELOPMENT, CALIBRATION, VALIDATION (The model was calibrated, validated, and peer-reviewed. The Authority and model consultant are currently working to incorporated recommended modifications.)

OPTIONAL TASK 3.5. SENSITIVITY ANALYSES (Completed; however, will need to be updated after model modifications, including recalibration as needed, are completed under Task 3.)

TASK 4. IDENTIFICATION OF MANAGEMENT SCENARIOS (The Authority has started this task.)

TASK 5. EVALUATION OF MANAGEMENT SCENARIOS (To be completed in 2016)

TASK 6. MODEL DOCUMENTATION AND TRAINING (To be completed in 2016)

**Timeline (September 2014 – Present)**

- Model Development Started September 2014
- Completion of Water Balance Calibration – November 2014
- Completion of Temperature Calibration – January 2015
- Completion of Water-Quality Calibration – June 2014
- Completion of Model Sensitivity Analyses – July 2015
- Task 3 Tech Memo Submitted – July 2015
- Peer Review Sessions – June-October 2015
- Model modifications underway in response to peer review.

## 2.3 Public Information and Education by Authority and Partners

Pursuant to Regulation 72, the Authority is responsible for developing and implementing a public information and education program. This program is to focus on the prevention of pollution from sources that could be mobilized during storm events from present and future activities as well as encouragement of measures that could abate known nonpoint source pollution. Areas for abatement are to include, but are not limited to, general agricultural and silvicultural practices, onsite wastewater treatment systems, large lot development greater than one acre, and other potential nutrient sources. The Authority fulfills this regulatory responsibility by partially funding and utilizing the service of the Cherry Creek Stewardship Partners (Partners).

The Partners are an association of a broad range of stakeholder's actively promoting effective stewardship and providing education and outreach activities in the Cherry Creek Reservoir watershed. The Partners emerged from the first Cherry Creek Reservoir Watershed Forum held in the fall of 1999. The Partners bring together representatives from:

- Land use jurisdictions,
- State and federal resource management agencies,
- Conservation, recreation, and historic preservation groups,
- Business communities, and
- Interested citizens.

In 2004, the Partners, aided by both funding and staff provided by the Authority developed a comprehensive and coordinated education strategy and action plan on a reservoir watershed scale

entitled the "Cherry Creek Basin Water Stewardship and Education Initiative". This plan contains a compilation of the key education and public involvement goals, strategies, and activities aimed at engaging the community in active stewardship of Cherry Creek basin, including parks, open space, trails, and tributaries within the watershed.

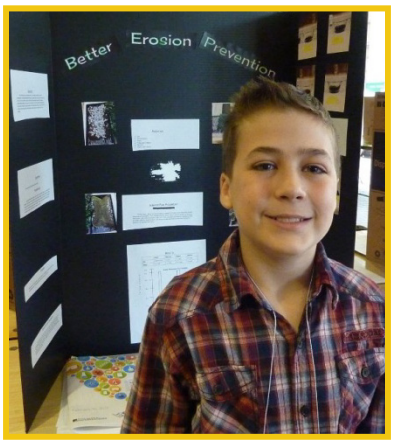
The purpose of the Education Initiative is to describe the approach recommended by the Partners and the Authority to promote active stewardship in the basin. The purpose of active stewardship is to preserve, protect, and restore water quality, wildlife habitat, recreational opportunities, and the natural function of the watershed. In coordination with key stakeholders in the Cherry Creek watershed, the Education Initiative makes recommendations and identifies next steps for the development and implementation of a public information and education outreach program for the Cherry Creek watershed that meet the regulatory requirements of Regulation 72 and the objectives identified in Cherry Creek Basin Watershed Plan.

### *2015 Highlights*

**Education and Outreach**

The Cherry Creek Stewardship Partners are proud to be a part of the Technical Advisory Committee of the Authority. Through this association they are able to provide a link to the community and highlight the many innovative endeavors that have been possible on Cherry Creek through the Authority-sponsored projects. The Partners have developed a program of outings and field trips that highlight the work that has been done to protect beneficial uses of our natural resource heritage throughout the watershed. The entire watershed is viewed as a connection for education and outreach and brings together people with a wide range of interests. From the Renaissance School in the Town of Castle Rock through Douglas, Arapahoe, and Denver counties to the Water Association of Student Stewards Urban Program (WASSUP) on the Auraria Campus, the Partners have hosted over 8500 citizen stewards of all ages at more than 37 events in 2015. Building on the assessment and recommendations identified in the Cherry Creek Basin Water Stewardship and Education Initiative, the Partners engage with schools and community groups, stormwater permit holders, municipalities, county agencies, Colorado Parks and Wildlife (CPW), and other scientific and cultural organizations to bring a water quality message to a diverse audience. The Partners have created a yearly calendar of outings and events that engage a diverse constituency. The majority of activities take place on Cherry Creek where nature is our teacher and the Creek is our classroom. Support from the Authority and other partners make these activities possible.

## Science and Stewardship




The Authority has been a sponsor of the Denver Metropolitan Regional Science Fair since 2007. This event includes more than 500 students, grades 6 through 12, from the seven-county Denver metropolitan area. The Partners lend assistance to this event, inviting volunteers to share their expertise as judges and mentors. Students are recognized for Excellence and Outstanding Achievements in study and experimentation for the protection and preservation of life's most important resource on earth, water! In 2015, the Cherry Creek Basin Water Quality Award was presented to Charles Wehner-Ortega for his undaunted pursuit of 'Better Erosion Prevention'.

## Acronyms Anyone?

Translating the language of water in Colorado is a happy challenge for the Partners. In June of 2015, the American Bar Association, Environmental Law Section, asked the Partners to help create a service opportunity for attendees at their national conference in Denver. With the help of Colorado River Watch, the Partners invited WASSUP and the Keep It Clean Neighborhood Environmental Trios (KICNET) to participate in a rollicking Cherry Creek visit. The environmental law professionals were given a presentation on water quality and macroinvertebrate identification by students from the Dr. Justina Ford Science, Technology, Engineering, and Mathematics (STEM) Institute. The growing relationships with institutions on the Auraria Campus provide unique opportunities to support water quality awareness and promote career development.

## Annual Stewardship Partners Conference

This event is supported by the Authority as a way to bring the broad range of watershed interests together to learn from one another. Since 1999, the Annual Stewardship Partners Conference has highlighted topics of interest for people who live, work, and play in the Cherry Creek watershed. The conference is truly a showcase for natural resource management and innovation. Highlights from the 2015 conference included a presentation on Douglas County's Agricultural Grazing Program, and an update on the Reuter-Hess Reservoir, and a presentation titled, "It's Complicated! How Complexity Influences Future Decision Making about the Reservoir and Meeting the Chlorophyll α Standard."

# 3 POINT SOURCES

Wastewater treatment facilities (WWTFs) in the basin provide total phosphorus (TP) removal through advanced wastewater treatment processes, followed by direct discharge, or further treatment through land application. Some also remove total inorganic nitrogen (TIN) to meet permit limits. There are currently five permitted wastewater treatment facilities located in the basin that discharge to Cherry Creek waters. Another, Plum Creek Water Reclamation Authority, is located outside the watershed but applies some of its treated effluent as irrigation water within the watershed.

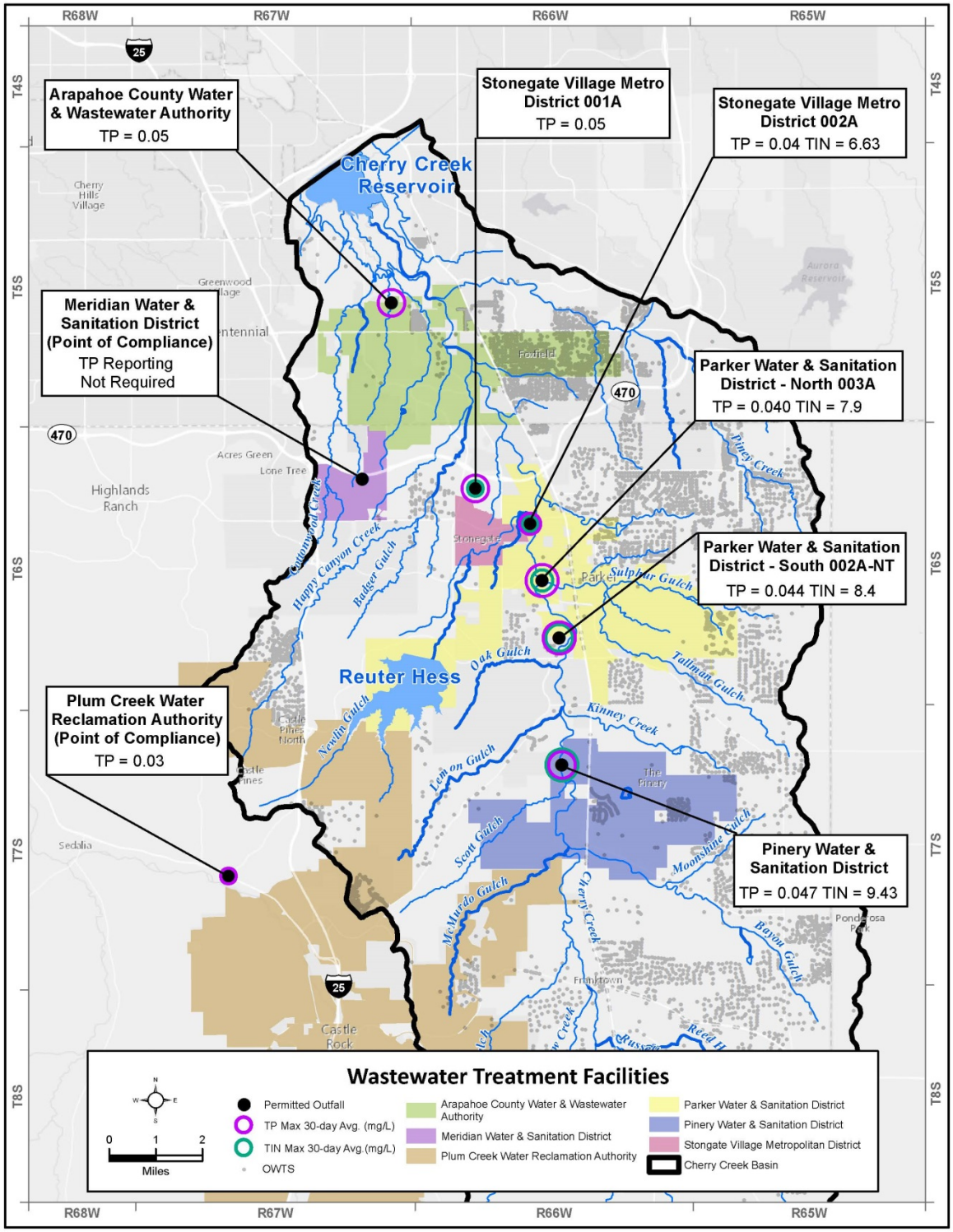
Wastewater and industrial process wastewater sources are limited in the amounts of phosphorus they are allowed to discharge to the Cherry Creek Reservoir watershed. Regulation 72 required phosphorus effluent limits for different categories of point source dischargers are in, later in this chapter.

Expiration dates for the wastewater treatment facilities' permits or Notices of Authorization (NOA) for land discharge are shown in Table 3-1. Locations of these wastewater district boundaries and outfalls can be seen on Map 3-1; it also shows the maximum 30-day average reported TP and TIN data for 2015.

### TABLE 3-1: CHERRY CREEK WATERSHED WASTEWATER FACILITIES AND PERMIT EXPIRATION DATES

| Permittee | Permit Number | Design Capacity (MGD) | Expiration Date | Comments | Does Permit or NOA Have Phosphorus Concentration Limits? | Does Permit or NOA have Nitrogen Concentration Limits? |
|---|---|---|---|---|---|---|
| **Arapahoe County Water & Wastewater Authority** | CO0040681 | 3.6 | 01/31/2018 | Active | Yes | No |
| **Pinery Water & Sanitation District** | CO0041092 | 2.0 | 10/31/2016 | Active | Yes | Yes |
| **Parker Water & Sanitation District** | CO0046507 | 4.0 | 01/31/2017 | Active | Yes | Yes |
| **Meridian Metropolitan District** | NOA, Reg.84 (COE-024000) | 1.5 | 10/31/2016 | Active | Yes | No |
| **Stonegate Village Metro District** | CO0040291 | 1.1 | 10/31/2016 | Active | Yes | Yes |
| **Plum Creek Water Reclamation Authority** | CO0038547 | 6.44 | 10/31/2017 | Active | Yes | No |

Note: Data obtained from EPA's ECHO (Enforcement & Compliance History Online) Detailed Facility Reports, December 2015 search as well as updated Permits provided by Water Quality Records Center, CDPHE December 2015.




MAP 3–1: LOCATIONS OF WASTEWATER TREATMENT FACILITY OUTFALLS

### Arapahoe County Water and Wastewater Authority

Arapahoe County Water and Wastewater Authority (ACWWA) primarily serve properties located in Arapahoe County. In addition, ACWWA also serves the Highfield Business Park, a small area in the northwest corner of Parker's Urban Growth Area. ACCWA's discharge permit contains total phosphorus concentration limits, as shown in Table 3-3 below. The facility discharges to Lone Tree Creek, a tributary of Cherry Creek.

### Pinery Water and Wastewater District

The Pinery Water and Wastewater District serves residential and commercial users located within the Pinery subdivision in Parker. In 1965, the District was formed as the "Denver Southeast Suburban Water and Sanitation District" and now serves about 4,000 residential customers, as well as 88 large irrigator and commercial customers in the basin. The Pinery's discharge permit contains total phosphorus and total inorganic nitrogen concentration limits (shown in Table 3-3). The facility discharges directly to Cherry Creek.

### Parker Water and Sanitation District

The Parker Water and Sanitation District (PWSD) operates two wastewater reclamation facilities: The North Water Reclamation Facility (WRF) (constructed in 2004), and the South Water Reclamation Facility (constructed in 1988). The facilities are currently permitted for hydraulic capacities of 2.0 MGD each, and both facilities provide tertiary treatment. PWSD's discharge permit contains both total phosphorus and total inorganic nitrogen concentration limits (shown in Table 3-3 and Table 3-4) and is permitted to discharge at two outfall locations, both directly to Cherry Creek.

Due to projected population growth in the basin, an increase in wastewater treatment capacity will be required in the North Water Reclamation Facility by 2021. A total treatment capacity of 6.0 MGD is anticipated to be sufficient for treatment requirements through 2032. Therefore, Parker

Water and Sanitation District is conducting an in-depth alternatives analysis to evaluate its facilities prior to increasing treatment plant capacity. One alternative being considered is to decommission the South Reclamation Facility. A comprehensive evaluation of the proposed North Water Reclamation Facility Infrastructure Improvement Plan was anticipated to be completed by December 2015.

### Meridian Metropolitan District

The Meridian Metropolitan District was formed in 1976 to serve development within the Meridian International Business Center. The District operates its own wastewater treatment plant, which also provides water and sewer service to two adjoining connectors (South Meridian and North Meridian Metropolitan Districts). The District has a Notice of Authorization (NOA) for the use and distribution of reclaimed water. The District applies treated effluent for irrigation purposes to a series of commercial customers. The District's NOA contains total phosphorus concentration limits at its point of compliance (after treatment, prior to discharge to a lined irrigation pond), as shown in Table 3-3 below.

In 2015, Meridian Metropolitan District amended its Notice of Authorization twice to include the delivery of reclaimed water to eight additional commercial sites in the Cherry Creek Basin for the purposes of irrigation.

### Stonegate Village Metropolitan District

Stonegate Village Metropolitan District provides wastewater services to Lincoln Park Metropolitan District, Compark Business Campus, and Potomac Metropolitan District. The Stonegate Village Metropolitan District is bounded by the Cottonwood Water and Sanitation District on the north, Jordan Road on the east, Chambers Road on the west, and north of Mainstreet to the South. This District began reconstruction of its wastewater treatment plant in June 2014 to better meet water quality standards in Cherry Creek. The Stonegate Village Metropolitan District's discharge permit contains total phosphorus and total inorganic concentration limits, as shown in Table 3-3 and Table 3-4 below. The facility discharges directly to Cherry Creek, and has a second permitted outfall that discharges to a storage facility, prior to use for irrigation.

### Plum Creek Water Reclamation Authority

The Plum Creek Water Reclamation Authority (PCWRA) is located outside the watershed but can apply some of its treated effluent as irrigation water within the Cherry Creek watershed. The District's discharge permit contains total phosphorus concentration limits, as shown in Table 3-3 below. The facility itself discharges directly to Plum Creek which is just west of the Cherry Creek basin.

## 3.1 Limits and Data Summary Requirements for Phosphorus and Nitrogen

In 2009 Regulation 72 was amended to include monitoring of nutrients, rather than only phosphorus. Previously, the main emphasis of watershed nutrient transport had been on the development of monitoring programs to provide information on the annual loads of phosphorus from various sources in the basin. The Commission expanded the monitoring requirements to include an emphasis on nitrogen as well as phosphorus. Thus, data on both phosphorus and nitrogen are included in this chapter where available.

Regulation 72 defines discharge limits for Total Phosphorus for various facilities, as shown in Table 3-2 below. There is no discharge limits required under Regulation 72 for nitrogen.

**TABLE 3-2: REGULATION 72 DISCHARGE LIMITS FOR PHOSPHORUS**

| Discharge | 30-Day Average[1] Total Phosphorus Limit (mg/L) |
|---|---|
| Wastewater Facilities/Industrial Process Wastewater Sources with Direct Discharges | ≤0.05 |
| Drinking Water Treatment Facilities (see section 3.6 of this report) | ≤ 0.2 |
| Discharges Using Land Application and Relying on a Return Flow Factor | ≤ 0.05[2] |
| Dischargers Using Land Application and Relying on Lysimeters | ≤ 1.0 |

1 Total phosphorus limit is a 30-day average, unless a 90-day average is approved by the Division at the request of the discharger

2 The 30-day flow-weighted average phosphorus concentration must be ≤ 0.05 mg/L total phosphorus divided by the land application return flow factor

Discharge limits for those using land applications are calculated using the volume of water land applied its concentration, plant and soil uptake rates, and return flows. For example, Stonegate Village Metropolitan District has a return flow factor of 20%. Therefore, its discharge phosphorus limit for outfall 001A is calculated to be 0.25 mg/L (0.05/0.20 = 0.25 mg/L: see footnote 2 to Table 3-2, above). Meridian Metropolitan District was issued an NOA under Regulation 84 – Reclaimed Water Control Regulation to reuse its treated effluent for irrigation by approved users. Meridian's discharge limits were calculated using a return flow factor of 10%, resulting in a limit of 0.50 mg/L phosphorus.

Current Colorado Discharge Permit System (CDPS) permits require all major WWTFs in the basin to monitor for phosphorus. Table 3-3 presents phosphorus concentration-based limits and 30-day average and maximum reported concentrations from October 2014 through September 2015 for the wastewater dischargers. Note that Meridian Metropolitan District's approved limit is a 90-day average (See footnote 1 to Table 3-2, above).

### TABLE 3-3: SUMMARY OF TOTAL PHOSPHORUS PERMIT LIMITS AND DATA 2015

| Facility | 30-day Avg. Total Phosphorus Limit (mg/L) (Note Meridian has a 90-day average) | Monitoring Requirements | Maximum Reported 30-day Avg. Total Phosphorus Concentration (mg/L) | Total Phosphorus Permit Limit Violation? (Yes/No) |
|---|---|---|---|---|
| **Arapahoe County Water & Wastewater Authority** | ≤ 0.05 | Monthly, mg/L | 0.05 | No |
| **Pinery Water & Sanitation District** | ≤ 0.05 | Monthly, mg/L | 0.047 | No |
| **Parker Water & Sanitation District** | ≤ 0.05 (Outfall 002A-NT: Combined North and South WRFs Discharge to Regional Reservoir) | 2 Days/Month, mg/L | .044 | No |
| | ≤ 0.05 (Outfall 003A: Combined North and South WRFs Discharge to Sulfur Gulch) | 2 Days/Month, mg/L | 0.040 | No |
| **Meridian Metropolitan District** | ≤ 0.5 [2] (90-day Avg) | Quarterly, mg/L | (no 30-day reporting requirements in NOA) [1] | No |
| **Stonegate Village Metropolitan District** | ≤ 0.25 [2] (Outfall 001A: Discharges to storage) | Monthly, mg/L | 0.05 | No |
| | ≤ 0.05 (Outfall 002A: Discharge to Cherry Creek) | Monthly, mg/L | 0.04 | No |
| **Plum Creek Water Reclamation Authority** | ≤ 0.05 (Outfall 007A: Cherry Creek Basin) | Monthly, mg/L | 0.03 | No |

1 Total phosphorus limit is a 30-day average, unless a 90-day average is approved by the Division at the request of the discharger

2 The flow-weighted average phosphorus concentration must be ≤ 0.05 mg/L total phosphorus divided by the land application return flow factor

Note, State and EPA records did not contain DMR for Meridian for September 2014.

Three wastewater treatment facilities in the basin currently have TIN limits of 10 mg/L in their discharge permits (Pinery, Parker, and Stonegate). Table 3-4 below shows TIN limits and reported 30-day average concentrations from October 2014 through September 2015 for the wastewater facilities.

## TABLE 3-4: SUMMARY OF TOTAL INORGANIC NITROGEN PERMIT LIMITS AND DATA 2015

| Facility | Daily Maximum Total Inorganic Nitrogen (TIN) Limit (mg/L) | Monitoring Requirements | Daily Maximum Reported Total Inorganic Nitrogen (TIN) Concentration (mg/L) | Nitrogen Permit Limit Violation? (Yes/No) |
|---|---|---|---|---|
| **Arapahoe County Water & Wastewater Authority** | (no TIN limit) | No Monitoring Requirement in the Cherry Creek Basin | -- | -- |
| **Pinery Water & Sanitation District** | 10 | 2 Days/Month | 9.43 | No |
| **Parker Water & Sanitation District** | 10 (Outfall 002A-NT Combined North and South WRFs Discharge to Regional Reservoir) | 3 Days/Week | 8.4 | No |
| | 10 (Outfall 003A Combined North and South WRFs Discharge to Sulfur Gulch) | 3 Days/Week | 7.9 | No |
| **Meridian Metropolitan District** | (no TIN limit) | No Monitoring Requirement in the Cherry Creek Basin | -- | -- |
| **Stonegate Village Metropolitan District** | 10 (Outfall 002A: Discharges to Cherry Creek) | 2 Days/Month | 6.63 | No |
| **Plum Creek Water Reclamation Authority** | (no TIN limit for discharges to Cherry Creek Basin from Outfall 007A) | No Monitoring Requirements in the Cherry Creek Basin | -- | -- |

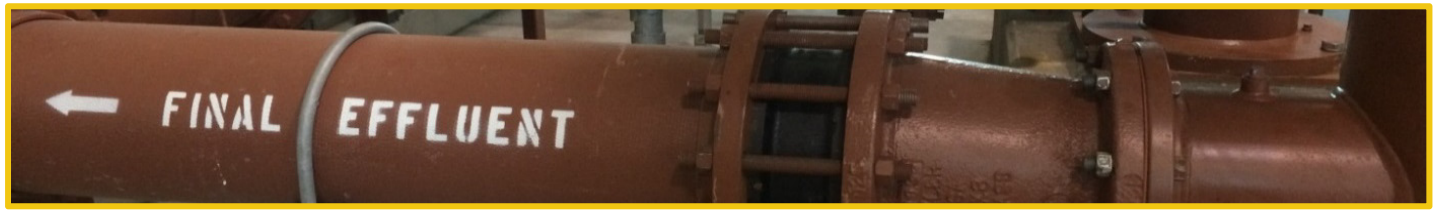
## 3.2 Monthly Phosphorus Concentrations

Table 3-5 summarizes monthly phosphorus concentrations in the effluent for each wastewater treatment plant, based on monthly Discharge Monitoring Reports (DMRs). For all reported values, all dischargers were consistently below their phosphorus discharge limits in Water Year (WY) 2015. In addition, all of dischargers are well below the average flow-weighted 0.200 mg/L phosphorus concentration goal for all inflows to the reservoir. The 0.200 mg/L value was determined by the Authority and the Commission to be the background concentration for phosphorus in the basin.

**TABLE 3-5: 2015 POINT SOURCE PHOSPHORUS MONTHLY CONCENTRATION**

| Month | Average Monthly Phosphorus Discharge Concentrations to Cherry Creek Basin | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Parker Water & San District | | | | Pinery Water & San District (monthly mg/L) | Stonegate Village Metropolitan District | | Plum Creek Water Recl Auth1 Outfall 007A (monthly mg/L) | Meridian Metro District (discharges to storage) (monthly mg/L) | Arapahoe County Water & Wastewater Auth (monthly mg/L) |
| | Outfall 002A-NT (mg/L) | | Outfall 003A (monthly mg/L) | | | Outfall 001A (discharges to storage) (monthly mg/L) | Outfall 002A (monthly mg/L) | | | |
| | Daily Max | 30-day Avg. | Daily Max | 30-day Avg. | | | | | | |
| Oct | 0.020 | 0.017 | 0.033 | 0.023 | 0.041 | 0.03 | 0.02 | 0.02 | Not Reported | 0.010 |
| Nov | 0.037 | 0.023 | 0.062 | 0.038 | 0.036 | 0.01 | 0.01 | 0.02 | Not Reported | 0.015 |
| Dec | 0.025 | 0.019 | 0.059 | 0.037 | 0.030 | No Discharge | 0.02 | 0.01 | N/A | 0.024 |
| Jan | 0.056 | 0.042 | 0.061 | 0.040 | 0.045 | No Discharge | 0.04 | 0.02 | Not Reported | 0.014 |
| Feb | 0.065 | 0.044 | 0.053 | 0.037 | 0.031 | No Discharge | 0.02 | 0.02 | N/A | 0.032 |
| Mar | 0.028 | 0.025 | 0.054 | 0.039 | 0.047 | No Discharge | 0.01 | 0.03 | N/A | 0.029 |
| Apr | 0.031 | 0.024 | 0.045 | 0.036 | 0.028 | No Discharge | 0.03 | 0.03 | N/A | 0.042 |
| May | 0.031 | 0.021 | 0.048 | 0.029 | 0.033 | 0.02 | 0.04 | 0.03 | Not Reported | 0.039 |
| Jun | 0.049 | 0.027 | 0.044 | 0.028 | 0.041 | 0.04 | 0.02 | 0.02 | N/A | 0.010 |
| Jul | 0.045 | 0.028 | 0.028 | 0.021 | 0.041 | 0.03 | No Discharge | 0.02 | Not Reported | 0.047 |
| Aug | 0.021 | 0.018 | 0.044 | 0.023 | 0.045 | 0.05 | No Discharge | 0.02 | Not Reported | 0.048 |
| Sep | 0.068 | 0.028 | 0.041 | 0.027 | 0.04 | 0.03 | No Discharge | 0.01 | N/A | 0.045 |

1The Plum Creek Wastewater Authority discharges in the Cherry Creek Reservoir watershed area through reuse irrigation.



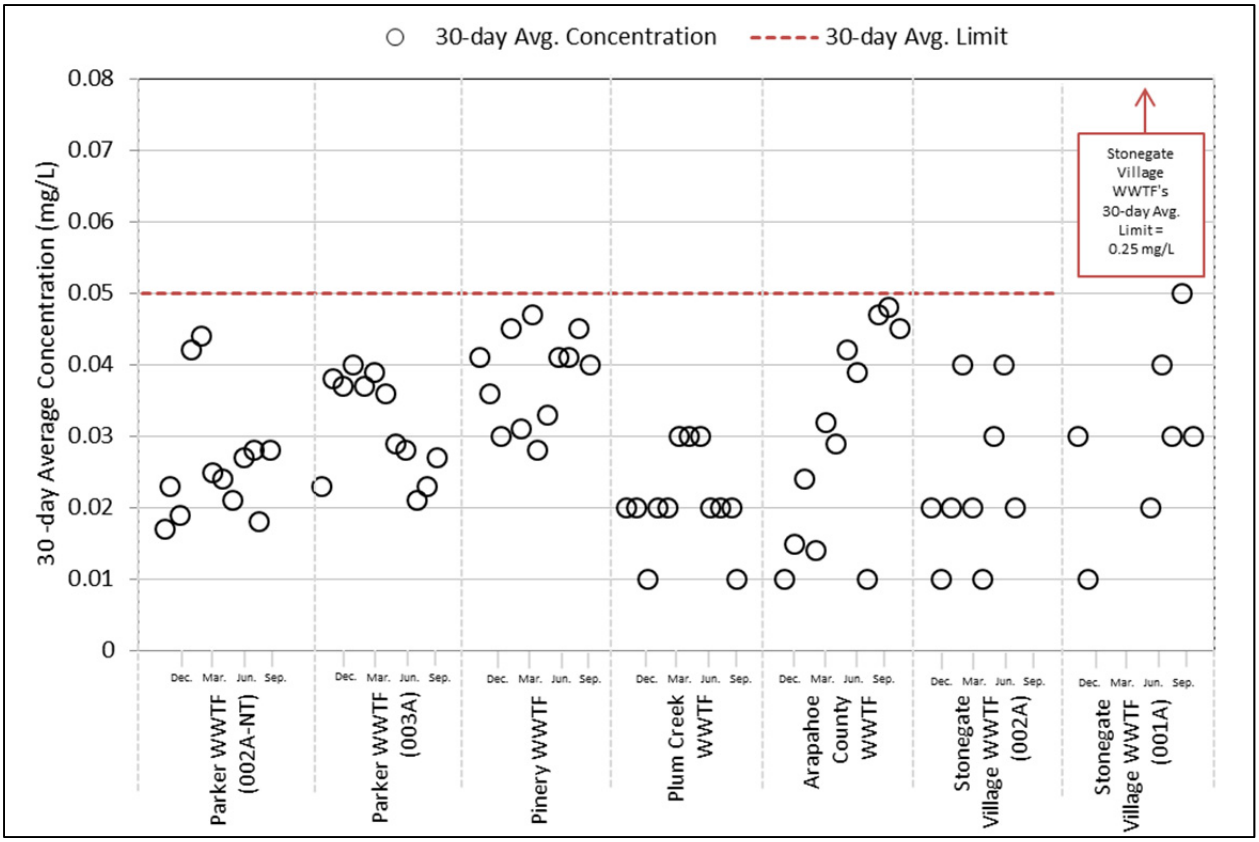



**FIGURE 3-1: 2015 SOURCE TOTAL PHOSPHORUS MONTHLY CONCENTRATIONS**

## 3.3 Monthly Nitrogen Concentrations

Table 3-6 and Figure 3-2 summarize the monthly total inorganic nitrogen concentrations in the effluent for each wastewater treatment plant that is required to monitor and report TIN in its monthly DMR. All facilities that had TIN discharge limits were in compliance with those limits in WY 2015.

**TABLE 3-6: 2015 POINT SOURCE TOTAL INORGANIC NITROGEN**

| Month | Average Monthly TIN Discharge Concentrations to Cherry Creek Basin | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Parker Water & San District | | Pinery Water & San District (monthly mg/L) | Stonegate Village Metropolitan District | | Plum Creek Water Recl Auth[1] (monthly mg/L) | Meridian Metro District (monthly mg/L) | Arapahoe County Water & Wastewater Auth (monthly mg/L) |
| | Outfall 002A-NT (monthly mg/L) | Outfall 003A (monthly mg/L) | | Outfall 001A (monthly mg/L) | Outfall 002A (monthly mg/L) | | | |
| **Oct** | 7.08 | 6.6 | 7.95 | N/A | 3.7 | N/A | N/A | N/A |
| **Nov** | 6.98 | 7.9 | 8.52 | N/A | 6.6 | N/A | N/A | N/A |
| **Dec** | 8.40 | 7.2 | 6.38 | N/A | 4.9 | N/A | N/A | N/A |
| **Jan** | 7.17 | 7.8 | 7.91 | N/A | 3.0 | N/A | N/A | N/A |
| **Feb** | 7.58 | 0.9 | 9.43 | N/A | 5.4 | N/A | N/A | N/A |
| **Mar** | 6.20 | 7.7 | 8.01 | N/A | 3.2 | N/A | N/A | N/A |
| **Apr** | 6.46 | 7.4 | 6.97 | N/A | 4.6 | N/A | N/A | N/A |
| **May** | 6.37 | 5.9 | 7.53 | N/A | 5.4 | N/A | N/A | N/A |
| **Jun** | 5.95 | 6.0 | 6.434 | N/A | 6.6 | N/A | N/A | N/A |
| **Jul** | 6.59 | 6.6 | 5.94 | N/A | No Discharge | N/A | N/A | N/A |
| **Aug** | 7.12 | 7.4 | 8.33 | N/A | No Discharge | N/A | N/A | N/A |
| **Sep** | 6.02 | 7.6 | 7.14 | N/A | No Discharge | N/A | N/A | N/A |

1The Plum Creek Water Reclamation Authority discharges to the Cherry Creek basin through reuse irrigation.

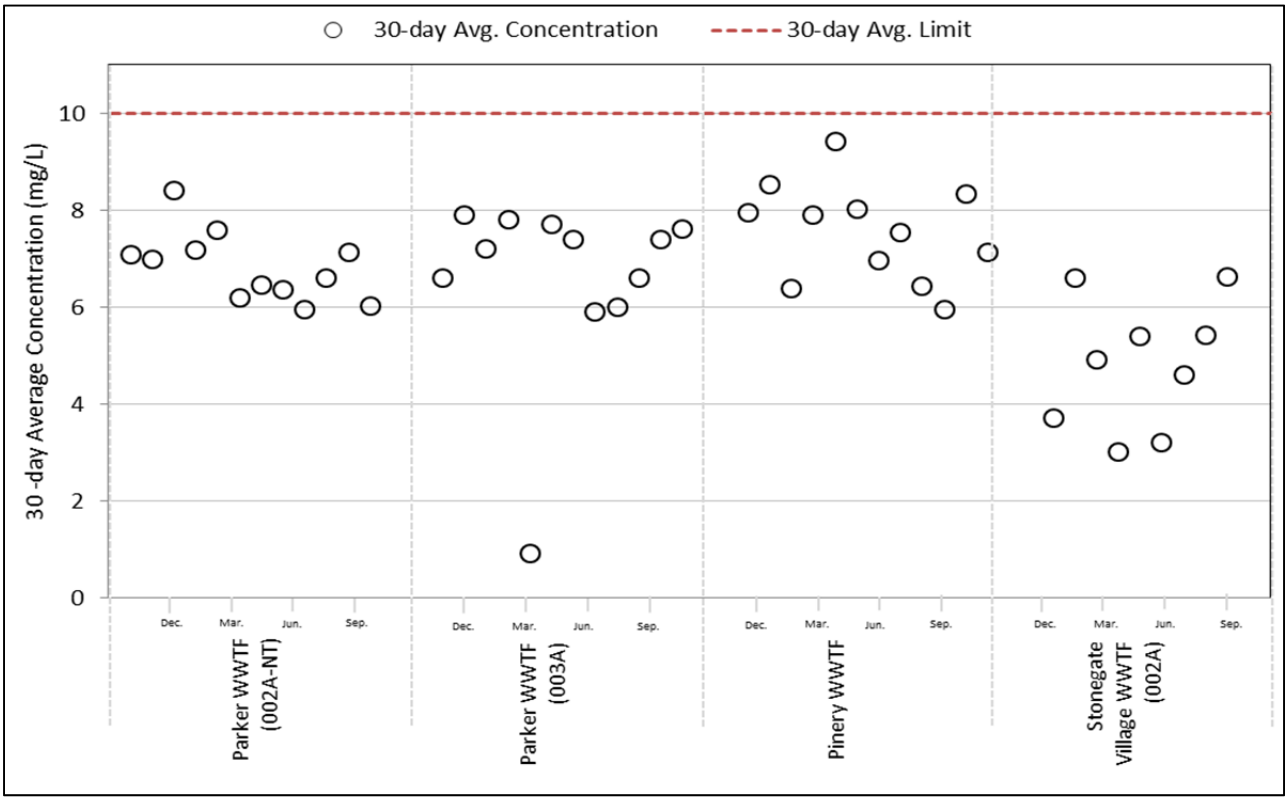



**FIGURE 3-2: 2015 POINT TOTAL INORGANIC NITROGEN MONTHLY CONCENTRATIONS**

## 3.4 Permit Compliance

Regulation 72 requires that the Annual Report identify wastewater facility permit violations. In 2015, no permits were in violation of phosphorus concentration limits. All wastewater treatment facilities were within the effluent limits included in their permits. The wastewater treatment facilities are removing substantial amounts of phosphorus, especially the forms of phosphorus that are readily available for algal or bacterial uptake in the reservoir; i.e., soluble reactive phosphorus (SRP). The WWTFs with TIN limits were also in compliance during 2015.

## 3.5 Permit Renewal Timing and Process

CDPHE prepares permit work plan schedules for the renewal of general and individual permits. The renewal of individual permits for the South Platte River Basin dischargers is expected to occur in 2016. Table 3-7 and Table 3-8 show the anticipated General Permit Work Plan Schedule for permits that are typically issued in the Cherry Creek watershed and that aren't discussed in other portions of this report (e.g., domestic wastewater treatment facility individual permits and MS4 discharge permits).

## TABLE 3-7: WORKPLAN SCHEDULE FOR RENEWAL OF GENERAL AND INDIVIDUAL PERMITS – SEWAGE SYSTEMS SECTORS

| General Permit Name | Permit Number | Expires[1] | Planned Renewal Year[2] | Phosphorus Limits and/or Phosphorus Monitoring Included? |
|---|---|---|---|---|
| **Sewage Systems Sector** | | | | |
| **Domestic Waste Water Treatment Plant with Chronic Low Flow Design** | COG588000 | 2018 | 2019 | Permit states: "Total Phosphorous limits will be established and included in the certification, where applicable, and will be based on the applicable [control] regulation (Regulation Nos. 71-74). The limits and reporting requirements, where applicable, will be fully enforceable under this permit." |
| **Domestic Waste Water Treatment Facilities** | COG589000 | 2018 | 2019 | Permit states: "Total Phosphorous limits will be established and included in the certification, where applicable, and will be based on the applicable [control] regulation (Regulation Nos. 71-74). The limits and reporting requirements, where applicable, will be fully enforceable under this permit." |
| **Domestic Septic Treatment Systems** | COX620000 | 2006 | --- | (This permit is no longer available on the WQCD website; it is being phased out in 2016.) |
| **Domestic Onsite Systems ISDS** | COX621000 | 2012 | 2017 | There are no phosphorus effluent limitations included in this permit. |
| **Domestic Onsite Systems OWTS - No Groundwater Monitoring Requirements** | COX622000 | 2012 | 2018 | There are no phosphorus effluent limitations included in this permit. |
| **Domestic Discharges Land Disposal** | COX631000 | 2012 | 2016 | There are no phosphorus effluent limitations included in this permit. |
| **Domestic Discharges Land Treatment** | COX632000 | 2012 | 2018 | There are no phosphorus effluent limitations included in this permit. |
| **Domestic Discharges Land Treatment Agronomic Rate** | COX633000 | 2012 | 2018 | There are no phosphorus effluent limitations included in this permit. |
| **Domestic Land Treatment New** | COX634000 | new | 2015 | (This permit is not available yet on the WQCD website.) |

1 Permits Expiration Year - When a general permit expires and is not renewed, it is Administratively Continued, allowing coverage under that general permit to continue until the renewed permit is issued.

2 Planned Renewal Year - This designates the year in which the Division plans on renewing a general permit. The actual completion of the renewal depends on time restraints, resource availability, and emergency requests or requirements.

3 Permit will be converted to a new general permit. This permit will be terminated when all certifications have been moved to the new general permit.

4 The Division has completed Phase I of renewing this permit, and is currently in Phase II. It is anticipated that the permit will be renewed

## TABLE 3-8: WORKPLAN SCHEDULE FOR RENEWAL OF GENERAL AND INDIVIDUAL PERMITS – CONSTRUCTION, COMMERCE, AND INDUSTRY SECTOR

| General Permit Name | Permit Number | Expires[1] | Planned Renewal Year[2] | Phosphorus Limits and/or Phosphorus Monitoring Included? |
|---|---|---|---|---|
| **Construction Sector** | | | | |
| **Construction Dewatering** | COG070000 | 2018 | 2019 | Only monitoring and reporting for phosphorus is required in the effluent limits table; however, the associated footnote indicates, "In accordance with the Cherry Creek Reservoir Control Regulation (Regulation 72), monitoring and compliance with the Total Phosphorus chronic numeric effluent limit of 0.05 mg/l is required." These statements are conflicting, and should be amended to ensure limits apply. |
| **Stormwater Construction** | COR030000 | 2012 | 2016 | Stormwater construction permits require a SWMP, BMPs, prohibitions of non-stormwater discharges, and other requirements. There are no numeric effluent limitations, including phosphorus. |
| **Commerce and Industry (non-mining) Sector** | | | | |
| **Commercial Washing of Outdoor Structures** | COG607000 | 2012 | 2017 | Daily maximum phosphorus limit of 0.05 mg/L, with footnote: "Monitoring and/or numeric effluent limits may apply to discharges to watersheds with a control regulation for Phosphorus." |
| **Subterranean Dewatering or Well Development** | COG603000 | 2018 | 2019 | Permit states: "In accordance with the Cherry Creek Reservoir Control Regulation (Regulation 72), monitoring and compliance with the Total Phosphorus chronic numeric effluent limit of 0.05mg/l is required." |
| **Water Treatment Plant — Wastewater Discharge** | COG641000 | 2010 | 2016 | For waters with a control regulation for phosphorus, permit contains monitoring & reporting only for total phosphorus; no effluent limits for TP are included. This is contrary to Regulation 72.4.2, which requires TP limits of 0.20 mg/L for drinking water facilities. |
| **Non-contact Cooling Water** | COG605000 | 2013 | TBD | For waters with a control regulation for phosphorus, permit contains monitoring & reporting only for total phosphorus; no effluent limits for TP are included. This is contrary to Regulation 72.4.1, which requires a 0.05 mg/L total phosphorus effluent limit for all industrial process wastewater discharges. |
| **Non Extractive Industries Storm Water** | COR900000 | 2017 | 2017 | The only phosphorus limits included with this permit are derived from Effluent Limitation Guidelines (for Agricultural Chemicals and Phosphate Fertilizer Manufacturing). Permit also states: "the Division may include a site specific water quality-based effluent limitation in the permit certification". |
| **Commerce and Industry (mining) Sector** | | | | |
| **Sand & Gravel Mining – Wastewater and Stormwater Combined** | COG500000 | 2013 | TBD | Permit states: "Phosphorus limitations apply to discharges to the Cherry Creek Reservoir Watershed, as defined in Regulation 72." For all industrial process wastewater, a 0.05 mg/L total phosphorus effluent limit is required (Regulation 72.4.1). |

From the table above, it is noted that the current Water Treatment Plant (wastewater discharges), Permit COG641000 is inconsistent with Regulation 72. The permit, which is scheduled for renewal in 2016, only requires monitoring and reporting for phosphorus, while Regulation 72 requires a permit limit of 0.2 mg/L for total phosphorus. This limit should be included in the 2016 draft permit for facilities in the Cherry Creek basin.

The same applies to the Non-contact Cooling Water permit (COG605000), which also only requires monitoring and reporting for phosphorus. A total phosphorus limit of 0.05 mg/L should be included in the new permit for facilities in the Cherry Creek basin.

The latest general construction dewatering permit (COG070000), issued July 24, 2014, contains footnote #4 (page 10 of 34), which states: "Analysis for Total Phosphorus, as P, will be included in the permit certification for all discharges to waters with a control regulation for P. In accordance with the Cherry Creek Reservoir Control Regulation (Regulation 72), monitoring and compliance with the Total Phosphorus chronic numeric effluent limit of 0.05 mg/l is required." However, footnote #4 appears inconsistent with the language in Table B.1 of the permit, which indicates that total phosphorus is a "report only" parameter. This should be clarified in the permit. All construction dewatering permits issued under the new permit should include the phosphorus limits and monitoring requirements for dischargers in the Cherry Creek basin, consistent with the footnote.

## 3.6 Other Point Source Discharge Permits in the Watershed

There were 31 other permitted point source discharges that were authorized to discharge in the watershed in 2015. These were identified using EPA's Enviromapper, Integrated Compliance Information System (ICIS), and Enforcement and Compliance History Online (ECHO) databases for CDPS-permitted facilities with general permits active during 2015. Administratively-continued permits were also included. Table 1 shows the various types of other permits found within the watershed.

## TABLE 3-9: TYPES AND NUMBERS OF ACTIVE CDPS PERMITS WITHIN THE WATERSHED IN 2015

| Permit No. | Facility Name | Permit Type | 2015 Total Phosphorus Concentration Range (mg/L) |
|---|---|---|---|
| COG641168 | Rueter-Hess Water Treatment Plant | Water Treatment Plant – Wastewater Discharges | 0.011 – 0.03 mg/L |
| COG641142 | Stonegate Village Metro District Water Treatment Facility | Water Treatment Plant – Wastewater Discharges | No discharge |
| COG603245 | Rueter-Hess Water Treatment Plant | Subterranean Dewatering or Well Development | 0.15 mg/L |
| COG603267 | Replacement Alluvial Aquifer Well 4 | Subterranean Dewatering or Well Development | No discharge |
| COG603027 | Parker Water & Sanitation District Drinking Water Wells | Subterranean Dewatering or Well Development | <0.01 – 0.218 mg/L |
| COG603282 | East Cherry Creek Valley Well A-1 | Subterranean Dewatering or Well Development | No discharge |
| COG500495 | Pioneer Clay Mine | Sand & Gravel Mining – Wastewater & Stormwater | No discharge |
| COG605034 | Nissan North America Data Center | Non-contact Cooling Water | No discharge |
| COX621105 | Direct TV Castle Rock Broadcast Center | Domestic On-site Wastewater Treatment Systems (≥ 2,000 gpd) | All lysimeters dry |
| COG072642 | Parker North WRF | General Permit-Covered Facility | No discharge |
| COGO73345 | Parker South WRF | General Permit Covered Facility | No discharges |

Numerous stormwater construction permits are issued every year, but it is difficult to readily obtain a total number from EPA's databases. However, through an extensive search of Enviromapper data, it was determined that there were 43 stormwater construction permit certifications that were active during 2015 for just the 12-digit HUC boundary closest to the reservoir, see pink area on the map below. The number of stormwater construction permits was not determined for the blue area.

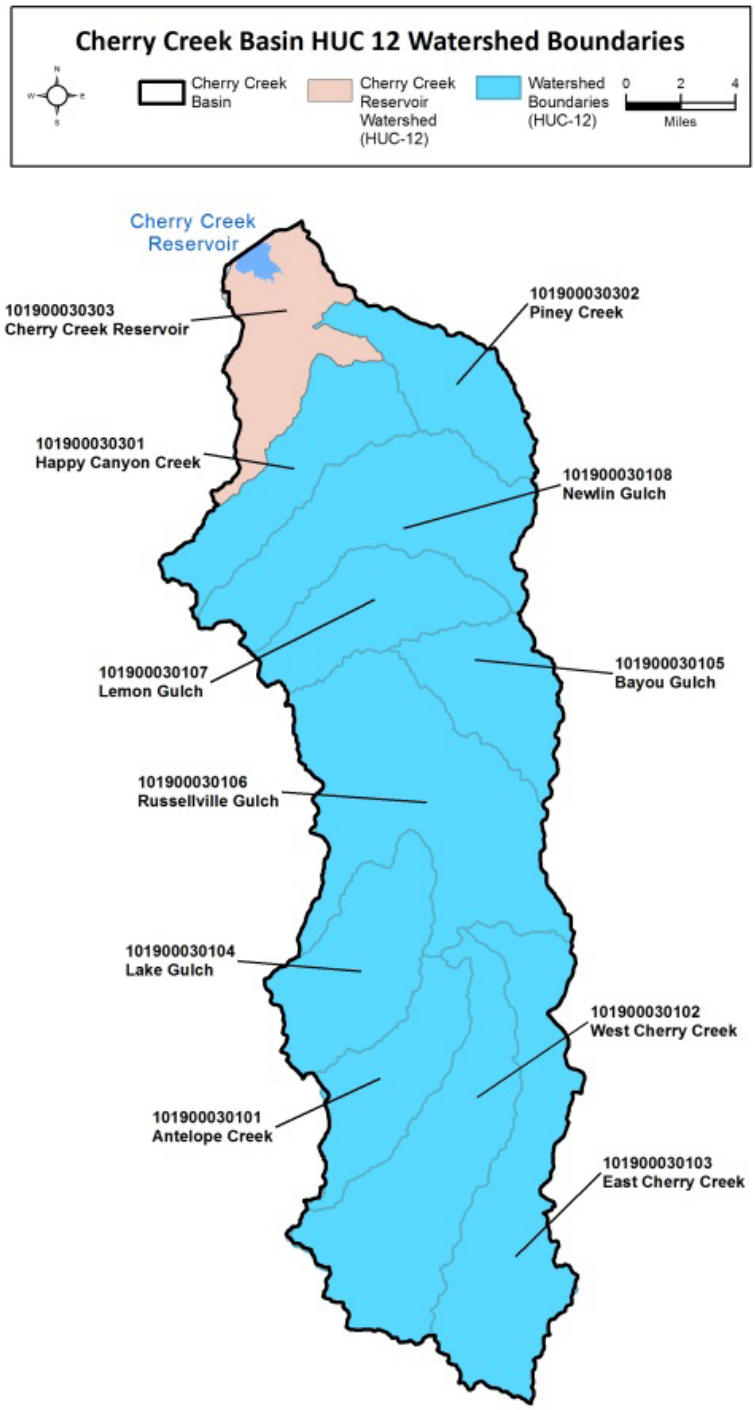



**FIGURE 3-3: CHERRY CREEK BASIN 12-DIGIT HUC BOUNDARIES.**

Table 3-10 summarizes the reported phosphorus concentrations in other permitted dischargers in the basin. This information give an indication of the type of operations occur in the basin.

**TABLE 3-10: TOTAL PHOSPHORUS CONCENTRATION RANGES REPORTED IN 2015 BY OTHER PERMITTED POINT SOURCE DISCHARGERS IN THE CHERRY CREEK BASIN**

| Permit No. | Facility Name | Permit Type | Total Phosphorus Concentration Range (mg/L) |
|---|---|---|---|
| COG641168 | Rueter-Hess Water Treatment Plant | Water Treatment Plant – Wastewater Discharges | 0.011 - 0.03 mg/L |
| COG641142 | Stonegate Village Metro District Water Treatment Facility | Water Treatment Plant – Wastewater Discharges | No discharge |
| COG603245 | Rueter-Hess Water Treatment Plant | Subterranean Dewatering or Well Development | 0.15 mg/L |
| COG603267 | Replacement Alluvial Aquifer Well 4 | Subterranean Dewatering or Well Development | No discharge |
| COG603027 | Parker Water & Sanitation District Drinking Water Wells | Subterranean Dewatering or Well Development | <0.01 - 0.218 mg/L |
| COG603282 | East Cherry Creek Valley Well A-1 | Subterranean Dewatering or Well Development | No discharge |
| COG500495 | Pioneer Clay Mine | Sand & Gravel Mining – Wastewater & Stormwater | No discharge |
| COG605034 | Nissan North America Data Center | Non-contact Cooling Water | No discharge |

During 2015, there was also one drinking water treatment plant with an individual permit in the Cherry Creek basin, which included a 30-day average total phosphorus discharge limit of 0.2 mg/L, as required by Regulation 72. Arapahoe County Water and Wastewater Authority/Cottonwood Joint Water Purification Plant (CO0047589) discharges waste backwash water from its water purification plant to Windmill Creek. This permit was amended in 2010 to incorporate the phosphorus limit of 0.2 mg/L, consistent with the new Regulation 72 limit. In 2015, the facility reported no discharge for all reporting periods.

## 3.7 Graywater Control

As a result of the 2013 legislation to allow graywater use in Colorado, the Water Quality Control Commission adopted a Graywater Control Regulation (Regulation 86) on May 11, 2015 (effective December 30, 2015). Graywater is a portion of the water used in a residential, commercial, or industrial building that may be collected after the first use and put to a second beneficial use. Regulation 86 outlines requirements, prohibitions, and standards for graywater use for nondrinking purposes. Graywater sources may include water discharged from bathroom and laundry-room sinks, bathtubs, showers, and laundry machines. These sources may contribute additional nutrients to the basin.

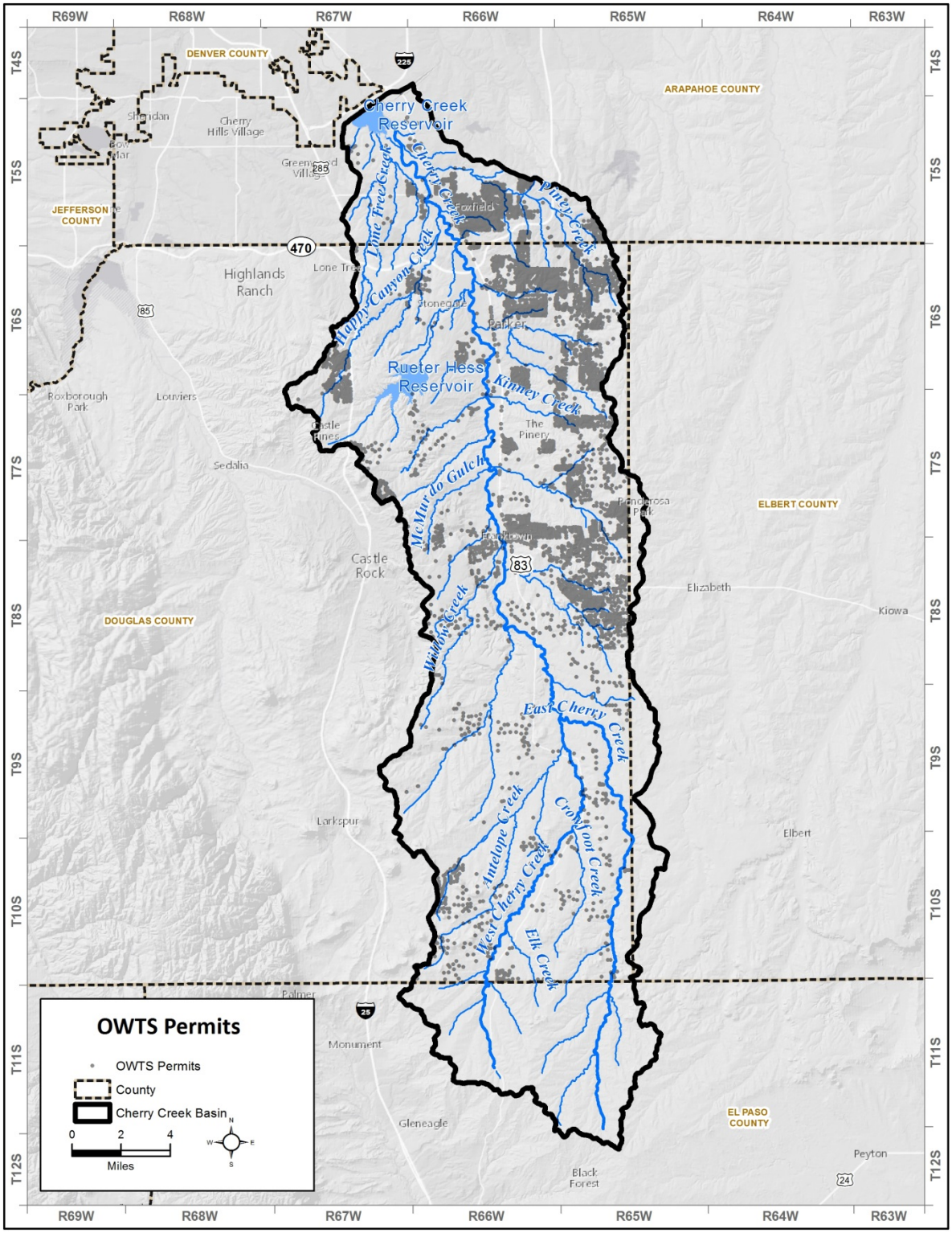
Regulation 86 requires that irrigation using graywater must be adjusted so that the application rates are closely matched with soil and weather conditions. The user must be mindful that the required amount of graywater and nutrients will change over time and therefore the graywater application rate must be adjusted. In addition, graywater must be applied in a manner that does not result in ponding, runoff, or unauthorized discharge to state waters, and must be applied at an agronomic rate.

Each local city or municipality, city and county, or county can decide whether or not to allow graywater use within its jurisdiction via the adoption of a resolution or ordinance. The Authority participated in the public meeting process and attended stakeholder meetings to assess potential impacts to the basin.

## 3.8 Onsite Wastewater Treatment Systems

The Authority is currently assessing the effects of total phosphorus and total nitrogen loading from the watershed through its reservoir model. The reservoir model will help the Authority better understand the relationship of total phosphorus and total nitrogen loading to the reservoir and assess the importance of phosphorus and nitrogen ratios. The results of the watershed model combined with the current understanding of loading contributions from the Authority's 2013 phosphorus and nitrogen estimate study will be used to help guide the Authority in the management of the watershed, and to better understand the significance of nutrient loading from onsite wastewater treatment systems.

Map 3-3 shows permitted onsite wastewater treatment systems in the basin. It is informative to compare Map 3-3 (showing OWTS coverage) with Map 3-1 (showing areas served by wastewater treatment plants).




**MAP 3-3: ONSITE WASTEWATER TREATMENT SYSTEMS**

## 3.9 Authority's Role in Site Application Process

In 2015, the Authority continued to review Applications for Site Location Approval (A.K.A., "site applications) for wastewater facilities. Wastewater facilities required to submit site applications include:

- new domestic wastewater treatment facilities;
- existing wastewater treatment facilities increasing or decreasing its design capacity;
- facilities constructing or expanding interceptor sewers not eligible for certification; and
- facilities constructing lift stations

CDPHE reviews wastewater facilities and must approve the facility prior to the start of construction. The process CDPHE uses for approval of wastewater facilities includes site applications, process design reports, basis of design reports, and final design documents. CDPHE only requires approval signatures from outside agencies such as the Cherry Creek Basin Water Quality Authority during the site application portion of the approval process. The site application is designed to collect information about the site, owner, operator, and a 30 percent concept design.

The Authority's directive to review site applications that are submitted within the Cherry Creek Basin stems from Section 208 of the Clean Water Act. Site applications for wastewater facilities are to be reviewed by 208 planning agencies designated by the Governor of Colorado. The 208 planning agency that serves the Cherry Creek Basin (the Denver Regional Council of Governments) is not currently active in Water Quality Planning, and is therefore not currently reviewing site applications for wastewater facilities. The Governor previously approved the Authority as the designated Management Agency for the Cherry Creek Basin. Thus, the Authority reviews on all site applications except for 208 planning agency-certified interceptors and site application amendments for a disinfection change only. An in-kind replacement also does not require a site application as long as it does not increase or decrease capacity.

The Authority focuses its review of site applications on the potential for an illicit discharge from the facility. The Authority's review is guided by the Authority's "Cherry Creek Basin Reservoir Watershed Site Application Review Process Emergency Response Plan Criteria." The review identifies;

- the purpose and background of the facility;
- potential overflow causes;
- operation and maintenance practices;
- features to prevent overflows; and
- the emergency preparedness plan.

Due to the difficulty of reviewing all of the above items with just a 30 percent concept level, correspondence is usually required with the design engineer. In most cases, a conditional approval is provided based on the conceptual level of the plans provided and recommendation regarding items need in the final design. The Authority also reviews the site applications for additional requirements set forth in the Authority's Emergency Response Plan Criteria.

### 3.9.1 Approved Site Applications

As the designated regional water quality management agency for the Cherry Creek Reservoir watershed, the Authority reviews site applications for domestic wastewater treatment works, including lift stations. Reviews of site location applications address protection of Cherry Creek Reservoir and the watershed with respect to phosphorus and nitrogen, general water quality, protection of downstream water quality to protect water supplies, and adequacy of proposed design processes and capacity to protect water quality. As required by Regulation 72, the Authority must report on approved site applications annually.

**Applications for Site Location Approval are reviewed in conformance with the following documents:**

- Cherry Creek Reservoir Control Regulation 72;
- Emergency Response Plan Criteria for the Cherry Creek Reservoir Watershed (Authority, March 2002);
- Regulation 22, "Site Location and Design Approval Regulations for Domestic Wastewater Treatment Works" (Commission, September 2009);
- Metro Vision Clean Water Plan: "Wastewater Utility Plan Guidance" (Denver Regional Council of Governments, March 2007); and
- Policy WPC-DR-1, "Design Criteria for Domestic Wastewater Treatment Works" (Colorado Water Quality Control Commission, effective Date: September 15, 2012).

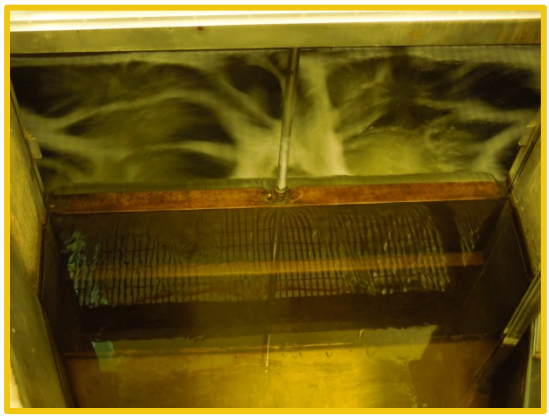
In 2015, five site applications were received by the Authority. The first site application was submitted by Castlewood Water and Sanitation District for Havana Street Lift Station retrofit. The existing lift station is located at the corner of S. Havana Street and E. Arapahoe Road. The lift station modifications included upgrade of the electrical service, upgrade of the standby power and addition of 27,133 gallons of overflow storage. The lift station is designed to convey wastewater from an existing development through an existing force main under Arapahoe Road to an existing sanitary sewer outside of the Cherry Creek Basin. After review of the site application, the Authority provided a conditional approval provided that: valve exercising be added to the maintenance plan, differential flow metering be placed on the force main, and the emergency response plan be updated to provide further detail in case of an emergency.

The second site application was submitted by Stonegate Village Metropolitan District (SVMD) for the Reclaimed Water Conveyance Project to convey wastewater effluent from the SVMD wastewater treatment facility to Rueter-Hess Reservoir as a water rights exchange for Cherry Creek surface water. The proposed lift station will be located at the Parker Water and Sanitation District's South Water Reclamation Facility. After review of the site application, the Authority determined that since this application was for a "pumpback" line for treated wastewater that the impact or potential impact to water quality was not readily apparent. Therefore, the Authority identified this application as a unique

situation for which the Authority has no established guidelines, and developed site-specific recommendations regarding the differential flow monitoring requirements.

The third application was submitted by RidgeGate development for the 1st Street Lift Station that will serve a portion of RidgeGate's 3,500 acre planned development district. That portion of the district that will be served by this lift station is estimated to include 12,327 single family equivalents. Phase 1 of the development will require the lift station to meet a peak demand of 2.44 MGD. The ultimate build out capacity will be 10.1 MGD. The lift station is being designed with an initial capacity of 5.0 MGD. Flows are conveyed to an existing Parker Water and Sanitation District's North Water Reclamation Facility gravity interceptor. After review of the site application, the Authority provided a conditional approval dependent upon: adding alarm testing to the operation and maintenance plan, increasing the proposed emergency overflow storage to allow the first responder time to evaluate and remedy the situation, incorporating the needed information into the emergency response plan, and ensuring that the force main differential flow measurement is included in the final design.

The fourth application was submitted by RidgeGate development for the Havana Street Lift Station that will serve a portion of RidgeGate's 3,500 acre planned development district. That portion of the district that will be served by this lift station is estimated to include 5,712 single family equivalents. The ultimate build out capacity will be 3.66 MGD. Phase 1 of the development will require the lift station to meet a peak demand of 1.12 MGD. The lift station is being designed with an initial pumping capacity of 1.83 MGD with provisions to expand to 3.66 MGD. After review of the site application, the Authority provided a conditional approval dependent upon: adding alarm testing to the operation and maintenance plan, increasing the proposed emergency overflow storage to allow the first responder time to evaluate and remedy the situation, incorporating the needed information into the emergency response plan, and ensuring that the force main differential flow measurement is included in the final design.



The fifth application was submitted by Kings Point Development Company for the Kings Point East Lift Station that will serve an area including approximately 944-acres and approximately 749 single family equivalents. The lift station is located south of E. Long

Avenue on the east side of Antelope Creek and will convey wastewater to Aurora's existing gravity system located east of the proposed lift station in Dry Creek Road. The lift station capacity is designed for 546 gpm. After review of the site application, the Authority provided a conditional approval dependent upon: confirming the proposed emergency overflow storage has sufficient capacity to allow the first responder time to evaluate and remedy the situation, incorporating the needed information into the emergency response plan, and ensuring that the force main differential flow measurement is included in the final design.

## 3.10 Effectiveness in Reducing Nutrient Concentrations

The control requirements placed on the point source dischargers described above were effective in reducing or controlling phosphorus concentrations to the watershed and reservoir. All wastewater treatment plants met their phosphorus discharge limits, which are designed to help meet the reservoir standard and the requirements of Regulation 72. In addition, wastewater treatment facilities that have total inorganic nitrogen limits in their permits also met their limits in 2015.

It is also noted that the required effluent limits for total phosphorus concentrations discharging from wastewater facilities and industrial process wastewater sources (i.e., for most dischargers, less than 0.05 mg/L total phosphorus concentration as a 30-day average) are significantly less than the flow-weighted total phosphorus concentrations currently entering the reservoir. Actual concentrations discharged by wastewater treatment plants were consistently below their limits and well below the 0.200 mg/L flow-weighted phosphorus concentration goal.

Several recommendations regarding the need for phosphorus limits in general permits when they are renewed are discussed above in Section 3.5.

# 4 REGULATED STORMWATER SOURCE CONTROLS

Regulated stormwater is stormwater runoff that discharges to State Waters (including reservoirs, streams, and groundwater) from regulated entities, such as commercial and industrial facilities, and municipal separate storm sewer systems (MS4s). MS4s are storm sewer systems that are owned or operated by a state, city, town, county, district, or association having jurisdiction over stormwater management.

There is one MS4 with an individual permit in the Cherry Creek Basin, the City of Aurora. There are eight permittees covered by the general MS4 permit (COR080000) for discharges in the Cherry Creek basin.

**MS4s Covered by the General Permit COR080000**

- Arapahoe County
- Douglas County
- SEMSWA (City of Centennial)
- City of Greenwood Village
- City of Lone Tree
- City of Castle Pines
- Town of Castle Rock
- Town of Parker

Non-standard MS4s are regulated separate storm sewer systems that discharge from entities other than municipalities and counties (e.g., State Parks, metropolitan districts). There are 11 non-standard MS4s permitted within the Cherry Creek basin.

**Non-Standard MS4s**

- Goldsmith Metro District MS4
- Cherry Creek School District MS4
- Cherry Creek State Park MS4
- Greenwood South Metro District MrS4
- Lincoln Park Metro District MS4
- Meridian Metro District MS4
- Castle Pines Metro District MS4
- Castle Pines North Metro District MS4
- Douglas County School District MS4
- Heritage Hills Metro District MS4
- Stonegate Village Metro District MS4

These entities are covered by COR070000, which expired on March 9, 2013, and was administratively extended. The Colorado Department of Transportation also has an MS4 permit.

Regulated stormwater sources are subject to the Colorado Discharge Permit System Regulations (Regulation 61). Larger sources are regulated under the EPA's Stormwater Phase I Rule (1990), which covers entities with populations over 100,000 and other significant dischargers. The City of Aurora and CDOT were the only Cherry Creek Basin entities that were included under Phase I. In 1999, the Stormwater Phase II Rule expanded the Phase I Rule to include several of the land use agencies that are part of the Authority. The Phase II Rule requires small MS4s to, at a minimum, adopt BMPs for six minimum control measures, implement them to the maximum extent practicable (MEP),

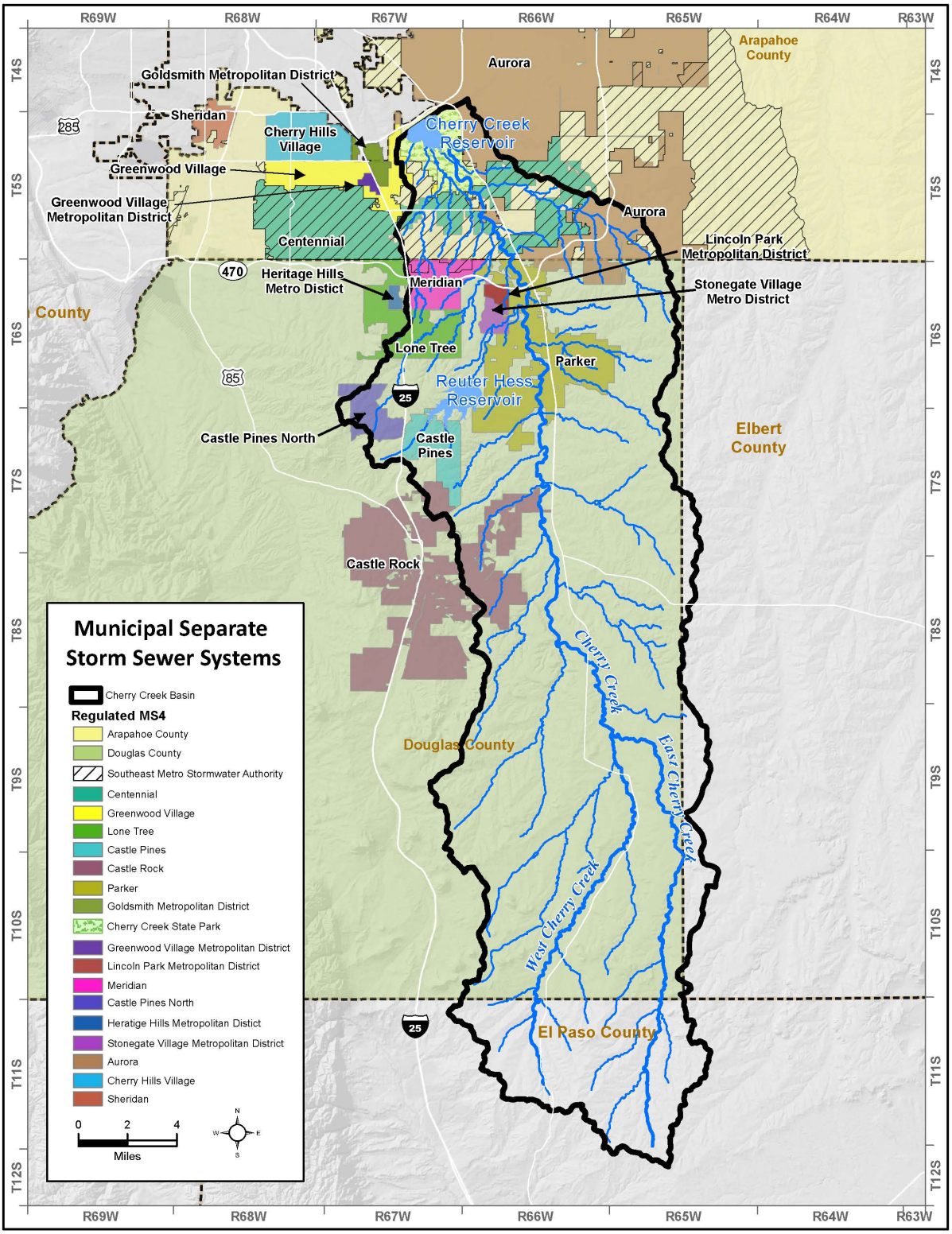
identify measurable goals for control measures, show an implementation schedule of activities or frequency of activities, and define the entity responsible for implementation. These requirements fit closely with the current programs in the Cherry Creek watershed as required by Regulation 72.

The six minimum requirements are:

- Public education and outreach
- Public involvement/participation
- Illicit connections and discharge detection and elimination
- Construction site stormwater runoff control
- Post-construction stormwater management in development/redevelopment
- Pollution prevention/good housekeeping for municipal operations

Phase II MS4s in the Cherry Creek Basin currently have coverage under General Permit COR080000, "Stormwater Discharges Associated with Cherry Creek Reservoir Drainage Basin Municipal Separate Storm Sewer Systems". This permit expired in 2013 and has been administratively continued. This permit incorporates relevant requirements of Regulation 72. More detailed information on implementation for each Phase II MS4 permittee can be found in the Stormwater Annual Reports that Phase II MS4s are required to submit to the Division by March 10th of every year. Phase II MS4 permittees must conduct an annual review of their stormwater programs including an assessment of compliance with measurable goals for each of the six program areas, the results of any monitoring, and plans for stormwater activities in the next year.

Regulation 72 also spells out several requirements that are in addition to Regulation 61 requirements. These additional requirements apply to regulated stormwater discharges. These include stringent watershed-specific requirements for MS4 permits, including public education and outreach efforts that target nutrient sources, detailed construction site controls, and tiered post-construction stormwater management requirements for new development and redeveloped areas, with special requirements for stream preservation areas (§72.7).




**MAP 4-1: STANDARD AND NON-STANDARD MUNICIPAL SEPARATE STORM SEWER SYSTEMS (NOTE: SCHOOL DISTRICTS MS4S NOT SHOWN ON MAP)**

## 4.1 Cherry Creek MS4 General Permit Renewal Process

CDPHE is still in the process of renewing the Cherry Creek Basin (COR080000) and Standard (COR090000) MS4 permits, which expired in 2013. Comments on the first draft of the permits were still under review by the CDPHE at the beginning of 2016. The second draft of the permit and fact sheet were released on May 1, 2015 including a separate permit and fact sheet for the Cherry Creek Basin. The public notice and comment period ended on June 30, 2015. During the comment period, CDPHE hosted several meetings and work sessions to review the changes from the first draft. The Authority participated in the meetings and work sessions for both permits and provided input on second draft to CDPHE. At the end of 2015, CDPHE was still in the process of addressing comments on the second draft of the permits and the fact sheets. No date has been given yet for when the final permits will be issued.

## 4.2 Sediment and Erosion Control Permits

Regulation 72 requires that an Erosion and Sediment Control Plan (ESCP) must be submitted to and approved by the local MS4 entity. All land use agencies in the basin require that an erosion and sediment control plan be approved prior to the start of any new land-disturbance activity. Land-disturbance activities include clearing, grading, or excavation of land; construction, expansion, or alteration of a residential, commercial, or industrial site or development; and construction of public improvements and facilities (e.g., roads, airports, and schools). Erosion and sediment control requirements during construction under the stormwater Phase I and II requirements are complementary to the programs required under Regulation 72.

## 4.3 Adoption and Implementation of BMPs by Local Governments

All MS4s in the watershed have adopted stormwater regulations setting requirements for construction and post-construction best management practices (BMPs) for new development and redevelopment projects within their jurisdictions that are consistent with Regulation 72 requirements.

## 4.4 Construction BMPs

The Authority's "Stormwater Permit Requirements Guidance Document" recommends implementation of substantive BMP measures to control the quality of stormwater runoff from land disturbances on private and public property. In addition, the requirements establish the minimum construction and post-construction BMPs in the reservoir watershed for all new development activities. All land use agencies maintain design standards or refer to the Urban Drainage and Flood Control District (UDFCD) design standards for construction BMPs to limit the amount of sediment that enters the water during construction activities within the basin. The following are the current BMP criteria manuals for each of the Authority's members with land use authority:

- Arapahoe County (and the Town of Foxfield), “Grading, Erosion and Sediment Control Manual”, last revision March 2013
- Douglas County (also City of Lone Tree and City of Castle Pines), “Grading, Erosion and Sediment Control (GESC) Manual”, last amendment January 2013
- City of Aurora (Aurora Water), “Rules and Regulations, Regarding Stormwater Discharges Associated with Construction Activities”, last amendment November 2010
- Town of Castle Rock, “2015 Grading, Erosion, and Sediment Control (GESC) Manual” and “Drainage, Erosion and Sediment Control (DESC) Manual,” last revision June 2015

- Southeast Metro Stormwater Authority (City of Centennial), “SEMSWA Grading, Erosion and Sediment Control Manual”, last updated in December of 2010
- Greenwood Village, “Drainage Criteria Manual”, last revised December 2010
- Town of Parker, “Storm Drainage and Environmental Criteria Manual”, last revised and adopted February 2014

## 4.5 Post-Construction BMPs

The Authority’s Guidance Document described above also includes requirements for post-construction control of stormwater quality. All regulated new development and redevelopment projects must submit a post-construction BMP plan to the MS4 agency for review and approval prior to commencing land-disturbance activities. As for construction BMPs, each land use agency maintains its own design standards and refers to UDFCD design standards for permanent BMPs. Plans for permanent BMPs are reviewed by the local land use agency prior to the start of construction. The Water Quality Control Commission has adopted the following three-tiered approach to stormwater management for post-construction development and redevelopment in the Cherry Creek Reservoir watershed. The level of required post-construction BMPS increases for the higher tiers (e.g., tier 3).

**Development and Redevelopment Tiers:**

**Tier 1:** Any land disturbance <1 acre that is independently developed, and which results in <500 square feet of imperviousness for new development or <500 square feet of increased imperviousness for redevelopment.

**Tier 2:** Any land disturbance <1 acre that is independently developed, and which results in >500 but <5,000 square feet of imperviousness for new development or >500 square feet and <5,000 square feet of increased imperviousness for redevelopment, including disturbances of existing impervious areas.

**Tier 3:** Any land disturbance >1 acre that is independently developed, or which results in ≥5,000 square feet of imperviousness for new development or ≥5,000 square feet of increased imperviousness for redevelopment, including disturbances of existing impervious areas.

## 4.6 Flood Control Facilities Retrofitting, Inspection, and Maintenance Actions

The Authority supports the retrofitting of stormwater facilities in order to address any potential water quality issues identified through monitoring and reporting of existing facilities. One of the priority items identified during the Watershed Plan effort was the opportunity to retrofit detention ponds for the control of nutrients and other pollutants. Table 4-1 shows the number of inspection and maintenance actions taken in 2015, which includes retrofitted facilities.

**TABLE 4-1: SUMMARY OF STORMWATER PERMIT, INSPECTION, AND ENFORCEMENT ACTIONS IN 2015**

| Land Use Agency | Construction Sites | Construction BMPs | | Permanent BMPs | | |
|---|---|---|---|---|---|---|
| | Total Sites | Number of Inspections | Number of Enforcement Actions | Number of BMPs (or BMP Sites) Constructed | Number of Inspections | Number of Enforcement Actions |
| **Arapahoe County** | 43 | 440 | 6 | 0 | 25 | 0 |
| **Douglas County** | 1,310 | 8038 | 176 | 88 | 10 | 0 |
| **City of Aurora** | 91 | 790 | 62 | 6 | 12 | 0 |
| **SEMSWA (City of Centennial)** | 55 | 634 | 2 | 6 | 37 | 0 |
| **City of Greenwood Village** | 0 | 0 | 0 | 21 | 17 | 0 |
| **City of Lone Tree** | 13 | 58 | 4 | 0 | 0 | 0 |
| **City of Castle Pines** | 14 | 76 | 2 | 0 | 2 | 0 |
| **Town of Castle Rock** | 973 | 3639 | 1200 | 5 | 329 | 0 |
| **Town of Parker** | 80 | 739 | 30 | 11 | 316 | 0 |
| **CDOT** | | | | | | |

Urban development results in greater and more intense runoff which in turn results in greater quantities of pollutants (e.g., sediment, organic matter, nutrients, and heavy metals) discharged into streams and waterbodies. Reducing pollutants in stormwater has been a goal of the Authority since its formation in 1989. Pollutant reduction in stormwater has been accomplished primarily using detention and infiltration facilities which reduce the rate of runoff and allow pollutants to be deposited in the detention facility. Stormwater detention for each new development and any redevelopment (called "on-site" detention) is a requirement of Colorado stormwater regulations. Over time, stormwater managers have determined that "regional" facilities (e.g., regional detention facilities treating runoff from larger urban areas) are more effective and economical approach to stormwater management. Local governments throughout the Cherry Creek Basin, with support from the Authority, have constructed and operated many regional facilities and have plans to construct more.

The Colorado Division of Water Resources (DWR), also known as the Office of the State Engineer, is responsible for administering water rights, dam construction, and other water related activities including stormwater detention facilities. The DWR has allowed stormwater detention and infiltration on individual sites providing those practices conform to the May 21, 2011 DWR memorandum titled "Administrative Approach for Storm Water Management." The primary requirement of the DWR's administrative approach was to require release of all runoff captured in the stormwater facility over a period of 72-hours or less, thus approximately maintaining the pre-developed storm runoff release rates and protecting downstream water rights holders. This rule is consistent with the goal of using stormwater detention to improve water quality, based on studies demonstrating that detention periods of 24- to 72-hours provided significant reduction in the discharge of particulate matter in stormwater runoff through the settling process. In 2015, the State Engineer's office indicated that the 72-hour rule applied only to on-site stormwater management facilities, and not to regional facilities. This interpretation resulted in considerable concern from the stormwater managers not only in the Cherry Creek Basin, but state-wide. Without the 72-hour rule for regional facilities, local governments would be unable to fulfill their critical roles in protecting property,

people, and public health from stormwater runoff. The Authority agreed with local governments' concerns and passed a resolution (Resolution 2015-3-01 A Resolution Supporting Legislation) that would protect public regional Stormwater Management activities and Pollutant Reduction Facilities. The resolution supported a bill in connection with municipalities and counties to adopt legislation that would exempt publicly owned regional stormwater management from administration and curtailment by DWR.

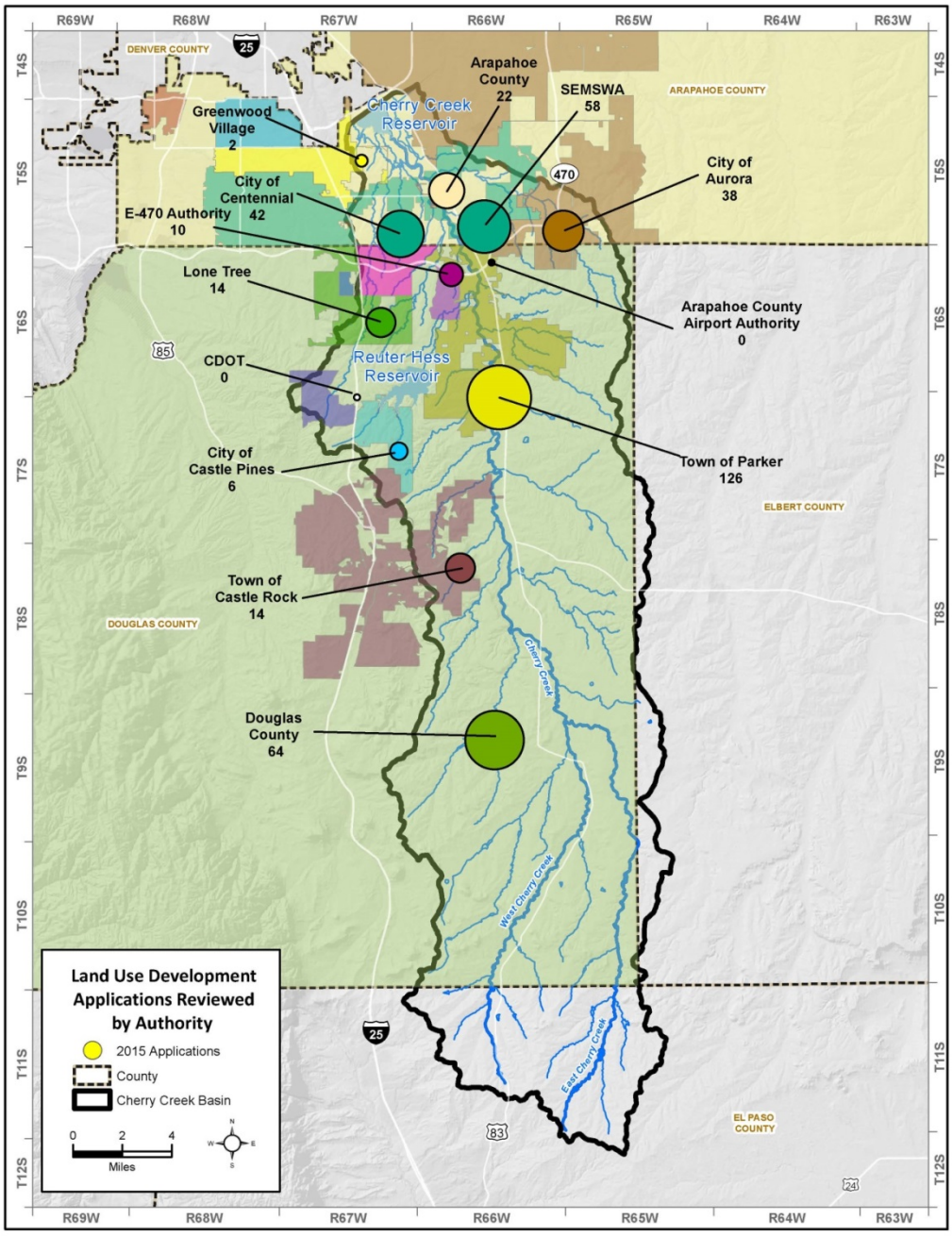
Senate Bill 15-212 was introduced into the legislature which added language §37-92-602 (8)(a) (Exemptions –presumptions-legislative definitions) declaring that storm water detention and infiltration facilities are essential for the protection of public safety and welfare, property, and the environment. Further, provided stormwater facilities are designed and operated in a specified manner, then the facilities do not cause injury to vested water rights. Senate Bill 212 thus would allow continued use of regional stormwater facilities without the looming threat of requiring water rights augmentation. The bill was signed into law by Governor Hickenlooper in May 2015 and became effective on August 5, 2015 as Colorado Revised Statute (CRS) §37-92-602(8). The Authority will continue to support research, design, and construction of regional stormwater facilities to further improve stormwater quality in the Cherry Creek Basin.

## 4.7 Effectiveness in Reducing Phosphorus Concentrations

The Commission has previously concluded that point source, nonpoint source, and regulated stormwater controls for total phosphorus are successfully reducing total phosphorus concentrations in stormwater and surface water flows to the reservoir. This is supported by ongoing monitoring being conducted both upstream and downstream of the PRFs, which effectively measures the cumulative benefits of BMP implementation in the upstream watershed. The data confirm that the BMPs and other controls placed on regulated stormwater continue to be effective. Watershed and reservoir modeling results have shown that, although population growth and surface flows have increased in the basin, the total phosphorus concentration in the inflow to the reservoir has remained relatively constant.

In addition to the controls required by Regulation 72 for regulated stormwater sources, the Authority also ensures implementation of effective BMPs through other activities. The Authority serves as a referral agency in the land use application process for local land use agencies within the Cherry Creek Reservoir watershed. When a land use agency receives a land use or development application, a copy is sent to the Authority for review. The Authority then has the opportunity to comment on the potential water quality impacts of the proposed application prior to approval of site plans and to determine

whether the proposed project complies with Regulation 72 and Authority's Guidelines. The Authority reviews land development applications, for the inclusion of construction (temporary) and post-construction (permanent) stormwater quality BMPs for land disturbances in the Cherry Creek Watershed. Map 4-2 provides a summary of the number of 2015 referrals by land use agency. Figure 4-1 provides a review of the number of land use and development applications that the Authority has received annually since March 1997.




**MAP 4-2: LAND USE DEVELOPMENT APPLICATIONS REVIEWED BY AUTHORITY, 2015**

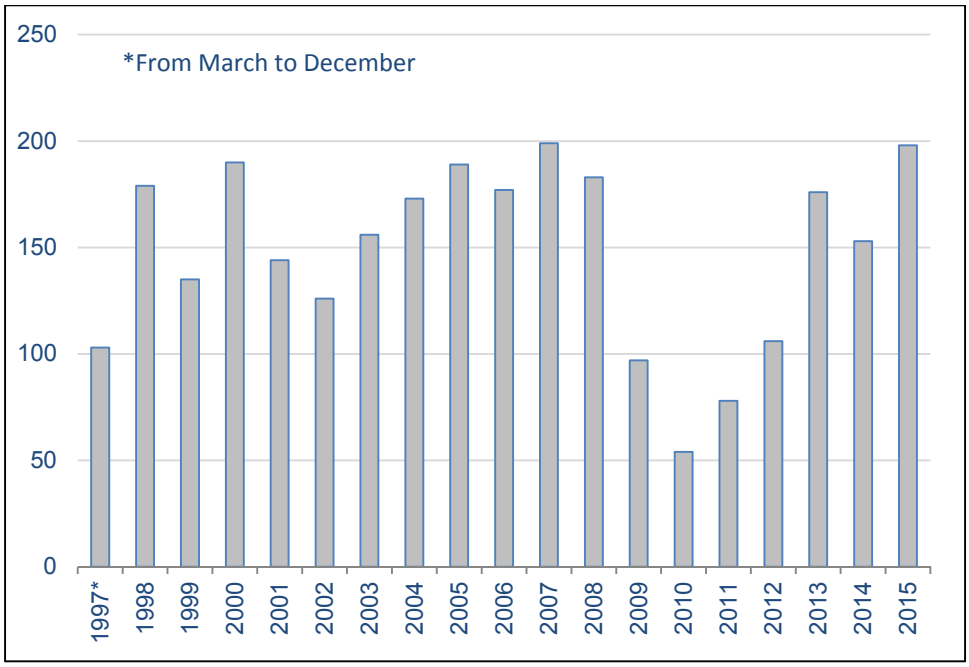



**FIGURE 4-1: NUMBER OF LAND USE AND DEVELOPMENT APPLICATIONS THAT THE AUTHORITY HAS RECEIVED ANNUALLY SINCE MARCH 1997**

The Authority's review of applications for land use changes in the Cherry Creek Reservoir watershed provides the following benefits:

- A better understanding of where and how development is occurring in the Cherry Creek Reservoir watershed. Currently, the bulk of development is occurring in the central reservoir watershed around Douglas County, Town of Parker, City of Aurora, Arapahoe County, and City of Centennial in several tributaries that previously were undeveloped. This pattern points to the need to focus on preventing or minimizing erosion in the tributaries by stabilizing the tributary drainage ways simultaneously with, if not in advance of, development.
- A better understanding of how well developers are complying with Authority requirements and improved communication with the land use agency personnel. Currently, the Authority's review comments are integral to the development process, and a negative response from the Authority has resulted in positive changes to the land use application.
- An opportunity for the Authority to work more closely with developers during initial stages of land use planning to identify projects where water quality enhancements and alternate BMPs are appropriate.

The number of land use referrals has risen substantially in 2015 and is comparable to development in years before the 2008 economic downturn. In 2015, the Authority received 198 referrals. The most land use applications submitted were from the Town of Parker, although there were significant application submittals from Douglas County, City of Centennial (SEMSWA), City of Aurora, and Arapahoe County. The type of land use for project referrals received in 2015 included residential, commercial, planned urban development, open space, parks or recreation facilities, highways, roadways and bridges, and other (airport, parking lots, water / sanitary sewer lines, transmission line, WWTF, lift station, etc.).

Figure 4-2 shows the distribution of land use for the referrals received in 2015. The Authority took no exception to most projects that were received, indicating strong stormwater regulations and implementations by Members. For the projects for which the Authority took exception, the Authority worked with the land use agency and engineering consultants to recommend improved stormwater quality controls and compliance with Regulation 72.

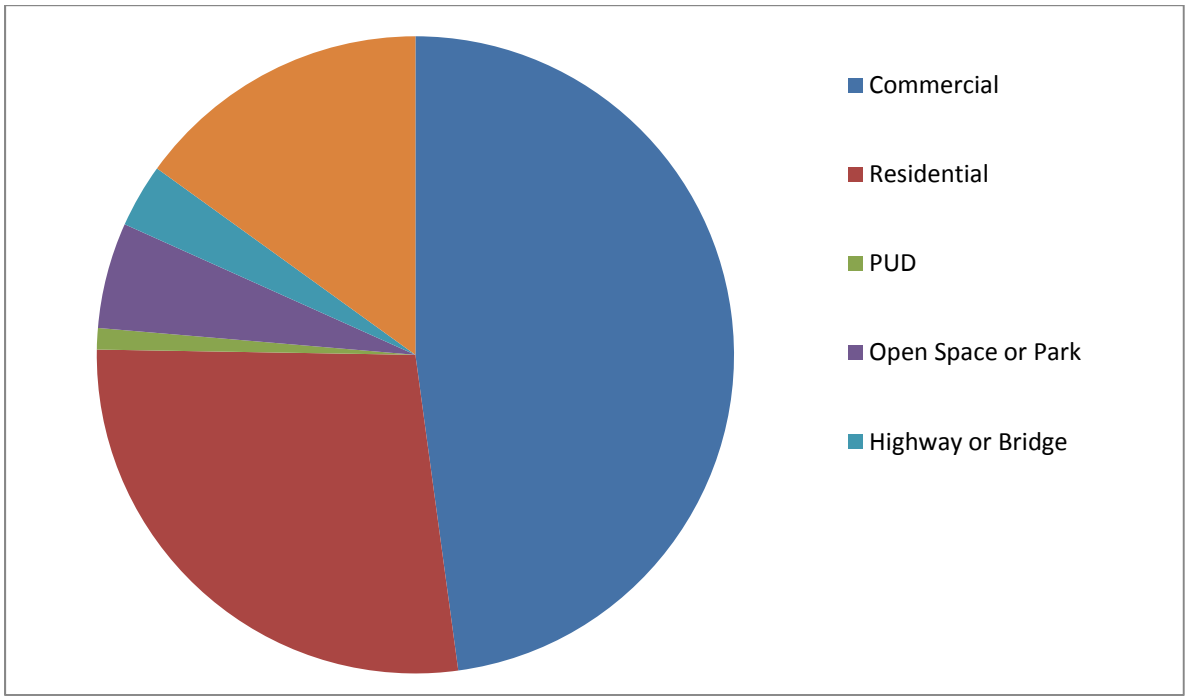



**FIGURE 4-2: DISTRIBUTION OF LAND USE FOR THE REFERRALS RECEIVED IN 2015**

## 4.8 Funding of Regulated Stormwater Projects

For new development and redevelopment projects within the jurisdictional boundaries of the land use agencies, the developer or land owner is generally held responsible for planning, constructing, operating, and maintaining construction and post-construction BMPs (unless the MS4 accepts operations and maintenance (O&M) responsibilities). The developer must make any necessary repairs to construction BMPs after a defect or need for repair is discovered. For permanent BMPs, the Post-Construction BMP plan requirement is to address the design, construction, and long-term operation and maintenance. The plan must contain procedures for maintaining and inspecting the facility on a regular basis to ensure the continued effectiveness of the BMPs. The plan also requires commitments from the responsible agency or owner that it will continue to maintain the BMPs once the facilities are complete. The plan must also contain provisions to access the BMPs for operation, maintenance, and inspection by the public entities by easement or other legal means of access. The Authority supports the use of Low Impact Development (LID) features that can be both protective of water quality and cost-saving for developers. An example of this is the recent adoption in Regulation 72 of a new Runoff Reduction Practices BMP that relies on LID strategies and Minimizing Directly-Connected Impervious Areas to promote onsite storage and infiltration, which can be cost-effective for new developments.

## 4.9 Monitoring of Regulated Stormwater Projects

The Commission requires the Authority to monitor and maintain all PRFs for nutrient control (PRF monitoring is further discussed in Chapter 5). The Commission also has concluded that individual monitoring of BMPs need not occur because PRF monitoring upstream and downstream of the project effectively measures the cumulative benefits of BMP implementation in the upstream watershed. PRF monitoring results are discussed in Section 5.5. In addition to Authority monitoring, MS4s are required to report separately to the Division (as part of their annual reports) on any monitoring data collected and analyzed to assess the effectiveness of stormwater controls in reducing the discharge of pollutants.

## 4.10 Public Information and Education Actions of MS4s

In 2015, Aurora Water's Water Words Program continued to offer free water presentations for local schools. Programs included sing-along learning for Preschool-1st Grade that teaches children about the water cycle and the needs of aquatic life. For grades 1-5, play-based learning is applied, where students can handle antiques to learn about water in the "Ol' West", or dress up in costumes to act out the water supply process. Middle schoolers are introduced to both local community and global water issues, focusing on source to tap, water conservation, and watershed protection. High schoolers are given the opportunity to learn about the types of careers involved in the water industry. Field trips are also available for all age groups.

Aurora Water sponsored ten Aurora High School Students to attend the "H2O Outdoors" at the Keystone Science School from October 28-30th. Students got the opportunity to hike along the Continental Divide, and learn about their watershed by testing river water quality, listening to guest lecturers, and participating in a mock town hall meeting to discuss water issues. The Fall 2015 Water Words Newsletter can be found at https://www.auroragov.org /cs/groups/public/documents/ document/024462.pdf

Aurora Water annually sponsors continuous education opportunities for K-12 educators in the area. Held every summer, "Forests to Faucets" is a way for K-12 teachers to receive 1.5 semester hours of graduate/re-certification credits. The course focuses on hands on learning where educators will learn about the sources of Aurora drinking water, conduct water quality studies in the field, and tour drinking water and wastewater treatment facilities. More information can be found at https://www.auroragov.org/LivingHere/Education/WaterEducation/Workshops/index.htm

Meridian Metropolitan District has a Kid's Page on its website which consists of an interactive game where you "Move the water-efficiency hero Flo through water pipes and answer water-efficiency questions while avoiding water-wasting monsters." The answers to the questions can be found on the rest of the District's website, so it encourages kids to read and learn about their water provider. For more information go to http://www.meridianranchmetro.org/kids.php

Parker Water and Sanitation District offers tours of their renewable water system infrastructure. It is a great opportunity for District customers, school classes, and anyone interest to tour the facility. The tour includes North Water Reclamation Facilities, Rueter-Hess Reservoir, Cherry Creek Diversion Dam and Pump Station, and the Multi-Use Regional Pump Station. Tours are approximately 4 hours long, and any District customer who attends a tour gets $15 off their next bill! (http://www.pwsd.org/8/Tours). Additionally, PWSD also offers free classes to the public on the benefits of xeriscape (drought-tolerant trees, flowers, and shrubs). For classes, see http://www.pwsd.org/1031/Classes

Arapahoe County SPLASH Education and Outreach has been educating the community about stormwater quality, and how everyday activities can drastically impact stormwater quality, and what community members can do to help. For a complete list of the ads in the campaign please visit http://www.splashco.org/education/stormwaterads.html

SPLASH also has a booth every year at the Western Welcome Week, held in Arapahoe County in August. SPLASH believes that the public plays a large role in protecting the water quality of waterways and reservoirs. At the booth the public can learn how they can positively impact storm water in the community. For more information, see http://www.splashco.org/activities/westernwelcomeweek.html

SPLASH participates annually in World Monitoring Day (October). Over 350 participants gather to take water samples and test water quality for parameters including dissolved oxygen, pH, turbidity, and temperature. Participants are usually students of all ages from local Arapahoe County schools. For more information, go to http://www.splashco.org/activities/worldmonitoringday.html

# 5 OTHER NONPOINT SOURCES

Nonpoint source stormwater controls consist of Pollutant Reduction Facilities (PRFs) constructed by the Authority and similar type projects constructed by local governments. These are water quality measures, such as stream reclamation, shoreline stabilization, detention, wetlands, and others that otherwise provide water quality benefits for the reservoir, reduce pollutants carried by stormwater from existing and future land disturbances. PRFs are different from the BMPs that are implemented by local land use agencies (i.e., MS4s) under the regulated stormwater program discussed previously in Section 4. The difference between PRFs and BMPs is formally recognized in the definitions in Regulation 72.

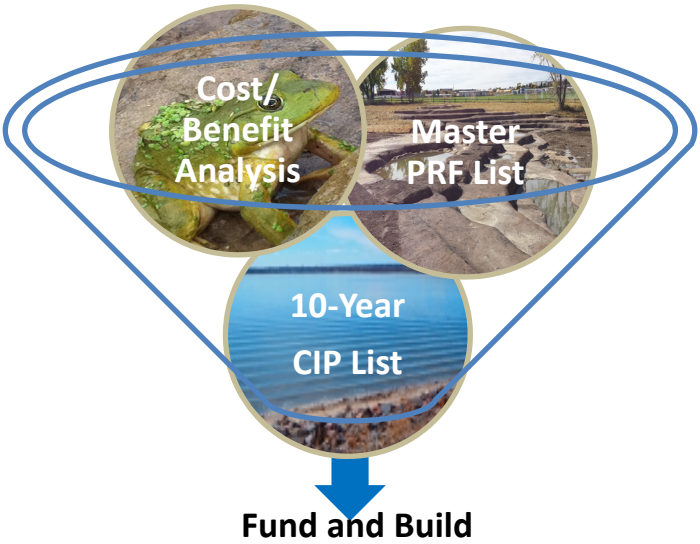
PRFs are selected based on a prioritization method considering cost/benefit and other factors that include quantitative and qualitative assessments and Authority consideration of all reasonable evaluation criteria. Evaluation criteria include estimates of pollution reduction, economic baselines, expected timeframe for benefits to be seen, cost, and potential downstream impacts.

PRFs are defined in Regulation 72 as "projects that reduce nonpoint source pollutants in stormwater runoff that may also contain regulated stormwater. PRFs are structural measures that include, but are not limited to: detention, wetlands, filtration, infiltration, and other technologies with the primary purpose of reducing pollutant concentrations entering the reservoir or that protect the beneficial uses of the reservoir."

## 5.1 Update list of PRFs Implemented

In accordance with statutory requirements, the Authority must spend at least 60 percent of its annual budget on design, construction, operation, and maintenance of PRFs. To implement this requirement, the Authority conducts a multi-year Capital Improvement Projects (CIP) planning process to identify PRF construction projects. Potential PRFs are first identified and evaluated, and costs are estimated over the life of design and construction for each project. The next step is development of a list of all potential PRFs (called the master PRF list), which includes capital, operation, and maintenance costs compared with potential benefits in terms of phosphorus reduction. As pollution reduction opportunities are identified during the year, they are evaluated at the conceptual level to determine costs and benefits. If project costs and benefits appear to be reasonable, the TAC recommends to the Board that the project be included on the master PRF list. Once the Board approves the project for inclusion on the master list, any future work towards design and construction, which also must be authorized by the Board, is

considered to be part of capital expenses of the Authority. The next step is to select the best projects from the master list of PRFs to be included on the CIP list.




The TAC evaluates projects annually on the master list and forwards recommendations to the Board for inclusion on the 10-year CIP. The Board then annually selects projects from the 10-year CIP, based on recommendations from the TAC and subject to available funds. The PRFs completed to date, ongoing PRFs, and the 10-year plan PRFs are listed in Table 5-1 and Table 5-2, and in section 5.2 below.

Table 5-1 and Table 5-2 provide a summary of recommended PRFs for 2016-2025, and estimated capital costs which include engineering, construction, administration, and contingency. Design costs include technical feasibility design, construction observation, and administrative costs. Prior year obligated funds are accumulative expenditures for the project, based on previous years' accounting and estimate of current year expenses. This budget in Table 5-1 is the TAC recommendation. The funds allocated to each project are subject to further Board approval, and the CIP is included in the Board's budget adopted annually in November. Where noted, some funds have been previously obligated to the specific project by the Board. Projects completed in prior years are not shown.

## TABLE 5-1: CCBWQA SUMMARY OF RECOMMENDED POLLUTANT REDUCTION FACILITIES 2015-2025 BUDGET PROJECTIONS ($1000)

| Project No. | Project Title | Current Project Budget | | | | Prior Year Obligated Funds[3] | Residual PRF Costs | Proposed 2016 Budget | | | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Capital[1] | Total | Authority Portion | Authority Portion | | | Design[2] | Capital | Total | Total | Total | Total | Total | Total | Total | Total | Total | Total |
| | CAPITAL | | | | | | | | | | | | | | | | | | |
| CCB-5.4 | CC Stream Stabilization at Main street | $1776 | $1776 | $200 | 11% | $- | $200 | $- | $- | $- | $- | $- | $- | $- | $- | $200 | $- | $- | $- |
| CCB-5.6 | CC Creek Stream Stabilization at Lincoln Avenue | $1447 | $1447 | $304 | 21% | $- | $304 | $- | $- | $- | $- | $- | $- | $- | $- | $304 | $- | $- | $- |
| CCB-5.11 | CC Stream Stabilization at Norton Open Space (Parker) | $900 | $900 | $255 | 28% | $255 | $- | $- | $- | $- | $- | $- | $- | $- | $- | $- | $- | $- | $- |
| CCB-5.14 | CC Stream Reclamation- CCSP to Eco Park (Ph II to V) | $12,172 | $12,172 | $3043 | 25% | $960 | $2083 | $- | $150 | $150 | $300 | $400 | $400 | $500 | $333 | $- | $- | $- | $- |
| | CC Stream Reclamation – CCSP Ph I | $2227 | $2227 | $2227 | 100% | $- | $2227 | $- | $50 | $-50 | $50 | $- | $- | $- | $- | $- | $900 | $900 | $427 |
| CCB-6.4 | Piney Creek Stream Stabilization at Caley Ave. Reach 6 & 7 | $10,500 | $10,500 | $2625 | 25% | $550 | $2075 | $- | $600 | $600 | $500 | $500 | $475 | $- | $- | $- | $- | $- | $- |
| CCB-16 | Stream Corridor Preservation | $100 | $100 | $100 | 100% | $- | $100 | $- | $- | $- | $- | $- | $- | $- | $- | $- | $- | $- | $- |
| CCB-17.4 | East Boat Ramp Shoreline Stabilization Phase II | $70 | $70 | $70 | 100% | $- | $70 | $- | $- | $- | $- | $- | $- | $20 | $50 | $- | $- | $- | $- |
| CCB-17.5 | East Shade Shelter Shoreline Stabilization Phase II | $50 | $50 | $50 | 100% | | $50 | $- | $- | $- | $- | $- | $- | $20 | $30 | $- | $- | $- | $- |
| CCB-17.6 | West Shade Shelter Shoreline Stabilization PRF | $950 | $950 | $950 | 100% | $- | $950 | $- | $- | $- | $- | $- | $- | $150 | $300 | $500 | $- | $- | $- |
| CCB-17.7 | Tower Loop Shoreline Stabilization Ph II | $90 | $90 | $90 | 100% | | $70 | $- | $- | $- | $- | $- | $- | $20 | $70 | $- | $- | $- | $- |
| CCB-19 | Non-Point Pollutant Management | $100 | $100 | $100 | 100% | $ | $100 | $- | $- | $- | $- | $- | $- | $- | $- | $- | $- | $- | $100 |
| CCB | Install 2 Piney Creek Monitoring Wells | $6 | $6 | $6 | 100% | | | $- | $6 | $6 | $- | $- | $- | $- | $- | $- | $- | $- | $- |
| CCB | Install 1 Meteorological Station at CCSP | $14 | $14 | $14 | 100% | | | | $14 | $14 | | | | | | | | | |
| CCB | Interpretive PRF Signage at 12-Mile Park & West Boat Ramp | $16 | $16 | $16 | 100% | | $16 | | | | $16 | | | | | | | | |
| | SUB-TOTALS | $ | $ | $ | $ | $ | $8880 | $- | $820 | $820 | $866 | $900 | $875 | $860 | $783 | #1004 | $900 | $900 | $527 |

## TABLE 5-2: CCBWQA SUMMARY OF RECOMMENDED POLLUTANT REDUCTION FACILITIES 2015-2025 BUDGET PROJECTIONS ($1000)

| | | Current Project Budget | | | | | | Proposed 2016 Budget | | | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project No. | Project Title | Capital[1] | Total | Authority Portion | Authority Portion | Prior Year Obligated Funds[3] | Residual PRF Costs | Design[2] | Capital | Total | Total | Total | Total | Total | Total | Total | Total | Total | Total |
| | **OPERATIONS AND MAINTENANCE** | | | | | | | | | | | | | | | | | | |
| | **Rehabilitation Categories** | | | | | | | | | | | | | | | | | | |
| OM- | Frame Restoration & Sign Replacement | $20 | $20 | $12 | 60% | | $12 | | $12 | $12 | | | | | | | | | |
| | **SUB-TOTALS** | | | | | | $12 | | $12 | $12 | | | | | | | | | |
| | **Restorative Categories** | | | | | | | | | | | | | | | | | | |
| OM- | Emergency or Unplanned Repairs | $- | $- | $- | 100% | | | | $40 | $40 | **$40** | **$40** | **$40** | **$40** | **$40** | **$40** | **$40** | **$40** | **$40** |
| OM- | Tree/Shrub Planting | $1 | $1 | $1 | 100% | | $1 | | $1 | $1 | | | | | | | | | |
| OM- | East Shoreline Floor Restoration | $6 | $6 | $6 | 100% | | $6 | | $6 | $6 | | | | | | | | | |
| | **SUB-TOTALS** | | | | | | $7 | | $47 | $47 | $40 | **$40** | **$40** | **$40** | **$40** | **$40** | **$40** | **$40** | **$40** |
| | **Routine Categories** | | | | | | | | | | | | | | | | | | |
| OM-7 | Reservoir Destratification | $90 | $90 | $90 | 100% | | $84 | | $83 | $83 | $86 | $88 | $92 | $94 | $96 | $98 | $100 | $103 | $106 |
| OM-14.1 | PRF Weed Control | $34 | $34 | $34 | 100% | | $34 | | $16 | $16 | $18 | $20 | $22 | $24 | $26 | $28 | $30 | $32 | $34 |
| OM-14.2 | PRF Reseeding at CCSP | $45 | $45 | $45 | 100% | | $45 | | $9 | $9 | $9 | $9 | $10 | $12 | $14 | $16 | $18 | $20 | $22 |
| | **SUB-TOTALS** | | | | | | $163 | | $108 | $108 | $113 | $117 | $124 | $130 | $136 | $142 | $148 | $155 | $162 |
| | | | | | | | | | | | | | | | | | | | |
| | **SUB-TOTAL O&M** | | | | | | $182 | | $167 | $167 | $153 | $157 | $164 | $170 | $176 | $182 | $188 | $195 | $202 |
| | GRAND TOTAL | | | | | | $9062 | | $987 | $987 | $1019 | $1057 | $1039 | $1030 | $959 | $1186 | $1088 | $1095 | $729 |

## 5.2 Overview of PRFs to Date

The Authority has completed 23 PRF projects in the basin since 1989 and has several specific PRF projects in the 10-year plan. The Authority's initial PRF focus area concentrated in Cherry Creek State Park along the shoreline and gradually moved upstream and outside of the Park limit. Funding for PRFs from 1989-1999 was provided 100 percent by the Authority due to the location of the first PRFs in the Cherry Creek State Park. However, as the Authority moves its focus area upstream, joint funding from municipalities and other stakeholders has augmented the funds available and reduced the percentage paid by the Authority for individual PRFs. For information on the total cost and percentage paid by the Authority, including Authority budgeted amounts from 2017 – 2025, see Table 5-1 above.

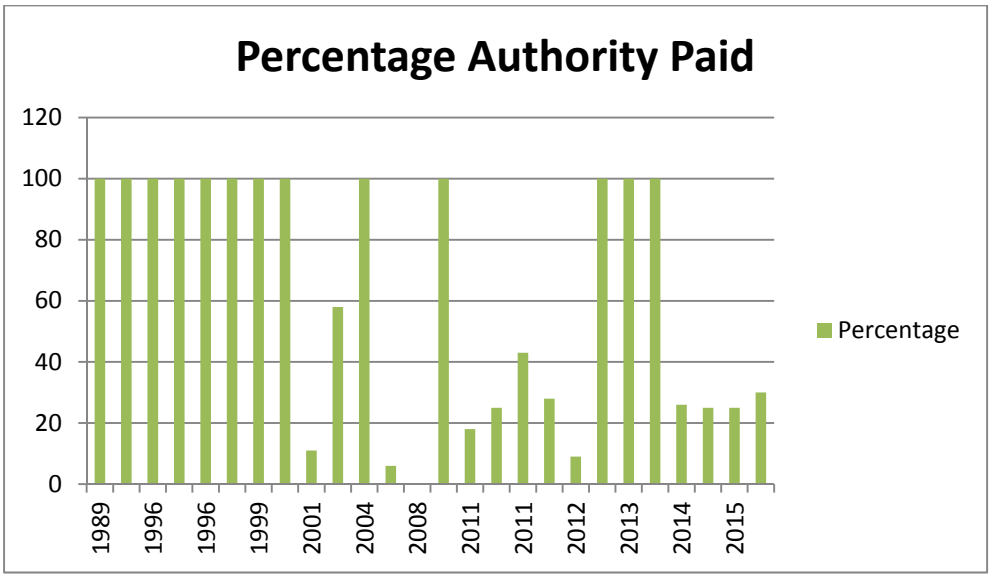



**FIGURE 5-1: PERCENTAGE OF FUNDING PAID BY AUTHORITY FOR PRF PROJECTS**

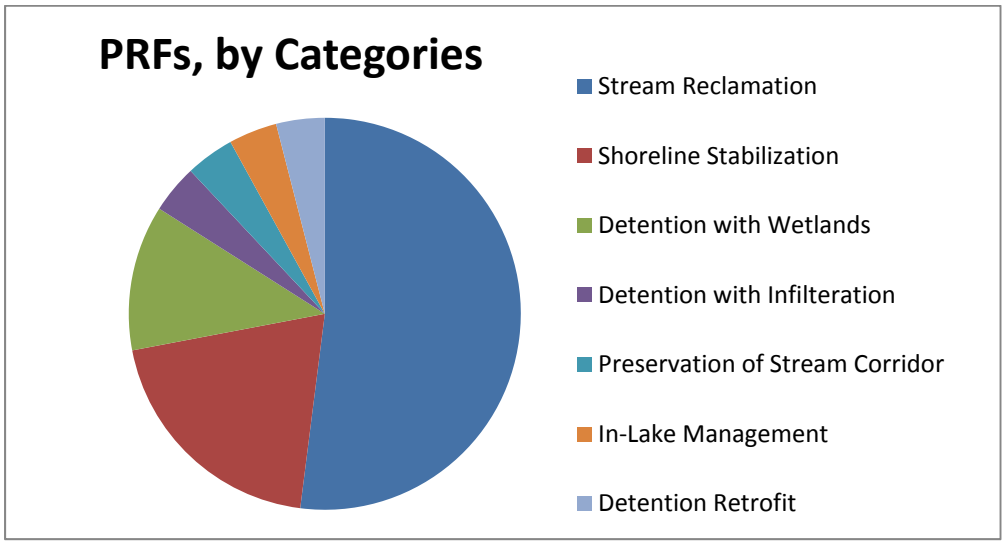
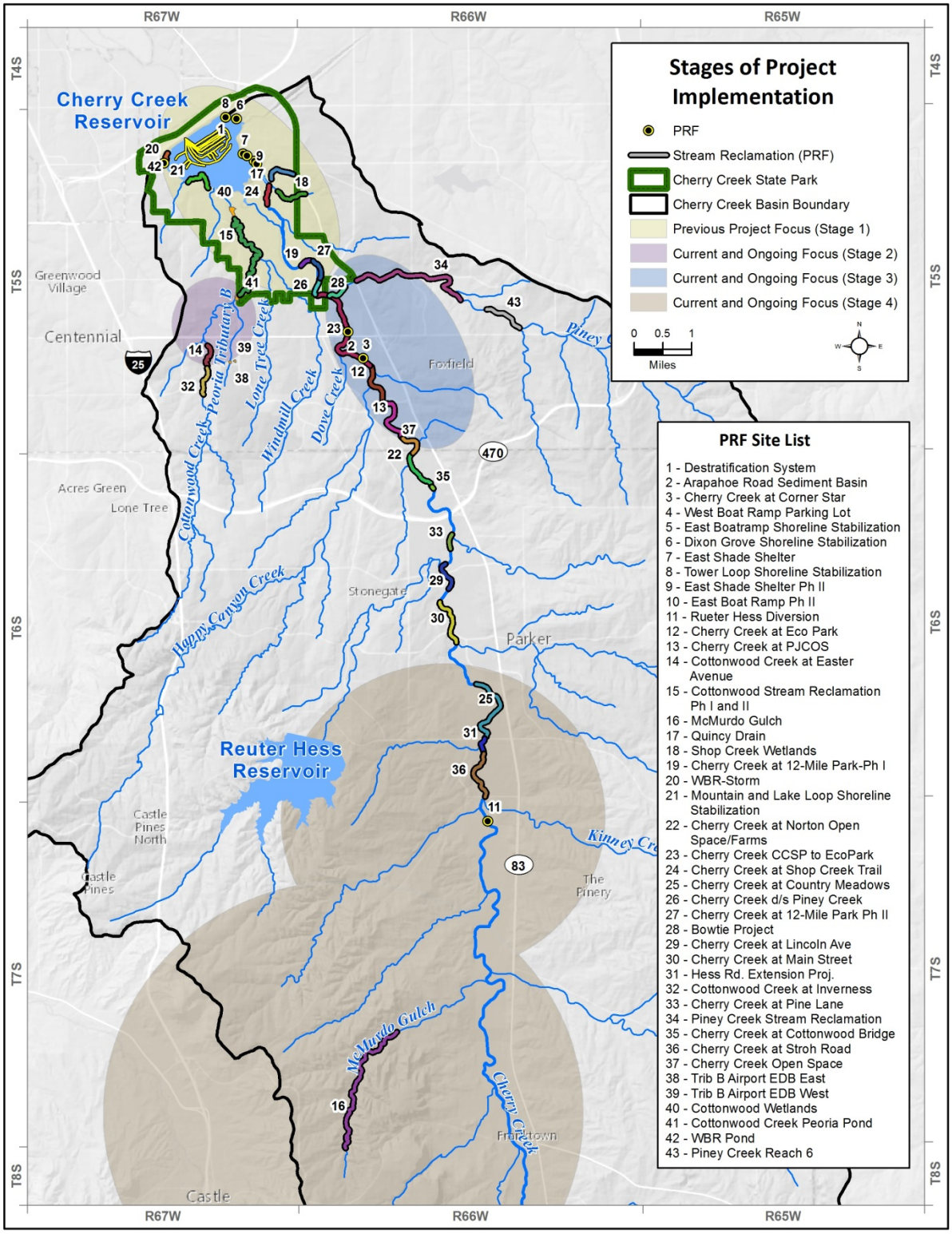



**FIGURE 5-2: PRF CATEGORIES, 1989-2015**




**MAP 5 – 1: POLLUTANT REDUCTION FACILITY (PRF) SITES LOCATED THROUGHOUT THE CHERRY CREEK WATERSHED**

## 5.3 2015 Pollutant Reduction Facilities (PRF) Activities

Over the course of the Authority's history, it has spent more than $13 million on capital projects and pollutant reduction facilities. Prior to 2010, Cherry Creek Reservoir was under a total maximum annual load limitation for phosphorus. Since capital projects and PRFs originally focused on reduction of phosphorus loads discharged into the reservoir, projected loads and treatment, and estimated pounds of phosphorus immobilized are estimated. Currently there is no TMAL; instead the control strategy identified in Regulation No. 72 is to minimize nutrient (phosphorus and nitrogen) concentrations. However, capital improvement projects and PRFs are still evaluated, in part, on phosphorus removal per year for consistency between all projects. Following are brief descriptions of the 2015 projects and in-progress projects.

### 5.3.1 Cherry Creek at Arapahoe Road Stream Reclamation, Reach 5

The Cherry Creek at Arapahoe Road Stream Reclamation, Reach 5 extends from the downstream end of the Cherry Creek at Eco Park project to a location south of Arapahoe Road adjacent to the Aurora soccer fields, a distance of approximately 2,800 lineal feet. The lower end of Reach 5 is anchored by Drop Structure No. 14. Construction of Drop Structure No. 14 and the stream section extending approximately 350 linear feet upstream was completed in the fall of 2014. This work was performed in advance of the remaining stream section within Reach 5 to protect an exposed 12 inch diameter raw waterline. Exposure of the raw waterline was caused by the extreme down cutting of the channel.

Drop Structure No.14 was constructed as a hand-sculpted concrete drop immediately downstream of the exposed waterline. This structure anchored the channel grade at an elevation identified in the preliminary design report completed in August 2013. The Reach 5 improvements are scheduled to be complete in the spring of 2016.

### 5.3.2 Cherry Creek Stream Reclamation at Norton Farms Open Space

In 2012, the Town of Parker requested Authority funding to assist with design and construction of the Cherry Creek Stream Reclamation Improvements at Norton Farms Open Space. This project is located in Parker, immediately upstream of the Cherry Creek Stream Reclamation Project at the 17-Mile House beginning at the Arapahoe/Douglas County Line and extending upstream for a distance of approximately 2,500 linear feet. Construction is scheduled to begin in early January 2016 and completed in the spring of 2016.

### 5.3.3 Piney Creek Stream Reclamation – Reaches 6 (Ranches) & 7 (Liverpool)

UDFCD and SEMSWA initially entered into an intergovernmental agreement (IGA), on December 22, 2006, for stream reclamation improvements on Piney Creek at Caley Avenue. The Authority became a party to this IGA, on September 3, 2014 with UDFCD and SEMSWA. This agreement established additional funding for needed stream reclamation improvements through Reaches 6 and 7 of Piney Creek. Urban growth and expansion of developed areas has resulted in an increase in the rate, frequency, and duration of stormwater run-off accelerating degradation of the streambed and banks.

In June of 2015, intense rainfall in the upper basin of Piney Creek caused localized flooding in Piney Creek eroding approximately 12,000 cubic yards of sediment from along Reaches 6 and 7. Phase 1 of the construction is scheduled to begin in early January 2016 and completed in the spring of 2016.

### 5.3.4 Cherry Creek Stream Stabilization at Hess Road

In 2011, the Town of Parker requested Authority funding to assist with design and construction of the Cherry Creek Stream Reclamation Improvements at Hess Road. The project is located in Parker, Colorado, immediately downstream of Hess Road and extends for a distance of approximately 4,200 linear feet. Cherry Creek in this area is a 20 to 50 foot wide sandy channel bed with incised banks between three and ten feet tall. The Authority's inspection of the Project area found that erosion and down cutting was resulting in steep bank slopes, lateral channel migration and loss of wetlands and upland vegetation due to lowering of the water table.

The Authority assessed the water quality benefits of the project and determined the Project met the Authority's goals and objectives for stream reclamation. The Project was added to the Authority's Capital Improvement Plan in 2011. On March 17, 2011, the Authority entered into an IGA with UDFCD, the Town of Parker and Douglas County contributing design funds in the amount of $20,000. On April 30, 2012, the Authority approved a second IGA amendment contributing an additional $500,000, for a total project contribution of $520,000.

Urban growth and expansion of developed areas has resulted in an increase in the rate, volume, frequency and duration of stormwater runoff accelerating degradation of the streambed and banks. The design approach to reclamation of this reach is a combination of a natural bioengineering approach connecting the streambed to the overbanks and a more engineered approach in areas where topography or site conditions constrain the channel geometry. In some locations, the existing channel bank and riparian vegetation was removed and replanted to meet the design detail for the constructed improvements.

Five hand sculpted concrete drop structures were incorporated into the Project to flatten and control the longitudinal grade, with strategically located sheet-pile cut-off walls installed to protect the structure from damages during a larger flood event. Side slopes along the main stem and secondary channels were graded with flatter slopes to reconnect higher flows to the riparian corridor. The secondary channel, incorporated into the project, aids in

conveyance of the larger flows. By splitting storm flows through the main stem and secondary channel velocity, shear forces and stream power are reduced. This design approach allows for more filtration and infiltration.

The Project was designed to raise the streambed and re-establish the water table to prevent further loss of vegetation and down cutting, erosion and sediment transport. The overall project goal was to restore and enhance the aquatic, wetland and riparian functions of Cherry Creek.

The overall project was split into two separate contracts, one for the stream civil reclamation and drop structures construction and the second for revegetation and landscaping. The Notice to Proceed was issued on October 20, 2014 and the project was completed in the spring of 2015.

An assessment of the stream stabilization and water quality benefits for the entire project was made by the Authority and found to include reductions in sediment and other pollutant loads, including phosphorus and nitrogen. These benefits are supported by Authority data, literature research, and quantitative analysis. Based on the outcome of this assessment, it is calculated that 72 lbs of phosphorus per year will be eliminated from being transported downstream from the Cherry Creek at Hess Road stream reclamation improvements. The project was found to lower stream velocities, channel shear and stream power from that found prior to the stream reclamation, all which minimizes the transport of sediment and pollutants.

## 5.4 Floodplain Preservation/Conservation Easements

The Water Quality Control Commission recognizes protection of floodplain, riparian corridor, and other environmentally sensitive lands through public acquisition or conservation easements and restoration of the same lands for nutrient control through erosion control, revegetation, or other means, to control nutrients. The Authority and local governments may collaborate with other entities in pursuing easements, ownerships, and rights to protect the streams, riparian corridors, tributaries, and wetlands in the Cherry Creek watershed.

In the past, the Authority was a founding partner in the acquisition of 21.5 acres of land at the confluence of Piney Creek and Cherry Creek whose shape resembled a bowtie and was hence called the Bowtie Property. The purchase was a joint effort between the City of Centennial, Arapahoe County, the UDFCD, the Trust for Public Lands, and the Authority and preserved the channel and riparian corridor of Piney Creek from future development, and returned an existing developed area into open space park.

## 5.5 Monitoring of PRFs

The Cottonwood Creek Stream Reclamation Project, which is paired with two wetland detention systems (PRFs), continue to be effective in reducing the total phosphorus load and suspended solids entering Cherry Creek Reservoir; although shows mixed results in terms reducing total nitrogen

concentrations (GEI 2016). PRF effectiveness is gauged by monitoring the concentration of total phosphorus, total nitrogen and suspended solids and determining the nutrient loading upstream and downstream of each PRF. The PRFs were designed to reduce the fate and transport of total phosphorus and sediment in the system with minimal design features to reduce total nitrogen loads along the Cottonwood Creek PRF system (GEI 2016).

In 2015, measured flow-weighted total phosphorus concentrations showed a reduction from the upstream (139 µg/L) to downstream (88 µg/L) monitoring locations along the Cottonwood PRF-Stream Reclamation reach. Similarly, measured flow-weighted total nitrogen concentrations showed a reduction from the upstream (1,414 µg/L) to downstream (1,342 µg/L) monitoring location before entering Cherry Creek Reservoir. Since the Cottonwood PRF-Stream Reclamation project was completed in 2008, the median annual flow-weighted TP and TN concentrations for inflows entering the reservoir are 77 µg/L and 1,608 µg/L, respectively, while the long-term median values are 75 µg/L and 1,592 µg/L, respectively.

The Cottonwood PRF-Stream Reclamation Project, combined with the wastewater treatment plant's effort to achieve the total phosphorus 50 µg/L permit limits, are believed to be the reasons behind the long-term reduction in phosphorus concentrations in Cottonwood Creek (Figure 5-3). Median baseflow TP concentrations have been below the warmwater total phosphorous interim standard of 170 µg/L since monitoring began and have been especially low since the completion of the reclamation project in 2008. The median baseflow TN concentrations have varied over the long-term and reflect the influence of dischargers in the Cottonwood Creek watershed during the mid-2000's. Since 2010, the annual median baseflow TN concentration has been less than the proposed interim TN value of 2,010 µg/L (Figure 5-4).

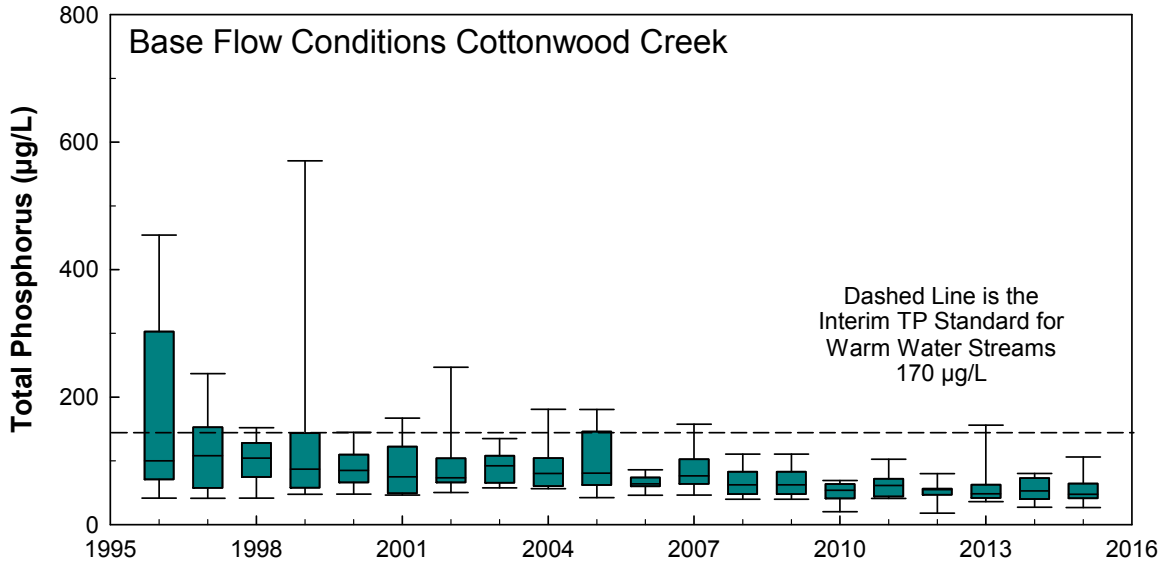



**FIGURE 5-3: BASE FLOW TOTAL PHOSPHORUS CONCENTRATIONS FOR COTTONWOOD CREEK, 1996-2015**

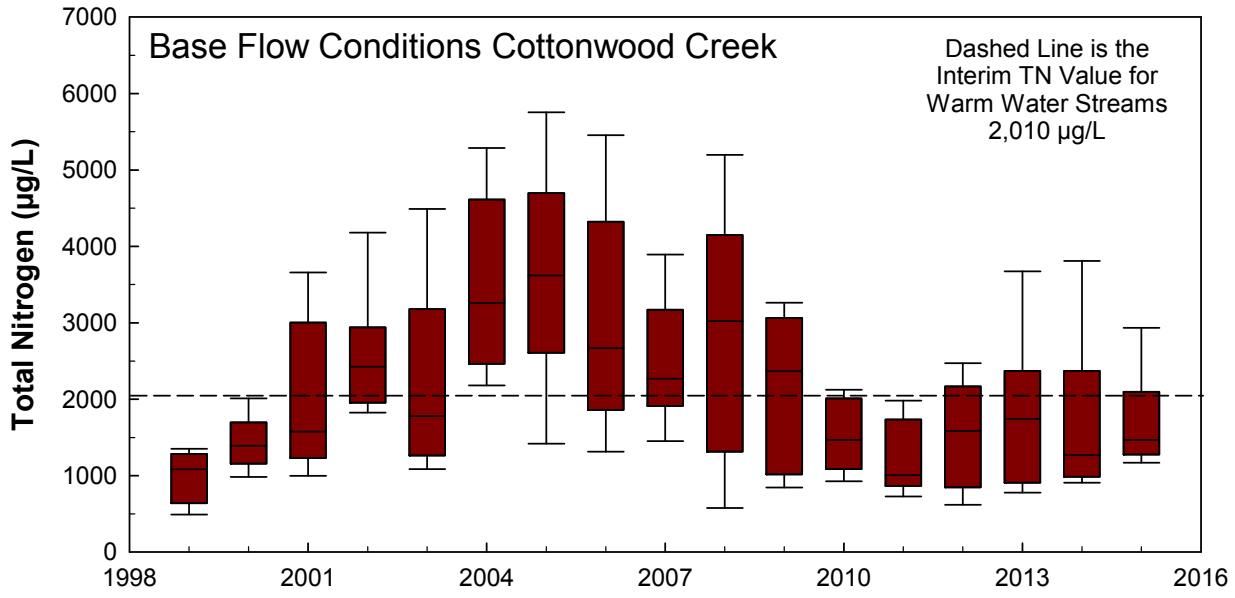



**FIGURE 5-4: STORM FLOW TOTAL NITROGEN CONCENTRATIONS FOR COTTONWOOD CREEK, 1996-2015**

## 5.6 PRF Effectiveness in Reducing Phosphorus Concentrations

The effectiveness of the PRFs was assessed by monitoring TP, TN, and TSS upstream and downstream of the facility and comparing concentrations. Total phosphorous and TN loads were used to evaluate the effectiveness of Peoria and Perimeter Pond on Cottonwood Creek and are not affected by the "normalization" of GEI inflow to USACE inflow values for the reservoir. Total phosphorous and TN concentrations at McMurdo Gulch and TSS concentrations all sites were used to evaluate the effectiveness of their respective PRFs.

A similar, but more pronounced trend for long-term reduction of phosphorus concentration entering Cherry Creek Reservoir from Cottonwood Creek inflows is found in the storm-flow data. Completion of the stream reclamation project in 2008 resulted in a more dramatic storm flow total phosphorus concentration reduction than between other years and have remained below the Warm Water total phosphorous interim value to date. Over the long-term, the Cottonwood Stream Reclamation project had a similar effect on storm flow TN concentrations such that in 2008 there was a decrease in annual median concentrations which have remained relatively consistent in recent years (Figure 5-6). However, a reduction in total nitrogen was not observed at each individual PRF component along Cottonwood Creek PRF-Stream Reclamation Reach (GEI 2016).

The Authority has used its PRF efficiency data to inform the expansion of their watershed management efforts to other tributaries in the Cherry Creek Basin. Currently, the Authority monitors water quality conditions in McMurdo Gulch (~20 miles upstream of Cherry Creek Reservoir) to document the efficiency of the McMurdo Stream Reclamation Project. Since 2012, the McMurdo Gulch Stream Reclamation project has been effective at reducing total phosphorous and total nitrogen concentration

downstream of the stream reclamation project. Total suspended solid reduction has historically not been successful (GEI 2016). In 2015, the Authority partnered with the Urban Drainage and Flood Control District, Southeast Metro Stormwater Authority, City of Aurora, and Douglas County to propose the construction of a new monitoring station on Piney Creek to begin documenting water quality conditions prior to construction of Piney Creek Stream Reclamation Project. Monitoring for this project will begin in 2016. The Authority also monitors the water quality conditions downstream of the Eco Park Stream Reclamation Project located on the mainstem of Cherry Creek (~4 miles upstream of Cherry Creek Reservoir).

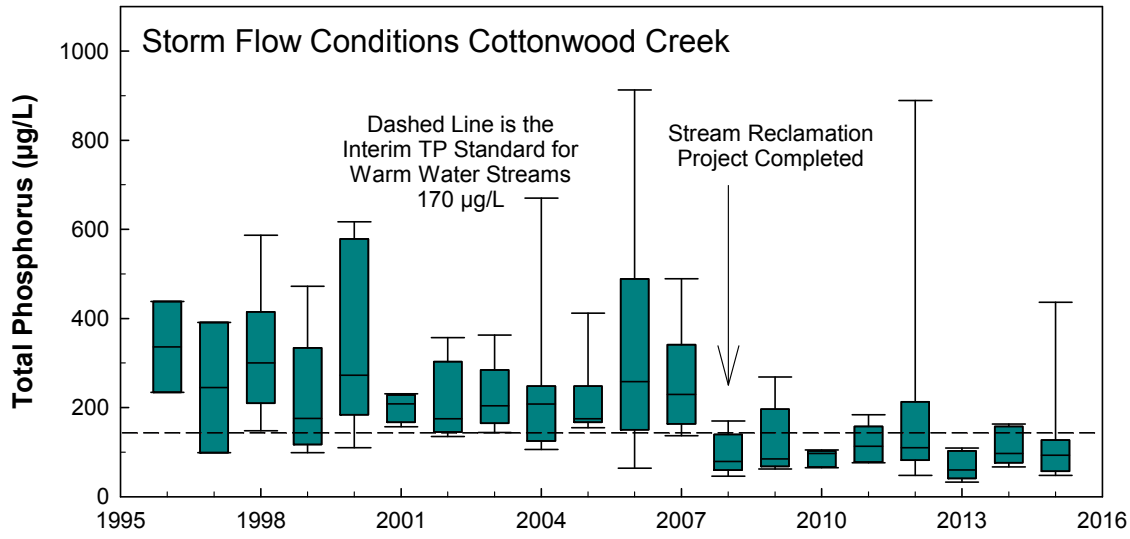



**FIGURE 5-5: STORM FLOW TOTAL PHOSPHORUS CONCENTRATIONS FOR COTTONWOOD CREEK, 1996-2015**

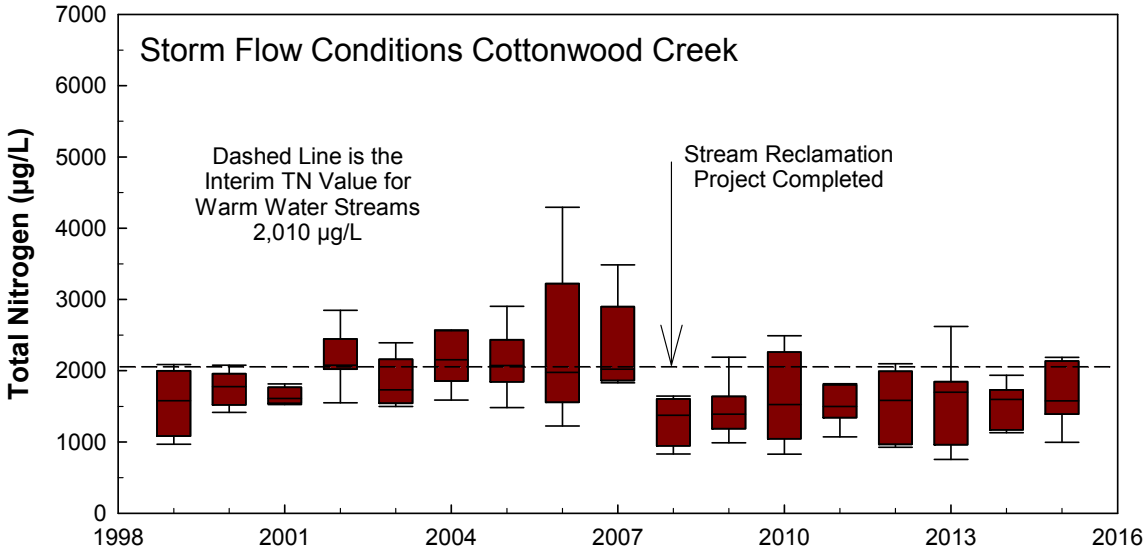
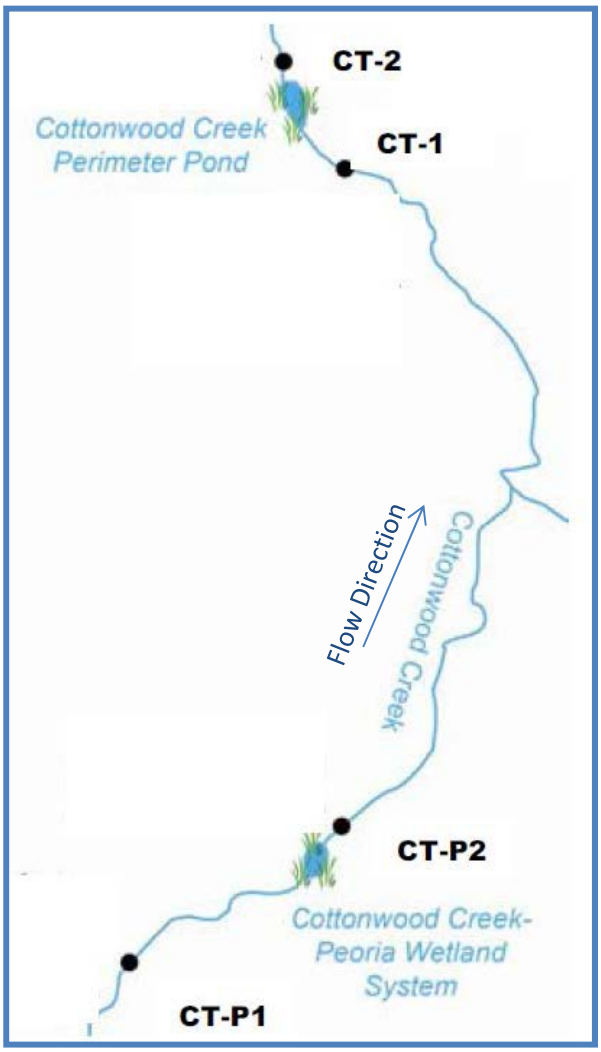



**FIGURE 5-6: STORM FLOW TOTAL NITROGEN CONCENTRATIONS FOR COTTONWOOD CREEK, 1999-2015**

### 5.6.1 Cottonwood Creek Peoria Pond




The PRF continues to be effective in reducing the amount of TP and TSS in Cottonwood Creek as it passes through Peoria Pond. In 2015, the flow-weighted TP concentration was 139 µg/L upstream of the PRF and 85 µg/L downstream which indicates efficiency in removing phosphorus from flow (Table 5-3). Over the life of the project, the PRF has reduced the flow-weighted TP concentration at the downstream site by approximately 20%. In 2015, the TSS concentration was reduced by approximately 36%, with the long-term reduction of 29%. In contrast, the 2015 flow-weighted TN concentration was 1,414 µg/L upstream of the PRF and 1,466 µg/L downstream which indicates that the RPF is not efficient in removing nitrogen from the system. This is consistent with the long term mean conditions which show that TN has increased by approximately 3% at the downstream site. It should be noted that the PRFs were not designed to target TN reduction, thus concentrations are not expected to decrease.

This PRF was particularly effective at reducing the TP concentration and TSS concentration in Cottonwood Creek flows during multiple storm events on April 17$^{th}$, May 5$^{th}$ and 19$^{th}$, June 12$^{th}$ and 25$^{th}$, and August 11$^{th}$. Total phosphorous reduction during these events ranged from 12 to 47%, except for the June 25$^{th}$ event in which TP increased by 240%, and TSS reduction ranged from 26 to 65%. For example, during the April 17$^{th}$ storm event, the inflow TP concentration at Site CT-P1 was 219 mg/L while the outflow concentration was 115 mg/L indicating an approximate 47% removal of TP. Similarly, the TSS concentration entering the PRF during this storm event was 107 µg/L while the outflow concentration was 46 µg/L indicating an approximately 57% removal of TSS. Peoria Pond was not substantially effective at reducing TN concentration in Cottonwood Creek flows during storm events and results ranged from a 9% decrease to a 24% increase in TN.

**TABLE 5-3: HISTORICAL FLOW-WEIGHTED TOTAL PHOSPHORUS, TOTAL NITROGEN, AND TOTAL SUSPENDED SOLIDS CONCENTRATIONS UPSTREAM AND DOWNSTREAM OF THE COTTONWOOD CREEK – PEORIA POND, 2002 TO 2015 WY**

| Water Year | Flow-Weight TP Concentration (µg/L) | | | Flow –Weight TN Concentration (µg/L) | | | Mean Total Suspended Solids (mg/L) | | |
|---|---|---|---|---|---|---|---|---|---|
| | CT-1 | CT-2 | % Difference | CT-1 | CT-2 | % Difference | CT-1 | CT-2 | % Difference |
| 2002 | 142 | 118 | -17 | 1,578 | 1,436 | -9 | 81 | 74 | -9 |
| 2003 | 117 | 109 | -7 | 1,350 | 1,354 | 0 | 30 | 33 | 10 |
| 2004 | 132 | 132 | 0 | 1,352 | 1,487 | 10 | 104 | 51 | -51 |
| 2005 | 129 | 119 | -8 | 1,304 | 1,429 | 10 | 50 | 53 | 6 |
| 2006 | 146 | 140 | -4 | 1,485 | 1,435 | -3 | 13 | 13 | 0 |
| 2007 | 156 | 120 | -23 | 1,425 | 1,374 | -4 | 78 | 41 | -47 |
| 2008* | 128 | 92 | -28 | 1,354 | 1,397 | 3 | 36 | 34 | -6 |
| 2009 | 114 | 83 | -27 | 1,231 | 1,281 | 4 | 48 | 27 | -44 |
| 2010 | 106 | 96 | -9 | 1,260 | 1,466 | 16 | 34 | 26 | -24 |
| 2011 | 153 | 131 | -14 | 1,385 | 1,450 | 5 | 48 | 30 | -38 |
| 2012 | 193 | 127 | -34 | 1,395 | 1,457 | 4 | 121 | 55 | -55 |
| 2013 | 267 | 113 | -58 | 1,679 | 1,510 | -10 | 97 | 35 | -64 |
| 2014 | 145 | 135 | -7 | 1,267 | 1,369 | 8 | 66 | 39 | -41 |
| 2015 | 139 | 85 | -39 | 1,414 | 1,466 | 4 | 68 | 43 | -36 |
| **Mean** | **148** | **114** | **-20** | **1,391** | **1,422** | **3** | **62** | **40** | **-29** |

* Eight months of operation.

### 5.6.2 Cottonwood Creek Reclamation and Perimeter Pond

Site CT-1, above Perimeter Pond, was affected by beaver activity for nearly all of 2015 WY except for June and September. Therefore, only two months were used to assess PRF efficiency, which greatly limits the assessment. Considering only these months, the PRF was effective in reducing the amount of TP, TN, and TSS in Cottonwood Creek as it passes through Perimeter Pond. The flow-weighted TP concentration was 149 µg/L upstream of the PRF and 88 µg/L downstream and the flow-weighted TN concentration was 1,617 µg/L upstream of the PRF and 1,342 µg/L downstream which indicates some effectiveness in removing TP, as well as TN (Table 5-4). Over the life of the project, the PRF has reduced the flow-weighted TP concentration at the downstream site by an approximate mean 24% while it has only reduced the flow-weighted TN concentration at the downstream site by an approximate mean 5%. The TSS concentration was reduced by approximately 42% in 2015, with the long-term mean reduction of 33%.

This PRF showed limited success at reducing the TP concentration and TSS concentration in Cottonwood Creek flows during multiple storm events on April 17$^{th}$, June 12$^{th}$ and 25$^{th}$, and August 11$^{th}$. Total phosphorous reduction during these events ranged from 5 to 47% and TSS reduction ranged from 13 to 70%. For example, during the June 25$^{th}$ storm event, the inflow TP concentration at Site CT-1 was 167 mg/L while the outflow concentration was 93 mg/L indicating an approximate 44% removal of TP. Similarly, the TSS concentration entering the PRF during this storm event was 97 µg/L while the outflow concentration was 29 µg/L indicating an approximately 70% removal of TSS. Perimeter Pond was not substantially effective at reducing TN concentration in Cottonwood Creek flows during storm events and results ranged from a 28% decrease to a 53% increase in TN.

**TABLE 5-4: HISTORICAL TOTAL PHOSPHORUS, TOTAL NITROGEN, AND TOTAL SUSPENDED SOLIDS CONCENTRATIONS UPSTREAM AND DOWNSTREAM OF THE COTTONWOOD CREEK PERIMETER POND, 1997 TO 2015 WY.**

| Water Year | Flow-Weight TP Concentration (µg/L) | | | Flow –Weight TN Concentration (µg/L) | | | Mean Total Suspended Solids (mg/L) | | |
|---|---|---|---|---|---|---|---|---|---|
| | CT-1 | CT-2 | % Difference | CT-1 | CT-2 | % Difference | | | |
| 1997 | 485 | 183 | -62 | NA | NA | NA | 207 | 87 | -58 |
| 1998 | 311 | 176 | -43 | NA | NA | NA | 311 | 129 | -59 |
| 1999 | 143 | 129 | -10 | 1,475 | 1,363 | -8 | 267 | 68 | -75 |
| 2000 | 266 | 161 | -39 | 1,821 | 1,586 | -13 | 96 | 64 | -33 |
| 2001 | 163 | 146 | -10 | 2,206 | 1,810 | -18 | 79 | 43 | -46 |
| 2002 | 124 | 105 | -15 | 2,669 | 2,594 | -3 | 150 | 86 | -43 |
| 2003 | 193 | 124 | -36 | 2,075 | 2,399 | 16 | 83 | 58 | -30 |
| 2004 | 194 | 149 | -23 | 3,072 | 2,909 | -5 | 156 | 128 | -18 |
| 2005 | 141 | 120 | -15 | 3,165 | 3,093 | -2 | 123 | 65 | -47 |
| 2006 | 165 | 135 | -18 | 2,864 | 2,866 | 0 | 31 | 20 | -35 |
| 2007 | 170 | 148 | -13 | 2,456 | 2,262 | -8 | 93 | 64 | -31 |
| 2008[a] | 87 | 86 | -1 | 2,555 | 2,578 | 1 | 31 | 59 | 90 |
| 2009 | 70 | 61 | -13 | 1,609 | 1,752 | 9 | 31 | 32 | 3 |
| 2010 | 77 | 77 | 0 | 1,569 | 1,521 | -3 | 33 | 33 | 0 |
| 2011 | 101 | 81 | -20 | 1,442 | 1,339 | -7 | 48 | 30 | -38 |
| 2012[b] | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 2013 | 119 | 59 | -52 | 1,937 | 1,752 | -10 | 57 | 21 | -63 |
| 2014 | 112 | 81 | -28 | 1,590 | 1,516 | -5 | 56 | 22 | -61 |
| 2015[c] | 149 | 88 | -41 | 1,617 | 1,342 | -17 | 51 | 30 | -42 |
| **Mean** | **171** | **117** | **-24** | **2,097** | **2,005** | **-5** | **106** | **58** | **-33** |

[a] Nine months of operation
[b] Offline for maintenance
[c] Two months of operation due to beaver dam.

### 5.6.3 McMurdo Gulch Stream Reclamation

Before extensive land use development occurs along McMurdo Gulch, the town of Castle Rock and the CCBWQA used a proactive approach to control stream erosion and implemented a stream reclamation project along three miles of McMurdo Gulch between the Cobblestone Ranch and Castle Oaks subdivisions. Reclamation activities were completed in fall 2011 and two water quality monitoring sites were established on McMurdo Gulch by the CCBWQA in January 2012. Site MCM-1, which serves as the upstream monitoring location, was established approximately 150 m upstream of the McMurdo Gulch Stream Reclamation Project Boundary and 120 m upstream of the confluence with an unnamed tributary that receives runoff from the Castle Oaks Subdivision. Site MCM-2 was established approximately 80 m upstream of the Castle Oaks Drive Bridge crossing of McMurdo Gulch, near the North Rocky View Road intersection and serves as the downstream monitoring location for the McMurdo Gulch Stream Reclamation Project. This site is located within the project boundary, and consistently maintains base flows, whereas reaches further downstream were dry due to flow going subsurface.

Base flow water quality samples were collected on a monthly basis at sites MCM-1 and MCM-2 during the 2015 WY. No storm samples were collected at these sites. The PRF was effective in reducing the amount of TP and TN in McMurdo Gulch as it passes through the reclamation area. The mean TP concentration was 392 µg/L upstream of the PRF and 272 µg/L downstream and the TN concentration was 547 µg/L upstream of the PRF and 305 µg/L downstream which indicates efficiency in removing TP and TN from flow.

The average concentrations for total phosphorus and total nitrogen upstream and downstream of the McMurdo Gulch Stream Reclamation PRF are shown in Table 5-5. The PRF is effective at removing total phosphorus and total nitrogen from upstream to downstream of the PRF.

**TABLE 5-5: AVERAGE CONCENTRATIONS OF TOTAL PHOSPHORUS, TOTAL NITROGEN, AND TOTAL SUSPENDED SOLIDS UPSTREAM AND DOWNSTREAM OF MCMURDO GULCH STREAM RECLAMATION, 2015**

| Parameter | MCM-1 Average Concentration (Upstream of PRF) | MCM-2 Average Concentration (Downstream of PRF) | Percent Change Down Stream |
|---|---|---|---|
| Total Phosphorus (µg/L) | 392 (base flow) | 272 (base flow) | -31% (base flow) |
| Total Nitrogen (µg/L) | 547 (base flow) | 305 (base flow) | -44% (base flow) |

### 5.6.4 Piney Creek Sediment Study

On June 16, 2011 the TAC published the Stream Reclamation Water Quality Benefit Evaluation – Interim Status Report. The purpose of this report was to investigate the history of stream reclamation in the Cherry Creek Watershed, documenting procedures for identifying and evaluating PRFs in general, evaluating impacts of regulatory changes, presenting the results of a literature search to identify other, nationwide perspectives, preparing more detailed analysis of existing stream water quality data, and identifying additional considerations for evaluating stream reclamation projects. In 2015 the Pine Creek Sampling Plan was conducted. Another purpose was to collect additional total phosphorus (TP) data from the channel and the bank sediment along the creek to compare to the TP data previously collected along Cottonwood Creek and Cherry Creek.

On February 19th eight sediment samples were collected at four locations along Piney Creek (Reach 1, 5, 6, and 7). The total average phosphorus level measured in lbs/ton from the samples collected along Piney Creek was 0.15 lbs/ton; see Table 5-6. Compared to Cottonwood Creek (1.5 lbs/ton) this was much lower, while it was comparable to Cherry Creek (>0.1 lbs/ton).

**TABLE 5-6: PINEY CREEK SUMMARY OF LAB RESULTS**

| Sample ID | Dry Weight Total Phosphorus (mg/kg) | Total Phosphorous (lbs/ton) |
|---|---|---|
| PC-01 | 120 | 0.23 |
| PC-02 | 95 | 0.15 |
| PC-03 | 42 | 0.07 |
| PC-04 | 39 | 0.08 |
| PC-05 | 63 | 0.11 |
| PC-06 | 97 | 0.18 |
| PC-07 | 27 | 0.04 |
| PC-08 | 189 | 0.35 |

Since completion of the Authority's Interim Status Report, UDFCD commissioned of a Piney Creek geomorphic assessment in 2015 to further study sediment and nutrient stability and movement. A part of that study included a Bank Erosion Assessment of Piney Creek. From the Bank Erosion Assessment, it was estimated that 2,437 tons of sediment per year is being delivered to the Cherry Creek watershed from bank erosion along Pine Creek (primarily from Reaches 6 and 7). Using this number and the TP results it was estimated that 365 pounds of TP is being delivered to the Cherry Creek watershed from Piney Creek bank erosion every year. This equates to approximately 321 lbs TP/mile of Piney Creek. The value is far greater than the estimated loading of 100 lbs TP/mile of stream length identified in the Stream Reclamation, Water Quality Benefit Evaluation – Interim Stream Report. Although Piney Creek has a low total average lbs TP/ton of sediment compared to other streams, the fact that the bank erosion is so extreme and the resulting sediment transport so significant results in an overall very high loading. Bank Stabilization, especially along Reaches 6 and 7, will improve water quality in Piney Creek and benefit the overall water quality within the Cherry Creek watershed.

## 5.7 Funding of PRFs and Nonpoint Source Projects

The Authority either funds or co-funds PRFs and other nonpoint source projects together with other agencies through taxes, fees, and wastewater surcharges. Funding varies year to year. As noted earlier in this chapter, the 10-year CIP (Table 5-1 and Table 5-2) identifies various cost components for the PRFs including design, capital, land acquisition, water augmentation

requirements, and operations and maintenance costs. The Authority's portion of the total costs for co-funded projects can be seen in the 10-year CIP. These costs are then spread out over a multi-year period for longer-range planning purposes, subject to available Authority funds. In addition, these tables show the amount spent (and obligated) to date by the Authority for the various PRFs that have been completed or that are in progress.

For 2015, the Authority projected a budget of $868,000 for capital improvements and O&M for projects shown in Table 5-1 and Table 5-2. The Authority plans and budgets for multiple year projects, from concept through construction processes, and projects it will have funds to plan for and implement the projects shown in the 10-year CIP. Implementation and timing of projects can vary from year to year; projects are sometimes funded through capital reserves.

The Capital Project and Maintenance Status Report is updated monthly for the TAC and Board meetings. It provides a brief summary of ongoing capital and maintenance projects, as well as current and planned activities for each.

## 5.8 Annual Inspection of PRFs

The 2015 annual inspection of pollutant reduction facilities, constructed by the Authority at Cherry Creek State Park, was conducted on July 28th and July 30th. The conclusions and recommendations of the 2015 annual inspection are:

All PRFs are performing as designed, but some routine, rehabilitative and restorative maintenance activities are recommended and are planned for 2016 and beyond.

1) Noted erosion areas will be included in the 2016 budget for restoration.
2) Signage upgrade, repair, and replacement needs will be included in the 2016 budget.
3) The projected total O&M cost as the result of this inspection is $50,200 as compared to the 2015 budget of $156,600. Noxious weed control and revegetation budget estimates are included in the 2016 projected costs.
4) Weed control (herbicide application) and reseeding work can be more readily accomplished by using the CCSP vendors for seeding (i.e., Starck Brothers Construction) and for weed control (i.e., Vegetation Management Inc., aka. VMI).
5) It is recommended that the Authority develop a capital maintenance program purchasing policy that facilitates pre-approved practices for contracts related to small maintenance projects included in the approved capital improvement program, rather than bidding the work.

## TABLE 5-7: 2015 ANNUAL INSPECTION REPORT OF PRFS AT CHERRY CREEK STATE PARK

| PRF | Action | Estimate of Cost to Authority |
|---|---|---|
| **Shop Creek Wetlands Channel** | Pond 1: Routine removal of woody vegetation. Trashrack to be replaced in 2015. Monitor water quality performance. Clean inlet pipe. | $1,400 |
| | Pond 2: Routine removal of woody vegetation. Trashrack to be replaced in 2015. Monitor water quality performance | $1,400 |
| | Pond 3: Routine removal of woody vegetation. Trashrack to be replaced in 2015. Monitor water quality performance | $1,400 |
| | Pond 4: Routine removal of woody vegetation. Trashrack to be replaced in 2015. Monitor water quality performance | $1,400 |
| | Pond 5: Routine removal of woody vegetation. Trashrack to be replaced in 2015. Monitor water quality performance | $1,400 |
| | Perform noxious weed control measures (50/50). Herbicide application | $200 |
| | Paint Frames and replace signs | $1,500 |
| **Cottonwood Creek Phase I & II** | Perform noxious weed control measures (50/50) and CCSP to continue operations to control prairie dogs. Herbicide application. | $4,800 |
| **Cottonwood Perimeter Road Wetlands** | Noxious weed control; two applications (continue in 2016). Anticipate 1 tree replacement. Herbicide application. | $3,500 |
| | Paint frames and replace signs. | $4,000 |
| **Cherry Creek at 12-Mile Park Phase I** | Perform noxious weed control and reseeding work. Continue to monitor sediment aggradation. Herbicide application. Revegetate the spill area and review need to perform additional grading work. Trim cottonwood trees. | $2,000 |
| **Cherry Creek at 12-Mile Park Phase II** | Perform noxious weed control and reseeding work. Revegetation replacement is anticipated. Continue to monitor sediment aggradation. | $11,000 |
| **Mtn/Lake Loop** | Continue with weed control and revegetation. Herbicide application. Trim cottonwood trees. | $4,000 |
| **East Boat Ramp** | Monitor condition. Include additional shoreline stabilization in 10-yr CIP budget. | $0 |
| **East Shade Shelter** | Monitor condition. Include additional shoreline stabilization in 10-yr CIP budget. Fill area under the paved access | $5,700 |
| **Tower Loop** | Paint frame and replace signs. | $3,100 |
| **General Signage** | Paint frames and replace signs. | $3,400 |
| **Total** | | $50,200 |

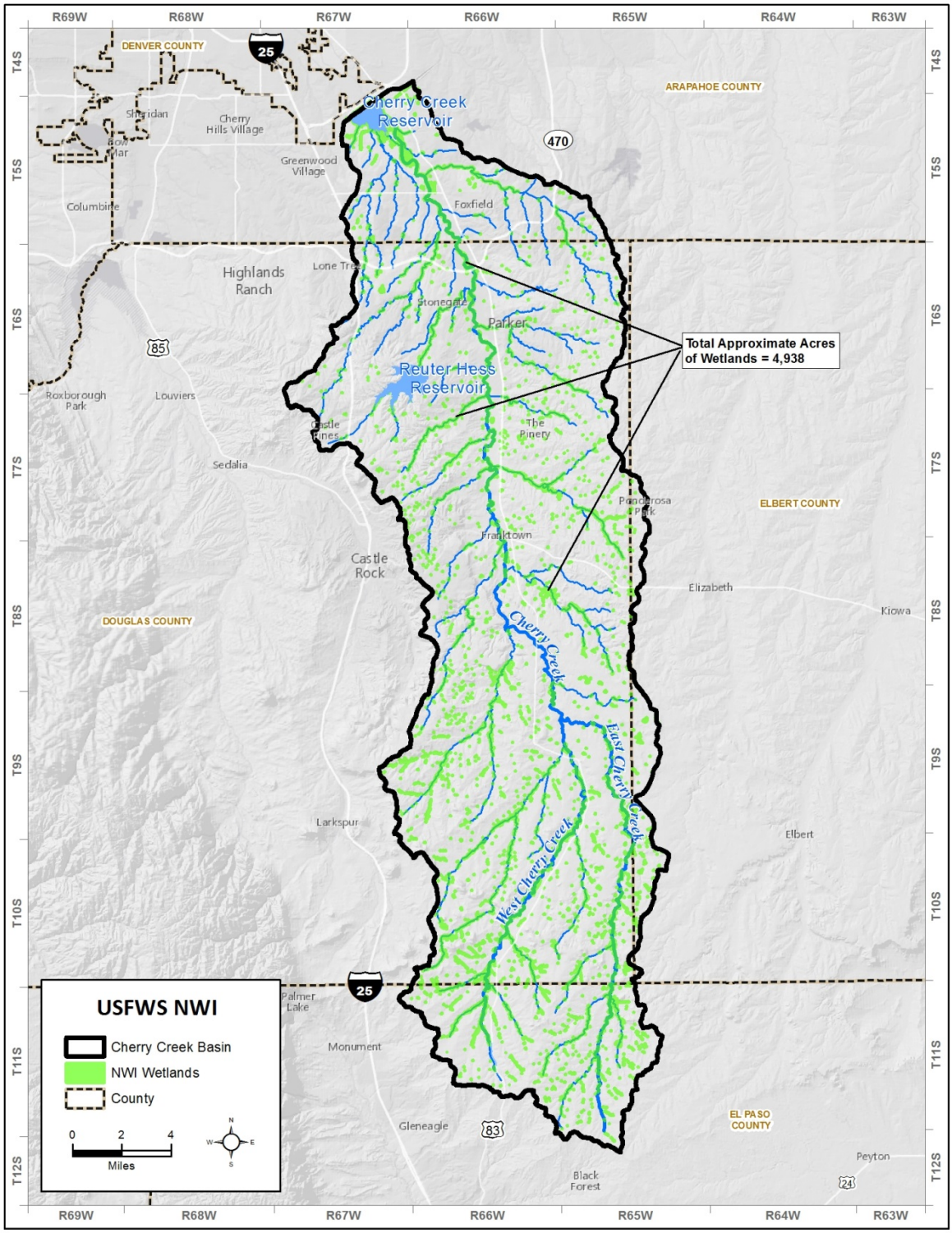
# 6 RIPARIAN AND WETLANDS PROTECTION

Wetlands and riparian areas occur as natural buffers between the uplands and Cherry Creek, Cherry Creek Reservoir, and its tributaries. They act as natural filters of nonpoint source pollutants, which include sediment, nutrients, and pathogens, and can play a significant role in managing adverse water quality impacts in the basin. Creating wetland and riparian areas along drainageways can help decrease the cost for stormwater and flood protection projects.

The functions of wetlands and riparian areas include water quality improvement, stream shading, flood attenuation, shoreline stabilization; ground water exchange, and habitat for aquatic, semiaquatic, terrestrial, and migratory species. Loss of these areas allows for a more direct contribution of pollutants to receiving waters. The pollutant removal functions associated with wetlands and riparian area vegetation and soils combine the processes of filtering, adsorption, and biochemical reactions, which removes and or immobilize pollutants. Wetlands and riparian areas may also stabilize the recharge of shallow aquifers in a manner that supports streamflows of longer natural duration. Wetlands and riparian areas can play a critical role in reducing pollution by intercepting surface runoff, subsurface flow, and certain ground water flows, which can process, remove, transform, and store sediment, nitrogen, phosphorus, and some heavy metals.

## 6.1 Riparian and Wetlands in the Cherry Creek Basin

The Cherry Creek Basin contains about 4,938 acres of wetlands/riparian areas. Figure 6-1 shows the approximate area of riparian/wetlands using the U.S. Fish Service National Wetlands Inventory (USFWS NWI). The majority of wetlands in the Cherry Creek Basin are characterized as riparian wetlands and occur directly adjacent to the streambanks of Cherry Creek and its tributaries. Other major wetland areas include the Wetlands Preserve area and other surrounding wetlands in the Cherry Creek State Park. However, as seen in Map 6-1, there are also other small areas of wetlands areas scattered throughout the basin.




**MAP 6 – 1: U.S. FISH AND WILDLIFE SERVICE NATIONAL WETLANDS INVENTORY OF WETLANDS AND WATERS OF THE U.S. IN THE CHERRY CREEK BASIN**

## 6.2 Regulatory Protection

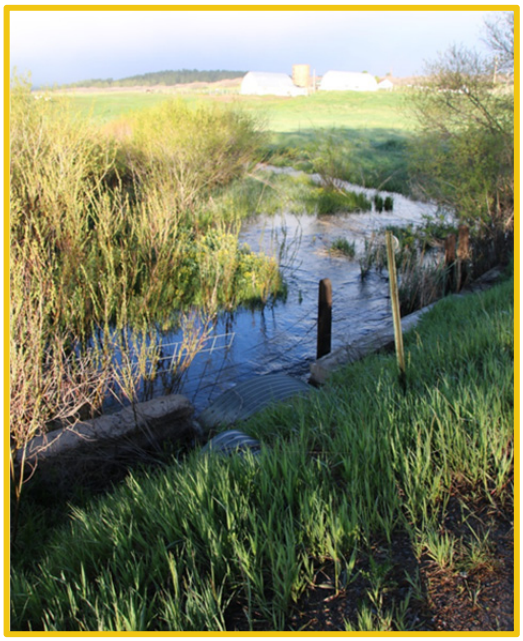
Regulation 72 recognizes the importance of protecting floodplains, riparian corridors, and other environmentally sensitive lands through public acquisition or conservation easement. Restoration of the same lands to reduce nutrients entering the channel by controlling erosion through re-vegetation, or other means, is encouraged. Riparian areas and wetlands are protected in the Cherry Creek basin by Regulation 72 as Stream Preservation Areas, providing special standards and procedures for land disturbances in riparian or wetland areas.

Stream Preservation Areas include Cherry Creek Reservoir, all of Cherry Creek State Park, surface drainage, and discharges to the park within 100 feet of the park boundary, lands overlying the Cherry Creek 100-year floodplain, and all lands within 100-year floodplain of Cherry Creek tributaries, as defined by the Urban Drainage and Flood Control District (Regulation 72(2)(c)(8)).

Regulation 72 requires additional BMPs for all land disturbances within a Stream Preservation Area, including both construction and post-construction BMPs. Examples of such BMPs include constructed wetlands basins, sand filter basins, porous landscape detention, and porous pavement detention.

Wetlands and riparian areas are also federally-protected as Waters of the United States under section 404 of the Clean Water Act. Land disturbances that include discharge of dredged or fill material to wetlands must obtain authorization for the discharge from the United States Army Corps of Engineers.

## 6.3 Land Development Activities



In 2015, the Authority reviewed all land development activities in the basin for point and non-point source pollutant impacts, water quality considerations, and activities in Stream Preservation Areas that may have affected wetlands and riparian areas. The Authority reviewed 13 land development activities that occurred in a Stream Preservation Area and provided comments to the land use agency. The type of projects included residential construction, stormwater detention facility upgrade, stormwater drainage easement, a dog park (located within an open space), recreation center expansion, transportation trail head and trail construction, stream reclamation, utility line, and a lift station. The Authority recommended construction and post-construction BMPs in compliance with Regulation 72 to protect wetlands and riparian areas.

## 6.4 Protection, Enhancement, and Restoration Actions

In the Cherry Creek basin, wetlands and riparian areas have been affected by construction, filling, channelization, urbanization, and the construction of the reservoir. Urbanization in the basin has increased the rate, volume, duration, and frequency of runoff during storm events, resulting in significantly higher stream erosion rates than from undisturbed watersheds. Urban runoff was identified as a major contributor of phosphorus loads to the reservoir during the Clean Lake Study of Cherry Creek Reservoir, degrading the water quality. The Authority has implemented protection, enhancement, and restoration actions in the basin for channel and stream stabilization, and has quantified the amount of nutrient reduction as a result of these projects. Channel or stream stabilization means the activities used to minimize erosion and sedimentation within a surface water or stormwater-runoff conveyance. Channel or stream stabilization projects are designed based on hydrology of the tributary watershed that factors in storm runoff rate, volume, frequency, and duration from projected future development conditions. Stabilization activities in the basin include: excavation and re-grading; placement of fill; construction of check structures, drop structures, and channel bed and bank protection measures; and placement of vegetation that protects the channel area of the

conveyance. Channel or stream reclamation also may include additional measures or enhancements to channel or stream stabilization such as riparian and floodplain vegetation plantings and construction of channel cross-sections that result in more frequent connection and flooding of the overbank area. Riparian vegetation promotes filtration of fine particles with attached nutrients, and over-bank flooding promotes additional filtration and, to some extent, infiltration, both of which reduce nutrient loads and concentrations. Therefore, benefits from stream reclamation include reduction in sediment and nutrients (i.e., phosphorus and nitrogen) transport from the main channel, as well as reduction in nutrient loads from riparian and floodplain vegetation through more frequent floodplain inundation. The design of channel and stream reclamation projects must also recognize the fact that urban development in the watershed has significantly altered the hydrologic regime.

The protection, enhancement, and restoration actions of the Authority have reduced nutrient contributions to the reservoir and have provided recreational and aesthetic value to the watershed. One of the main focuses of the Authority is re-integrating the stream channel and floodplain along the corridor of Cherry Creek and its tributaries. By reconnecting the channel and floodplain, more frequent stormflows spill out of the channel onto the riparian and floodplain area, thus reducing stream velocities and increasing filtration/infiltration on the overflow banks.

Revegetation along the corridor with grasses, shrubs, and trees provide an aesthetic corridor buffer and promote enhanced riparian habitat. Re-establishment of riparian habitat also benefits many animal species that rely on riparian areas for at least part of their lives. The following measures have been implemented in the basin:

- Reduction of stream flow velocities in certain areas in the basin by reducing longitudinal channel grade and constructing drop structures that anchor the channel and floodplain cross-section. These structural components stabilize both the channel and buffer area (between the outer edges of the floodplain and the channel) against continued channel and riparian area degradation.
- Maintenance of long-term stability and water quality benefits in the basin, and channel geometry based on storm flows that reflect changes in watershed hydrology due to urbanization. Watershed development increases frequency, duration, and magnitude of storm runoff, all factors which influence channel geometry. When channel geometry is based on runoff from an urban watershed, the design approach is more appropriately

referred to as reclamation, instead of restoration (i.e., pre-urbanized geometry). If an urban stream is "restored" instead of "reclaimed", there is a greater risk of failure because the restored channel will eventually change geometry to reflect increased runoff from an urban watershed.

- Incorporation of trails has occurred along and across the corridor in many areas which encourage public use and connectivity with the stream corridor amenities and neighborhoods. Recreation trails also serve as access locations for routine channel maintenance activities that help preserve flood control and water quality protection benefits of channel reclamation. Often, the trail crossings become part of the drop structures used to reduce longitudinal channel grades, thereby integrating flood control, water quality, and recreation benefits into a multi-purpose project.

The Authority encourages local governments to collaborate with other entities in pursuing easements, ownerships, and rights to protect the streams, riparian corridors, tributaries, and wetlands in the Cherry Creek watershed. As part of its Watershed Plan efforts, the Board and TAC jointly prioritized future work plan efforts, choosing among several identified likely pollutant sources and management strategies that could be implemented. The highest ranking priority, by far, was stream erosion and the need to continue to implement erosion control strategies.

Management options chosen to prevent and control stream erosion that have received the most support from Authority include:

- Protecting riparian zones through stream buffer programs;
- Being preemptive and performing stream reclamation projects before the streams are eroded due to development (i.e., before they "unravel"); and
- Studying the impacts of water development and increasing alluvial well withdrawals on riparian vegetation.

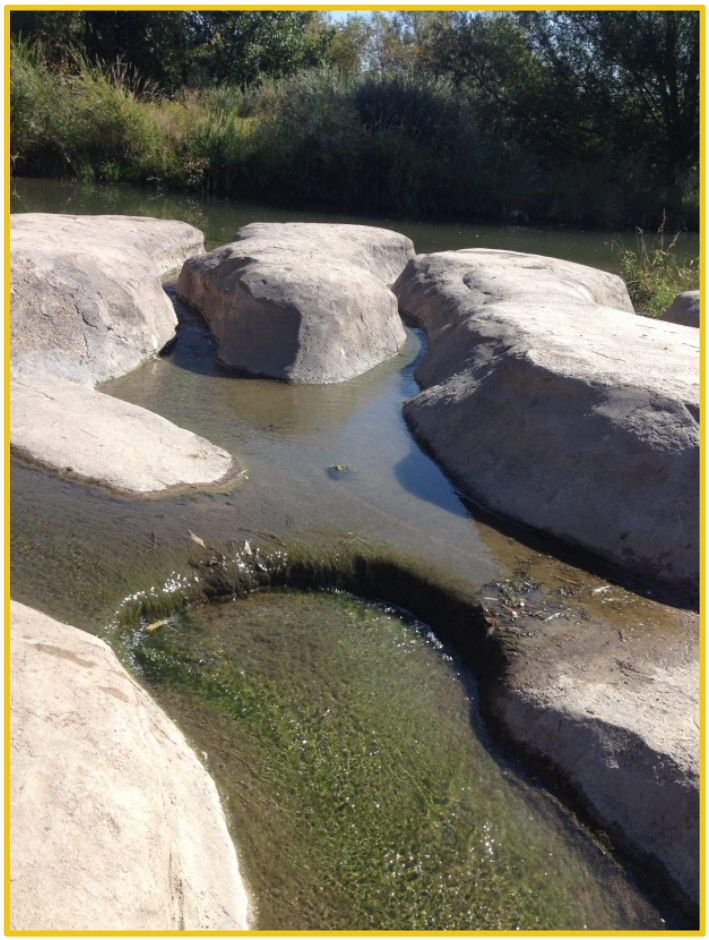
It is believed that if stream reclamation projects can be identified and the channels protected before they unravel, the reclamation approach can be more surgical with improvements that are constructed in specifically identified locations at less cost of an entire stream reclamation project.

### Cherry Creek Ecological Park Wetlands Creation and Restoration

The Cherry Creek Ecological Park project area was severely degraded, banks were eroded resulting in steep slopes and material sloughing, and there was lateral channel migration. This resulted in the loss of wetlands and upland vegetation due to lowering of the water table by the streambed erosion. In 2013, the Authority and its Partners implemented a natural bio-engineering approach to connect the

streambed to the overbanks, and developed an engineered approach to alter the topography of the channel. In some locations, essentially all of the existing channel bank and riparian vegetation had to be removed and replanted due to the substantive changes in channel geometry necessary to accommodate topographic and floodplain limitations. The project was designed to raise the streambed and reestablish the water table to prevent further loss of vegetation and to restore and enhance wetland and riparian functions of Cherry Creek.

In 2015, the Authority conducted site visits after the restoration project to assess wetlands in the park and effects on wetlands as a result of the restoration project. Wetland assessments were conducted using the U.S. Army Corps of Engineers guidelines for the three parameter indicator tests, and required a survey of soil, hydrology, and vegetation in the area. A wetland map was created in 2015 to assess restoration effects on Cherry Creek compared with pre-project wetland areas. Figure 6-1 shows that approximately 1.4 acres of wetlands were created as a result of the restoration project.



Pre-project wetland conditions were limited to banks that were immediately adjacent to Cherry Creek. Wetlands in the area were characterized as narrow riparian wetlands along Cherry Creek, and adjacent wetlands on the banks surrounding the pond. The pre-project wetland estimates were based on 2012 imagery.

In 2015, the Authority documented significant evolution of wetlands along the west tributary (including the creation of a small pond), as a result of the constructed drop structure completed in 2013. The drop structure caused a small tributary branching to the west of the pond onsite, which returns back to Cherry downstream of the pond. This has resulted in seepage of water from the tributary to adjacent lands. Pooling and ponding of water occurs for the majority of the year. As a result of this standing water, hydrophitic vegetation (e.g. sedges, rushes, pond weeds, broad arrowheads, common duckweed, watermilfoil, cattail, allisium) has dominated the areas adjacent to the tributary.

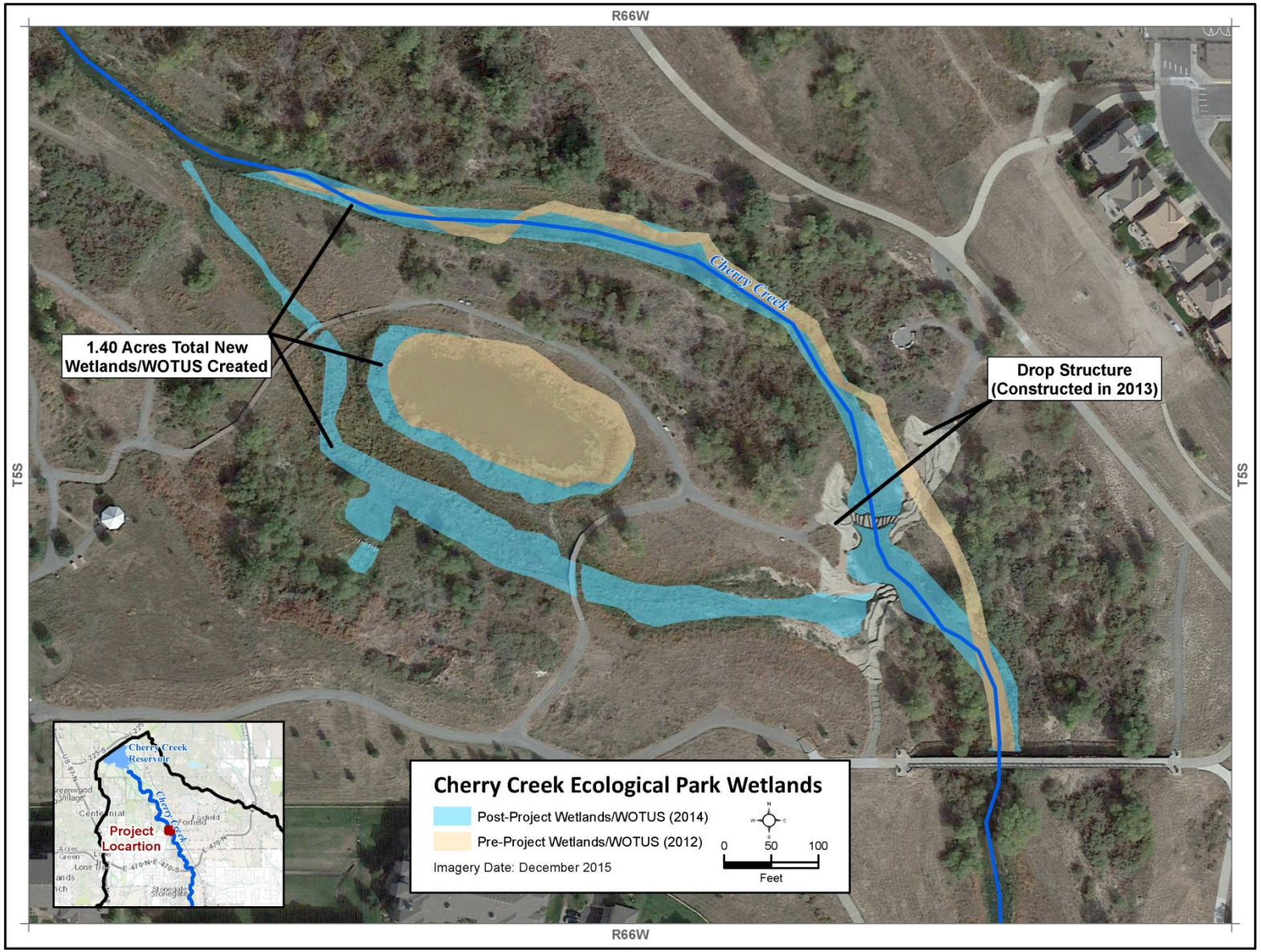
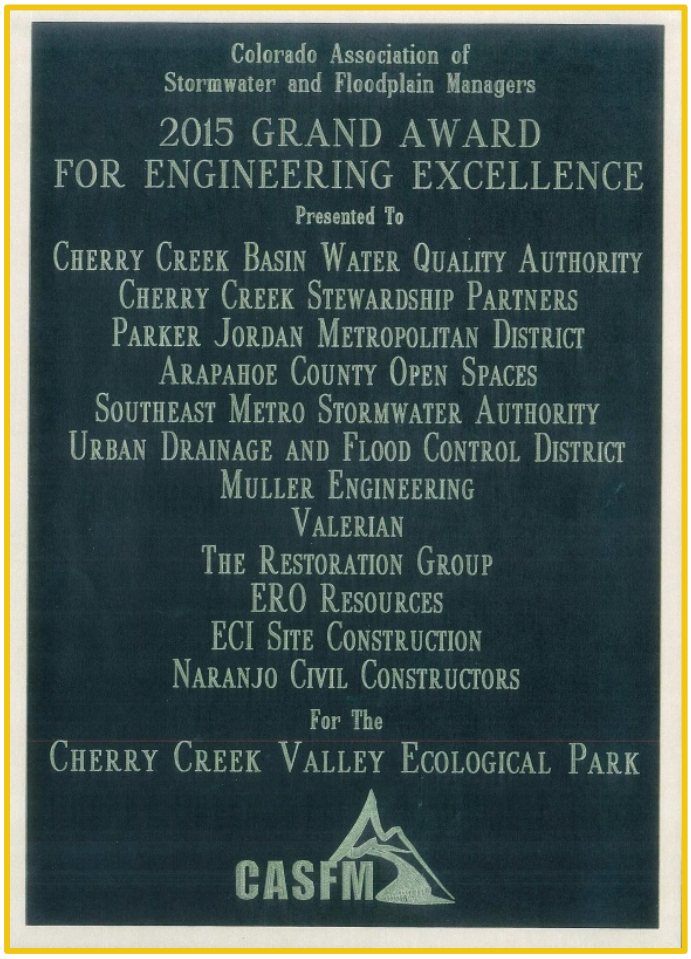



FIGURE 6-1: CHERRY CREEK ECOLOGICAL PARK WETLANDS

## Cherry Creek Ecological Park CASFM Grand Award




The Cherry Creek @ Eco Park Stream Reclamation Project won the 2015 Grand Award for Engineering Excellence by the Colorado Association of Stormwater and Floodplain Managers at their annual conference in Vail, CO in September 2015. This project was initiated in 2009 with several goals in mind to restore this reach of Cherry Creek back to a healthy stream corridor. The project goals identified were:

- Improve the quality of water flowing downstream and entering Cherry Creek Reservoir
- Create a stable storm flow corridor that maintains/improves the current flood capacity
- Protect existing infrastructure from stream erosion
- Preserve where appropriate, restore where needed, and enhance the overall wildlife habitat in the Cherry Creek channel and overbank areas
- Enhance educational and recreational amenities

Four funding agencies (UDFCD, SEMSWA, CCBWQA and Arapahoe County Open Space) worked closely with a team of four consultants and two contractors to complete this award winning project.

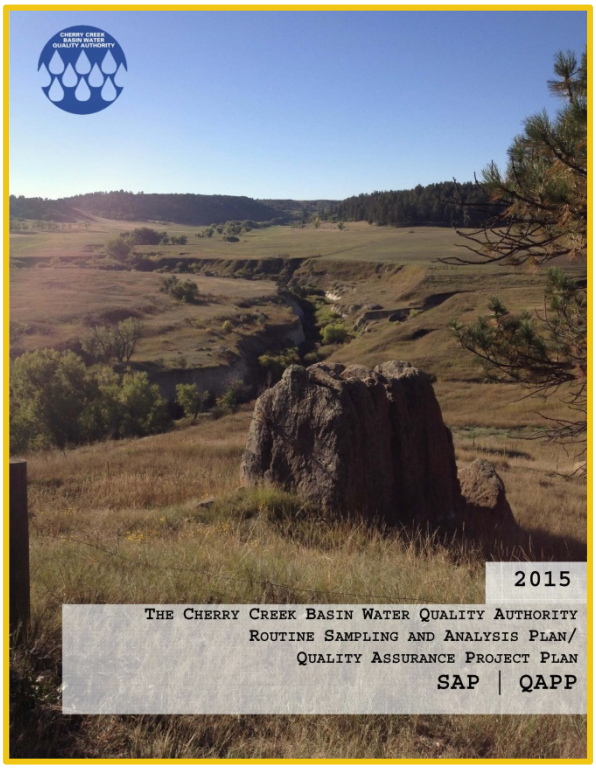
Water quality was enhanced by stabilizing and raising the channel to reconnect the channel with the overbanks while protecting wetland areas. Grade control structures and channel/overbank grading were designed to improve flood conveyance and to minimize erosion during large storm events. The improvements took advantage of perennial base flows, allowing native wetland species to be planted along with willow stakes, trees, upland shrubs, and grasses, thus further establishing habitat for wildlife. A series of trail crossings (formal and informal) were constructed to facilitate the expanded recreational trail network and park. Signage, outdoor classrooms, and other park amenities provide additional educational and recreational opportunities within the Eco Park.

# 7 MONITORING

The Authority implemented its 2015 Routine Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP) in Cherry Creek Reservoir and the Watershed. The updated SAP/QAPP continued to focus monitoring efforts on reservoir and tributary water quality, inflows and outflow, loads and export, surface and groundwater quality in the watershed, and PRF effectiveness in Cottonwood Creek and McMurdo Gulch.

In 2015, routine water quality sampling occurred at three sites in Cherry Creek Reservoir (Map 7-1). Sampling also occurred along transects in the reservoir throughout the summer in order to spatially measure dissolved oxygen conditions and oxidation-reduction potentials. This also provided insight to the areal extent of internal nutrient loading. Cherry Creek Reservoir tributary inflows (from Cherry Creek and Cottonwood Creek) were monitored immediately upstream of reservoir and the outlet was monitored immediately downstream to develop an annual mass balances for total phosphorus (TP) and total nitrogen (TN). The Authority continued to monitor sites upstream and downstream of its PRFs on Cottonwood Creek and McMurdo Gulch to evaluate their effectiveness of reducing suspended solids, TP, and TN. The Authority also continues to monitor the Eco Park site established in 2013 on the mainstem of Cherry Creek to evaluate the stream reclamation project.

Watershed monitoring included seven surface water sites along Cherry Creek, from Castlewood Canyon to Cherry Creek Reservoir and seven alluvial groundwater well locations from Franktown to Cherry Creek Reservoir.




## 7.1 Sampling and Analysis Plan

In 2015, the Authority updated the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) which includes long-term monitoring of nutrient levels within the reservoir and its tributaries, nutrient levels in precipitation and groundwater, and chlorophyll α levels within the reservoir. The overall goal of the monitoring program is to assess attainment of the water quality standards (including beneficial uses and the numeric criteria adopted to protect the uses) and to assess the effectiveness of the Authority's actions.

### 7.1.1 PURPOSE

The Authority is required to sample biological, physical, and nutrient parameters in the Cherry

Creek Reservoir and its tributaries under Regulation 72. Pursuant to this charge, the monitoring program is to meet the following purposes stemming from Regulation 72:

- For the purpose of supporting and calibrating the reservoir water quality model, as anticipated by Regulation 72 ;
- For the purpose of meeting parameter-specific monitoring required of the Authority by Regulation 72 and additional non-specified monitoring determined by the Authority to be supportive of Authority goals;
- For the purpose of meeting nutrient Pollutant Reduction Facility (PRF) monitoring required of the Authority by Regulation 72;
- For the purpose of assessing the effects of the destratification system, as required of the Authority by Regulation 72 as part of its PRF monitoring for nutrients and additional monitoring as may be determined by the Authority;
- For the purpose of determining attainment of applicable water quality standards, as required of the Authority by Regulation 72; and
- For the purpose of evaluating nutrient sources and transport, evaluating fate and transport of phosphorus, and calculating flow-weighted phosphorus concentrations, as required of the Authority by Regulation 72.
- For the purpose of calculating flow-weighted nitrogen concentrations and evaluating the fate and transport of nitrogen, as well as calculating mass balances for both phosphorus and nitrogen inputs and losses from the reservoir, as determined by the Authority to be supportive of its goals, according to the 2010 expansion of Regulation 72 to consider all nutrients, and not just phosphorus.

**As future special studies are identified, the SAP/QAPP will be reviewed to determine if any modifications need to be made to support the new study. In some instances, a short, stand-alone SAP may be more appropriate. "Special studies" are anticipated by Regulation 72, the Cherry Creek Reservoir Control Regulation, Section 72.8.4: "Special studies may include, but are not limited to, the following areas of investigation: (a) Feasibility study of nutrient removal from point sources; (b) Quantification of effectiveness of nonpoint source concentration-based phosphorus control strategies called PRFs; (c) Quantification of effectiveness of regulated stormwater concentration-based phosphorus control strategies called BMPs; and (d) Quantification of the effectiveness of source control BMPs that include low-impact development techniques." The reservoir model qualifies as a special study. A special study such as a side-by-side comparison of methods for cyanobacteria analysis, e.g., filtering vs. settling, would also require a separate special SAP.**

### 7.1.2 Sampling Program Objectives

The Authority's long-term goals serve as assessment end-points for the reservoir and watershed (for example, protection of beneficial uses, and preservation and enhancement of water quality). The sampling program helps the Authority evaluate whether it is attaining its long-term goals. Specific objectives of the sampling program are to:

- Determine biological productivity in the reservoir, as measured by chlorophyll α concentrations and collect other data (i.e., phytoplankton) related to the effect of chlorophyll α on beneficial uses;

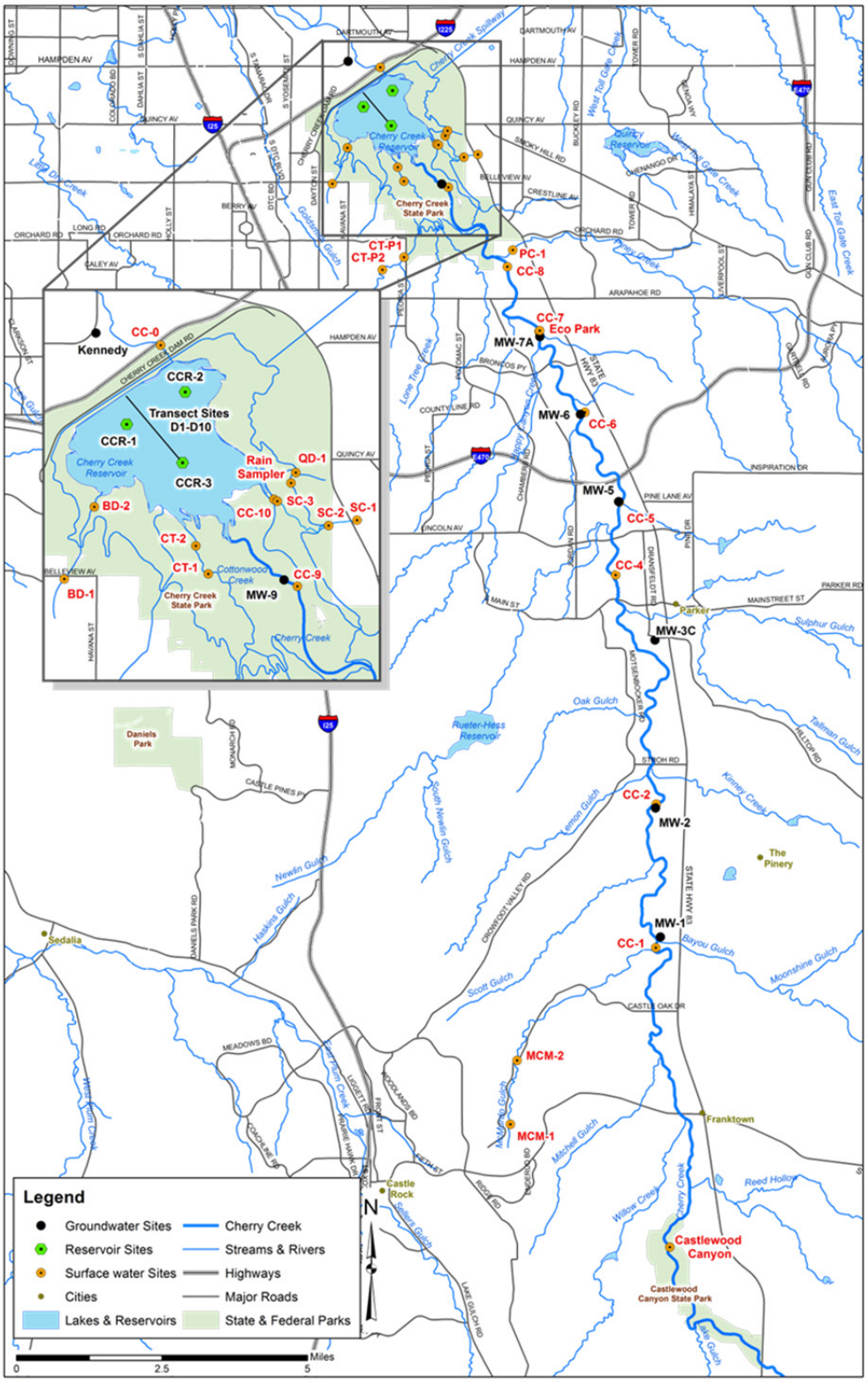
- Determine the concentrations of phosphorus and nitrogen species in the reservoir and streams, and how they change over time;
- Determine the annual flow-weighted phosphorus concentration and changes to the concentrations entering the reservoir from streams and precipitation, as well as the phosphorus export from the reservoir via the outlet structure;
- Determine the effectiveness of pollutant removal by Pollutant Reduction Facilities; and
- Determine the effectiveness of the destratification system[1] in protecting the beneficial uses by reducing the algal biomass as measured by chlorophyll α and reducing cyanobacteria production as measured by species identification, enumeration, and biovolume.

The SAP/QAPP identifies field and laboratory protocols necessary to achieve high quality data. The 2014 SAP/QAPP is intended to expand upon the 2008 Sampling and Analysis Plan and Quality Assurance Work Plan (GEI 2008) and includes: quality assurance objectives for the measurement of data in terms of accuracy, representativeness, comparability, and completeness; field sampling and sample preservation procedures, laboratory processing and analytical procedures; guidelines for data verification and reporting; quality control check; corrective actions; and quality assurance reporting.

## 7.2 Sampling Sites

Reservoir, watershed, and PRF samples will be routinely conducted at 13 sites, including three sites in Cherry Creek Reservoir, eighteen stream monitoring sites (on Cherry Creek, Cottonwood Creek, Piney Creek, and McMurdo Gulch), eight alluvial groundwater sites along Cherry Creek mainstem, and one site on Cherry Creek downstream of the reservoir (Map 7 -1, Table 7-1, and Table 7-2). Data from many of these monitoring sites are used to assess the effectiveness of several of the Authority's PRFs. In addition to these routine monitoring sites, 10 transect sites (D1 to D10) were established from the approximate mid-point of the dam face extending perpendicular across the destratification zone in the reservoir, as well as three continuous temperature logging sites near routine reservoir monitoring sites.

[1] Note that the destratification system was originally designed to achieve the following goals: 1) reduce the release of phosphorus and nitrogen nutrients from the bottom sediments into the water column of the reservoir in a typical year by 810 lbs/yr and 1140 lbs/yr, respectively; 2) decrease the seasonal mean (July-Sept) chlorophyll α concentrations by approximately 8 ug/L under typical year conditions; 3) decrease annual peak chlorophyll α concentrations by up to 30 ug/L; 4) increase dissolved oxygen concentrations in the deepest and most vulnerable zones of the reservoir into the range of 5 mg/L; and 5) reduce the production of blue-green algae by making the habitat of the reservoir less suitable for the production of blue-green algae via vertical mixing. (AMEC Earth & Environmental, Inc., Alex Horne Associates, Hydrosphere Resource Consultants, Inc. (December 5, 2005). Feasibility Report Cherry Creek Reservoir Destratification.)

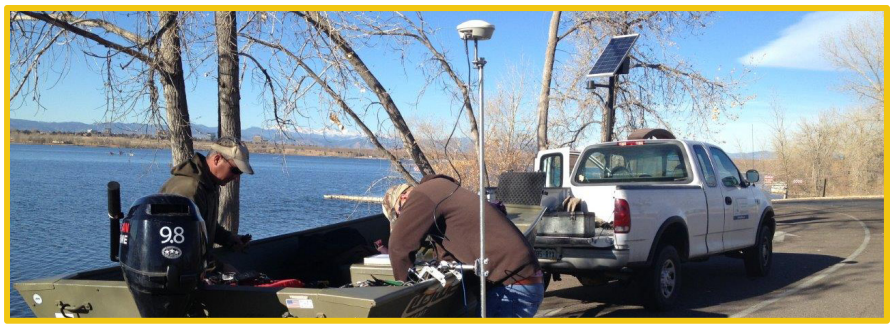



**MAP 7–1: SAMPLING SITES ON CHERRY CREEK RESERVOIR, SURFACE WATER MONITORING SITES, AND ALLUVIAL GROUNDWATER SITES**

**(NOTE: MW-7A WAS REPLACED BY MW-7B IN AUGUST 2015)**

## TABLE 7-1: RESERVOIR SAMPLING PARAMETERS AND FREQUENCY

| ANALYTE | Monthly Vertical Profile WQ Sonde (Oct – April) | Monthly Nutrient-Biological Samples (Photic Zone) | | Monthly Nutrient Profile (4m-7m) | Bi-monthly Sonde & Nutrient Samples (May-Sept) | Precipitation | Destratification Transect Vertical Profile WQ Sonde (Jun-Aug) |
|---|---|---|---|---|---|---|---|
| | CCR-1, CCR-2, CCR-3 | CCR-1, CCR-3 | CCR-2 | CCR-2 | CCR-1, CCR-2, CCR- 3 | Rain Sampler | 11 Sites (D-1, D-2, D-3, D-3.5, D-4, D-5, D-6, D-7, D-8, D-9, D-10) |
| **Physical** | | | | | | | |
| Temperature | X | | | | X | | X |
| Conductivity | X | | | | X | | X |
| pH | X | | | | X | | X |
| Dissolved Oxygen | X | | | | X | | X |
| Oxidation/Reduction Pot'l | X | | | | X | | X |
| 1% Transmittance | X | | | | X | | |
| Secchi disk | X | | | | X | | |
| Temperature, Continuous | X | | | | | | |
| **Inorganics** | | | | | | | |
| Total Nitrogen | | X | X | X | X | X | |
| Total Dissolved Nitrogen | | X | X | X | X | X | |
| Ammonia as N | | X | X | X | X | X | |
| Nitrate+Nitrite as N | | X | X | X | X | X | |
| Total Phosphorus | | X | X | X | X | X | |
| Total Dissolved Phosphorus | | X | X | X | X | X | |
| Orthophosphate as P | | X | X | X | X | | |
| **Organics** | | | | | | | |
| Total Organic Carbon | | | X | X | X | | |
| Dissolved Organic Carbon | | | X | X | X | | |
| Total Volatile Suspended | | X | X | | X | | |
| Total Suspended Solids | | X | X | | X | | |
| **Biological** | | | | | | | |
| Chlorophyll α | | X | X | | X | | |
| Phytoplankton | | | X | | X | | |
| Zooplankton | | | X | | X | | |



## TABLE 7-2: STREAM AND GROUNDWATER SAMPLING PARAMETERS AND FREQUENCY

| ANALYTE | Monthly Surface Water Samples | Storm Event Surface Water ISCO Samples | Bi-annual Surface Water Samples | Bi-annual Groundwater Samples |
|---|---|---|---|---|
| | **10 sites** (CC-0, CC-10, CC-7-Eco Park, CT-1, CT-2, CT-P1, CT-P2, MCM-1, MCM-2, PC-1) | **7 sites** (CC-10, CC-7-Eco Park, CT-1, CT-2, CT-P1, CT-P2, PC-1) | **9 sites** **(Castlewood, CC-1, CC-2. CC-4. CC-5, CC-6, CC-8, CC-9)** | **8 sites** (MW-1, MW-2, MW-3c, MW-5, MW-6, MW-7a, MW-9, Kennedy) |
| **Physical** | | | | |
| Temperature | X | | X | X |
| Conductivity | X | | X | X |
| pH | X | | X | X |
| Dissolved Oxygen | X | | X | X |
| Oxidation/Reduction Pot'l | | | | X |
| Water Level, Continuous (15-minute interval) | | X | | X (MW-9 only) |
| Discharge, Rating Curve | | X | | |
| **Inorganics** | | | | |
| Total Nitrogen | X | X | | |
| Total Dissolved Nitrogen | X | X | | |
| Ammonia as N | X | X | X | X |
| Nitrate+Nitrite as N | X | X | X | X |
| Nitrate as N | | | X | X |
| Nitrite as N | | | X | X |
| Total Phosphorus | X | X | X | |
| Total Dissolved Phosphorus | X | X | X | X |
| Orthophosphate as P | X | X | X | X |
| Chloride | | | X | X |
| Sulfate | | | X | X |
| **Organics** | | | | |
| Total Organic Carbon | | | | X (MW-9 only) |
| Dissolved Organic Carbon | | | | X (MW-9 only) |
| Total Volatile Suspended Solids | X | X | | |
| Total Suspended Solids | X | X | | |

The purpose of the 2015 supplemental cyanotoxin SAP is to document the concentration of microcystins in the photic zone of the reservoir and at the Swim Beach during the routine monitoring events. In the event of a cyanobacteria bloom, opportunistic samples will be collected to document the concentrations of microcystins, anatoxin-a, cylindrospermopsin, and saxitoxin. These data will allow the Authority and its stakeholders the opportunity to evaluate potential risks to the beneficial uses.

### 7.2.1 2015 Reservoir Water Quality

#### *7.2.1.1* Chlorophyll α

The annual pattern of chlorophyll α concentrations was quite variable throughout the 2015 WY. From October 2014 through September 2015, chlorophyll α concentrations ranged from 8.1 µg/L in early August to 35.2 µg/L in mid-October (Figure 7-1) with an annual mean chlorophyll α concentration of 18.4 µg/L. Mid-October and early November were characterized by relatively high chlorophyll α concentrations (i.e., > 30 µg/L).

The autumn (October and November) chlorophyll α concentrations were the highest observed and continued an increasing chlorophyll α trend observed at the end of the 2014 WY. Another peak in Chlorophyll α was observed in late May (Figure 7-1) which was in response to the onset of internal nutrient loading. Alternatively, Chlorophyll α concentration was lowest in mid-August as Cherry Creek reservoir experienced a storm-induced mixing event. As a result, phytoplankton were likely mixed into deeper water where they could not photosynthesize as efficiently. Overall, an increase in chlorophyll α from mid-June through September resulted from the internal nutrient loading that occurred in June and July. The released nutrients were mixed throughout the water column in early July and mid-August which supported the growth of algae into autumn. This pattern is typical of historical conditions, absent the destratification system.

During the regulatory growing season, the mean chlorophyll α concentrations were 12.9 µg/L in July, 13.4 µg/L in August, and 22.3 in µg/L September which resulted in a seasonal mean concentration of 16.0 µ/L (Figure 7-1). These variable algal biomass conditions are typical of reservoir conditions absent the destratification system and reflect seasonal mean total phosphorus and nitrogen concentrations observed during the July to September period. The reservoir attained the site-specific chlorophyll α standard of 18 µg/L, although the reservoir remains out of compliance with the allowable exceedance frequency, because 2015 was the first out of five consecutive years that the standard was achieved.

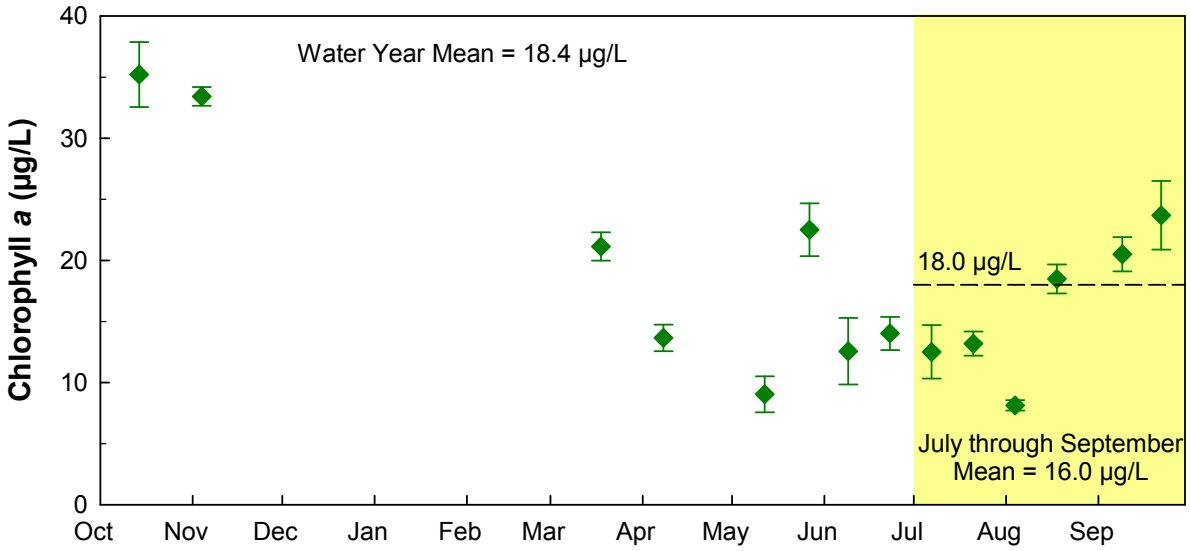



**FIGURE 7-1: CONCENTRATION OF CHLOROPHYLL A (MG/L) IN CHERRY CREEK RESERVOIR, 2015 WY.**

**Error bars represent a 95% confidence interval around each mean. Highlighted area denotes the seasonal period for the chlorophyll α standard**

### 7.2.1.2 Long-Term Chlorophyll α Concentrations

Data are plotted in Figure 7-2 below for the years from 1987 through 2015. Patterns seen in the data correspond to factors such as different annual conditions (e.g. dry summer, 2002; wet summers, 2007 and 2009, and 2015) or operation of the destratification system (2008-2013). Seasonal mean chlorophyll α concentration for this period was 26.9 µg/L and was considerably greater than the site-specific standard. In 2014, the first year the destratification system was not operated since its start-up, the chlorophyll α concentration remained above the standard, at 24.4 µg/L, and was similar to that of the previous four years. Chlorophyll α in 2015 was, however, much lower than the previous five years and very similar to conditions observed in 2007 through 2009 when extremely wet year type conditions existed during spring and early summer which greatly influenced seasonal growing conditions.

From Figure 7-2, it can be seen that before the destratification system was operational, the chlorophyll α concentration exceeded the current water quality standard 10 out of 21 years. When the destratification system was operated, the reservoir exceeded the water quality standard 4 out of 6 years. The Authority decided to not operate the system in 2014 and 2015. In 2014, the first year the destratification system was not operated, the chlorophyll α concentration exceeded the standard. Chlorophyll α in 2015, however, met water quality. Exceedances of the chlorophyll α standard occurred in 1988, from 1997-2003, and again from 2010-2014. The Authority is completing its reservoir model, and anticipates its effort may shed light on the mechanisms that affect chlorophyll α concentrations.

It is noted that after one full year (2009) of the operation of the destratification system the reservoir was out of compliance from 2010 through 2014. After one year (2014) where the destratification system was not operated the reservoir was once again in compliance (2015).

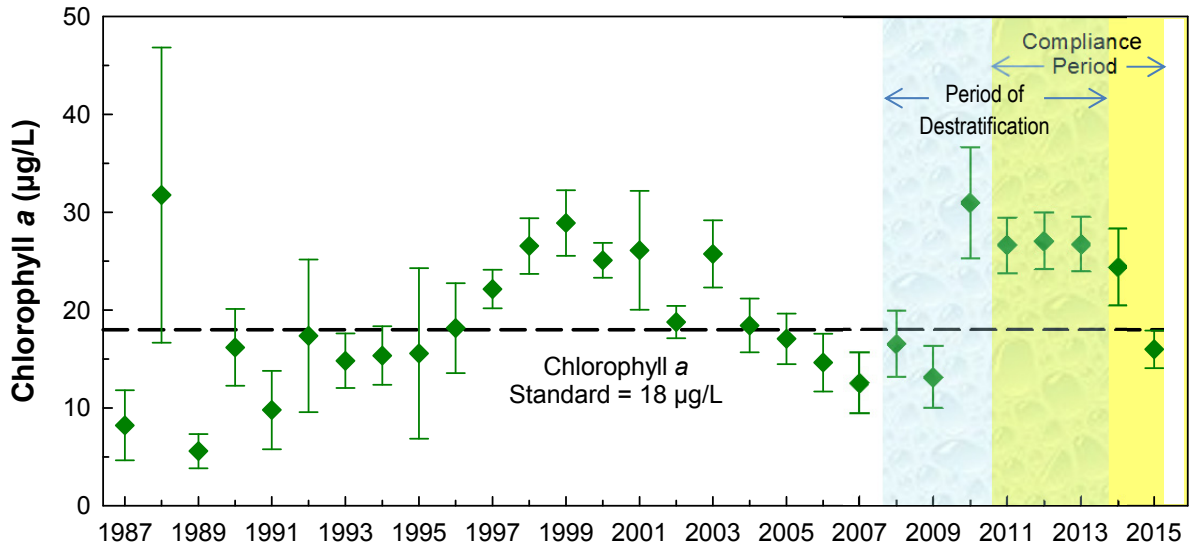



**FIGURE 7-2: SEASONAL MEAN (JULY THROUGH SEPTEMBER) CONCENTRATIONS OF CHLOROPHYLL A (MG/L) MEASURED IN CHERRY CREEK RESERVOIR, 1987 TO 2015.**

**Error bars represent a 95% confidence interval around each mean. Changes in the chlorophyll α levels were significant when the 95% confidence intervals did not overlap.**

### 7.2.1.3 Bioavailable Phosphorus and Nitrogen

In 2015, Cherry Creek Reservoir continued to experience internal nutrient loading which released soluble reactive phosphorus (SRP) and dissolved inorganic nitrogen (DIN) from the sediment into the water column. This loading occurred from approximately mid-May though early August (i.e., bottom SRP and DIN) and was facilitated by the low dissolved oxygen concentrations (i.e., <2 mg/L) near the water/sediment interface. SRP remained elevated through the early July mixing event but was evenly distributed through the water column (Figure 7-3). The TIN concentration decreased during this event but returned to stratified concentrations by the following sampling event (Figure 7-4). Internal loading decreased substantially in August when Cherry Creek Reservoir slowly became more mixed and temperature and dissolved oxygen stratification was limited.

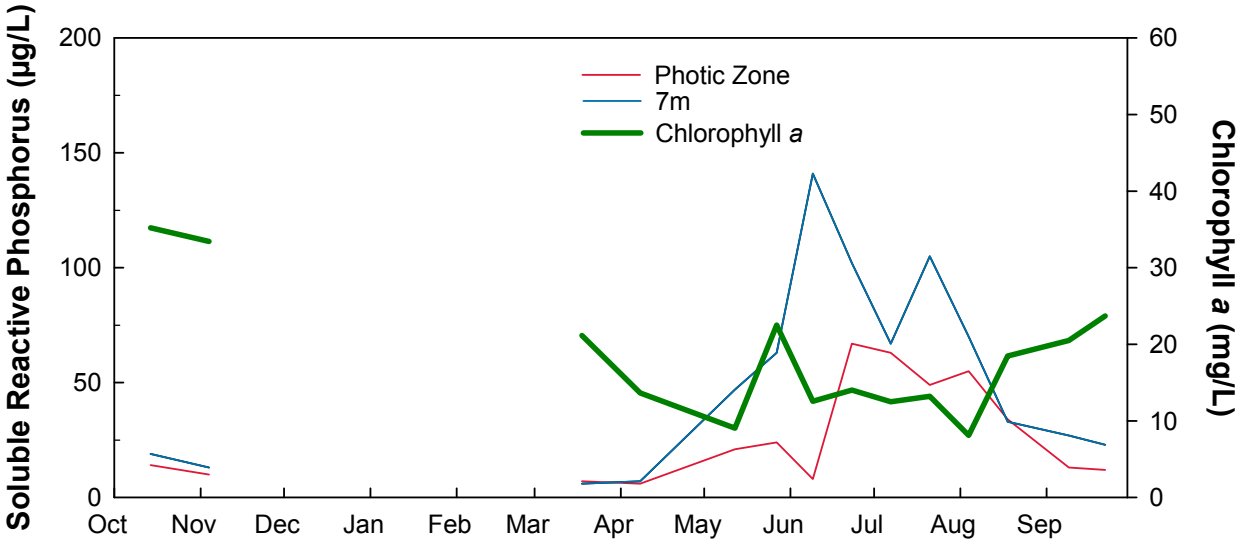



**FIGURE 7-3: SOLUBLE REACTIVE PHOSPHORUS AND CHLOROPHYLL A CONCENTRATIONS MEASURED IN CHERRY CREEK RESERVOIR, 2015 WY**

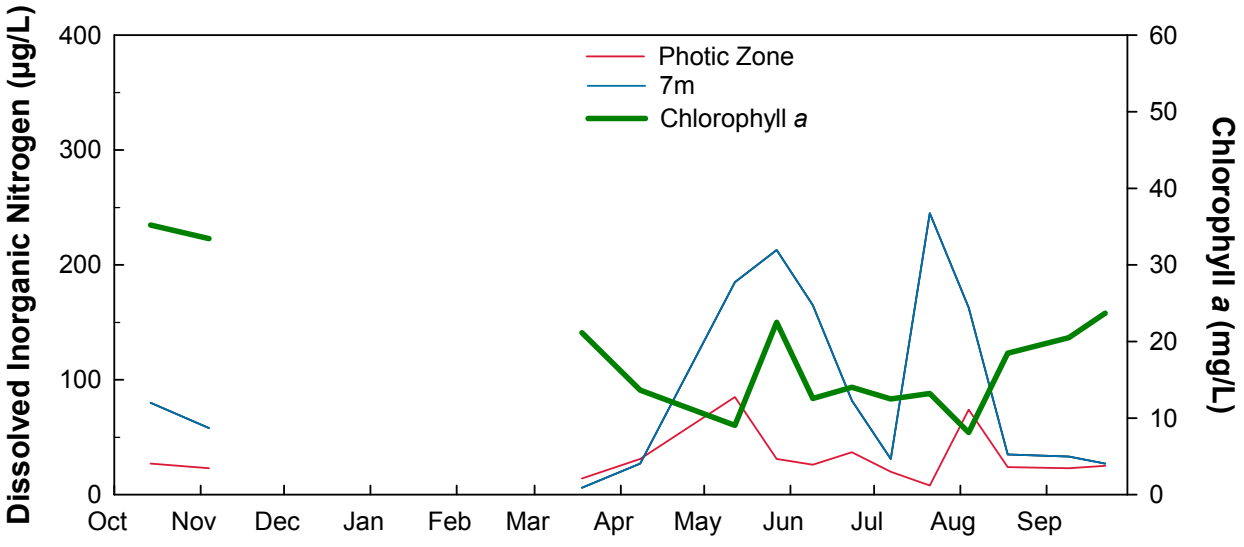



**FIGURE 7-4: DISSOLVED INORGANIC NITROGEN AND CHLOROPHYLL A CONCENTRATIONS MEASURED IN CHERRY CREEK RESERVOIR, 2015 WY**

### 7.2.1.4 Long-Term Total Phosphorus and Total Nitrogen

The summer mean total phosphorus concentrations in the upper three meters of Cherry Creek Reservoir, i.e., photic zone, are shown in Figure 7-5 for the years 1987 through 2015. In 2015, the July through September (seasonal) mean concentration of total phosphorus was 93 µg/L which is greater than long-term median value of 87 µg/L. The 2015 seasonal mean total phosphorous concentration is less than the six years in which the destratification system was operational and within the range of historical conditions absent destratification. In addition, the seasonal total phosphorus concentration was greater than interim total phosphorus value for lakes and reservoirs (> 25 acres) of 83 µg/L. Linear regression analyses performed on the 1987 to 2015 the summer mean total phosphorus concentration showed an increasing trend, with an $R^2$ of 0.6722.

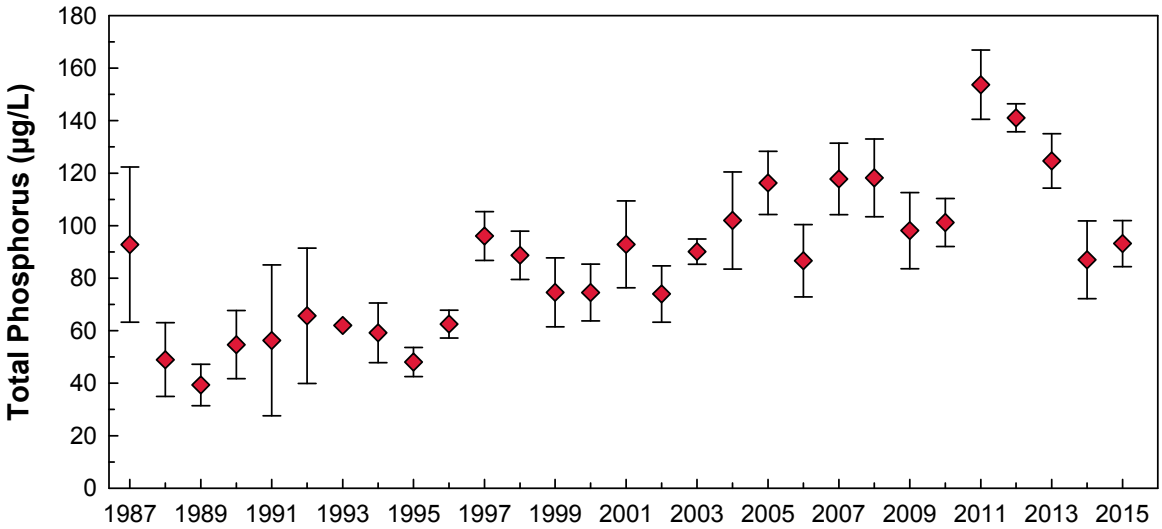



**FIGURE 7-5: SEASONAL MEAN (JULY THROUGH SEPTEMBER) TOTAL PHOSPHORUS CONCENTRATIONS (MG/L) MEASURED IN CHERRY CREEK RESERVOIR, 1987 TO 2015**

**Error bars represent a 95% confidence interval for each mean**

The seasonal mean total nitrogen concentrations have remained relatively stable over the monitoring period and indicate no long-term trend in the photic zone. In 2015, the July through September mean concentration of total nitrogen was 759 µg/L (Figure 7-6) which is less than the long-term median value of 923 µg/L. The concentration is less than the previous seven years which includes the period in which the destratification system was operational and is within the range of historical conditions absent destratification (i.e., prior to 2008). In addition, the seasonal total nitrogen concentration was less than the interim total nitrogen value for lakes and reservoirs (> 25 acres) of 910 µg/L.

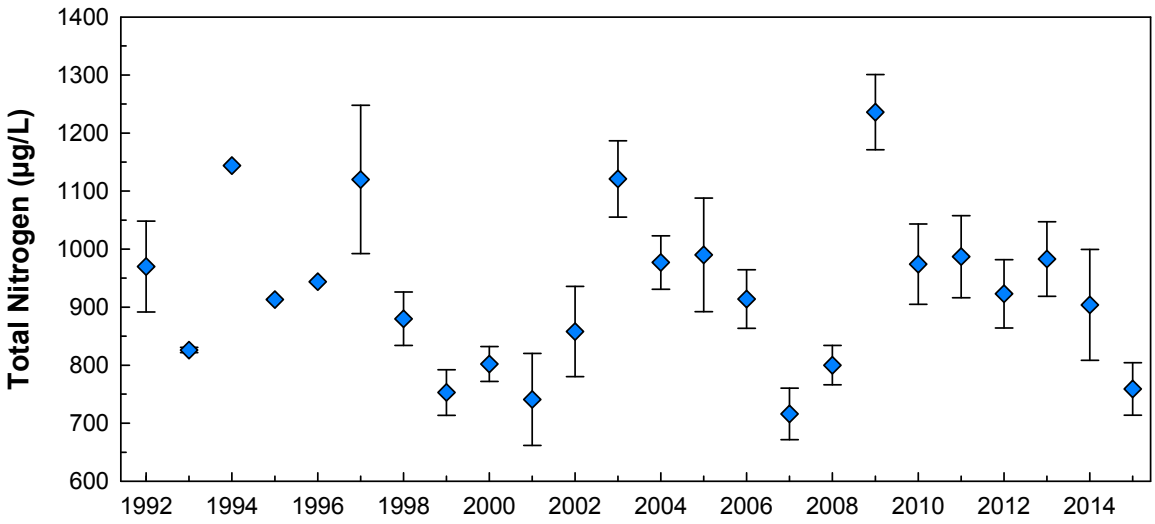



**FIGURE 7-6: SEASONAL MEAN (JULY THROUGH SEPTEMBER) TOTAL NITROGEN CONCENTRATIONS (MG/L) MEASURED IN CHERRY CREEK RESERVOIR, 1992 TO 2015**

**Error bars represent a 95% confidence interval for each mean**

### 7.2.1.5 Temperatures and Dissolved Oxygen

The CCBWQA maintains an array of thermistors in Cherry Creek Reservoir to evaluate thermal conditions as well as to examine factors that contribute to periods of low dissolved oxygen. In addition, the Authority generally performs over 100 temperature and dissolved oxygen profiles of the water column to document variable conditions. Based on the thermistor data, Cherry Creek Reservoir experienced 95 days of thermally stratified conditions in 2015 (Figure 7-7) beginning in early May. This value is greater than the mean number of 24 days Cherry Creek Reservoir was thermally stratified when the destratification system was in operation. The Daily Maximum (DM) temperature was 25.6°C on June 30, and the Maximum Weekly Average Temperature (MWAT) was 23.9°C during the seven day period from July 26$^{th}$ to August 1. Cherry Creek Reservoir was in attainment of both the acute (DM = 29.5°C) and chronic (MWAT = 26.3°C) Warm Water lakes and reservoirs temperature standards for the summer months (loggers not operated during the winter).

Cherry Creek Reservoir was in attainment of the Warm Water lake and reservoir dissolved oxygen standard of 5 mg/L (i.e., 0.5 – 2 m layer) for 68 of the 72 profiles collected from Cherry Creek Reservoir. The exceedances to the dissolved oxygen standard occurred on August 4, with mean dissolved oxygen values of 4.7 mg/L, 4.8 mg/L, and 4.9 mg/L at site CCR-1, CCR-2, and CCR-3, respectively, and on August 18 with a value of 4.6 mg/L at CCR-2.

Dissolved oxygen stratification with low concentration conditions (i.e., <2 mg/L) near the bottom of Cherry Creek Reservoir were associated with consistent thermal stratification. Both of these conditions began in early June and persisted throughout most of the summer months until the end of July (Figure 7-8) indicating a lack of water column mixing in Cherry Creek Reservoir. The major precipitation even on June 11 prolonged thermal stratification into early July and contributed to poor dissolved oxygen

conditions near the bottom of the reservoir. On July 7, the reservoir experienced a strong wind-mixing event that resulted in complete reservoir turnover that eliminated thermal stratification and circulated oxygenated water to the bottom of the reservoir. Cherry Creek Reservoir remained relatively un-stratified through the remainder of the WY, except for brief inflow-induced stratification event in mid-August.

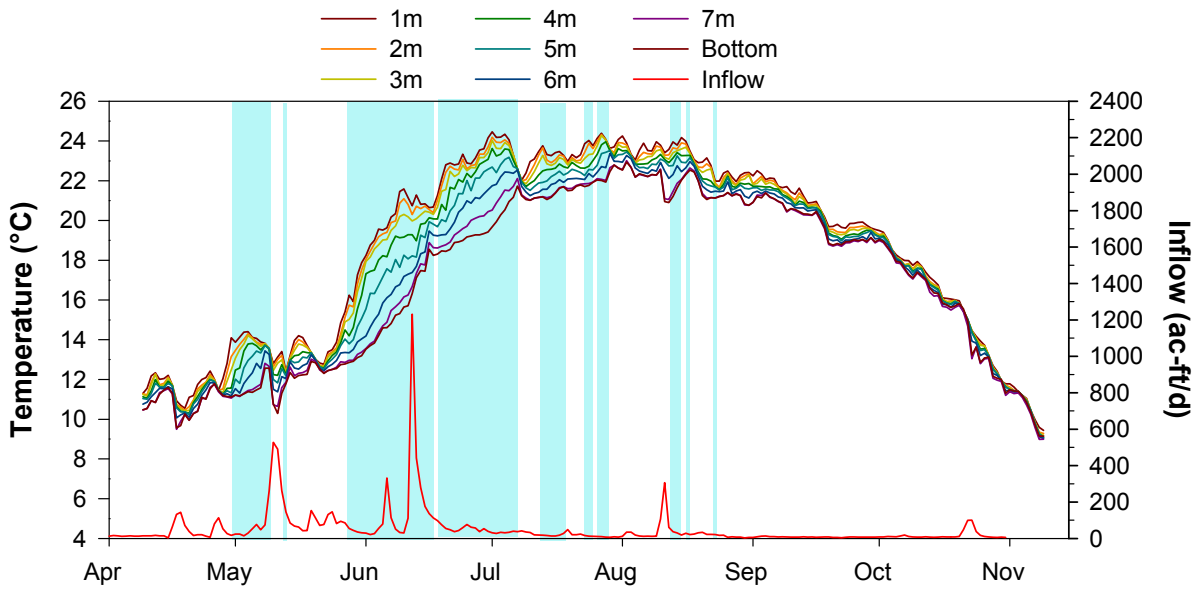



**FIGURE 7-7: DAILY MEAN TEMPERATURE (°C) RECORDED AT DEPTH FOR CCR-2 BASED ON 15-MINUTE INTERVAL DATA COLLECTED BY TEMPERATURE LOGGERS, WITH USACE INFLOW IN 2015**

**Shaded areas denote periods of thermal stratification**

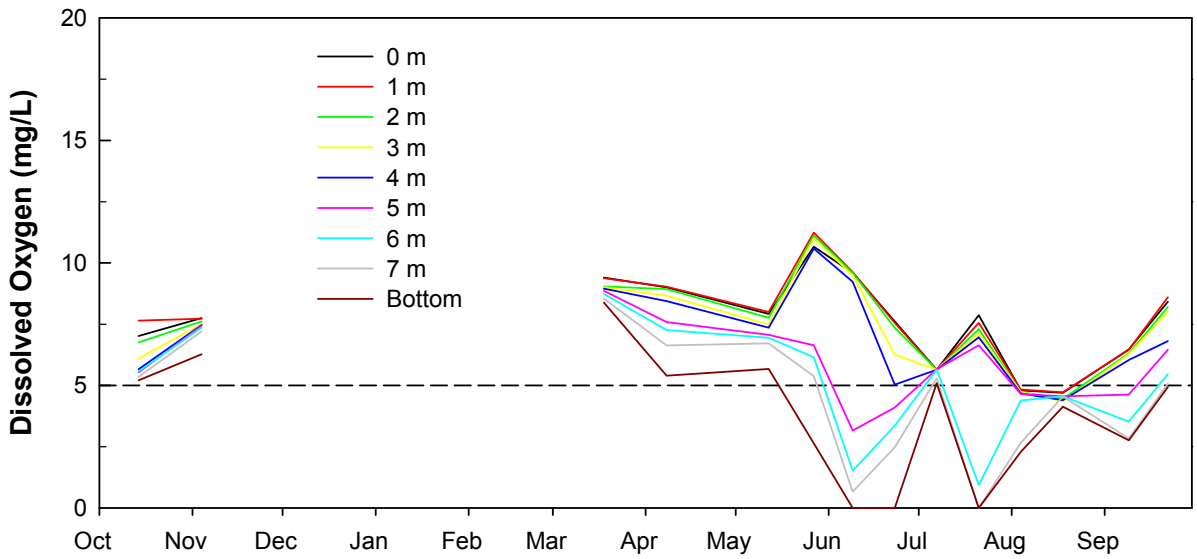



**FIGURE 7-8: DISSOLVED OXYGEN (MG/L) RECORDED AT DEPTH DURING ROUTINE MONITORING AT CCR-2 DURING THE 2015 WY**

**Bottom depth ranged from 7.2 to 8.8 m depending on water storage**

## 7.3 2015 Reservoir Inflows – Outflows and Total Phosphorus Loads

A primary objective of the Authority's monitoring program is to document the various sources of phosphorus and nitrogen that can limit or enhance algal growth in a reservoir. These sources can either come from within Cherry Creek Reservoir (internal loading) or from outside Cherry Creek Reservoir (external loading). Fish and plankton excrement, direct sediment re-supply, and the decay of organic matter are all internal sources of nutrients in a reservoir. Based on modeling efforts, net internal phosphorus loading to Cherry Creek Reservoir has been estimated to be 2,000 lbs/yr (Nürnberg and LaZerte 2008). Other studies evaluating internal loading using a variety of methodologies suggest phosphorus loading ranges between 810 lbs/yr and 1,590 lbs/yr (AMEC et al. 2005) and alluvial phosphorus loads of approximately 1,170 lbs/yr (Lewis et al. 2005). Internal nitrogen loading remains unquantified, although internal loading is evident given measurements of dissolved inorganic nitrogen near the water/sediment interface.

External sources of nutrients include inflow from streams, direct precipitation, and the alluvium which carry nutrients from soil erosion, agricultural and municipal runoff, treated wastewater, and airborne particulates. Phosphorus and nitrogen loading was determined for several primary sources and exports in 2015, including the tributary streams Cherry Creek and Cottonwood Creek, and Cherry Creek Reservoir outflow (export) as summarized in Table 7-3.

Total phosphorus is the measure of the combined impact from total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), and particulate forms of phosphorus and is used for many regulatory

baselines and goals. Total phosphorus loading to Cherry Creek Reservoir from surface flows of Cherry Creek and Cottonwood Creek was estimated at 14,436 lbs for the 2015 WY (Table 7-3). The annual flow-weighted phosphorus concentrations from surface flows of Cherry Creek and Cottonwood Creek were 268 µg/L and 75 µg/L, respectively. The external total phosphorus load for all sources of inflow to Cherry Creek Reservoir, including precipitation and alluvium, was 16,701 lbs. The 2015 WY flow-weighted total phosphorous concentration for all external sources of inflow to Cherry Creek Reservoir was 222 µg/L. This concentration is greater than the Authority's goal for an inflow flow-weighted total phosphorus concentration of 200 µg/L and the background phosphorus concentration of 190 µg/L observed in the upper portion of the watershed. Cherry Creek Reservoir retained 8,479 lbs of phosphorus in 2015 and discharged 8,222 lbs through the outlet structure (i.e., export). The flow-weighted total phosphorus concentration in the outflow was 121 µg/L.

Total nitrogen loading to Cherry Creek Reservoir from surface flows of Cherry Creek and Cottonwood Creek was estimated at 65,729 lbs for the 2015 WY (Table 7-3). The annual flow-weighted total nitrogen concentrations from surface flows of Cherry Creek and Cottonwood Creek were 910 µg/L and 1,592 µg/L, respectively. The external total nitrogen load for all sources of inflow to Cherry Creek Reservoir, including precipitation and alluvium, was 79,515 lbs. The flow-weighted total nitrogen concentration for all sources of inflow to the reservoir was 1,057 µg/L. The Authority currently does not identify a flow-weighted goal for total nitrogen entering the reservoir. Cherry Creek Reservoir retained 21,329 lbs of nitrogen in 2015 and discharged 58,186 lbs through the outlet structure (i.e., export). The flow-weighted total nitrogen concentration in the outflow was 853 µg/L.

## TABLE 7-3: NORMALIZED PHOSPHORUS LOADS, EXPORTS, AND FLOW-WEIGHTED PHOSPHORUS CONCENTRATIONS FOR CHERRY CREEK RESERVOIR, 1992 TO 2015

| Water Year | Loads and Exports | | | | | | | | Flow-weighted Concentrations | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cherry Creek Load (lbs/yr) | | Cottonwood Creek Load (lbs/yr) | | External Load (lbs/yr) | | Reservoir Export (lbs/yr | | Cherry Creek Flow-weighted (µg/L) | | Cottonwood Creek Flow-weighted (µg/L) | | External Flow-weighted (µg/L) | | Reservoir Export Flow-weighted (µg/L) | |
| | TP | TN | TP | TN | TP | TN | TP | TN | TP | TN | TP | TN | TP | TN | TP | TN |
| 1992 | 3,024 | -- | 334 | -- | 4,796 | -- | 1,328 | -- | 270 | -- | 170 | -- | 246 | -- | 91 | -- |
| 1993 | 1,521 | -- | 229 | -- | 3,162 | -- | 1,000 | -- | 251 | -- | 187 | -- | 198 | -- | 92 | -- |
| 1994 | 2,525 | -- | 168 | -- | 3,907 | -- | 964 | -- | 248 | -- | 88 | -- | 196 | -- | 73 | -- |
| 1995 | 2,064 | -- | 1,396 | -- | 5,556 | -- | 1,366 | -- | 189 | -- | 203 | -- | 178 | -- | 63 | -- |
| 1996 | 2,548 | -- | 600 | -- | 4,509 | -- | 1,382 | -- | 232 | -- | 332 | -- | 208 | -- | 87 | -- |
| 1997 | 2,131 | -- | 616 | -- | 4,299 | -- | 1,129 | -- | 264 | -- | 184 | -- | 200 | -- | 88 | -- |
| 1998 | 10,007 | -- | 1,838 | -- | 13,574 | -- | 4,139 | -- | 279 | -- | 178 | -- | 237 | -- | 81 | -- |
| 1999 | 10,495 | 34,138 | 1,290 | 10,727 | 16,403 | 68,747 | 6,388 | 25,365 | 268 | 1099 | 135 | 1361 | 234 | 485 | 102 | 485 |
| 2000 | 11,801 | 46,268 | 1,379 | 13,602 | 14,582 | 68,592 | 4,113 | 35,727 | 312 | 1224 | 159 | 1565 | 265 | 1245 | 83 | 718 |
| 2001 | 6,283 | 36,855 | 2,101 | 32,225 | 10,068 | 80,564 | 5,524 | 44,150 | 257 | 1506 | 130 | 1990 | 198 | 1582 | 127 | 1011 |
| 2002 | 2,091 | 12,227 | 438 | 14,168 | 3,746 | 33,727 | 1,971 | 16,048 | 221 | 1289 | 88 | 2850 | 171 | 1542 | 107 | 868 |
| 2003 | 6,199 | 24,772 | 1,052 | 14,346 | 9,359 | 52,141 | 4,774 | 31,344 | 287 | 1145 | 138 | 1877 | 229 | 1275 | 140 | 919 |
| 2004 | 4,307 | 18,306 | 1,640 | 30,762 | 7,377 | 58,107 | 2,682 | 26,970 | 247 | 1050 | 157 | 2937 | 201 | 1584 | 96 | 964 |
| 2005 | 8,757 | 41,414 | 1,347 | 34,251 | 11,518 | 84,627 | 3,964 | 40,761 | 247 | 1166 | 120 | 3046 | 208 | 1525 | 78 | 803 |
| 2006 | 3,568 | 19,066 | 1,224 | 28,128 | 6,174 | 55,596 | 3,251 | 25,868 | 231 | 1236 | 132 | 3033 | 187 | 1677 | 115 | 913 |
| 2007 | 15,987 | 74,158 | 2,072 | 31,791 | 19,601 | 115,545 | 7,891 | 57,798 | 295 | 1367 | 149 | 2281 | 254 | 1494 | 115 | 843 |
| 2008 | 7,254 | 50,473 | 832 | 24,508 | 9,384 | 82,191 | 4,785 | 42,072 | 205 | 1423 | 84 | 2489 | 177 | 1548 | 104 | 912 |
| 2009 | 13,591 | 62,651 | 936 | 28,372 | 16,052 | 101,234 | 9,483 | 60,724 | 276 | 1272 | 62 | 1873 | 218 | 1371 | 148 | 948 |
| 2010 | 12,049 | 71,138 | 1,037 | 20,248 | 14,488 | 100,586 | 7,880 | 61,891 | 239 | 1410 | 78 | 1528 | 200 | 1389 | 115 | 907 |
| 2011 | 7,341 | 43,936 | 652 | 11,043 | 9,301 | 62,234 | 4,114 | 32,120 | 263 | 1572 | 81 | 1373 | 212 | 1420 | 108 | 843 |
| 2012 | 5,531 | 32,035 | 588 | 10,186 | 7,462 | 50,141 | 3,478 | 28,706 | 244 | 1412 | 91 | 1572 | 200 | 1344 | 118 | 972 |
| 2013 | 6,043 | 26,223 | 846 | 26,079 | 8,588 | 63,244 | 3,378 | 29,804 | 291 | 1261 | 59 | 1817 | 190 | 1401 | 120 | 1058 |
| 2014 | 5,567 | 23,695 | 508 | 11,406 | 7,419 | 43,159 | 4,408 | 36,627 | 231 | 999 | 73 | 1625 | 190 | 1106 | 119 | 987 |
| 2015 | 13,501 | 45,830 | 935 | 19,899 | 16,701 | 79,515 | 8,222 | 58,186 | 268 | 910 | 75 | 1592 | 222 | 1057 | 121 | 853 |
| **Mean** | 6,199 | 36,855 | 936 | 20,248 | 9,301 | 68,592 | 4,113 | 36,627 | 254 | 1261 | 131 | 1873 | 201 | 1401 | 106 | 912 |
| **Median** | 6,043 | 32,035 | 652 | 11,406 | 8,588 | 62,234 | 4,114 | 32,120 | 263 | 1261 | 75 | 1592 | 200 | 1344 | 119 | 972 |

## 7.4 Reservoir Management Strategy

In 2008, the Authority implemented the reservoir destratification management strategy based upon aeration to control nuisance algal growth (large filamentous cyanobacteria). The destratification system was designed, in part, to reduce the periods of thermal stratification as well as to reduce suitable habitat conditions for large filamentous cyanobacteria by vertical mixing. Over time, it was estimated that, by oxygenating the bottom sediments, the destratification system could reduce the internal phosphorus load to approximately 50 percent of historical conditions by limiting the periods of stratification (AMEC 2005). In addition, the destratification system was anticipated to reduce both the seasonal mean and peak annual chlorophyll α concentrations in the reservoir by controlling nuisance cyanobacteria blooms. The uncertainty associated with these objectives lies both in the timing (when) and magnitude (how) of potential benefits that the reservoir might experience.

From 2008 through 2013, the reservoir revealed mixed results when placed in the context of design objectives for the destratification system. The temperature data indicate that the periods of thermal stratification were reduced when the destratification system was operated, yet dissolved oxygen conditions near the bottom remained conducive (i.e., <2 mg/L) for internal nutrient loading. As a result, the internal nutrient loading continued to supply bioavailable SRP and DIN that facilitated algal production. Despite the destratification system's apparent inability to completely mix oxygenated water all the way to the bottom of the reservoir, the system did sufficiently mix the bioavailable nutrients released from the sediment into the photic zone for uptake by algae. This mixing created more uniform conditions in the reservoir and facilitated the growth of algae as indicated by the elevated chlorophyll α levels during the growing season. This highlights the propensity of algae to respond to optimal growing conditions (see Section 7.2.1.2). There has also been uncertainty regarding the destratification system's ability to control nuisance cyanobacteria. This was confounded by a change in the algal identification laboratory that occurred in 2009, which resulted in algal identification being performed differently by each laboratory. The change in laboratories (2009) coincided closely with the initiation of operation of the destratification system (2008). At the request of the reservoir modeling consultant, the Authority decided to not operate the destratification system in 2014 and 2015. That way, it could specifically examine the response of the nuisance cyanobacteria and the rest of the algae community in terms of both composition and biovolume as well as biomass (i.e., chlorophyll α), both with and without destratification utilizing the same laboratory and in the absence of continuous mixing. The algal biovolume data are discussed herein because it provides information relative to the size and density of the algae taxa, as well as provides more information relative to chlorophyll α (algal biomass).

## 7.5 2014 Phytoplankton and Cyanotoxins

A primary goal of the destratification system was to mimic wind-induced mixing events that are a dominant feature of the reservoir dynamics. The induced vertical mixing of algae, especially large filamentous cyanobacteria, disrupts their preferred habitat which can limit their full growth potential at the surface of Cherry Creek Reservoir. Cyanobacteria are of particular concern because they can produce cyanotoxins which can negatively affect the beneficial uses of the reservoir. Cyanobacteria blooms have historically been associated with large chlorophyll α levels (i.e., > 30 µg/L) observed during the summer.

Cyanotoxins are becoming a primary concern for many drinking water supply reservoirs as well as many primary water contact recreational use reservoirs, although Cherry Creek Reservoir is not a Direct Use Water Supply Reservoir. As a result of the Authority's decision to not operate the destratification system in 2014 and 2015, a cyanotoxin (anatoxins, microcystins, saxitoxins, cylindrospermopsin) monitoring program was implemented in response to concerned stakeholders. The goal of this supplemental data collection effort was to document cyanotoxin concentrations (primarily microcystins) within the main body of Cherry Creek Reservoir and at the Swim Beach area on a biweekly basis. Two opportunistic samples are also collected during visual confirmation of two cyanobacteria blooms, one in late May, and the other in late September 2015.

During the spring through fall months of 2015, Cherry Creek Reservoir experienced two events of increased chlorophyll α concentrations. The first occurred in late May when Cryptophytes (68%; primarily *Cryptomonas erosa*) were the most abundant phytoplankton (Figure 7-9). These algae are considered beneficial in terms of a food source for zooplankton and fish, and posed no risk to recreational contact. Reservoir conditions that contributed to these algae blooms are discussed in the 2015 Annual Monitoring Report (GEI 2016). However, *Anabaena flos-aquae* (cyanobacteria) were also present at a moderately large biovolume in the composite photic sample (23%) and in an opportunistic sample (95%) collected from the surface waters between CCR-2 and the dam outlet. Factors contributing to its bloom were evident in the water quality data collected during the May 27$^{th}$ sampling event. At this time, water clarity was relatively transparent and temperature, dissolved oxygen, and nutrient data all indicate stratification of the water column and that internal nutrient loading was beginning to occur. Both SRP and TIN concentrations increased from being relatively low during the early spring which allowed *A. flos-aquae* to gain a competitive advantage in terms of growing well at the surface. *A. flos-aquae* contain gas vacuoles which allows them to maintain position at the water's surface where they have the ability to fix atmospheric nitrogen, if needed. These physiological characteristics allowed this species to grow very rapidly at the surface of Cherry Creek Reservoir and create a visible algal layer that covered much of Cherry Creek Reservoir surface.

The second event of heightened chlorophyll α occurred at the end of the year when concentrations steadily increased from a low in early August to above 30 µg/L in early November. During this time, diatoms were dominant in late September (27%; primarily *Gomphoneis herculeana*), chlorophytes in mid-November (54%; primarily *Chlamydomonas sp.*), and cryptophytes in early November (47%; primarily *C.* erosa; Figure 7-9). Again, these algae are considered beneficial in terms of a food source for zooplankton and fish, and posed no risk to recreational contact. In late September, however, *A. flos-aquae* biovolume was moderately large in the composite photic sample (19%), while dominant in an opportunistic sample collected near the east boat ramp (98%). Cyanobacteria abundance can be relatively large in late summer algal assemblages, however, the late September *A. flos-aquae* bloom occurred under much different conditions than that in late May. Water temperature was few degrees warmer, water transparency was low, and Cherry Creek Reservoir had recently mixed as evident by the non-stratified water temperature, and SRP and TIN was relative low throughout the water column. Despite the abundant surface water accumulations of *A. flos-aquae* in late May and late September, no cyanotoxins were detected in the composite photic sample, the swim beach sample, or the opportunistic samples.

Two other blooms, not associated with increased chlorophyll α concentrations, occurred in the summer of 2015. The large algal bloom in early June responded in similar fashion to conditions as the cyanobacteria but consisted primarily of beneficial diatoms (90%; primarily *Melosira granulata*) and no cyanobacteria (Figure 7-9). Diatoms bloomed even larger in early July (95%) during the major mixing event and consisted primarily of a species (*Fragilaria crotonensis*) which prefers nutrient rich and well mixed water (GEI 2016).

All other routine composite photic and Swim Beach samples did not contain cyanotoxins except for a composite photic sample collected on September 9th in which microcystin measured 0.18 µg/L, a value slightly greater than the method detection limit (0.1 µg/L). Microcystin at this level is not considered a human health risk according to recreation thresholds established by World Health Organization microcystins. *A. flos-aquae* was detected in the photic sample that day (4%) but at a very low biovolume.

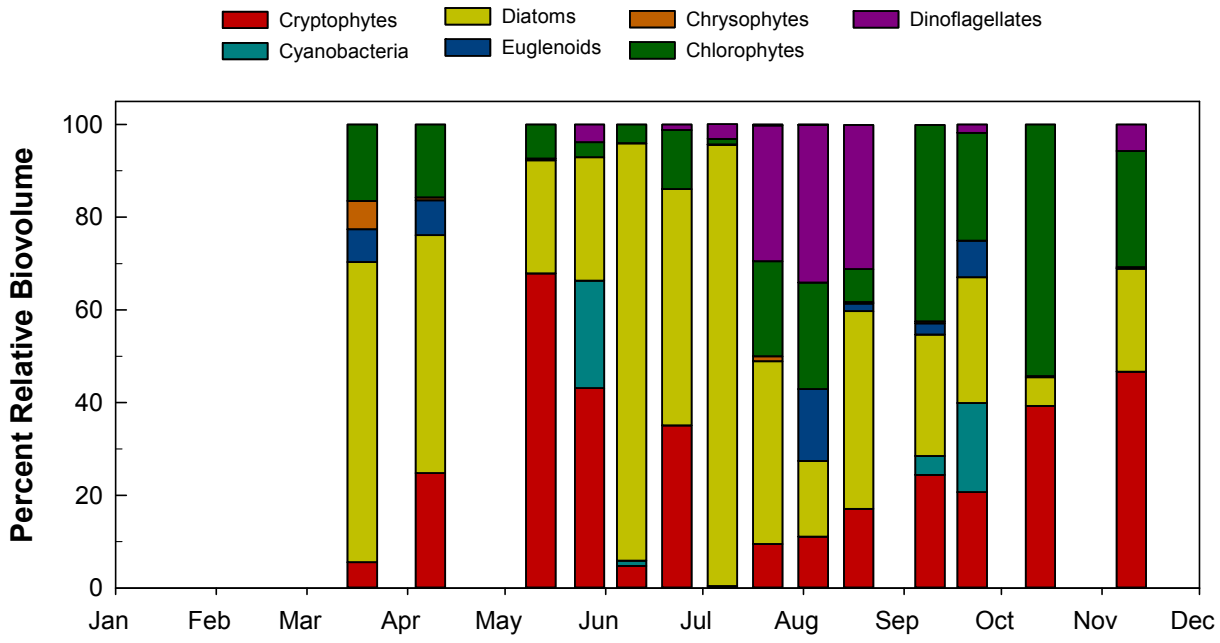



**FIGURE 7-9: PERCENT RELATIVE BIOVOLUME OF ALGAL GROUPS FOR EACH ROUTINE PHOTIC ZONE COMPOSITE SAMPLE COLLECTED IN CHERRY CREEK RESERVOIR, 2015 CY**

## 7.6 Long-Term Phytoplankton

Algal biovolume in the photic zone composite samples has been more variable in the past few years (2014 and 2015) as compared to the previous three years when the destratification system was operated (Figure 7-10). Annual mean chlorophyll α concentration from 2011 through 2014 was relatively consistent with a mean concentration of 23.2 µg/L while the 2015 annual mean concentration was 18.4 µg/L despite the increased algal biovolume for diatoms (Bacillariophyte). Diatoms were the most dominant algal group, in terms of biovolume, from 2011 through 2015 (20-42%) followed by green algae (Chlorophyte) 18-29%, and Cryptophytes, 15-26% (Figure 7-10). Cyanobacteria biovolume

averaged 7.2% of the total algal biovolume, and in terms of dominance, they were the 6th most dominant type of algae observed in the reservoir from 2011 through 2015. However, this group revealed periods of dominance in many years, such as 2012 mid to late summer period and spring 2014.

In general, the past two years have resulted in more variable conditions with respect to algal biovolumes as compared to the previous years during destratification. In 2015, the total phytoplankton biovolume was larger than any other year, primarily due to diatoms, yet the annual chlorophyll α concentration was approximately 9 µg/L less than in previous years. The response of the algal community, including nuisance cyanobacteria, to destratification management or its absence will continue to be studied by the Authority. As part of the reservoir model, the Authority will continue to evaluate the mechanisms and effects that various natural and man-induced conditions have on the biological assemblages of Cherry Creek Reservoir.

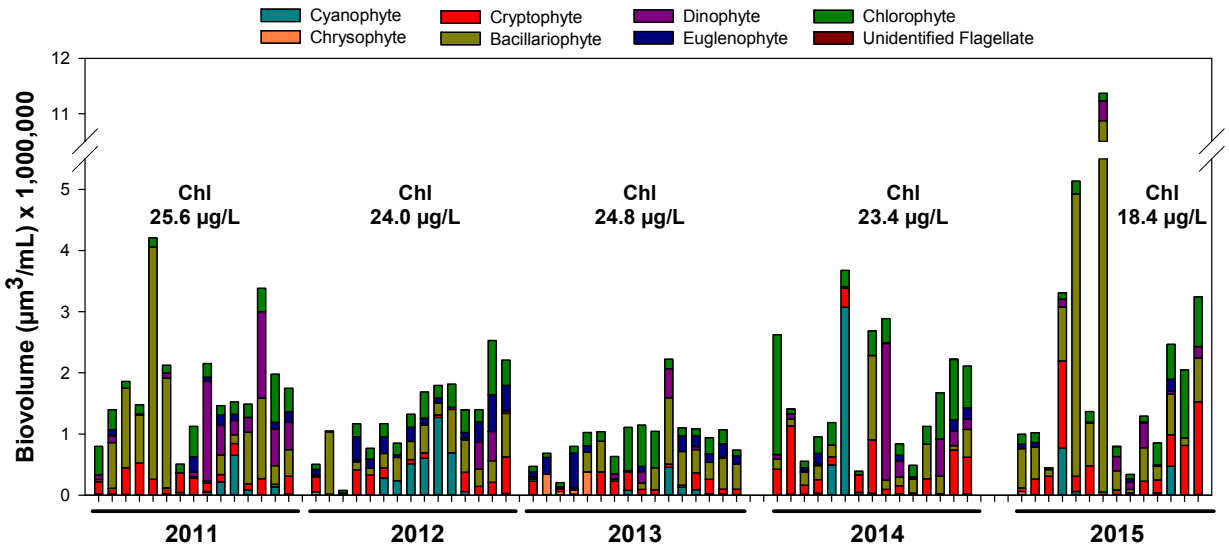



**FIGURE 7-10: ALGAL BIOVOLUME OF MAJOR TAXONOMIC GROUPS IN THE PHOTIC ZONE COMPOSITE SAMPLES IN CHERRY CREEK RESERVOIR FROM 2011 THROUGH 2015, BY CY**

**Chl values are annual mean chlorophyll α concentrations**

## 7.7 Water Quality in Cherry Creek from a Watershed Perspective

The Authority's watershed monitoring program includes an additional seven surface water sites along the mainstem of Cherry Creek from Castlewood Canyon downstream to Cherry Creek Reservoir. Monitoring data from four key sites are presented herein – Castlewood Canyon (upstream background), CC-1, CC-4, and CC-9. Site CC-1 is located on Cherry Creek at the confluence with McMurdo Gulch, downstream of Castle Rock. Site CC-4 is located downstream of the confluence with Sulphur Gulch and Parker Water and Sanitation South (PWSD) wastewater treatment facility discharges. Site CC-9 is located just upstream of Cherry Creek Reservoir near Perimeter Road within the park boundary. The distance from the Castlewood Canyon site to Cherry Creek Reservoir is approximately 25 miles.

Changes in water quality resulting from urbanization can be observed by comparing phosphorous concentrations at each of surface flow site. Little or no change in concentrations can be interpreted as maintained water quality conditions through the urban corridor while reduction in concentrations indicate that watershed control measures may be improving water quality. Increases in concentrations may indicate other influences outside regulatory control.

### 7.7.1 NUTRIENTS

The total phosphorus concentrations from 1994 through 2015 indicate that concentrations entering Cherry Creek Reservoir (CC-9) are nearly identical to "background" concentrations conditions in the watershed at the Castlewood and CC-1 sites (Figure 7-11). Seasonal variability existed during the years prior to 2003 when monthly sampling occurred and in more recent years when biannual samples were collected. Beginning in 2011, total phosphorus concentrations at Site CC-4, downstream of Sulfur Gulch and the PWSD discharge, was less than the other sites due to stream water dilution by wastewater discharge. This dilution dissipated downstream to Cherry Creek Reservoir and concentration at subsequent sites increased (i.e., CC-9). In Cherry Creek, a sandy alluvial plains stream, the mixing of surface waters and shallow groundwater results in total phosphorus concentrations between that of both water sources.

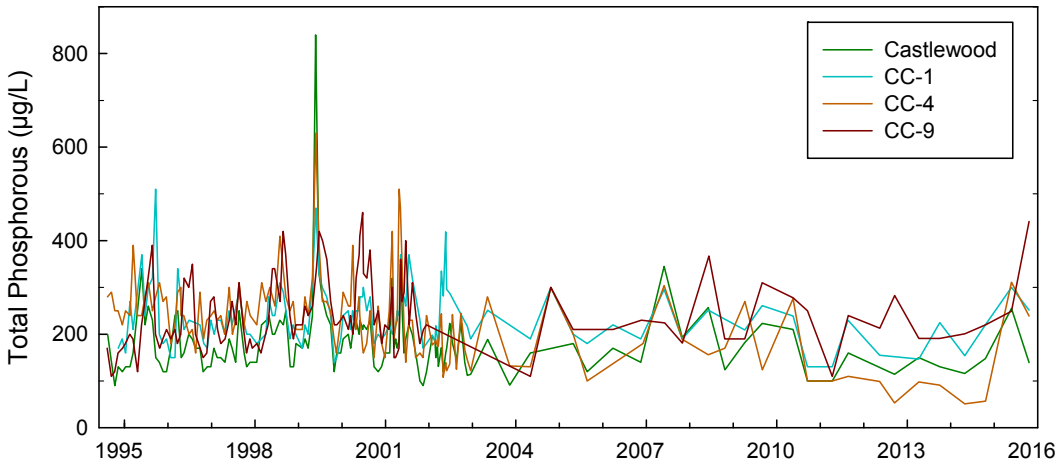



**FIGURE 7-11: TOTAL PHOSPHORUS CONCENTRATION MEASURED AT CHERRY CREEK SURFACE WATER STATIONS, CASTLEWOOD, CC-1, CC-4, AND CC-9**

Nitrogen is a nutrient found in several forms (e.g., ammonium ($NH_4$), nitrite ($NO_2$), and nitrate ($NO_3$)), with nitrate being the most important inorganic form relative to algal production in Cherry Creek. The Authority's nitrate-nitrogen data from 1994 through 2015 (Figure 7-12) indicates that concentrations entering Cherry Creek Reservoir (~500 µg/L) are greater than "background" conditions (~50 µg/L) at sites Castlewood and CC-1, but have remained relatively stable over the period of record. The data collected at Site CC-4 (downstream of PWSD) reflects the influence of the wastewater discharge on surface water nitrate concentrations (i.e., greater than other sites) and, since 2002, an increasing trend in nitrate concentrations has existed at this site. It is important to note that concentrations at Site CC-9 are substantially less than at CC-4, which highlights the ability of the stream corridor to reduce nitrate through natural process. This process – denitrification – is a microbial mediated process that reduces nitrate to nitrite and eventually to nitrogen gas ($N_2$). In essence, the stream is functioning well in terms of nitrate reduction and efforts to improve this ecological function, especially related to stream habitat and bank restoration should maintain this function.

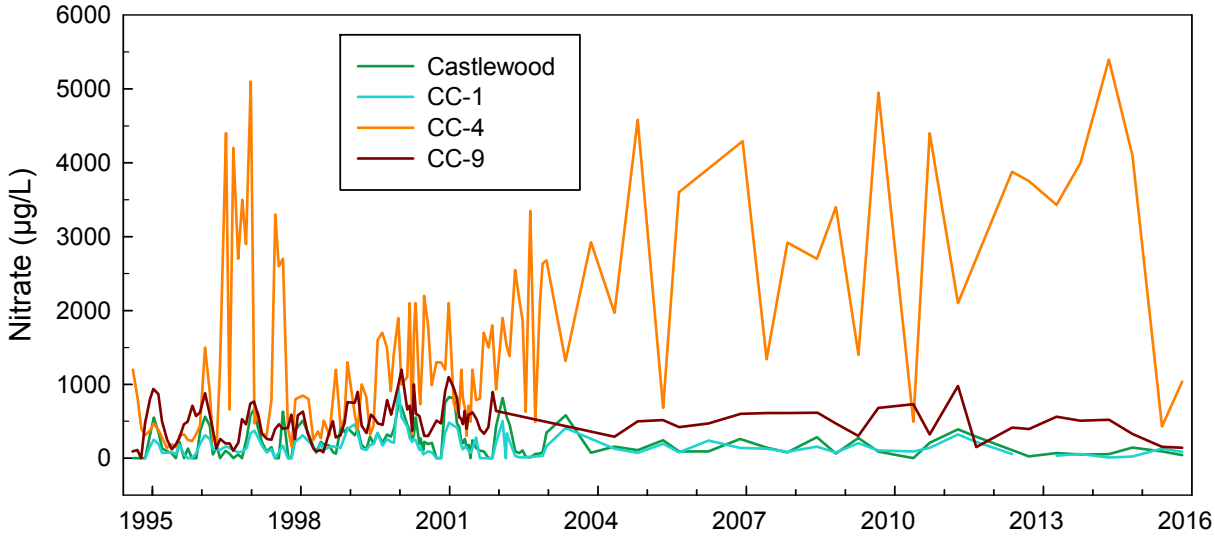



**FIGURE 7-12: NITRATE CONCENTRATION MEASURED AT SURFACE WATER STATIONS CASTLEWOOD, CC-1, CC-4, AND CC-9**

### 7.7.1.1 Regulation 85 and Instream Nutrient Monitoring Data

Regulation 85 requires the implementation of a nutrient monitoring program for wastewater treatment plant dischargers. Cherry Creek Basin WWTFs are required to monitor for total phosphorus and total inorganic nitrogen upstream, downstream, and in the effluent prior to discharge to the stream.

Nutrient monitoring results for 2015 are to be submitted by April 15, 2016, so data are not yet available for 2015. Regulation 85 upstream and downstream nutrient data will be available for three of the five WWTFs located in the basin (Parker Water and Sanitation District, Pinery Water and Sanitation District, and Arapahoe County Water and Wastewater Authority). Once the data is available, the Authority will review the data.

### 7.7.1.2 Chloride and Sulfate

The Authority monitors chloride and sulfate concentrations in the watershed because these constituents that are strongly tied to anthropogenic sources. Chloride is a chemical compound often found in de-icing agents used to control roadway ice and in water softeners for in-home use. Chloride concentrations from 1994 through 2015 (Figure 7-13) have slightly increasing but overall remained relatively consistent in the upper watershed. Chloride concentrations at sites CC-4 and CC-9 remained relatively consistent from 1995 through 2001 with a slight increase in concentration observed downstream near Cherry Creek Reservoir (i.e., culmination of the watershed). Beginning in 2002, the chloride concentrations began increasing in the watershed and, over the last five years, chloride concentrations have substantially increased at Site CC-9 before entering Cherry Creek Reservoir. This trend was also documented within the Cherry Creek Basin in a recent Colorado Department of Transportation Report and a U.S. Geological Survey (USGS) study (Corsi et al. 2015). Both studies attribute the increasing chloride concentrations to the use of road de-icing agents – especially magnesium chloride associated with urban development. The USGS study noted that chloride concentrations have outpaced the urbanization rate in many watersheds and that the de-icing agents used in winter time are likely stored in the shallow alluvium and slowly released throughout the year. This trend indicates the need for watershed controls for de-icing agents through education and use-specific BMPs (requirement of Control Regulation 72).

Sulfates are often found in streamways as a result of wastewater treatment practices used to reduce phosphorus from discharge. Sulfate concentrations from 1994 through 2015 (Figure 7-14) indicate the influence of wastewater treatment downstream of Site CC-4 when compared to background concentrations at sites Castlewood and CC-1. Sulfate concentrations at site CC-4 have increased since 1994. Concentrations at CC-9 were moderately consistent until 2011 after which they have increased substantially and are approaching the water quality table value standard for domestic water supply use.

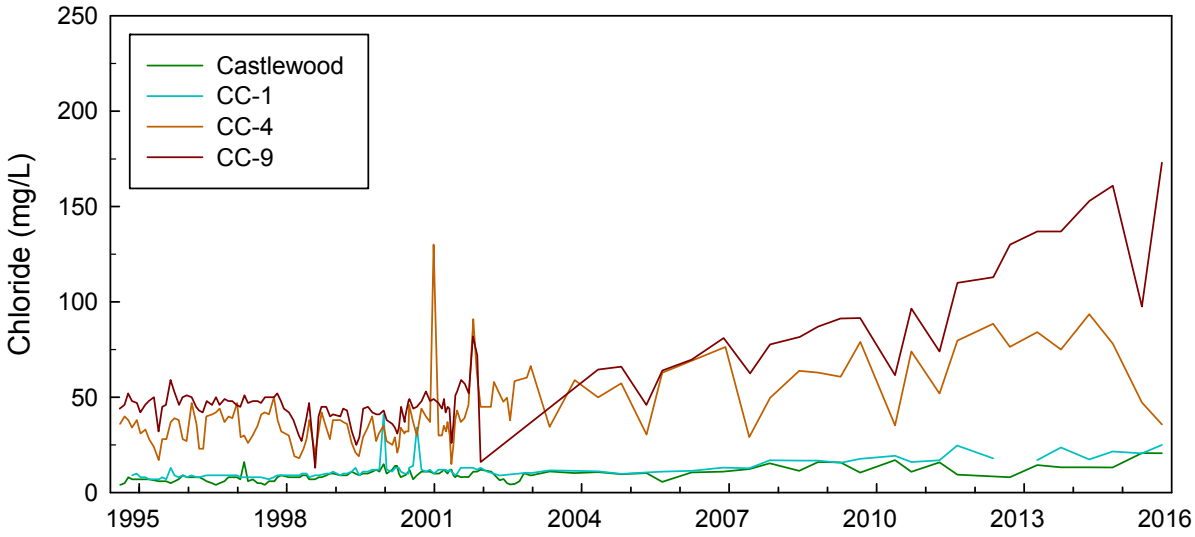



**FIGURE 7-13: CHLORIDE CONCENTRATION MEASURED AT SURFACE WATER STATIONS CASTLEWOOD, CC-1, CC-4, AND CC-9**

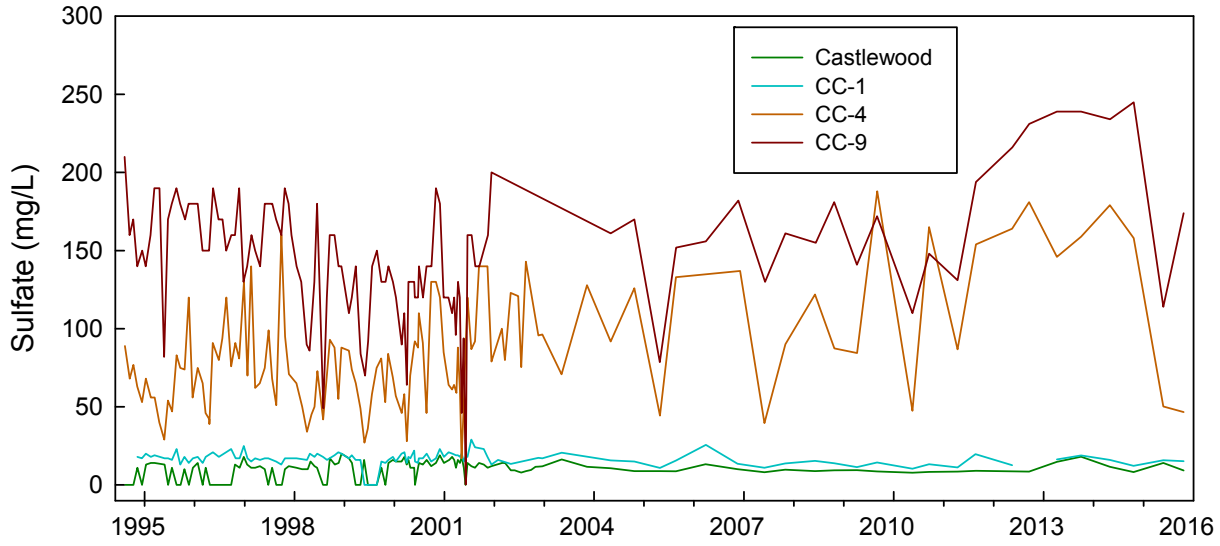



**FIGURE 7-14: SULFATE CONCENTRATION MEASURED AT SURFACE WATER STATIONS CASTLEWOOD, CC-1, CC-4, AND CC-9**

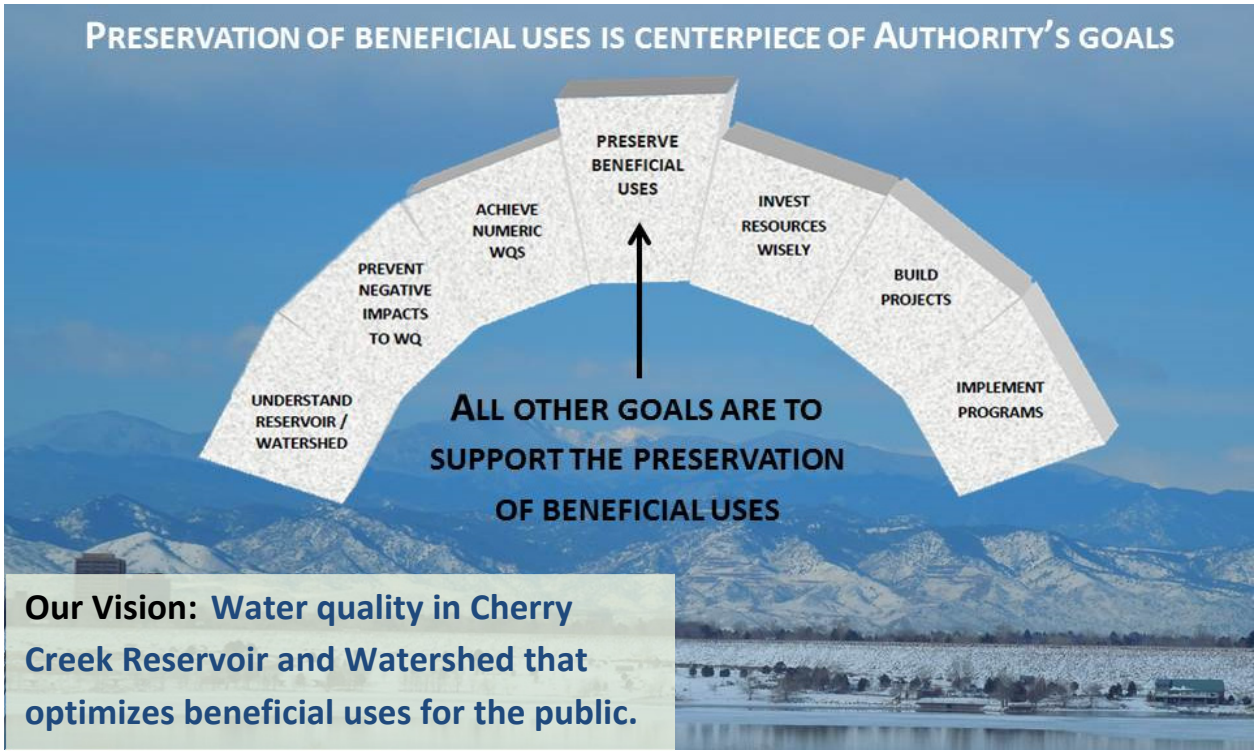
## 7.8 Proposed Modifications to Monitoring Program

The Authority recently revised its baseline sampling and analysis plan and quality assurance project plan (SAP/QAPP) and will be adding a water quality sampling site on Piney Creek immediately upstream of the confluence with Cherry Creek. Monitoring at this site will document baseline water quality conditions prior to and post implementation of the stream reclamation project on Piney Creek. The Authority will continue in 2016 to monitor the effects, or the lack thereof, of not operating the destratification system in Cherry Creek Reservoir in order to evaluate the advantaged and disadvantages of the system.

### 7.8.1 Installation of New Monitoring Well #7b

Installation of a new Monitoring Well #7b (MW #7b) was constructed on August 5, 2015, at a depth of 30 feet to provide the Authority with a Cherry Creek alluvium sampling location close along Cherry Creek within Eco Park. This well replaces the existing Monitoring Well #7a (MW #7a), which was drilled too deep, and the original Monitoring Well #7 which was abandoned in 2000. Closure of MW-7a was a part of this work.

MW #7b is located approximately 400 feet upstream of the Authority's flow monitoring and sampling equipment, previously installed with the Eco Park project in 2014. This new monitoring well is located within the Arapahoe County open space, close to constructed trails.




## 8 WATERSHED PLAN IMPLEMENTATION

The Watershed Plan serves as a living document to define the pathway to meeting all of our goals and reaching our long-term vision.

The overarching goal is preservation of the beneficial uses of the reservoir and streams. This can be viewed as a keystone; all of the Authority's activities described in this Annual Report are intended to help achieve this goal.

The final chapter in the Plan is perhaps the most important chapter. It identifies priorities and an implementation strategy. Proposed action plans are shown for the next few years. Every year, progress is evaluated as part of the Annual Report. The action plans are updated as needed to reflect shifting priorities and to incorporate new knowledge about the reservoir and watershed.

## 8.1 Strategic Planning Meeting

Held on August 6, 2015, the Strategic Planning meeting was a 2- hour long workshop with participants from the Board, the TAC, and the CCBWQA Staff. The focus was on "Existing Authority Programs and Drivers (Statute vs. Regulation 72)". Our Statute, which is discussed on page 1-1 of this Annual Report, gives the Authority much broader abilities and opportunities than are derived from Regulation 72.

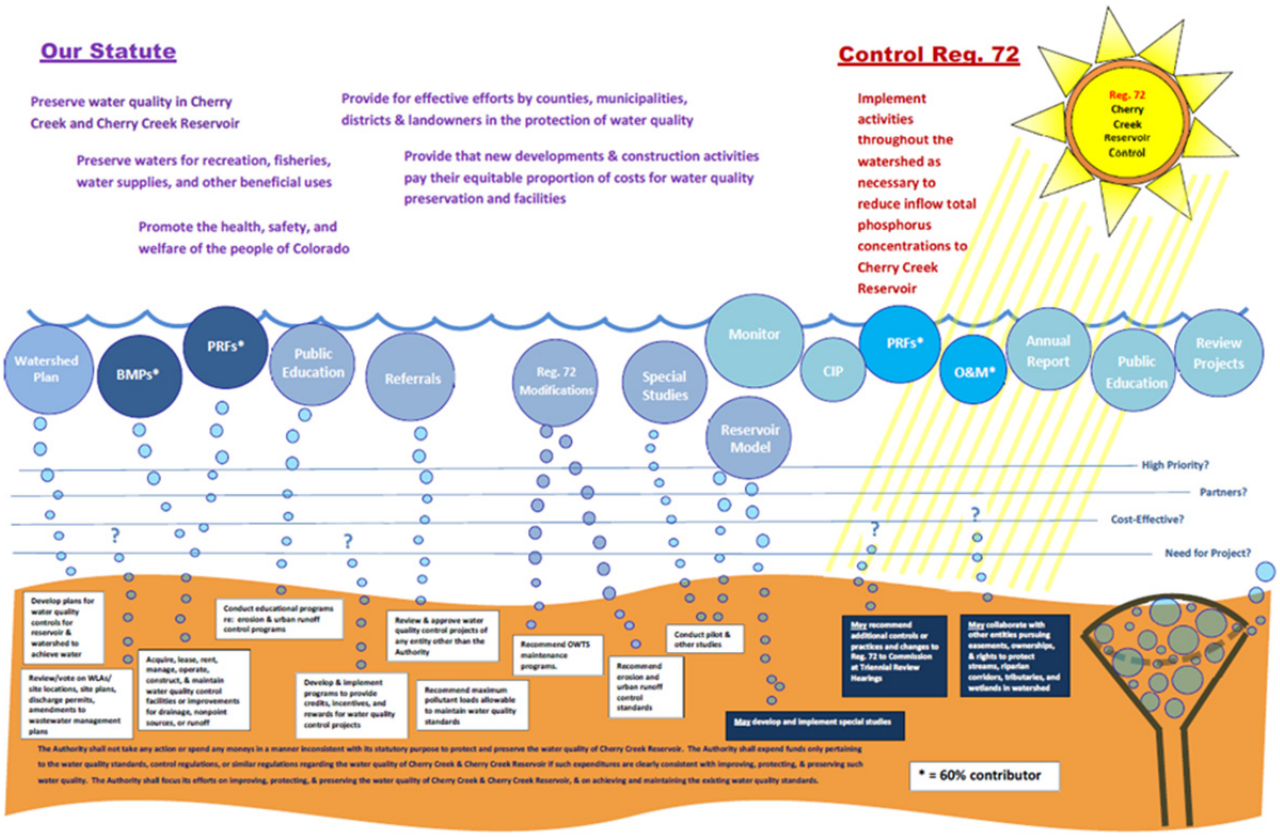
**Regulation 72 vs Statute:**

Regulation 72 is adopted by the Water Quality Control Commission, to achieve the water quality standards of Cherry Creek Reservoir.

Our Statute provides the Authority broad statutory powers to help preserve water quality in the reservoir, and to benefit the people of Colorado by preserving the waters for recreation fisheries, water supplies, and other beneficial uses.

The goal of the planning sessions was to help identify future projects of highest priority to pursue in the upcoming year or beyond. Some "screening" questions were presented to help narrow down the projects:

- Does the project support the CCBWQA's mission?;
- What is the cost/benefit ratio of the project?;
- What does the reservoir model predict the impact of the project will be?; and
- How will the project affect water quality standards?



At the workshop,  the highest priority projects were identified to be completed next:

- Finish and apply the reservoir model;
- Complete the watershed model immediately after the reservoir model and use it as a tool to determine how to implement the reservoir model's recommendations;
- Identify any needed changes to our capital projects process, to incorporate findings from the items above; and
- Greater public outreach about the Authority and what it does.

## 8.2 Implementation of Watershed Plan in 2015

The Cherry Creek Reservoir Watershed Plan is a strategic plan for achieving watershed and reservoir health. 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.

Some of the activities undertaken in 2015 action plan are highlighted below:

- Monitoring Program:  In 2015, both the reservoir and watershed monitoring programs were evaluated, and an updated Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP) resulted from this significant effort.  Both programs were modified, and expanded in some areas to support the ongoing reservoir modeling effort.  Initial discussions identifying potential data needs for the planned watershed modeling effort were also part of this effort.  Additional cyanotoxin sampling was conducted in 2015, under a tiered "mini-SAP" prepared specifically for this focused effort.

- MS4 Permit Support: The Authority actively participated in the review and development of the basin's Cherry Creek MS4 permit, which is currently being revised. The Authority strived to ensure that the requirements and proven effectiveness and flexibilities inherent in our Control Regulation 72 will be incorporated into the new Cherry Creek MS4 permit, and reflect our unique opportunities.
- Reservoir Model: The model was calibrated and validated, and underwent a rigorous outside peer review process. Several recommendations to modify some model components are currently under Authority discussion. Management scenarios are also being evaluated for use with the model in 2016.
- Stream Reclamation Projects: The Authority continued its stream reclamation efforts along the mainstem of Cherry Creek, focusing in 2015 on five projects upstream of the State Park. The projects are aimed at providing longitudinal stream connectivity and replicating the successful "treatment train" approach that was used in Cottonwood Creek.
- Partnering: The Authority continues to focus on more effectively using its funding and resources, through partnering with others and leveraging its own resources. We are partnering with UDFCD, SEMSWA, Douglas County, and the City of Aurora on the Piney Creek project, designed to prevent further loss of property, minimize risk to the public, and improve water quality through stream reclamation and stabilization. The Authority has partnered with the Town of Parker on the Norton Farms Open Space and Hess Road stream reclamation projects.
- Education: The Authority partnered with the Cherry Creek Stewardship Partners to provide photo and written documentation of the progress of the Cherry Creek Ecological Park (Eco Park) project in developing and expanding the wetlands in the area. Wetland assessments were conducted, and a wetland map was created in 2015, for comparison with pre-project 2012 imagery.

## REFERENCES

AMEC Earth & Environmental, Inc., Alex Horne Associates, and Hydrosphere Resource Consultants, Inc. December 2005. Draft Feasibility Report Cherry Creek Reservoir Destratification.

AMEC Earth & Environmental, Inc., Alex Horne Associates, Hydrosphere Resource Consultants, Inc. (December 5, 2005). *Feasibility Report Cherry Creek Reservoir Destratification*

AMEC Earth & Environmental, Inc., Alex Horne Associates, and Hydrosphere Resource Consultants, Inc. October 2005. Draft Feasibility Report Cherry Creek Reservoir Destratification.

Berg, Joe. "Baseflow Stream Channel Design: An Approach to Restoration that Optimizes Resource Values and Ecosystem Services." *Water Resources IMPACT,* September 2009: Vol. 11 No. 5.

Board of Health of Tri-County Health Department. "Regulation No. I-11 individual sewage Disposal Systems." July 1, 2011.

Center for Watershed Protection. (n.d.). Irreducible Pollutant Concentrations Discharged from Stormwater Practices. Watershed Protection Techniques, pp. Technical Note #75: 2(2): 369-372.

Cherry Creek Basin Water Quality Authority. (2013). 2012 Annual Report of Activities.

Cherry Creek Basin Water Quality Authority. (2011). Stormwater Permit Requirements Guidance Document.

Cherry Creek Basin Water Quality Authority. (2011). Stream Reclamation, Water Quality Benefit Evaluation - Interim Status Report.

Cherry Creek Basin Water Quality Authority. October 2012. Cherry Creek Basin Water Quality Authority Watershed Plan 2012.

Cherry Creek Stewardship Partners. (2004). Cherry Creek Basin Water Stewardship and Education Initiative.

Cherry Creek Basin Water Quality Authority. February 2000. Cherry Creek Reservoir Watershed Stormwater Quality Requirements.

Cherry Creek Basin Water Quality Authority. March 2002. Emergency Response Plan Criteria for the Cherry Creek Reservoir Watershed.

Cherry Creek Basin Water Quality Authority. August 2003. Cherry Creek Reservoir Watershed Plan 2003.

Cherry Creek Basin Water Quality Authority. 2013. 2013 Annual Inspection of Pollutant Reduction Facilities.

Cherry Creek Basin Water Quality Authority. 2013. 2013 Capital Improvement Projects.

Cherry Creek Stewardship Partners. January 2011. Cherry Creek Stewardship Partners 2010 Annual Report.

Colorado Water Quality Control Commission. March 2009. Regulation No. 72 – Cherry Creek Reservoir Control Regulation.

Colorado Water Quality Control Commission. June 2004. Regulation No. 22 – Site Location and Design Approval Regulations for Domestic Wastewater Treatment Works.

Colorado Water Quality Control Commission. September 2012. Regulation No. 85 – Nutrients Management Control Regulation.

Colorado Water Quality Control Commission. September 2012. Policy WPC-DR-1, Design Criteria for Domestic Wastewater Treatment Works.

Colorado Water Quality Control Commission. January 2013. Regulation No. 31 – The Basic Standards and Methodologies for Surface Water.

Colorado Water Quality Control Commission. June 2013. Regulation No. 43 – On-site Wastewater Treatment System Regulation

Colorado Water Quality Control Commission. (2008). Policy 96-1, Design Criteria Considered in the Review of Wastewater Treatment Facilities.

Colorado Water Quality Control Commission. Regulation No. 61 - Colorado Discharge Permit System Regulations.

Corsi, S.R., L.A. De Cicco, M.A. Lutz, and R.M. Hirsch. 2015. River Chloride Trends in Snow-Affected Urban Watersheds: Increasing Concentrations Outspace Urban Growth Rate and are Common Among All Seasons. Science of the Total Environment, 508:488-497.

Denver Regional Council of Governments. October 2000. Lift Station Report Guidance and Checklist.

Denver Regional Council of Governments. January 2003. Metro Vision 2020 Clean Water Plan: Wastewater Utility Plan Guidance.

Denver Regional Council of Governments. March 2007. Metro Vision Clean Water Plan: Wastewater Utility Plan Guidance/

GEI Consultants, Inc. 2015. Cherry Creek Reservoir 2014 Annual Aquatic Biological and Nutrient Monitoring Study and Cottonwood Creek Phosphorus Reduction Facility Monitoring.

GEI Consultants, Inc. 2013. Cherry Creek Reservoir 2012 Annual Aquatic Biological and Nutrient Monitoring Study and Cottonwood Creek Phosphorus Reduction Facility Monitoring.

GEI Consultants, Inc. 2016. Annual Reservoir Monitoring Report. Water Year Aquatic Biological and Nutrient Monitoring Study and Cottonwood Creek Pollutant Reduction Facilities Monitoring.

John C. Halepaska and Associates, Inc. 2008. West Cherry Creek Background Phosphorus Report – Special Study.

Knowlton, M.R., and J.R. Jones. 1993. Limnological Investigations of Cherry Creek Lake. Final report to Cherry Creek Basin Water Quality Authority.

Lewis, W.M., J. H. McCutchan, and J.F. Saunders. 2005. Estimation of Groundwater Flow into Cherry Creek Reservoir and its Relationship to the Phosphorus Budget of the Reservoir. Prepared for the Cherry Creek Basin Water Quality Authority.

Lindon, M.J. and S.A. Heiskary. 2009. Blue-green Algal Toxin (Microcystin) Levels in Minnesota Lakes. Lake and Reservoir Management 25:240-252.

Lindon, M.J. and S.A. Heiskary. 2008. Blue-green Algal Toxin (Microcystin) Levels in Minnesota Lakes. Environmental Bulletin No. 11. Minnesota Pollution Control Agency, St. Paul, MN.

Maryland Department of the Environment. 2012. Guidelines for Interpreting Dissolved Oxygen and Chlorophyll α Criteria in Maryland's Seasonally-Stratified Water Supply Reservoirs.

Memorandum dated November 14, 2014 from Colorado Parks and Wildlife (Mindi May) to Cherry Creek Basin Water Quality Authority (Chuck Reid), re: Phytoplankton Analysis.

Memorandum dated January 15, 2015 from Hydros Consulting (Jean Marie Boyer) to GEI (Craig Wolf) re: Algal Species Data for Cherry Creek Reservoir.

Memorandum dated February 3, 2015 from Hydros Consulting (Jean Marie Boyer) to Leonard Rice Engineers (Katie Fendel) re: Recommendation Regarding Cherry Creek Reservoir Destratification System Operations in 2015.

Nürmberg, G., and LaZerte, B. 2008. Cherry Creek Reservoir Model and Proposed Chlorophyll Standard. Prepared for the Cherry Creek Basin Water Quality Authority.

Tri-County Health Department. July 2011. Regulation No. I-11 - Individual Sewage Disposal Systems.

U.S. Environmental Protection Agency. December 2013. Enforcement and Compliance History Online. Detailed Facility Reports.