2016 ANNUAL REPORT ON ACTIVITIES

CHERRY CREEK BASIN WATER QUALITY AUTHORITY

2016 Annual Report on Activities
Cherry Creek Basin
Water Quality Authority

CCBWQA Board and TAC Leadership

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
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Heather Beasley	Rich Borchardt
Roger Kilgore	Max Grimes
Myrna Poticha	Casey Davenhill
Alan Vajda	Elaine Hassinger
Christopher Lewis	Jason Trujillo
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WHO ARE WE?

We are the Cherry Creek Basin Water Quality Authority (Authority), tasked with improving, protecting, and preserving water quality for beneficial uses. The Authority was formed following the completion of a Clean Lakes Study in 1984, which led to the development of our first Master Plan in 1985. Subsequent to the adoption of the Master Plan, the local governments in the Cherry Creek Basin formed an Authority by intergovernmental agreement and worked diligently to gain state approval of legislation to create the Cherry Creek Basin Water Quality Authority. That goal was accomplished during the 1988 General Assembly with the Governor signing the Cherry Creek Basin Water Quality Authority Act, House Bill 1029, on April 28, 1988 (C.R.S. 25-8.5-101 et seq.).

Authority Board

The governing body of the authority is its Board of Directors. According to our statute, the Authority Board is to include representatives from the following:

- Arapahoe and Douglas Counties;
- The Cities and or Town of Aurora, Castle Pines, Castle Rock, Centennial, Foxfield, Greenwood Village, Lone Tree, and Parker;
- One member representing the seven special districts providing wastewater services in the Authority's boundaries; and
- Seven citizens representing sports persons, recreational users, and concerned citizens appointed by the governor.

Technical Advisory Committee (TAC)

The Authority's Bylaws allow each county, municipal, and special district member to appoint one representative to serve on the TAC. The Board may appoint other individuals who represent non-profit public interest groups/association having an interest in stormwater drainage and water quality in the Cherry Creek Basin, and any governmental or quasi-governmental agency. The role of the TAC is to consider and report to the Board on matters of a scientific or technical nature.

The following entities and interests are represented on the Board and TAC.

Board	TAC
2 Counties	**2 Counties**
Arapahoe	Arapahoe
Douglas	Douglas
8 Municipalities	**8 Municipalities**
Aurora	Aurora
Castle Pines	Castle Pines
Castle Rock	Castle Rock
Centennial	Centennial
Foxfield	Foxfield
Greenwood Village	Greenwood Village
Lone Tree	Lone Tree
Parker	Parker
1 Special District	**1 Special District**
Representative from Parker Water & Sanitation District	Representative from Parker Water & Sanitation District
7 Governor-Appointees	**Ex-Officio Members (as appointed at Board's discretion)**
1. Sports person or recreational organization with members that use Cherry Creek Reservoir (must be Colorado resident)	Southeast Metro Stormwater Authority (governmental entity)
2. Sports person or recreational organization with members that use Cherry Creek Reservoir (must be Colorado resident)	Cherry Creek Stewardship Partners (non-profit public interest)
3. Citizen or environmental organization interested in water quality with members that use Cherry Creek Reservoir or live in Cherry Creek Basin.	Colorado Parks and Wildlife (CPW) (governmental entity)
4. Citizen or environmental organization interested in water quality with members that use Cherry Creek Reservoir or live in Cherry Creek Basin.	U.S. Corps of Engineers (governmental entity)
5. Person with background or professional training in water quality issues.	Urban Drainage & Flood Control District (governmental entity)
6. Person with background or professional training in water quality issues.	Tri-County Health Department (governmental entity)
7. Person with background or professional training in water quality issues.	Colorado Department of Transportation (governmental entity)
	TAC Chair (other individual with interest in Cherry Creek Basin)

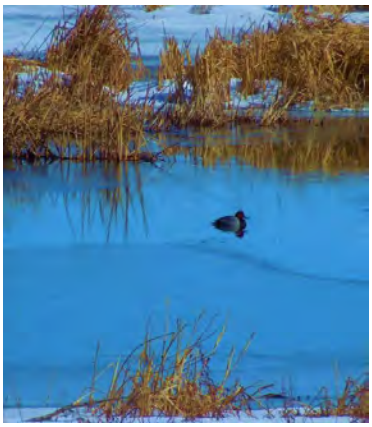
In 2016, there were two Board and two TAC vacancies: Castle Pines and Foxfield.

WHAT MAKES US UNIQUE?

The Cherry Creek Basin Water Quality Authority was formed by Statute, and given powers and authorities unique to our basin, such as the ability to establish rates, tolls, fees, and charges for the Authority's facilities and program. No other watershed in the state has a statute specifically designed to protect its reservoir. Our reservoir is also subject to the Cherry Creek Reservoir Control Regulation 72, as are many other Colorado reservoirs with similar control regulations. It is the additional powers in our Statute that sets us apart.

Statute

The purposes of creating the Authority were declared by the State Legislature to include benefitting the public, inhabitants, and landowners within the basin, and the people of the state of Colorado by:



Preserving water quality in Cherry Creek and Cherry Creek Reservoir;

Preserving waters for recreation, fisheries, water supplies, and other beneficial uses; and

Promoting the health, safety, and welfare of the people of Colorado.

The Legislature declared that the Authority is to provide for effective efforts by counties, municipalities, districts, and landowners in the protection of water quality as well as provide that new developments and construction activities pay their equitable proportion of costs for water quality preservation and facilities.

The statute gives us expansive powers, including the power to: Develop and implement plans for water quality controls for the reservoir and watershed, to achieve and maintain water quality standards; Conduct pilot and other studies useful for the development of potential water quality solutions; Recommend erosion control standards and educational programs about the need for controls; 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 in the basin.

Control Regulation

Regulation No. 72 identifies activities to be implemented throughout the watershed, as necessary to reduce inflow total phosphorus (TP) concentrations to Cherry Creek. The purpose is to achieve the chlorophyll α water quality standard in the reservoir. Several other watersheds in Colorado have similar control regulations to protect their reservoirs.

The chlorophyll α standard is 18 ug/L, as a chronic seasonal mean measured in the upper 3 meters of the water column, from July through September, with an exceedance frequency of once in 5 years.

The regulation sets a concentration-based management strategy for phosphorus controls in the basin. It sets phosphorus effluent limits that the Water Quality Control Division (Division) must implement through point source discharge permits, as well as basin-specific Best Management Practices (BMPs) that the Division must include in stormwater permits. It assigns responsibilities for nonpoint sources to local governments and other entities with responsibilities for their own pollution-causing activities. It includes public education requirements as well as limitations on constructions of new On-Site Wastewater Treatment Systems (OWTS) within the 100-year floodplain. It encourages collaboration on floodplain preservation areas and conservation easements. Regulation 72 also requires nutrient monitoring and, finally, submission of this Annual Report.

WHAT ARE THE KEY THINGS WE ACCOMPLISHED IN 2016?

Reservoir and Watershed Models

The Reservoir Model was completed in 2016. The initial management scenario runs indicated that various management controls, or combinations, showed promise in decreasing chlorophyll α levels. A Watershed Model will be developed in 2017, to provide refined inputs into the Reservoir Model.

Point Source, Regulated Stormwater, and Nonpoint Source Controls

Wastewater treatment plants, Municipal Separate Storm Sewer Systems (MS4s), and Pollutant Reduction Facilities (PRFs) built by the Authority and its partners were effective in reducing phosphorus entering the reservoir.

Water Quality Monitoring and Program Effectiveness

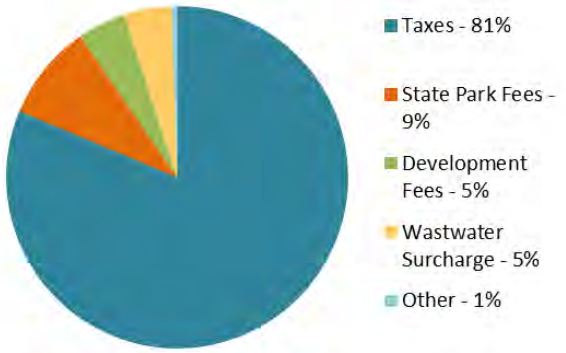
The chlorophyll α standard was exceeded in 2016, as well as in 4 of the last 5 years. The Reservoir and Watershed Models will be used to evaluate watershed and in-reservoir options to achieve the standard.

HOW DO WE FUND AUTHORITY ACTIVITIES?

Our statute provides several funding mechanisms that the Authority can use in a manner that is consistent with its statutory purpose to improve, protect, and preserve the water quality of Cherry Creek and Cherry Creek Reservoir.

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, which 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 CPW Board and add an additional $3 on annual passes and $1 on single-day passes. The estimated percentages of the revenues for 2017 are shown in the pie chart.

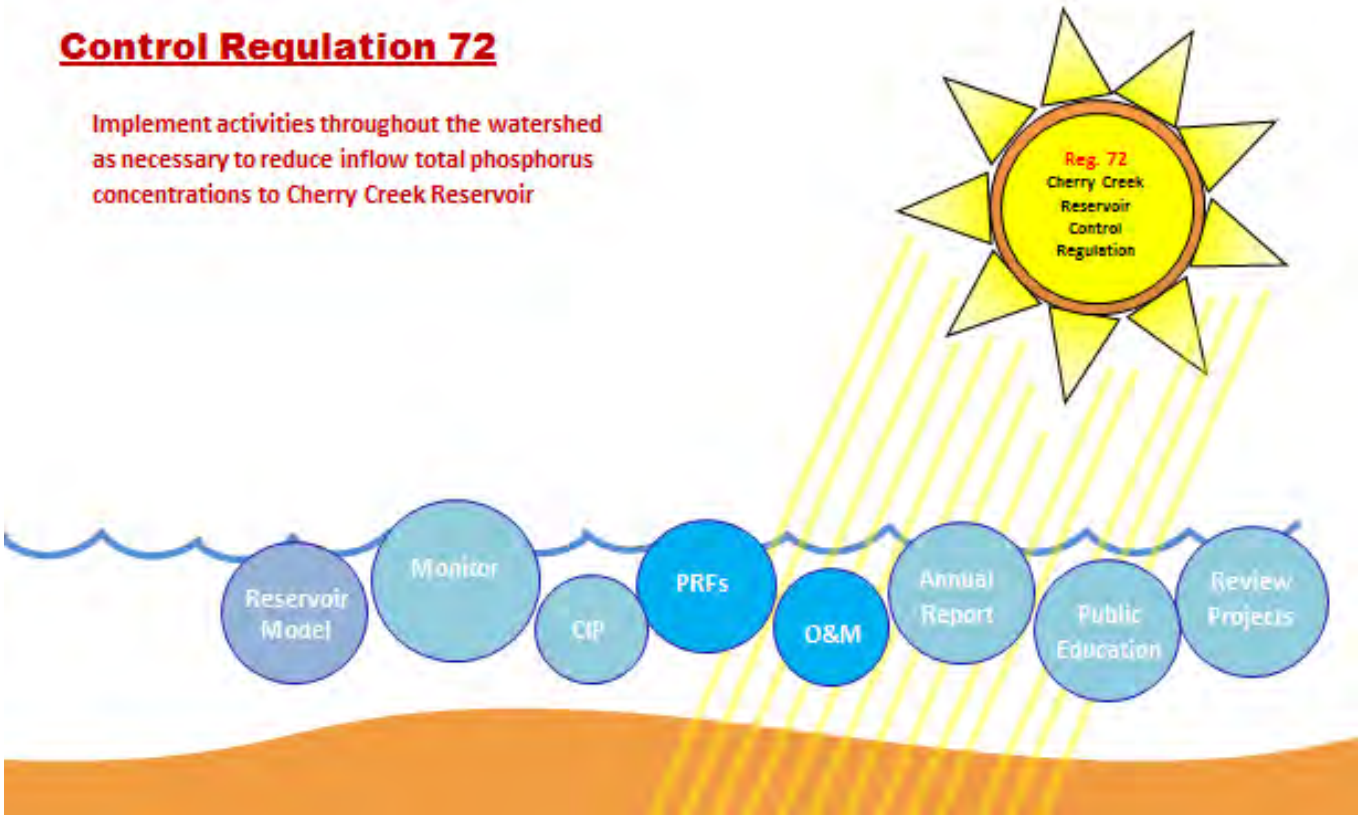


The 2017 budget includes $2.4 million in revenues: of which $1.9 million is from taxes, $200,000 from State Park user fees, $100,000 each from building permit fees and from wastewater surcharges, and the rest from miscellaneous income.

Expenditures and revenues are often not matched each calendar year because implementation and timing of project costs for the capital improvement program (CIP) can vary significantly from year to year. The statute mandates that the Authority spend at least 60% of the annual revenues on the construction and maintenance of Pollution Abatement Projects. 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 2016, the Authority did not meet the 60% requirement, and needs to spend approximately $180,000 on Pollution Abatement Projects in future years to be compliant, through December 31, 2017.

WHAT ARE OUR REGULATION 72 RESPONSIBILITIES?

The Authority's responsibilities under the Cherry Creek Control Regulation include construction, operation, and maintenance of Authority Pollutant Reduction Facilities (PRFs), as well as oversight of long-term operation maintenance of PRFs owned by others. The Authority is to provide a prioritized list of future PRFs annually to the Division. We develop and implement, with local governments, a routine annual water quality monitoring program of the Cherry Creek watershed and Cherry Creek Reservoir, as well as, develop and implement an education program focused on the abatement of nonpoint source pollution. The Authority may collaborate with local governments and other entities in pursuing easements, ownerships, and rights to protect the streams, riparian corridors, tributaries, and wetlands in the Cherry Creek basin. We provide comments to the Division on site applications and dischargers' requests for permit compliance schedules and consult with the Division and others in development of any water quality investigative special studies. Finally, the Authority is to submit an annual report to the Water Quality Control Commission (Commission) and Division on point source controls, regulated stormwater controls, nonpoint source stormwater controls, riparian and wetland protection, and concentration-based phosphorus control measures. This results in activities including development of a reservoir model, monitoring, building capital improvement projects, and other activities.

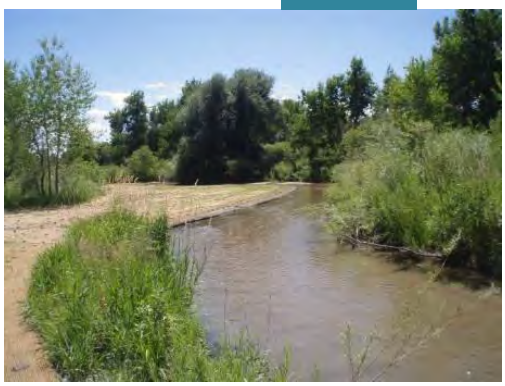


WHAT'S NEW WITH PRFs IN 2016?

The Authority had three pollutant reduction facilities projects either under construction or completed in 2016. These were: Cherry Creek Stream Reclamation at Arapahoe Road - Reach 5; Cherry Creek Stream Stabilization at Norton Farms Open Space; and Piney Creek Stream Reclamation - Reach 6, Phase 1

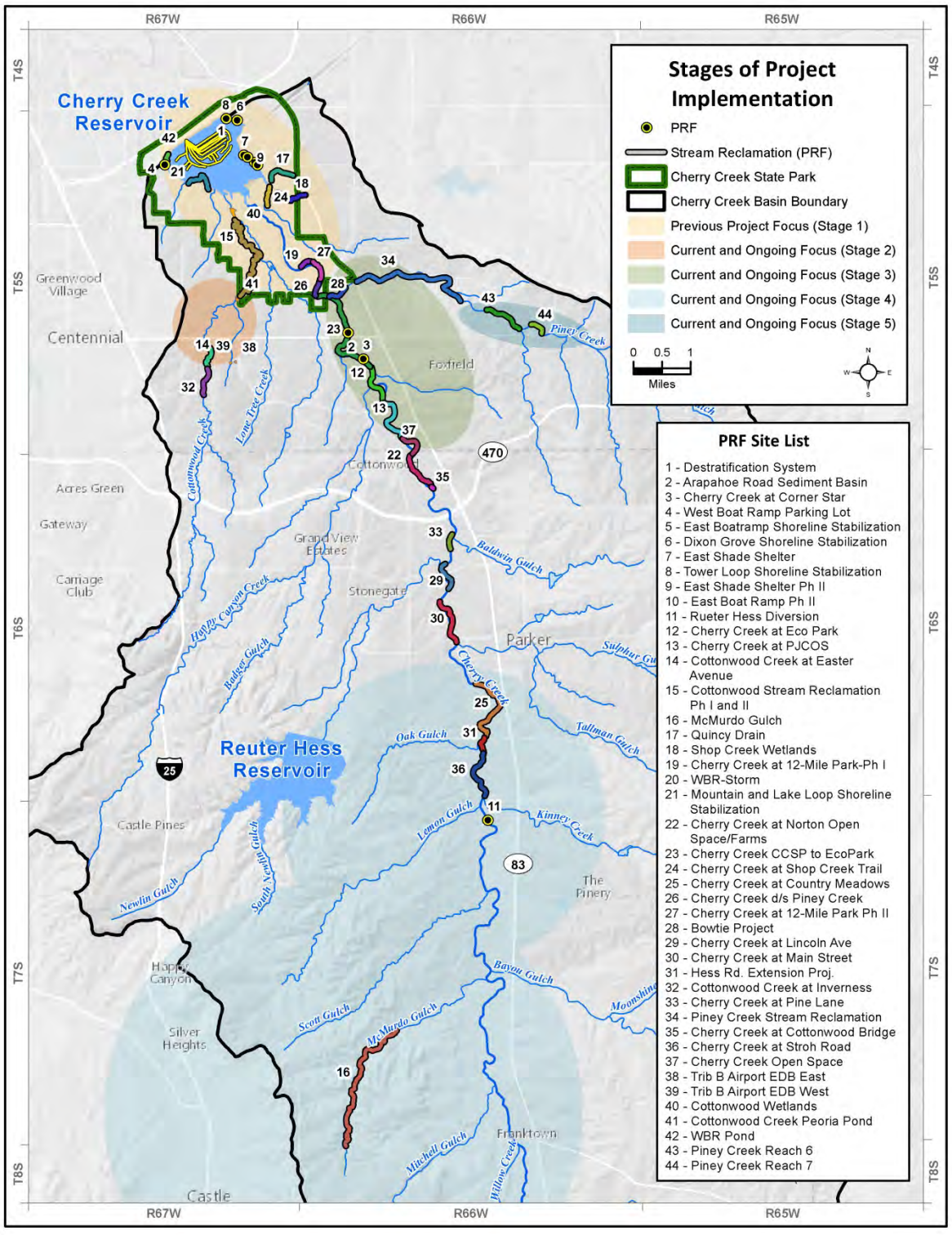
A PRF is a project that reduces nonpoint source pollutants in stormwater runoff that may also contain regulated stormwater. PRFs are structural measures that include, but are not limited to, detention, wetlands, filtration, infiltration, and other technologies with the primary purpose of reducing pollutant concentrations entering the reservoir or that protect the beneficial uses of the reservoir. The PRFs completed to date are shown on the map on the next page; further information on these may be found in the PRF Summary Reports.

PRF Effectiveness in reducing phosphorus concentration



The Authority conducted a Stream Reclamation Water Quality Benefit Evaluation in 2011. This framework is used to complete assessments of the stream stabilization and water quality benefits for all PRFs. Authority data, literature research and quantative analysis show that PRFs reduce sediment and other pollutant loads, including phosphorus and nitrogen. PRFs effectively reduce the pounds of phosphorus per year that are transported downstream, lower stream velocities, and reduce channel shear, which minimizes the transport of sediment and pollutants.

2016 Featured PRF Projects	Phosphorus Removed, lb/yr	Project Length, LF/yr	Total Construction Cost, $
Cherry Creek Stream Reclamation at Arapahoe Road Reach 5 (#23 on map on next page)	44	2,300	$1,322,811
Cherry Creek Stream Stabilization at Norton Farms Open Space (#22 on map on next page)	38	2,500	$799,790
Piney Creek Stream Reclamation Reach 6, Phase 1 (#44 on map on next page)	37	2,175	$2,154,083


R67W
R66W
R65W
T4S
T5S
T6S
T7S
T8S
Cherry Creek Reservoir
Reuter Hess Reservoir
Greenwood Village
Centennial
Foxfield
Cottonwood
Acres Green
Gateway
Grand View Estates
Carriage Club
Stonegate
Parker
Castle Pines
Happy Canyon
Silver Heights
The Pinery
Franktown
Castle
Lone Tree Creek
Cottonwood Creek
Happy Canyon Creek
Badger Gulch
Baldwin Gulch
Cherry Creek
Sulphur Gulch
Tallman Gulch
Oak Gulch
Lemon Gulch
Kinney Creek
Newlin Gulch
South Newlin Gulch
Bayou Gulch
Moonshine
Scott Gulch
McMurdo Gulch
Mitchell Gulch
Willow Creek
Piney Creek
470
83
25
Stages of Project Implementation
PRF
Stream Reclamation (PRF)
Cherry Creek State Park
Cherry Creek Basin Boundary
Previous Project Focus (Stage 1)
Current and Ongoing Focus (Stage 2)
Current and Ongoing Focus (Stage 3)
Current and Ongoing Focus (Stage 4)
Current and Ongoing Focus (Stage 5)
0 0.5 1
Miles
N
W
E
S
PRF Site List
1 - Destratification System
2 - Arapahoe Road Sediment Basin
3 - Cherry Creek at Corner Star
4 - West Boat Ramp Parking Lot
5 - East Boatramp Shoreline Stabilization
6 - Dixon Grove Shoreline Stabilization
7 - East Shade Shelter
8 - Tower Loop Shoreline Stabilization
9 - East Shade Shelter Ph II
10 - East Boat Ramp Ph II
11 - Rueter Hess Diversion
12 - Cherry Creek at Eco Park
13 - Cherry Creek at PJCOS
14 - Cottonwood Creek at Easter Avenue
15 - Cottonwood Stream Reclamation Ph I and II
16 - McMurdo Gulch
17 - Quincy Drain
18 - Shop Creek Wetlands
19 - Cherry Creek at 12-Mile Park-Ph I
20 - WBR-Storm
21 - Mountain and Lake Loop Shoreline Stabilization
22 - Cherry Creek at Norton Open Space/Farms
23 - Cherry Creek CCSP to EcoPark
24 - Cherry Creek at Shop Creek Trail
25 - Cherry Creek at Country Meadows
26 - Cherry Creek d/s Piney Creek
27 - Cherry Creek at 12-Mile Park Ph II
28 - Bowtie Project
29 - Cherry Creek at Lincoln Ave
30 - Cherry Creek at Main Street
31 - Hess Rd. Extension Proj.
32 - Cottonwood Creek at Inverness
33 - Cherry Creek at Pine Lane
34 - Piney Creek Stream Reclamation
35 - Cherry Creek at Cottonwood Bridge
36 - Cherry Creek at Stroh Road
37 - Cherry Creek Open Space
38 - Trib B Airport EDB East
39 - Trib B Airport EDB West
40 - Cottonwood Wetlands
41 - Cottonwood Creek Peoria Pond
42 - WBR Pond
43 - Piney Creek Reach 6
44 - Piney Creek Reach 7

2016 PRF Activity

Over the course of the Authority's history, it has spent more than $14 million on capital projects and PRFs. Prior to 2010, Cherry Creek Reservoir was under a total maximum annual load limitation for phosphorus. The Authority's initial focus (based on the 1985 Regulation 72) was on reduction of phosphorus loads discharged into the reservoir. However, there is no longer a phosphorus load limitation; in 2009, the control strategy in Regulation 72 changed to minimizing all nutrient concentrations instead of just phosphorus loads. However, capital improvement projects and PRFs are still evaluated, in part, on phosphorus removal per year for consistency among all projects. The following are the 2016 project and in-progress projects.

Cherry Creek at Arapahoe Road Stream Reclamation, Reach 5

The Cherry Creek at Arapahoe Road Stream Reclamation Reach 5 project extends from the downstream end of the Cherry Creek @ Eco Park project to a location south of Arapahoe Road adjacent to the Aurora Soccer fields, a distance of approximately 2,800 lineal feet. During the initial project field survey, it was noted that channel downcutting had progressed to the point where a City of Aurora raw waterline was exposed and the channel flow was undercutting below their pipe. This exposed pipe condition accelerated design and construction of Drop Structure 14. Design for the balance of the Reach 5 stream reclamation channel improvements was performed concurrently with construction of Drop Structure 14.

Construction of the Reach 5 channel improvements (length = 2,300 linear feet) started in the fall of 2015 and was completed in spring of 2016. Four Void Filled Rip-Rap Riffle Drops and one Boulder Cascade Drop, in addition to the sheet-pile cut-off wall installed at the Boulder Cascade Drop, protects the channel section from damage during larger flood events. The sideslopes along the stream channel mainstem were graded with flatter slopes to reconnect higher channel flows to the riparian corridor.

Cherry Creek Stream Reclamation at Norton Open Space

In 2011, the Town of Parker requested Authority funding to assist with design and construction for the Cherry Creek Stream Reclamation Improvements through the Norton Farms Open Space. The project is located in Parker, Colorado, immediately upstream of the Cherry Creek Stream Reclamation project at 17 – Mile House beginning at the Douglas/Arapahoe County Line and extending upstream for a distance of approximately 2,500 linear feet.

Urban growth and expansion of developed areas have resulted in an increase in the rate, 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 conditions constrain the channel geometry.

Piney Creek Stream Reclamation, Reach 6, Phase 1

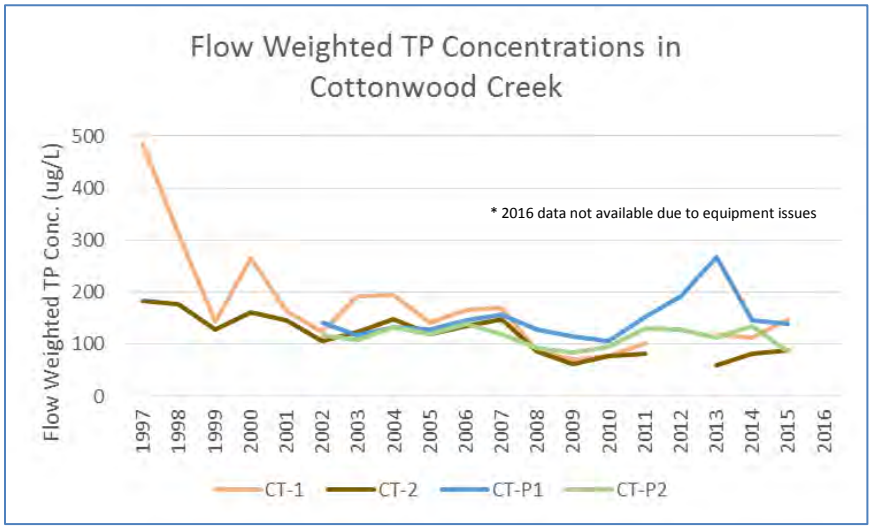
The Piney Creek Reach, Phase 1 Stream Reclamation project is located immediately downstream of the Caley Drive Bridge Project and extends for a distance of approximately 2,200 linear feet downstream. Piney Creek, in this area, was experiencing significant erosion particularly during significant storm events. This continued erosion threatened water quality within the basin, sensitive riparian areas and wildlife habitat as well as existing trails and utilities. The project includes grade control / drop structures and bank stabilization that will mitigate the existing erosion and minimize future erosion on Piney Creek.

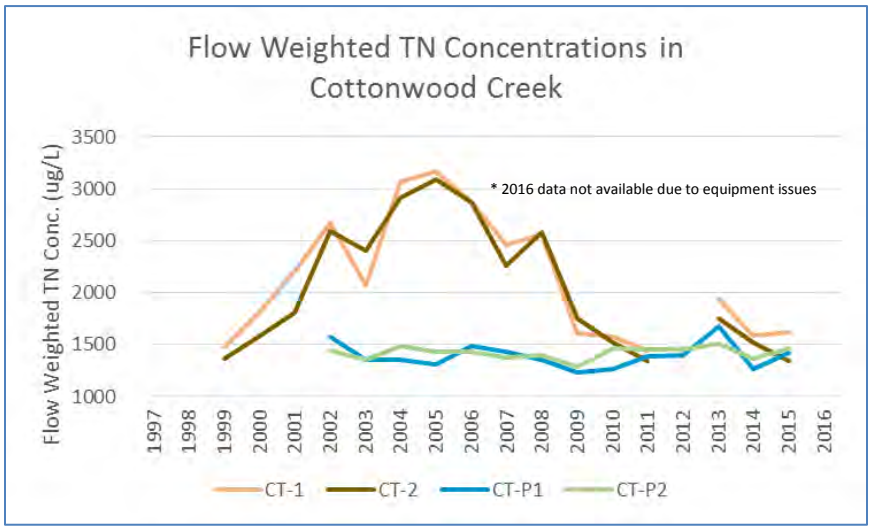
One constructed grouted boulder drop structure and a 475-linear foot section of void filled channel bottom rip-rap lining, constructed at a two percent longitudinal grade, was incorporated into the Project to flatten and control the channel thalweg. A sheet-pile cut-off wall was installed in conjunction with the grouted boulder drop structure to protect the drop and channel from damage during a larger flood event and anchor the lower end of the project reach. The project was completed in June 2016.

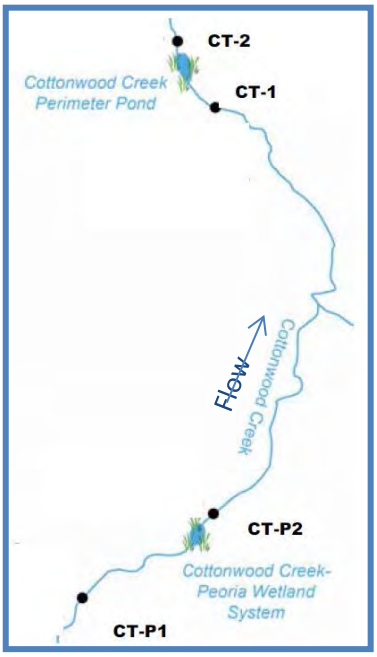
PRF Monitoring Under Regulation 72

Cottonwood Creek Treatment Train

The passive treatment train approach in Cottonwood Creek includes a series of wetland detention systems and stream reclamation. The Authority monitors upstream (CT-P1) and downstream (CT-2) of the entire reach from Peoria Wetland System to the Perimeter Pond. Comparison between these two sites shows the combined effectiveness of the entire treatment train. The figures display the flow weighted concentrations for TP and TN from 1996 through 2015*.







Median	CT-P1		CT-2	
µg/L	Base Flow	Stormflow	Base Flow	Stormflow
TP	42	81	62	65
SRP	12	5	9	14
TN	1,196	1,820	1,927	1,860

The 2016 Monitoring Report separates data into base and storm flows. In 2016, TP concentrations during stormflow were reduced by 20% over the entire treatment train. During base flow, there was an increase in TP concentrations; however, soluble reactive phosphorus (SRP) concentrations were reduced by 25% during base flow. TN concentrations increased during both base flow and stormflow, showing a net gain of nitrogen.

McMurdo Gulch Stream Reclamation Project

Although relatively undeveloped at the time of the project design, there are significant plans for further build-out in the McMurdo Gulch watershed. This made the timing of a reclamation project ideal for a proactive approach to protect the gulch and reduce sediment and nutrient loads into Cherry Creek before the system "unravels". It is believed that implementing measures to protect the gulch *before* the onset of severe erosion will be more cost effective and more favorable to downstream water quality than reacting after increased runoff has a chance to degrade the gulch.

In 2016, the Authority collected water quality samples only under base flow conditions at two monitoring sites on McMurdo Gulch. Monitoring site MCM-1 is located upstream of the stream reclamation project area while monitoring site MCM-2 is located downstream of the stream reclamation project area, and downstream of the planned development area.

The table shows that in 2016, the McMurdo Gulch Stream Reclamation Project reduced the median TP and median SRP concentrations by 14% and 30%, respectively. TN concentrations were essentially unchanged through the stream reclamation project area in McMurdo Gulch in 2016. However, an increase in pollutant load was observed during some individual months for TN and TP, resulting in a net export of pollutant loads between the upstream and downstream stations. Streamflow, water quality, and load calculations for these stations are provided in 2016 Monitoring Report and Appendices.

Median	MCM-1 (upstream)	MCM-2 (downstream)
µg/L	Base Flow	Base Flow
TP	351	300
SRP	276	192
TN	495	476

Funding of PRFs

All potential PRFs are evaluated at the conceptual level to determine cost and benefits. If these appear to be reasonable, they are added to the master PRF list maintained by the Authority. Annually, the Authority compiles its 10-year CIP list (see summary below) of projects to fund in the coming years.

Summary of Recommended PRFs (Capital and O&M) 2016 – 2025 Budget Projects (1000$)					
Project Title	**Current Project Budget**		**Proposed 2017 Budget**	**Out-year budget**	**Funding (Year(s))**
	Total	**Authority Portion**			
Cherry Creek Stream Stabilization at Main Street (Parker)	$1,776	$200		$200	2022
Cherry Creek Stream Stabilization at Lincoln Avenue (Parker)	$1,447	$304		$304	2022
Cherry Creek Stream Stabilization at Norton Open Space (Parker)	$900	$255			
Cherry Creek Stream Reclamation - CCSP to Eco Park (Ph II to V)	$12,172	$3,043	$300	$1,233	2019-2021
Cherry Creek Stream Reclamation - CCSP Ph I	$2,227	$2,227	$50	$2,227	2023-2025
Piney Creek Stream Stabilization at Caley Avenue Reaches 6 & 7	$10,500	$2,625	$500	$975	2018-2019
Stream Corridor Preservation	$100	$100			
East Boat Ramp Shoreline Stabilization Phase II	$70	$70		$70	2020-2021
East Shade Shelter Shoreline Stabilization Phase II	$50	$50		$50	2020-2021
West Shade Shelter Shoreline Stabilization PRF	$950	$950		$950	2020-2022
Tower Loop Shoreline Stabilization Phase II	$90	$90		$90	2020-2021
Non-point Pollutant Management	$100	$100		$100	2025
Install 2 Piney Creek Monitoring Wells	$6	$6			
Install 1 Meteorological Station at CCSP	$14	$14			
Interpretive PRF Signage at 12-Mile Park (2 signs) & West Boat Ram (1 sign)	$16	$16	$16		
Total Capital Projects	$30,418	$10,050	$866	$6,199	
Rehabilitation	$20	$12			
Restorative	$7	$7	$80	$320	2018-2025
Routine	$169	$169	$226	$1,114	2018-2025
Total Operations and Maintenance	$196	$188	$306	$1,434	

Decisions/Agreements for PRF Project Funding

The Authority often shares project costs with partners. The table on the previous page contrasts the Authority's portion of the project with the total project cost. More detailed cost-sharing information on the featured 2016 projects is summarized here.

Cherry Creek at Arapahoe Road Stream Reclamation, Reach 5

Stakeholders cooperated to update the Major Drainageway Plan to include a preliminary design level through Reach 5. Stakeholders included Southeast Metro Stormwater Authority (SEMSWA), Urban Drainage and Flood Control District (UDFCD), City of Aurora (COA), Cherry Creek Basin Water Quality Authority (Authority) and Arapahoe County (AC).

In 2012, UDFCD requested Authority funding to assist with design/construction of this project, which was funded by the To date the Authority's funding contribution has totaled $900,000.

Cherry Creek Reclamation Project at Norton Farms Open Space

On May 15, 2013, the Authority entered into an intergovernmental agreement (IGA) with UDFCD and the Town of Parker and contributed Authority funds in the amount of $30,000 for the design. On September 18, 2014, the Authority approved a second IGA amendment contributing an additional $225,000, for a total project contribution of $255,000.

Piney Creek Stream Reclamation, Reach 6, Phase 1

Piney Creek - UDFCD and SEMSWA initially entered into an IGA on December 22, 2006 for stream reclamation improvements on Piney Creek at Caley Drive. The Authority entered into this IGA, on September 3, 2014. This agreement established funding for needed stream reclamation improvements through Reaches 6 and 7 of Piney Creek. Since the Authority entered into the initial IGA with UDFCD and SEMSWA, five amendments have been executed. With each amendment increasing project funding. To date the Authority's funding contribution totals $1,550,000.

Information on the 2016 Annual Inspections of PRFs is found on our website.

HOW ARE WE PROTECTING RIPARIAN AREAS & WETLANDS?

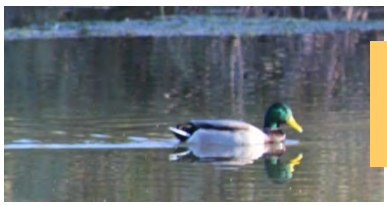
Many of the Authoirty projects aim to re-integrate the stream channel and floodplain along the corridor of Cherry Creek and its tributaries. This re-integration causes more frequent stormflows to spill out of the channel onto the riparian and floodplain area, increasing filtration/infiltration of the overflow banks. Revegetation along the corridor with wetland plants, grasses, scrubs, trees provides an aesthetic buffer and promotes enhanced riparian habitat.

Floodplain Preservation/Conservation Easements

The Cherry Creek Basin contains 4,938 acres of wetlands and riparian areas. The Commission, in Regulation 72, 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, as an important method 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 Urban Drainage Flood Control District (UDFCD), the Trust for Public Lands, and the Authority; it preserved the channel and riparian corridor of Piney Creek from future development, and returned an existing developed area into open space park.

Authority reviews of land use agency referrals ensure our special standards in stream preservation areas are implemented. In 2016, the Authority reviewed a total of 265 referrals (compared to 198 in 2015 and 154 in 2014)



Stream preservation areas are defined in Regulation 72 as:

Cherry Creek Reservoir;

All of Cherry Creek State Park;

Discharges to the park within 100 ft of the boundary

Lands overlying the Cherry Creek 100-yr floodplain; and

All lands within the 100-yr floodplain of its tributaries.

WHAT'S NEW WITH OUR MS4s IN 2016?

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. For example in 2016, 19,620 inspections and 1,666 enforcement actions were reported by the MS4s in the basin.

Implementation of MS4 Permit Requirements

Regulation 61 requires Phase II MS4s to implement 6 minimum requirements. Phase I MS4s, have different Regulation 61 requirements. Regulation 72 imposes additional, more stringent watershed-specific requirements for MS4s, 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.

Erosion and Sediment Control Plans and post-construction BMPs must be submitted to and approved by the local MS4 entity. 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). BMP requirements are defined by the Regulation 72 Tiered Structure.

Tier 1: Land disturbance < 1 acre with < 500 ft² new or increased imperviousness

Tier 2: Land disturbance > 1 acre with between 500 ft² and 5,000 ft² new or increased imperviousness, including disturbances of existing impervious areas

Tier 3: Land disturbance > 1 acre with ≥ 5,000 ft² new or increased impreviousness, including disturbances of existing impervious areas

CHERRY CREEK DAM - 4 April 1947
Looking toward left abutment at equipment placing backfill in cutoff trench.

CHERRY CREEK DAM - 1 April 1950
View from top of Dam looking downstream past outlet structure and channel.

CHERRY CREEK DAM - 20 November 1951
Upstream face of Intake/ Control Tower showing trash racks.

The following table summarizes the 2016 stormwater permits, inspections, and enforcement actions for construction BMPs and permanent BMPs. Further information on each of the MS4's programs can be found in their annual reports, due to the Division on March 10 (Phase II MS4s) and April 1 (Phase I MS4s) of every year.

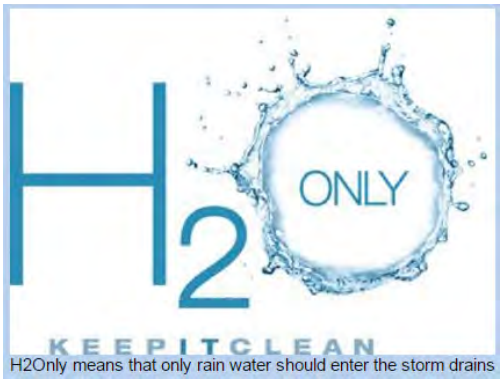
Land Use Agency	Construction Sites	Construction BMPs		Permanent BMPs		
	Total Permitted Sites	Number of Inspections	Number of Enforcement Actions	Number of BMPs (or BMP Sites) Constructed	Number of Inspections	Number of Enforcement Actions
Arapahoe County	56	481	0	0	2	0
Douglas County	1,527	12,281	370	12	34	0
City of Aurora	54	503	40	5	30	0
SEMSWA (City of Centennial)	69	930	18	1*	30	0
City of Greenwood Village	1	18	0	22	18	0
City of Lone Tree	18	184	0	1	8	0
City of Castle Pines	17	99	3	0	4	0
Town of Castle Rock	1617	3699	1145	7	363	2
Town of Parker	68	1,425	59	10	321	0
CDOT	Not yet available					

*SEMSWA considers a BMP constructed once all permitting associated is granted Final Accptance

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 in our Watershed Plan is looking for opportunities to retrofit detention ponds for the control of nutrients and other pollutants.

Public Information and Education Actions for MS4s

In 2016, Aurora Water's Water Words Program continued to offer free water presentations for local schools. These presentations were available for preschool aged children to high school aged young adults. Aurora Water also continued to implement its Forests to Faucets educators' workshop. Attending this workshop allows educators to earn 1.5 semester hours of K-12 graduate/recertification credits.



H2Only means that only rain water should enter the storm drains

Meridian Metropolitan District continued to manage its Kid's Page on their website which consists of interactive games that teach children about the water cycle and the importance of water conservation.

Parker Water and Sanitation District continued to offer tours of the North Water Reclamation Facilities, Rueter-Hess Reservoir, Cherry Creek Diversion Dam and Pump Station, and the Rueter-Hess Water Purification Facility. The four hour long tours begin at North Water Reclamation Facility, and the District provides transportation to the other locations. The Park Water and Sanitation District also continued to partner with Tagawa Gardens in 2016 and offer free workshops on drought-tolerant landscaping.

The Arapahoe County SPLASH Education and Outreach program continued in 2016. The SPLASH program teaches community members (both young and old) about how their day to day actions influence stormwater and water pollution. The "H_2O Only" message was adopted by SPLASH in an effort to protect and enhance the water quality in South Metro Denver. Each August, SPLASH hosts a booth at the West Welcome Week. And in October SPLASH participates in World Monitoring Day where participants (usually school children) can learn how to take water samples, test for physical parameters, and why these parameters are important.

Monitoring of Nonpoint Source Control Projects

The Colorado Regulation 85 Nutrient Data Gap Analysis Report identifies information that exists and whether additional monitoring needs to be conducted in the future to determine the approximate nitrogen and phosphorus contribution to state waters due to discharges from MS4s. The report found that TP concentrations were statistically higher in residential runoff and natural open space runoff than in commercial, industrial, and highway-related land uses. Total nitrogen (TN) concentrations were statistically higher in residential runoff than in commercial, industrial, and highway-related land uses. TN in natural open space runoff was not statistically different relative to urban land uses and within the range of concentrations documented for urban land uses.

The Gap Analysis concluded that additional monitoring for the purpose of general characterization of nutrient concentrations and loads in urban runoff in Colorado is not necessary to meet the Regulation 85 requirements. The Analysis recommended that select site-specific monitoring may be necessary to identify watershed-specific sources of nutrient loading, and could aid in the selection and placement of BMPs.

The Commission concluded that point source, nonpoint source, and regulated stormwater controls for TP are successfully reducing TP 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.

Funding of Nonpoint Source Control Projects

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 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 low impact strategies and Minimizing Directly-Connected Impervious Areas to promote onsite storage and infiltration, which can be cost-effective for new developments.

WHAT'S NEW WITH POINT SOURCE CONTROLS IN 2016?

Limits contained in the point source discharge permits in the basin effectively reduced nutrient concentrations in the receiving streams. For example, discharge limits for wastewater treatment plants (i.e., for most dischargers, less than 0.05 mg/L TP concentration as a 30-day average) are significantly less than the flow-weighted TP concentrations currently entering the reservoir from the aggregated sources (surface and groundwater inflows, precipitation). Actual concentrations discharged by wastewater treatment plants continue to be consistently below their limits and well below the 0.200 mg/L flow-weighted phosphorus concentration goal established for flows into the reservoir.

Wastewater treatment facilities (WWTFs) in the basin provide 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.

Phosphorus and Nitrogen Effluent Concentration; Identification of Permit Violations

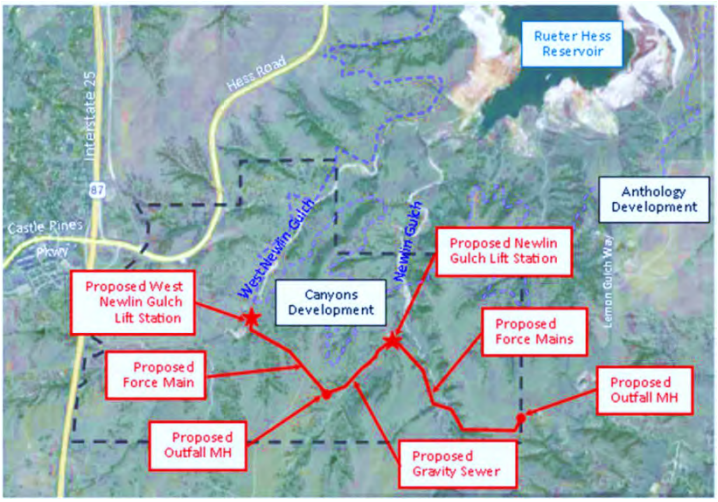
Monthly TP concentrations for each wastewater treatment plant based on discharger-submitted monthly Discharge Monitoring Reports are summarized in the table on the next page. Three wastewater treatment facilities currently have TIN limits in their permits (Pinery, Parker, and Stonegate). TIN concentrations for these facilities are also included in the table. In 2016, no permits were in violation of phosphorus concentration limits. All 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). With one exception (Parker Water and Sanitation District in June 2016), the three facilities with TIN limits were in compliance. Parker Water and Sanitation District, in its DMR sent to the Division, stated: "Sample results from the composite samples the day before and after exceedance were normal as were the remaining samples for the month. Review of plant parameters that would affect TIN did not show any abnormalities that would indicate an issue was imminent. Since there were no other problems with any other parameter during the month, the issue was documented as a onetime spike of unknown origin."

Facility	Parameter	30-day Avg. TP Limit (mg/L) or Daily Maximum TIN Limit (mg/L)	Reporting Requirements	Maximum Reported Value	Met Permit Limits? (yes/no)	
					TP	TIN
Arapahoe County Water & Wastewater Authority	**TP**	≤ 0.05 (30-day avg)	Monthly	0.046 (30-day avg)	Yes	
	TIN	No Reporting Requirement	--	--		***
Pinery Water & Sanitation District	**TP**	≤ 0.05 (30-day avg) (Outfall 002A: Discharges to Cherry Creek)	Monthly	0.035 (30-day avg)	Yes	
	TIN	10 (daily max) (Outfall 002A: Discharges to Cherry Creek)	2 Days/Month	8.08 (daily max)		Yes
Parker Water & Sanitation District	**TP**	≤ 0.05 (30-day avg) (Outfall 002A-NT: Combined North & South WRFs Discharge to Regional Reservoir)	2 Days/Month	0.033 (30-day avg)	Yes	
		≤ 0.05 (30-day avg) (Outfall 003A: Combined North and South WRFs Discharge to Sulfur Gulch)	2 Days/Month	0.04 (30-day avg)	Yes	
	TIN	10 (daily max) (Outfall 002A-NT: Combined North and South WRFs Discharge to Regional Reservoir)	3 Days/Week,	18.28 (daily max) (June 2016)		No+
		10 (daily max) (Outfall 003A: Combined North and South WRFs Discharge to Sulfur Gulch)	3 Days/Week	9 (daily max)		Yes
Meridian Metropolitan District	**TP**	≤ 0.5* (90-day avg)	Quarterly	no 30-day reporting requirements in Notice of Authorization**	Yes	
	TIN	No Reporting Requirement	--	--		***
Stonegate Village Metropolitan District	**TP**	≤ 0.25* (30-day avg) (Outfall 001A: Discharges to storage)	Monthly	0.13 (30-day avg)	Yes	
		≤ 0.05 (30-day avg) (Outfall 002A: Discharges to Cherry Creek)	Monthly	0.04 (30-day avg)	Yes	
	TIN	10 (daily max) (Outfall 002A: Discharges to Cherry Creek)	2 Days/Month	8.61 (daily max)		Yes
Plum Creek Water Reclamation Authority	**TP**	≤ 0.05 (30-day avg) (Outfall 007A: Cherry Creek Basin)	Monthly	0.03 (30-day avg)	Yes	
	TIN	No Reporting Requirement	--	--		***

*The flow-weighted average phosphorus concentration must be ≤ 0.05 mg/L TP divided by the land application return flow factor
** TP limit is a 30-day average, unless a 90-day average is approved by the Division at the request of the discharger
***No TIN permit limit
+This was documented as a onetime spike of unknown origin. PWSD met the TIN limit 99.3% of the time in 2016.

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.



In 2016, two site applications were received by the Authority.

The first site application was submitted for the Newlin Gulch Lift Station, located upstream of Rueter-Hess Reservoir. The lift station service area includes approximately 2,177 acres at build-out, including the West Newlin lift station service area. The lift station is designed to convey 2,600 gallons per minute (gpm) of wastewater from the proposed service area through parallel force mains around Reuter-Hess reservoir into the Parker Water and Sanitation District's existing collection system. The Authority provided a conditional approval provided that: differential flow metering be placed on the force mains pursuant to the requirements of Section II – Emergency Response Plan Criteria; Cherry Creek Basin Water Quality Authority - Site Application Review Process, dated March 28, 2002 and the final design documents identify the type of overflow pond liner system proposed.

The second site application was for the West Newlin Gulch Lift Station, also located upstream of Rueter-Hess Reservoir. The lift station service area includes approximately 1,477 acres at build-out. The lift station is designed to convey 1,600 gpm of wastewater from the proposed service area through a 10-Inch diameter force main to a proposed gravity collection system discharging into the Newlin Gulch Lift Station, where the wastewater flow reaches the Parker Water and Sanitation District's collection system. The Authority provided a conditional approval provided that: differential flow metering is placed on the force mains pursuant to the Emergency Response Plan Criteria and the final design documents identify the type of overflow pond liner system proposed.

Effectiveness in Reducing Nutrient Concentrations

Control requirements for point source dischargers were effective in reducing phosphorus concentrations to the watershed and reservoir.

All wastewater treatment plants met their phosphorus discharge limits. Required effluent limits for TP concentrations discharging from wastewater facilities and industrial process wastewater sources (i.e., for most dischargers, less than 0.05 mg/L TP concentration as a 30-day average) are significantly less than the flow-weighted TP concentrations currently entering the reservoir. Actual effluent concentrations were consistently below their limits. Wastewater treatment facilities also met their TIN limits in 2016 with one exception.

HOW DO WE IMPLEMENT PUBLIC INFORMATION/EDUCATION?

The Authority is responsible for developing and implementing a public information and education program, which it fulfills by partially funding and utilizing the service of the Cherry Creek Stewardship Partners (Partners).

The Partners formed in response to the need for cross-jurisdictional coordination and communication on watershed issues such as open space, recreation, and water quality in our streams and reservoir. 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. For over 17 years the Cherry Creek Stewardship Partners have provided a forum for active engagement with the natural resources of the Cherry Creek watershed. In 2016, Partners' events included over 40 public activities with more than 5,000 participants.

Education and Outreach - The Authority has been a sponsor of the Denver Metropolitan Regional Science Fair for 10 years. In 2016, Anit Tiyagi, an 11th grader from Cherry Creek High School received the Cherry Creek Basin Water Quality Science Award from the Authority for his project: Diurnal Variation of Nutrients & Bacteria in an Urban Western U.S. River. In 2016, over 12,000 contact hours were logged by the Partners working with students ranging from second graders to professional educators.

PRF and Water Quality Education - The Partners invite bird and wildlife fans to walk the Cherry Creek trails and learn about benefits of stream stabilization and riparian buffers The annual Hawk Walk on Cottonwood Creek in Cherry Creek State Park is the perfect opportunity to explore the ecology of our watershed and consider the effects of human activity in the Cherry Creek Basin.

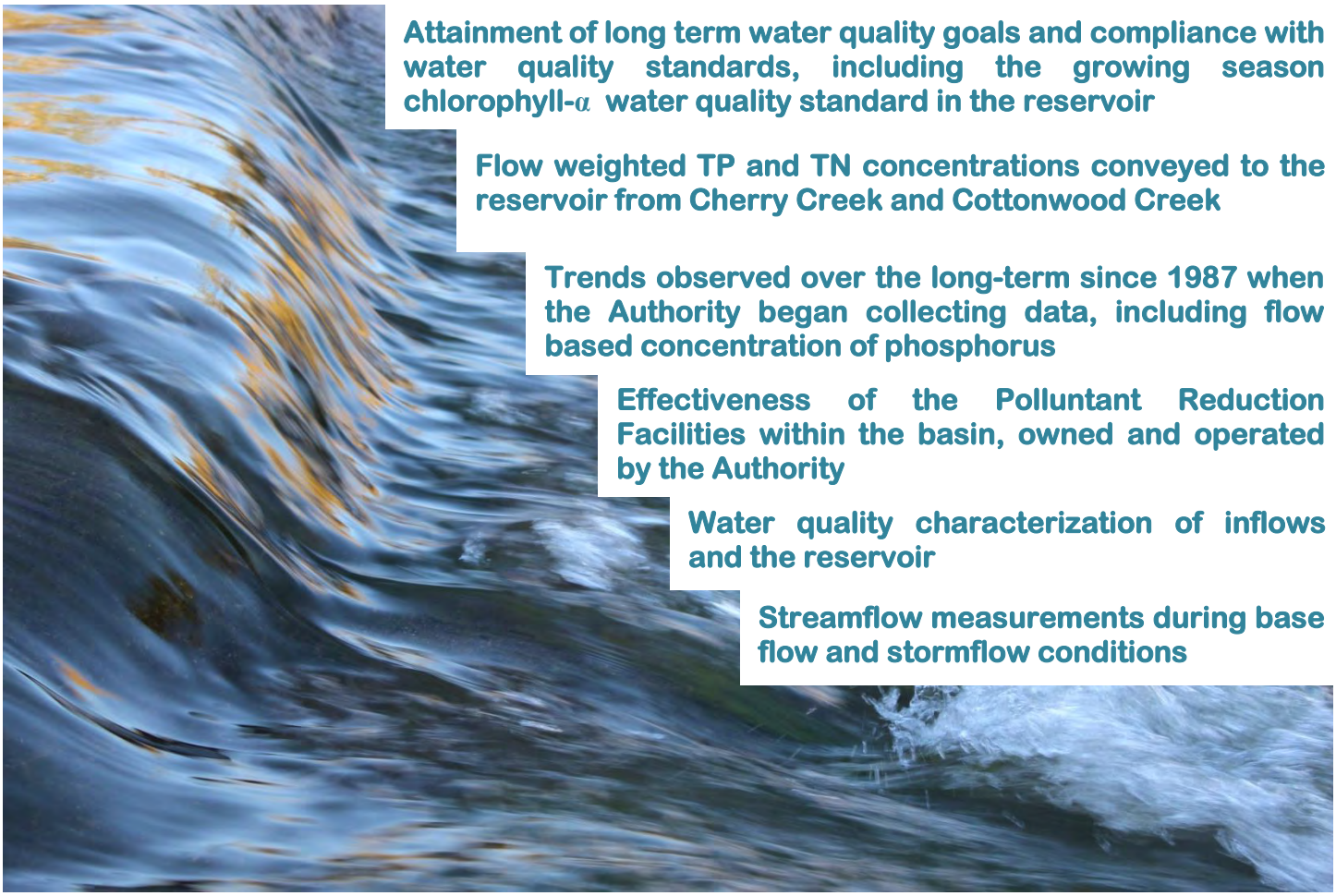
The Right Message at the Right Time and Place - Tagawa Gardens has invited the Partners to repeat their successful soil chemistry classes geared to local homeowners to promote good fertilizing practices, to explore biology with the annual Unique to the Creek hikes and to expand our outreach as partners with Tagawa's Summer Day Camp on the Creek.

Annual Stewardship Partners Conference - This event brings a broad range of watershed interests together to learn from one another. In 2016 the Partners celebrated 17 years of active stewardship with presentations ranging from the Reservoir Model, the importance of play, local history of trails and good old days at the 17 Mile House Farm Park.

WHAT DO OUR MONITORING RESULTS SHOW IN 2016?

Temperature, pH, and D.O. in the reservoir met water quality standards. The chlorophyll α growing season standard was exceeded. The reservoir chlorophyll α growing season (July through September) concentration was 23.6 µg/L, in exceedance of the 18 µg/L growing season average standard for chlorophyll α. Nutrient concentrations in the reservoir were elevated, representative of inflow concentrations, sediment recycling, and algal biomass (as chlorophyll α).

The Authority's reservoir and watershed monitoring program is conducted in the reservoir and watershed in accordance with Cherry Creek Reservoir Control Regulation No. 72 and the Cherry Creek Sampling and Analysis Program and Quality Assurance Procedures and Protocols. The program is comprised of routine monitoring of physical, chemical, and biological conditions, including evaluation of:



- **Attainment of long term water quality goals and compliance with water quality standards, including the growing season chlorophyll-α water quality standard in the reservoir**
- **Flow weighted TP and TN concentrations conveyed to the reservoir from Cherry Creek and Cottonwood Creek**
- **Trends observed over the long-term since 1987 when the Authority began collecting data, including flow based concentration of phosphorus**
- **Effectiveness of the Polluntant Reduction Facilities within the basin, owned and operated by the Authority**
- **Water quality characterization of inflows and the reservoir**
- **Streamflow measurements during base flow and stormflow conditions**

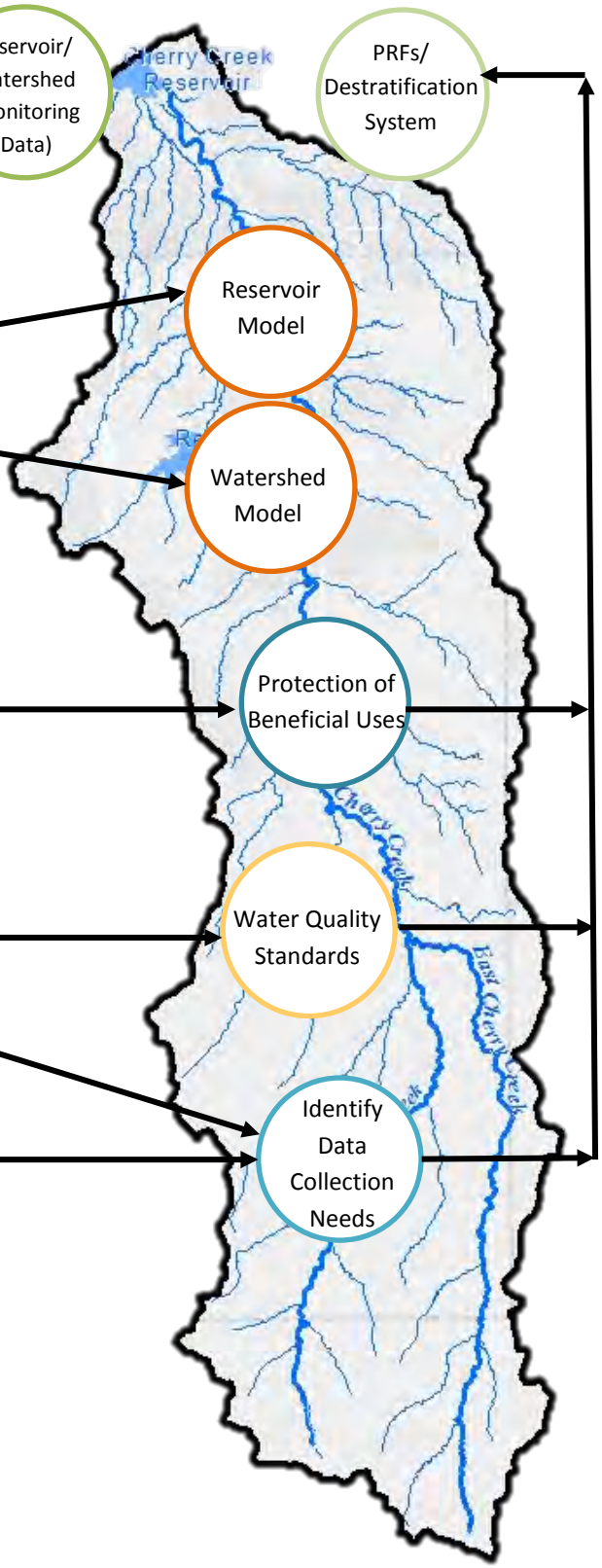
WHERE ARE WE TODAY?

WHAT ARE THE DATA TELLING US?

WHAT IS THE GOAL?

ARE WE MEETING WATER QUALITY STANDARDS?

WHAT ARE THE PROPOSED MODIFICATIONS?



Where Are We Today?

Reservoir Water Quality

Key reservoir findings from the 2016 monitoring season are summarized here:

- The reservoir is getting more productive as time goes on due to the natural progression of man-made lakes, elevated nutrient concentrations observed within the watershed (particularly from Cherry Creek), and recycled nutrients in the reservoir sediments that are between two and 100 times that of the flushing rate under current conditions in the reservoir.
- Reservoir operations and storm events in 2016 resulted in a higher flushing rate that provided a short-term water quality benefit to the reservoir in mid-June.
- Phytoplankton and zooplankton data indicated over-productive and nutrient-rich reservoir conditions in 2016, as indicated by planktonic communities, density, pH, and dissolved oxygen (D.O.).
- Harmful algal blooms were observed near the marina and Tower Loop Road between May 31 and June 9, 2016. A stronger partnership and collaborative effort was instilled between Authority and CPW regarding the harmful algal blooms response plan.
- Nutrient concentrations in the reservoir were elevated, representative of inflow concentrations, sediment recycling, and algal biomass (as chlorophyll α).
- Average TP and TN concentrations measured in the reservoir photic zone during the growing season were 122 µg/L and 897 µg/L, respectively.
- A portion of both TP and TN that has settled to the bottom sediments is available to recycle into the reservoir.
- Elevated external nutrient loading coupled with nutrient recycling from the sediments, supported the growing season chlorophyll α concentrations observed in the reservoir, 23.6 µg/L.

The Authority has continued to consolidate and maintain environmental and water quality data in a relational database management system, the CCBWQA Data Portal, which requires registration for access. Additional data, studies, and project reports can also be found on the Authority's website.

In 2016, the Authority added several technical reports to its website and sorted them into categories for ease of use. The website also provides a list of members of both the Board and TAC, the Authority by-laws, past and current Annual Reports to the Commission and Annual Monitoring Reports, Stream Reclamation Projects, and various maps. Board and TAC meeting packets can be found under the Meetings tab.

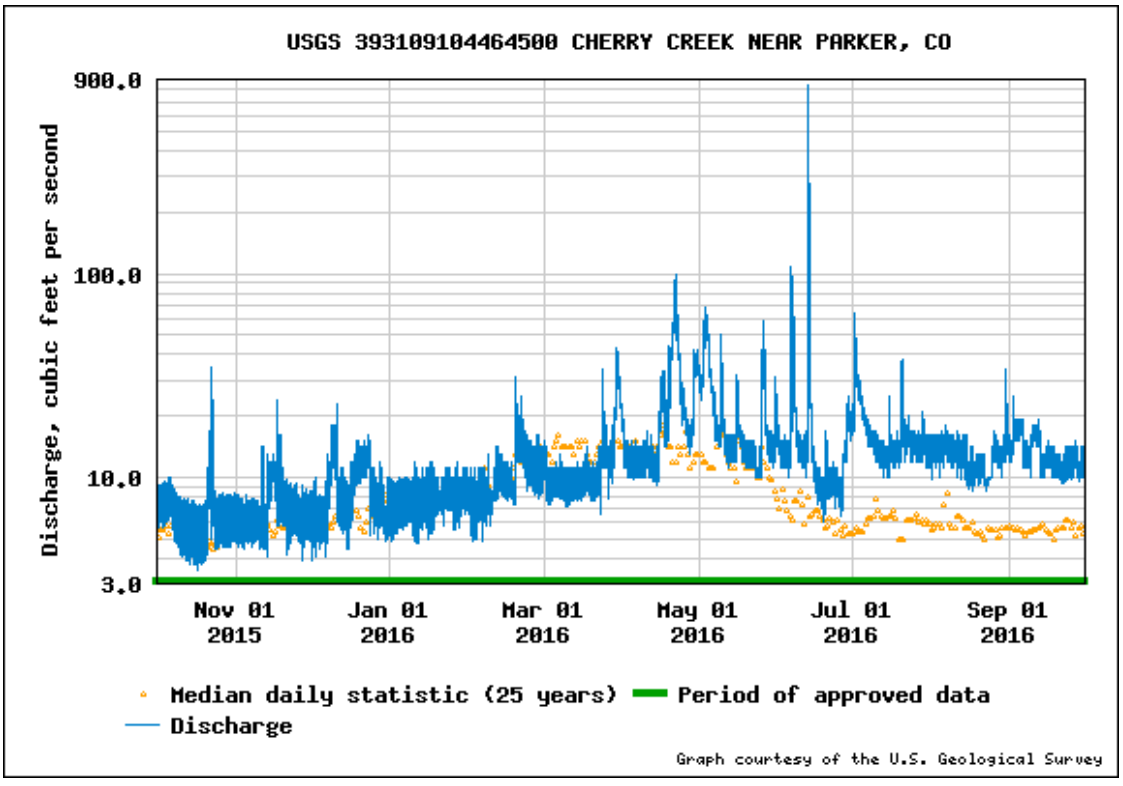
What is the Data Telling Us?

Reservoir Inflows

Higher than normal streamflow was observed in the watershed from April through September. Annual precipitation, 15.3 inches, was 93 % of average; however, the July through September total was only 44% of average. The higher inflows observed July through September may be a function of recharged shallow groundwater from the March through June precipitation events, resulting in sustained higher return flows through September.

Reservoir operations were more variable in 2016 and the higher flushing rate provided water quality benefits to the reservoir. The higher inflows from the Cherry Creek watershed resulted in higher annual pass-through volume from the reservoir outlet works, an average of 15.7 cubic feet per second (cfs), or 11,400 acre-feet. This was over three times the 57-year average daily discharge of 4.6 cfs, or 3,300 acre-feet. While the Reservoir continued to retain much more nitrogen and phosphorus on a mass basis than it was flushing, the increased flush in the outflow provided a temporal improvement that would have otherwise resulted in greater water quality impacts to the Reservoir.

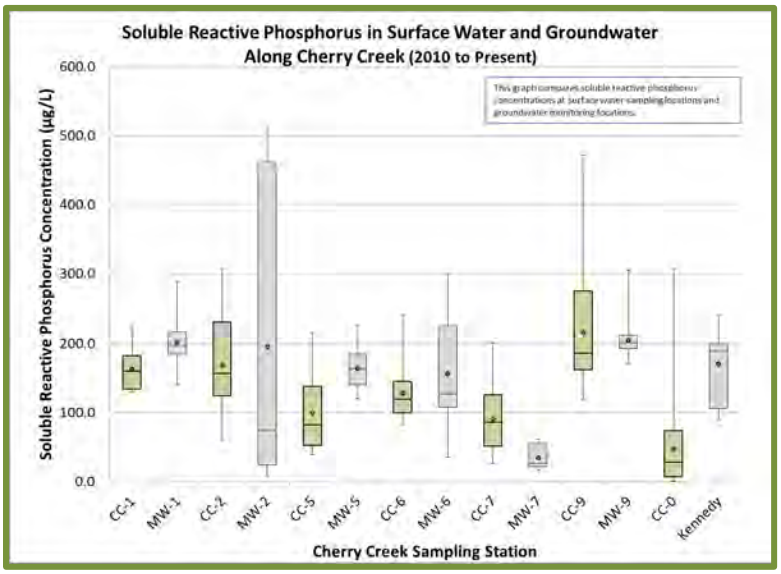
More detailed information on streamflows is in the 2016 Cherry Creek Monitoring Report.



Alluvial Water Quality

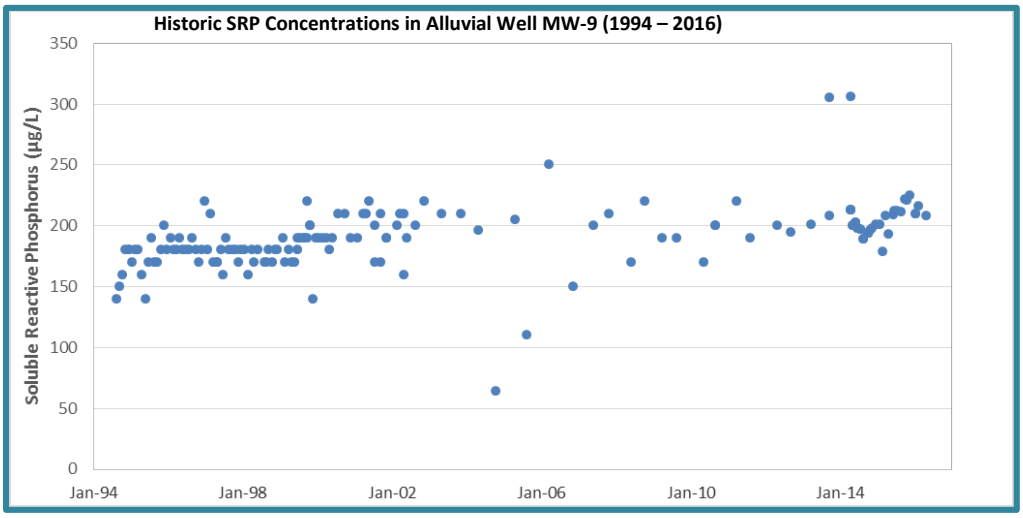
Alluvial groundwater quality indicated differences in TN and TP concentrations between surface water and ground water media. A comparison of Cherry Creek surface water and alluvial groundwater data from the May 2016 basin-wide sampling event suggested a difference in TN concentrations between the two media. (Surface water sites are labeled "CC-xx", and groundwater sites are denoted as "MW-x"; see the map in the 2016 Monitoring Report.) The median concentrations of TN in May 2016 were 1,500 µg/L in surface water and 300 µg/L in alluvial groundwater. In contrast to TN, comparison of Cherry Creek surface water and alluvial groundwater data from the May 2016 basin-wide sampling event suggests little difference in TP concentrations between the two media, with the exception of groundwater well MW-2.

The median concentrations of TP differed little between the two media in May 2016 (207 µg/L in surface water and 214 µg/L in alluvial groundwater).



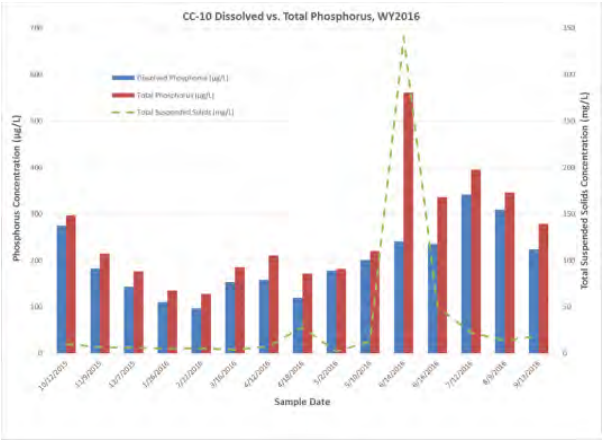
Median soluble reactive phosphorus (SRP) levels in the Cherry Creek alluvial groundwater (2010 – present) were generally similar to median concentrations observed in nearby Cherry Creek surface water (approximately 200 µg/L), over ten times the level use to define eutrophic level for phosphorus. In general, upstream of the reservoir the median SRP levels (the horizontal lines located in rectangle of each box and whisker plot) in the alluvial groundwater were fairly consistent with median concentrations observed in nearby surface water.

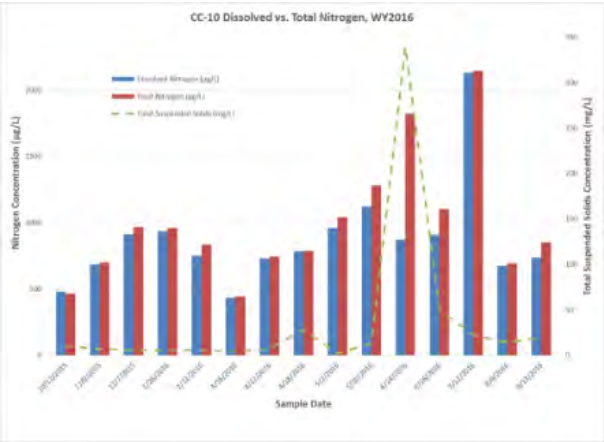
Due to the geochemistry of the area (higher in phosphorus), the groundwater is expected to have a higher SRP concentration than surface water. However, at some sites (MW-7 and MW-9), the groundwater SRP was at or lower than the surface water levels, and less variable than surface water. Ground-water SRP levels at MW-9, the well immediately upstream of the reservoir, are plotted for the last 23 years in the adjacent graph.



Surface Water Quality – Cherry Creek and Cottonwood Creek

- In 2016, Cherry Creek nutrient and sediment concentrations were elevated upstream of the reservoir.
- The Cottonwood Creek PRF passive treatment train approach provided reasonable phosphorus concentration reduction during storm events.
- Cherry Creek nutrient concentrations were elevated just upstream of the reservoir (site CC-10)
- Phosphorus was 4 times higher in Cherry Creek than in Cottonwood Creek.
    - The flow-weighted average TP concentration atCC-10 was 250 µg/L.
    - The observed Cherry Creek surface water inflow SRP concentration was 200 µg/L.
- TN concentrations are higher in Cottonwood Creek than in Cherry Creek, but the TN load from Cherry Creek is larger. Most of the nitrogen is present in the dissolved form.

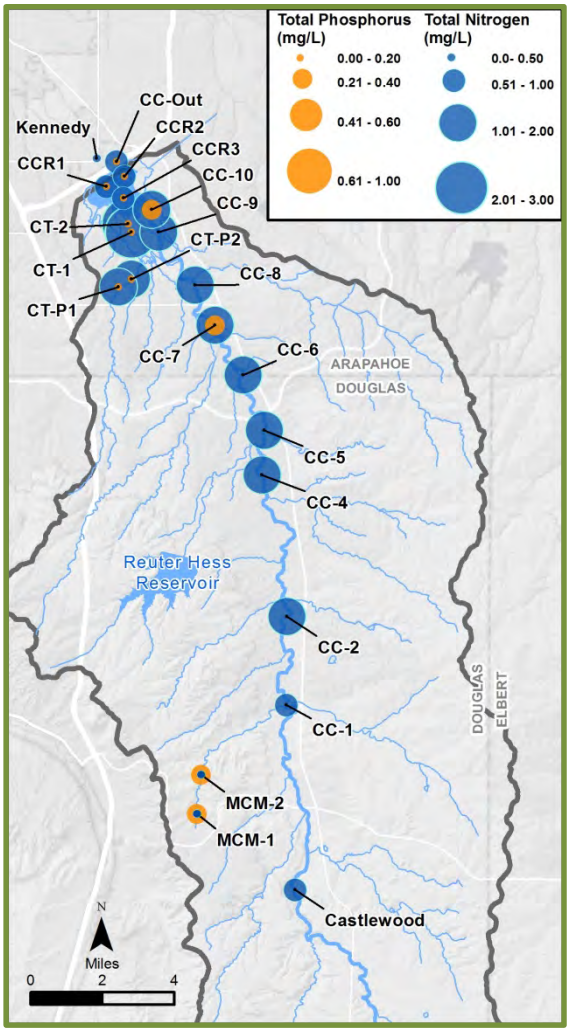




- In 2016, the overall flow-weighted TP concentration entering the reservoir (from all sources) was 213 µg/L. This is lower than the 2015 value of 222 µg/L, but higher than the 2011-2015 median of 200 µg/L. The 2016 TN flow-weighted concentration of 1,175 µg/L is higher than the 2015 value of 1,057 µg/L, but well below the 2011-2015 median of 1,344 µg/L.

More detailed information on water quality in Cherry Creek and Cottonwood Creek are found in the 2016 Cherry Creek Monitoring Report.

The four maps show the relative changes in TP and TN concentrations during the months of May, June, July, and August in the watershed and reservoir. Note that several watershed sites (Castlewood, CC-1, CC-2, CC-3, CC-4, CC-5, CC-6, CC-8, and CC-9) are only sampled once during these months. For example, total phosphorus concentrations increase during June, which is likely related to the peak runoff flows during that period.



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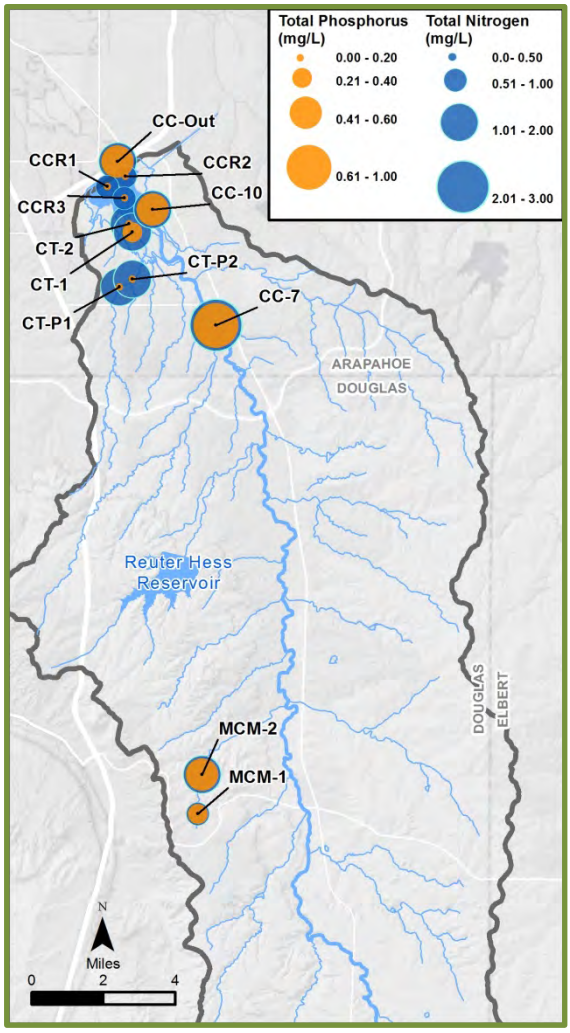

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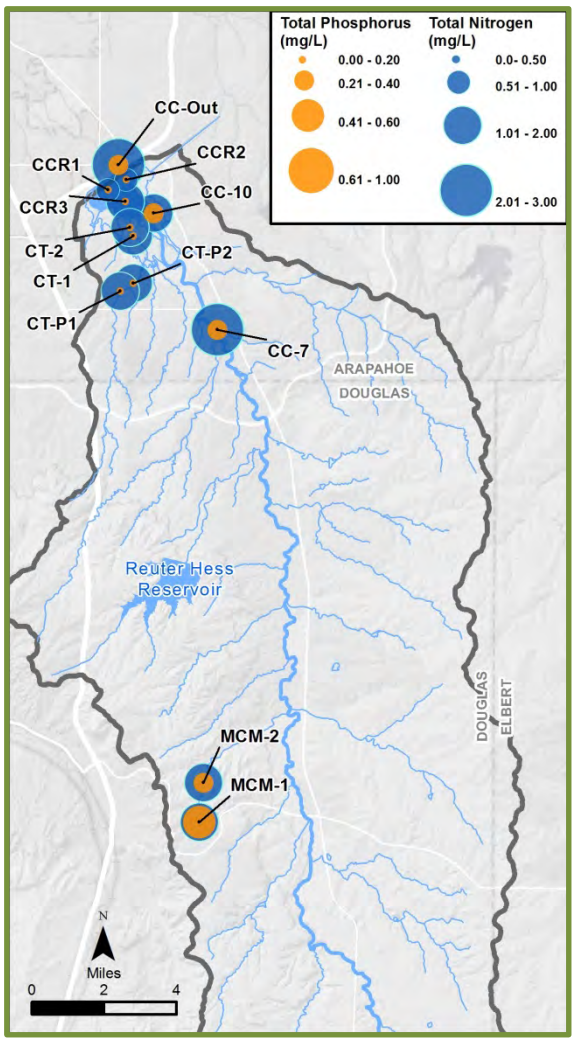

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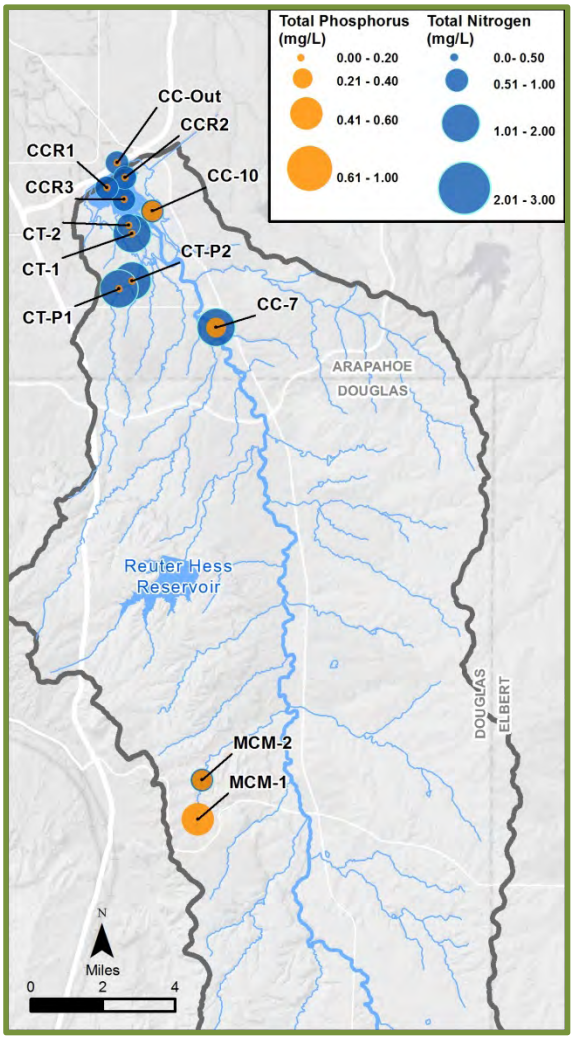
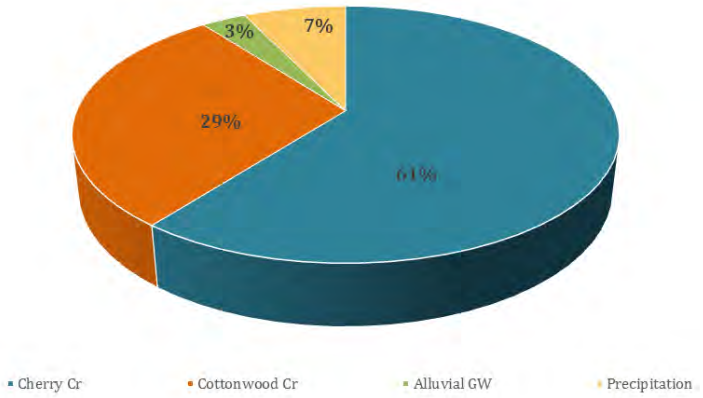


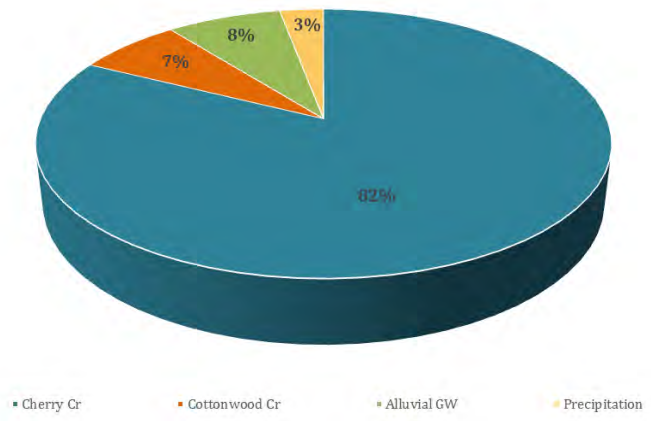
August 2016

2016 Net Nutrient Loading

- Total Phosphorus
    - 14,783 pounds (7.4 tons) were imported into reservoir in WY2016.
    - 5,627 pounds (2.8 tons) were retained in reservoir in WY2016.
    - The flow-weighted TA concentration was 213 µg/L in 2016.
- Total Nitrogen
    - 81,619 pounds (40.8 tons) were imported into reservoir in WY2016.
    - 20,992 pounds (10.5 tons) were retained in reservoir in WY2016.



Relative Contribution to Cherry Creek Inflows to Reservoir Phosphorus Balance in2016



Relative Contribution of Cherry Creek Inflows to Reservoir Nitrogen Balance in 2016

Are We Meeting Numeric Water Quality Standards?

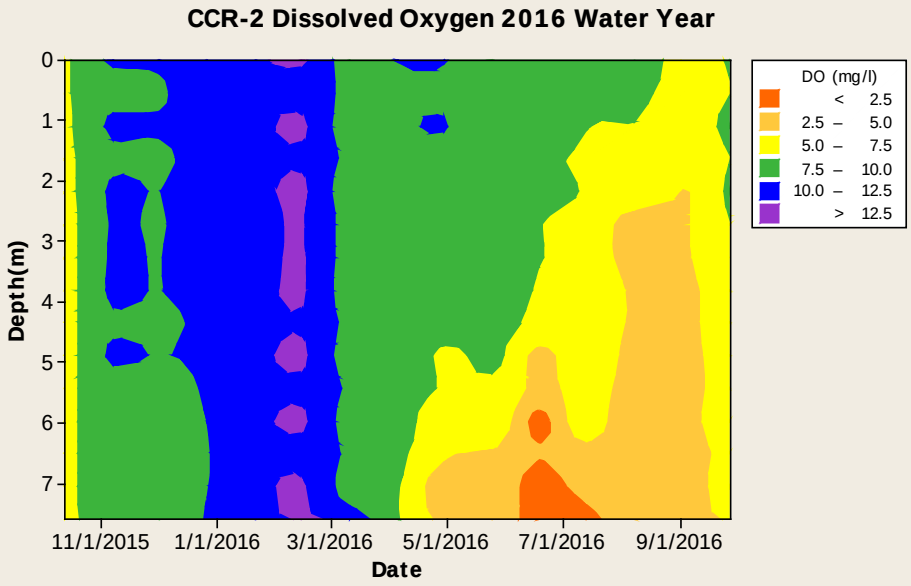
Attainment of Standards & Goals

Physical Parameters

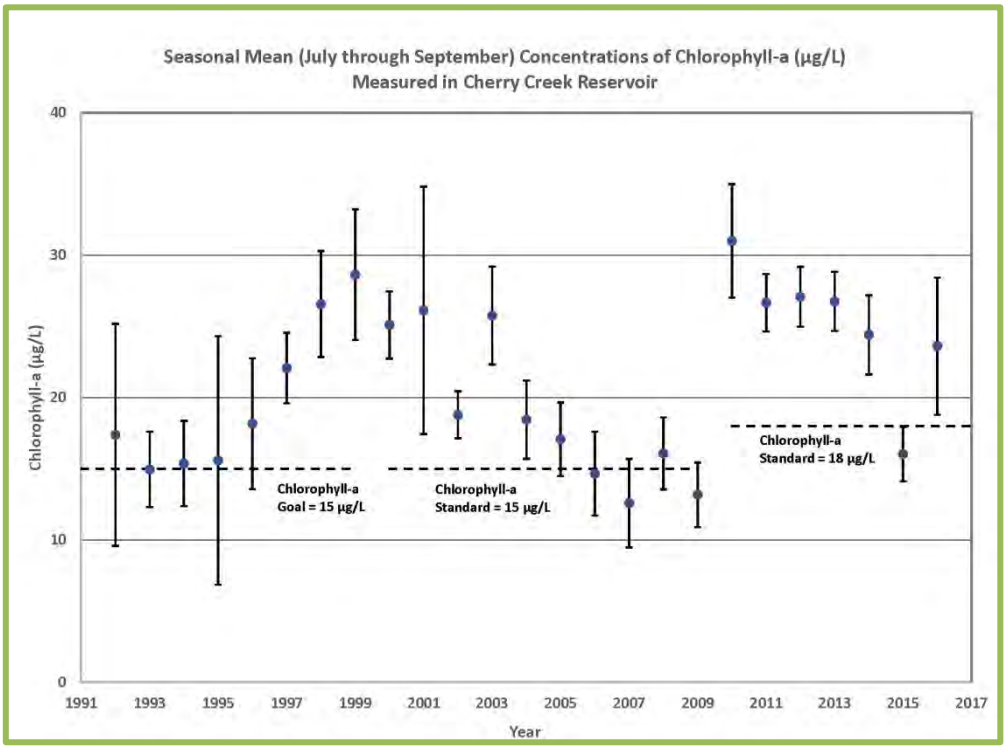
Temperature, pH, and DO in the reservoir met numeric water quality standards. The 2016 Dissolved Oxygen (DO) profile at Cherry Creek Reservoir station CCR-2 shows DO concentrations of more than 5 mg/L throughout the majority of the Reservoir, thus providing refuge for fish species. Lower DO levels, measured at depths near 5 to 7 meters in June through September, were a result of the anoxic conditions that occurred in the reservoir sediments and sediment-water interface, which promoted internal phosphorus loading.

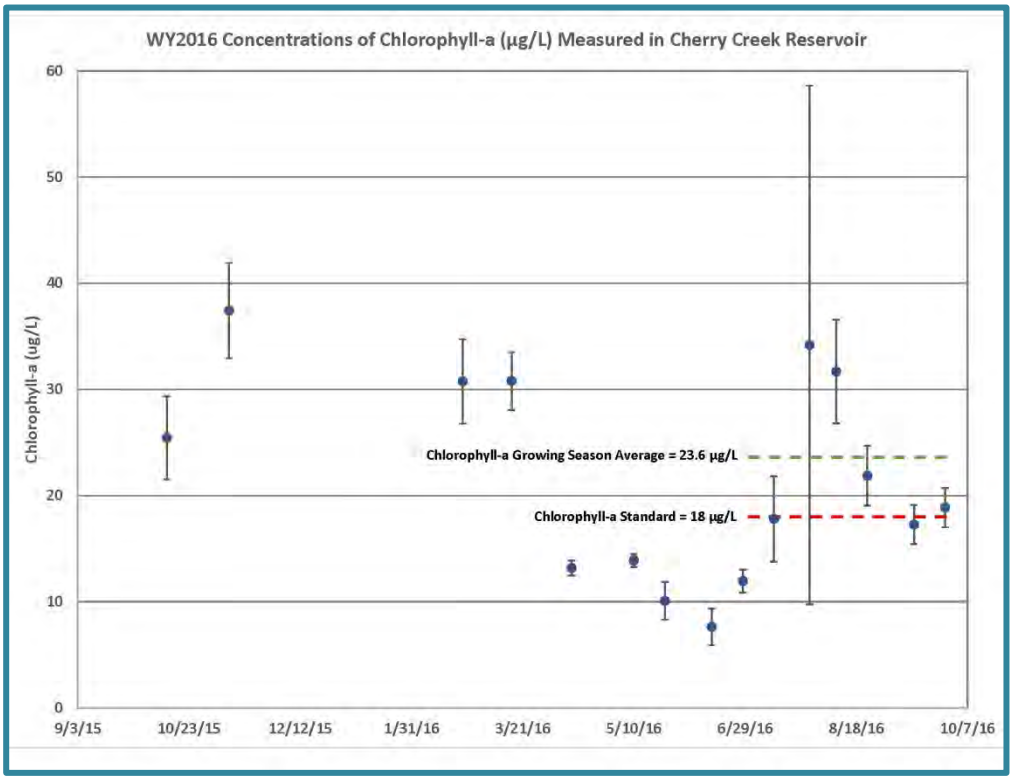
Chlorophyll α

The Chlorophyll α growing season standard was exceeded. The reservoir chlorophyll α growing season (July through September) concentration was 23.6 µg/L, in exceedance of the 18 µg/L growing season average standard for chlorophyll α. The seasonal mean concentration is measured in the upper three meters of the water column (photic zone), with an exceedance frequency of once in five years. The reservoir has exceeded the chlorophyll α standard in four of the last five years.



D.O. was above 5 mg/L (i.e., levels of oxygen needed by fish) in all of the yellow, green, blue, and purple areas, as shown in the graph. This occurred most of the time (horizontal axis) and at most of the depths (vertical axis) during 2016. For example, on 5/1/2016, D.O. was above 5 mg/L between a depth of about 6.5 m and the top of the reservoir (depth= 0m). For more information, see the Annual Monitoring Report.


Seasonal Mean (July through September) Concentrations of Chlorophyll-a (µg/L)
Measured in Cherry Creek Reservoir
Chlorophyll-a (µg/L)
40
30
20
10
0
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
Year
Chlorophyll-a
Goal = 15 µg/L
Chlorophyll-a
Standard = 15 µg/L
Chlorophyll-a
Standard = 18 µg/L


WY2016 Concentrations of Chlorophyll-a (µg/L) Measured in Cherry Creek Reservoir
Chlorophyll-a (ug/L)
60
50
40
30
20
10
0
9/3/15
10/23/15
12/12/15
1/31/16
3/21/16
5/10/16
6/29/16
8/18/16
10/7/16
Chlorophyll-a Growing Season Average = 23.6 µg/L
Chlorophyll-a Standard = 18 µg/L

What are the Proposed Monitoring Program Modifications?

2016 Implemented Changes to Monitoring Program

In 2016, a variety of field procedure refinements were implemented in the Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP) (e.g., improve sampling methodology for plankton samples, discontinuance of certain monitoring locations due to access issues, etc.). The QAPP documents the 2016 refinements and approaches used to manage change in the dynamic program. The refinements to the program recognize opportunities to enhance the integrity of the data to promote sound science and limnology, while maintaining the dynamic nature of the program and changes that are warranted from time to time based on:

- Improved laboratory turnaround times for phytoplankton to understand water quality health and beneficial use protection in a timely manner.
- New purchases of field equipment and materials to provide the Authority and reduce rental costs.
- Automated quality control programs to meet monitoring objectives were performed, including using the Authority's on-line database tool to maximize value added monthly reporting.
- An increase of 5% of field quality control sample duplicates and blanks was performed to support defensible data.
- Lab splits were also performed to document lab variability between 2015 and 2016 laboratory.

In 2016, nutrients and chlorophyll α samples were split between IEH Analytical and GEI Consultants to understand lab variability and data comparability. A preliminary evaluation of the comparability of TP and TN between labs showed the results are within a margin of error of approximately 20%. For chlorophyll α, total dissolved phosphorus, and soluble reactive phosphorus, concentrations were more variable between the two laboratories and a more thorough analysis of split samples is necessary.

The following next steps are recommended in 2017 for the monitoring program:

- Split Sampling - Continue split sampling of nutrients and chlorophyll α to support QAPP and parametric and nonparametric statistical evaluations to understand and quantify inter-lab variability.
- Replace Stream Gaging Equipment at Strategic Locations - Replace continuous monitoring hardware at CC-10 and CT-2.

WHAT OPPORTUNITIES DOES OUR STATUTE PROVIDE?

While Regulation 72 requires us to carry out specified tasks, we have additional authorities that we may implement under our Statute. These are unique powers given to the Cherry Creek Basin Water Quality Authority by the State Legislature. These powers include those shown in the text boxes in the diagram; the goals of the Statue are shown in red. Many of the water quality control techniques shown below are already being implemented, as discussed previously in this report. The Authority is also currently exploring additional options to help preserve water quality in the basin, such as developing reservoir and watershed models, and exploring expanded riparian protection options.

Our Statute

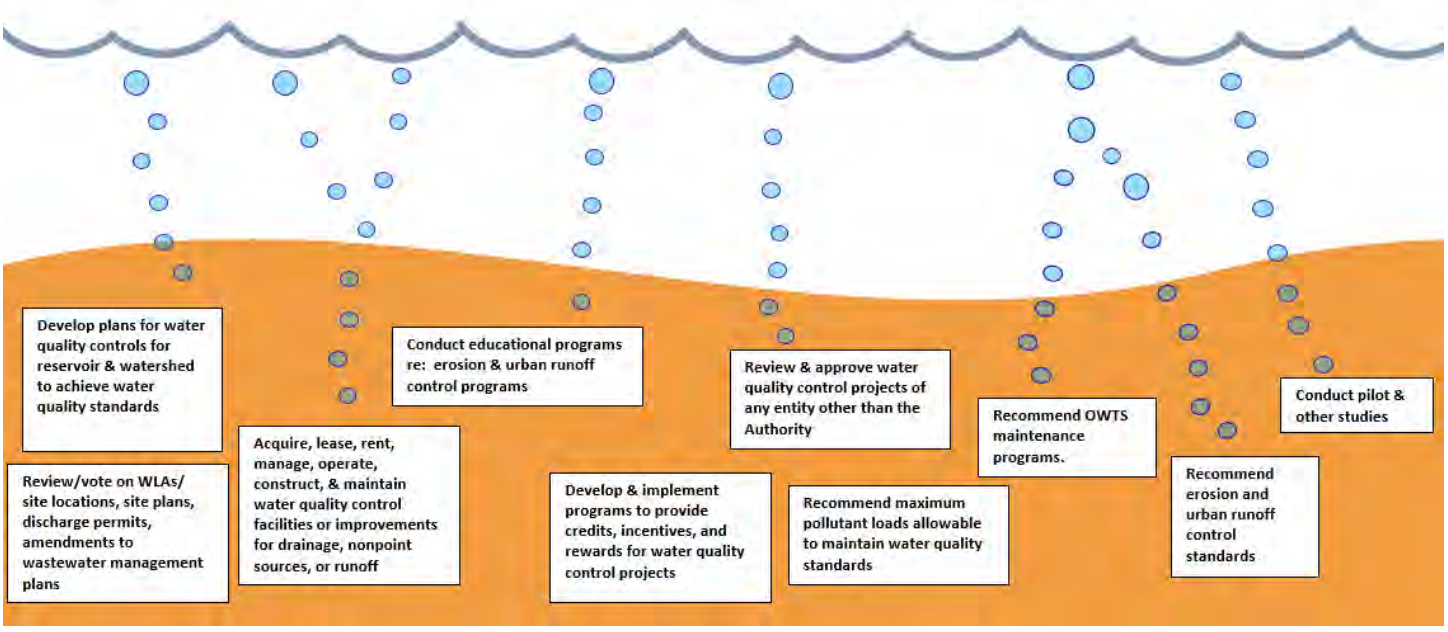
Preserve water quality in Cherry Creek and Cherry Creek Reservoir

Preserve waters for recreation, fisheries, water supplies, and other beneficial uses

Promote the health, safety, and welfare of the people of Colorado

Provide for effective efforts by counties, municipalities, districts, & landowners in the protection of water quality

Provide that new developments & construction activities pay their equitable proportion of costs for water quality preservation and facilities



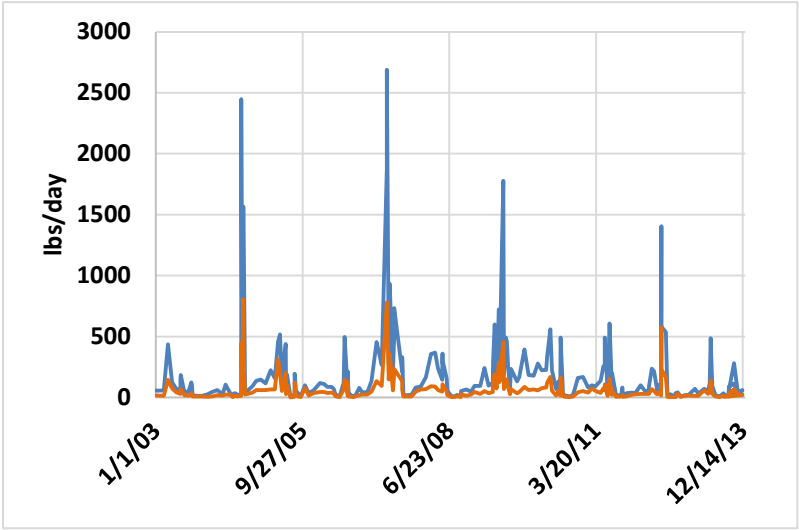
Ongoing Water Quality Investigative Studies: Reservoir and Watershed Models

The Authority has developed a Reservoir Model to evaluate water quality and ecological conditions of the reservoir under different hydrologic scenarios, and to evaluate the potential effects of alternative management scenarios, 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.

In 2016, the Authority chose the first five scenarios to run through our CE-QUAL-W2 Reservoir Model:

Scenario	Run Description	Question Addressed
1	Optimal watershed control of nutrients	How would the reservoir respond to the optimal reduction of nutrients (nitrate [NO_3], ammonia [NH_4], and phosphate [PO_4]) through watershed controls?
2	Increased destratification system mixing	How much increased vertical mixing is needed for the destratification system to meet the original bottom D.O. design target of 5 mg/L?
3	Optimal watershed controls plus increased destratification	How would the reservoir respond to a combination of the optimal watershed controls and destratification mixing that achieves 5 mg/L D.O. at the bottom?
4	Inflow PO_4 percent reduction needed to meet chlorophyll α standard	What percent reduction in inflow PO_4 concentration is needed to meet the 18 ug/L chlorophyll α standard value for ***all*** simulated years?
5	Nitrogen-to-Phosphorus ratio	Would the amount of cyanobacteria in the reservoir increase if nitrogen inputs from the watershed decreased? (Cyanobacteria can "fix" nitrogen directly from the atmosphere.)

Results for each of the management scenario runs are presented in the Task 5 Technical Memorandum (Cherry Creek Reservoir Water Quality Modeling Project: Management Model Runs). Watershed inputs for model Scenarios 1, 3, and 5 were developed assuming best possible nutrient reductions, based on removal efficiencies seen to date in Cottonwood Creek with its treatment train approach. The graph shows the difference between current baseline TN loads (blue) and loads after best possible nutrient reductions (orange) from Cherry Creek. These assumptions should be checked once the Watershed Model is completed.



Run 1 – Best Anticipated Watershed Control of Nutrients: This assumed large reductions in both phosphorus and nitrogen in Cherry Creek (load reductions of 48% for phosphates, 70% for nitrate, and 64% for ammonia). Similar reductions for nitrogen in Cottonwood Creek were also assumed (Cottonwood Creek already achieves significant phosphorus removal through the treatment–train approach). Full results of Run 1 are found in the Task 5 Memorandum.

Run 2 – Increased Destratification Mixing: The goal of this run was to estimate how much the vertical mixing by the destratification system would need to be increased to meet the original design target of 5 mg/L D.O. as the bottom of the reservoir. Full results of Run 2 are included in the Task 5 Memorandum.

Run 3 – Increased Destratification System Mixing and Best Anticipated Watershed Control of Nutrients: The purpose of this run was to determine how chlorophyll a in the reservoir would respond to a combination of the first 2 runs. Run 3 results are found in the Task 5 Memorandum.

Run 4 – Reduction of Inflow Phosphorus Concentration Needed to Meet Chlorophyll a Standard: The model's sensitivity analysis completed in mid-2016 indicated that a 50% reduction in inflow soluble phosphorus along would not be adequate to meet the standard in all years. Run 4 was designed to determine the percent reduction in inflow soluble phosphorus would be needed to meet the standard. Run 4 results are included in the Task 5 Memorandum.

Run 5 – Nitrogen-to-Phosphorus Ratio: This was designed to determine whether further reductions in inflow inorganic nitrogen concentrations could exacerbate nitrogen-limited conditions, possibly increasing cyanobacteria growth. Full results of Run 5 are included in the Task 5 Memorandum.

These preliminary model run results will need to be re-evaluated after the Watershed Model is completed, to check the efficacy of the watershed nutrient input assumptions. The Authority also has not yet developed any cost estimates for achieving any of these management scenarios.

In 2016 the Authority released a request for proposal for the Chery Creek Watershed Model. In early 2017, the Authority anticipates a selection of a Watershed Modeling Consultant. The model will be used to prioritize recommendations for additional water quality controls and management strategies in the watershed.

The goal is to maintain compliance with the reservoir's water quality standards, including its chlorophyll α standard, and to protect beneficial uses.

WHAT ARE THE KEY TAKEAWAYS?

Reservoir/Watershed

Reservoir Model: Model results indicate that the major reductions in watershed inflow nutrient concentrations would decrease summer chlorophyll *a* concentrations by an average of 6.4 ug/L. Further, the average summer chlorophyll *a* concentrations would to be at or below the site-specific standard value of 18 ug/L in the 11 years modeled. Lower summer cyanobacteria peak concentrations are also predicted.

The preliminary model results estimate that a destratification system with three times the vertical mixing effect of the current system would result in a D.O. of at least 5 mg/L at the bottom of the reservoir nearly all the time. A corresponding decrease in average summer chlorophyll *a* would occur, though it would exceed the current site-specific standard value once in the 11 years. A decrease in the summer cyanobacteria blooms would also result from an increase in vertical mixing.

If the focus is just on phosphorus reduction (and not nitrogen), a 75% reduction in inflow Cherry Creek soluble phosphorus would be needed to meet the chlorophyll *a* standard.

These are all only preliminary results, which will need to be re-reviewed after the Watershed Model is completed and input assumptions can be cleared, and after cost estimates are developed for the options.

Watershed Model: A Watershed Modeling Consultant will be selected in 2017.

Point Source Controls

Phosphorus Concentrations, Permit Violations, and Effectiveness in Reducing Nutrients Concentrations: All wastewater treatment plants met their phosphorus discharge limits in 2016. Wastewater treatment facilities with nitrogen limits also met these limits, with one exception.

Approved Site Applications: The Authority provided conditional approval on the two site applications that were received in 2016.

Regulated Stormwater Controls

Regulated Stormwater Controls: In 2016, the MS4s conducted 19,620 inspections and 1,666 enforcement actions in the basin.

Riparian and Wetlands Protection

Protection, enhancement, and restoration actions: The Authority reviewed 265 land use agency referrals to ensure protection of stream preservation areas and compliance with Regulation 72.

Nonpoint Source Controls

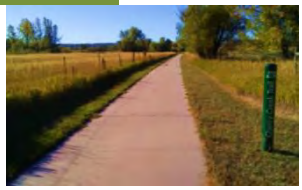
Nonpoint Source Controls: Three pollutant reduction facilities were under construction in 2016: Cherry Creek Stream Reclamation at Arapahoe Road, Cherry Creek Stream Stabilization at Norton Farms Open Space, and Piney Creek Stream Reclamation. The combined projects are expected to remove approximately 119 lbs/yr of phosphorus from Cherry Creek.

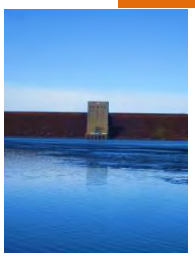
Water Quality Monitoring

Water Quality Monitoring: The chlorophyll α growing season standard was exceeded in 2016 as well as in four of the last five years. Now that the Reservoir Model is completed, it can be used to help evaluate specific options to achieve the standard.

Program Effectiveness

Program Effectiveness: Our statute provides several funding mechanisms that the Authority can use to improve, protect, and preserve the water quality of Cherry Creek and the reservoir. We are currently implementing and/or exploring several options allowed under the Statute, such as developing the reservoir and watershed models, and exploring riparian protection options.





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List of Abbreviations and Acronyms

Authority	Cherry Creek Basin Water Quality Authority
µg/L	Micrograms per Liter
BMP	Best Management Practices
cfs	Cubic Feet per Second
CIP	Capital Improvement Program
Commission	Water Quality Control Commission
CPW	Colorado Parks and Wildlife
Division	Water Quality Control Division
DO	Dissolved Oxygen
ft^2	Square Feet
gpm	Gallons per Minute
IGA	Intergovernmental Agreement
mg/L	Milligram per Liter
MS4	Municipal Separate Storm Sewer System
N	Nitrogen
O&M	Operations and Maintenance
OWTS	On-Site Wastewater Treatment Systems
P	Phosphorus
Partners	Cherry Creek Stewardship Partners
PRF	Pollutant Reduction Facility
QAPP	Quality Assurance Project Plan
SAP	Sample and Analysis Plan
SEMSWA	Southeast Metro Stormwater Authority
SRP	Soluble Reactive Phosphorus
TAC	Technical Advisory Committee
TIN	Total Inorganic Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
UDFCD	Urban Drainage and Flood Control District
WWTF	Wastewater Treatment Facility
WY	Water Year

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