2017 Annual Report

Clear Creek / Standley Lake Watershed Agreement

October 1, 2018

2017 Clear Creek Watershed Annual Report

October 1, 2018

Submitted to the Water Quality Control Commission by:

Black Hawk/Central City Sanitation District
Central Clear Creek Sanitation District
Church Ditch Water Authority
City of Arvada
City of Black Hawk
City of Golden
City of Idaho Springs
City of Northglenn
City of Thornton
City of Westminster
Clear Creek County
Clear Creek Skiing Corporation
Clear Creek Watershed Foundation
Climax Molybdenum Company/Henderson Operations
Colorado Department of Transportation
Farmers' High Line Canal and Reservoir Company
Farmers' Reservoir and Irrigation Company
Molson Coors Brewing Company
Gilpin County
Jefferson County
St. Mary's Glacier Water and Sanitation District
Town of Empire
Town of Georgetown
Town of Silver Plume
Upper Clear Creek Watershed Association

Report photographs contributed by the Cities of Westminster, Thornton, and Northglenn; the Clear Creek Watershed Foundation and the Church Ditch Water Authority.

Prepared by:
Hydros Consulting Inc.
1628 Walnut Street
Boulder, CO 80302

2017

Highlights

- ***Stakeholders continued their efforts to work collaboratively and completed a number of important activities to protect water quality.***
- ***Sample timing and lower peak flows resulted in lower nutrient concentrations in Clear Creek near the canal headgates.***
- ***Monitoring data again point to significant nonpoint source loading of TSS and TP in the Croke Canal between the headgate and the lake.***
- ***Although Standley Lake experienced high internal loading of phosphorus (three times the 1999-2016 average), the chlorophyll a standard was met.***

CONTENTS

Standley Lake profiler

PURPOSE OF REPORT

This report provides a summary of the accomplishments and collaborative efforts to enhance and protect water quality in the Clear Creek Watershed and Standley Lake in 2017. This document fulfils the reporting requirements set forth in the Clear Creek Standley Lake Watershed Agreement, providing results from best management practices (BMPs) and control efforts, as well as results from the monitoring program in 2017. Additional information pertaining to the agreement, monitoring plan, and in-depth water-quality analyses, are included in the Supplemental Information sections.

Pelicans at Standley Lake

1. THE 1993 AGREEMENT

In 1993, the Clear Creek/Standley Lake Watershed Agreement (1993 Agreement) was signed by a contingent of governmental and private entities to address water-quality issues and concerns within the Clear Creek watershed, specifically as they affect the water quality in Standley Lake. The 1993 Agreement shaped the Watershed Monitoring Program and has resulted in a long term, robust data set that is used to both monitor the success of water-quality actions and to inform future projects. To continue efforts to protect Standley Lake water quality, a numeric chlorophyll *a* standard was implemented in 2009.

Chlorophyll a Standard

In 2009, the Water Quality Control Commission adopted a numeric chlorophyll a standard for Standley Lake. A 4.0 µg/L chlorophyll a standard was established as a protective measure for this drinking water supply reservoir. The standard is evaluated on an annual basis using the running average of observed data for the nine-month period from March through November.

Standley Lake

CLEAR CREEK WATERSHED AND THE UPPER BASIN

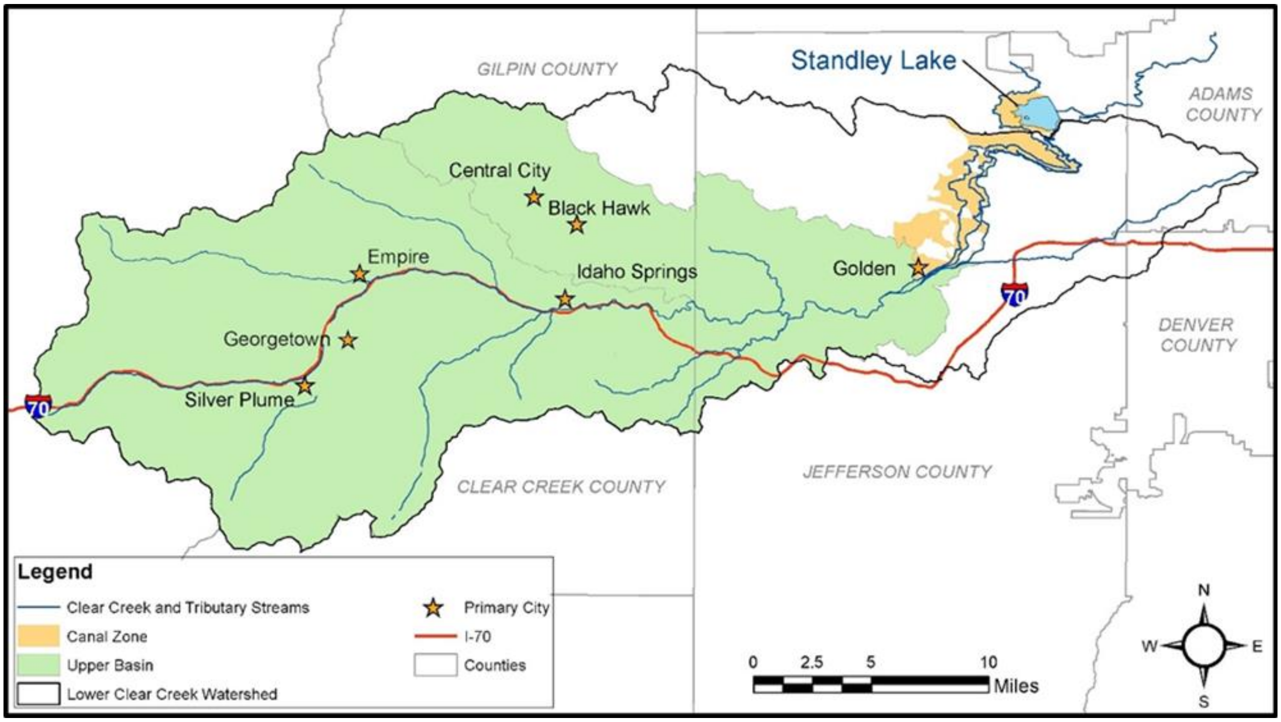


Figure 1. The Standley Lake Watershed: Upper Basin and Canal Zone

Rafters on Clear Creek

The Upper Clear Creek Watershed covers 450 square miles and is located west of Denver, Colorado, with headwaters at the Continental Divide (Figure 1). The Upper Basin of the watershed is the portion above the headgates for the three canals supplying Standley Lake. It extends from the headwaters downstream to near the City of Golden. In addition to supplying drinking water for 350,000 residents in the watershed (including the Cities of Northglenn, Thornton and Westminster), Clear Creek provides water for recreational, agricultural, and industrial purposes.

CANAL ZONE

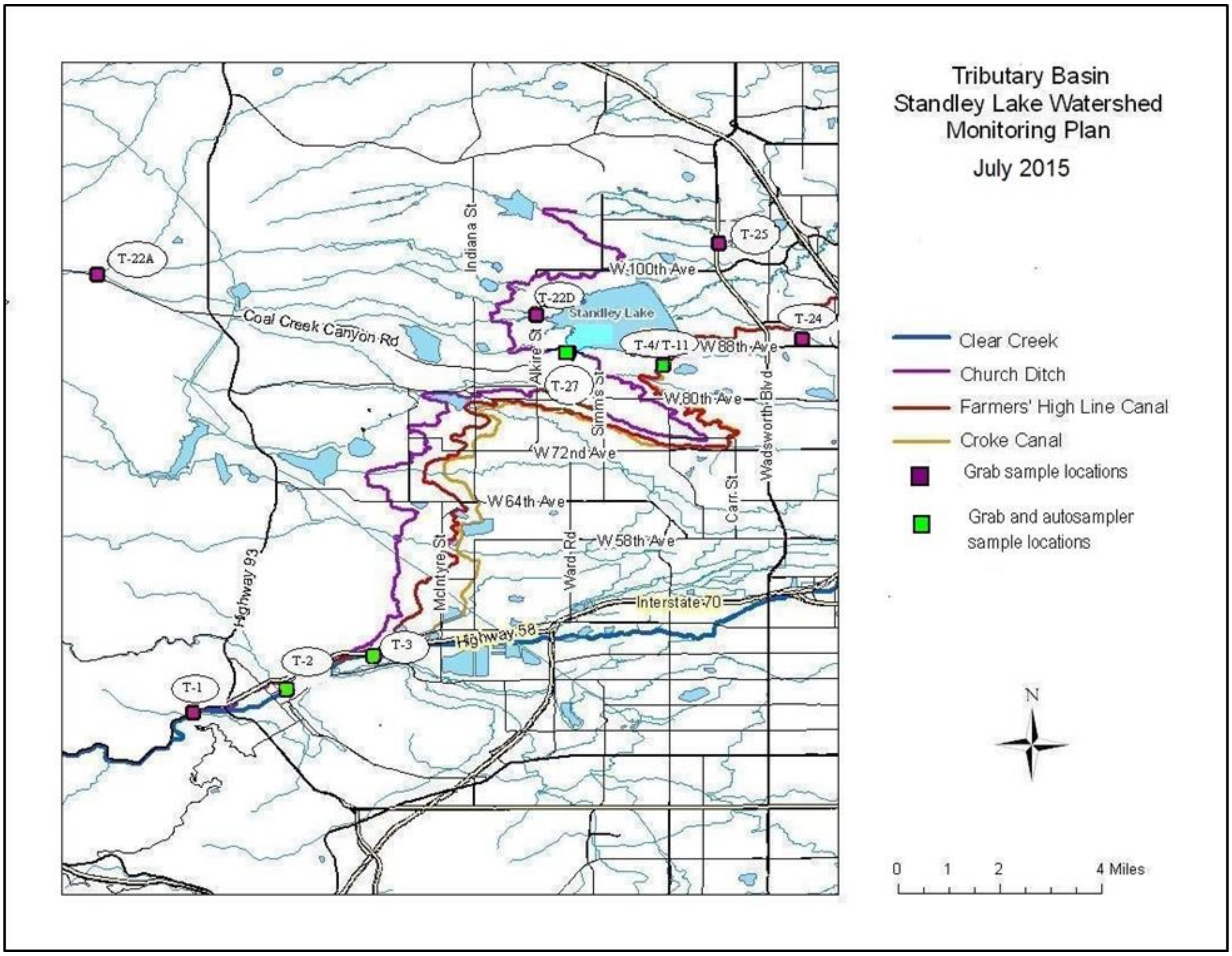
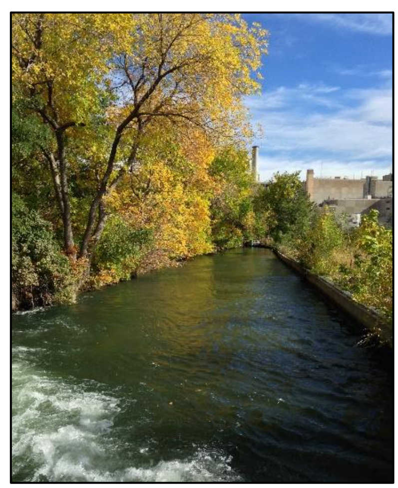


Figure 2. The Canal Zone Showing the Three Canals that Divert Water from Clear Creek to Standley Lake

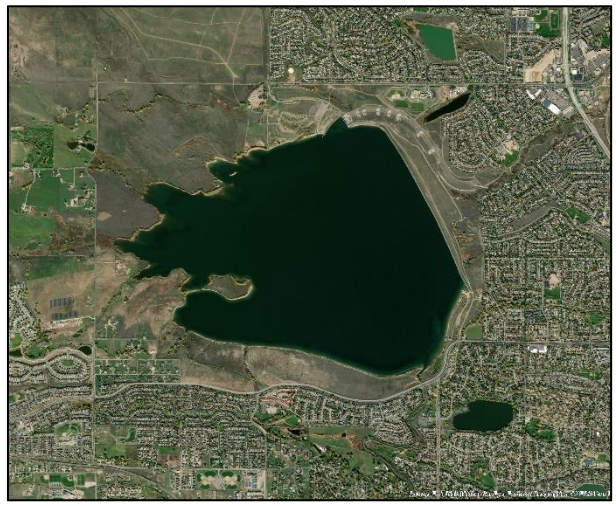
The Canal Zone is the drainage area that includes three canals that divert water from Clear Creek into Standley Lake: Church Ditch (Church), Farmers' High Line Canal (FHL), and the Croke Canal (Croke) (Figure 2). The Kinnear Ditch Pipeline (KDPL), which provides flow from the Fraser River, South Boulder Creek, and Coal Creek, also contributes water to Standley Lake (< 6%). The three canals are low-gradient, earthen, open, and unlined. In addition, they are subject to nonpoint-source loading from adjacent horse and cattle operations, other agricultural operations, and residential properties (some with on-site wastewater treatment systems, OWTS). To protect Standley Lake water quality, efforts have been made since the 1990s to reduce the majority of storm water inputs/runoff into the Clear Creek canals, as a result, ~80% of stormwater inputs have been hydrologically disconnected from the canals.



The Farmers' Highline Canal

Standley Lake

STANDLEY LAKE



Aerial image of Standley Lake

Standley Lake is a municipal and agricultural reservoir located in Jefferson County, Colorado. Construction of the dam was completed in 1912 and in 1963 the City of Westminster expanded the reservoir to its present storage capacity of 43,000 acre-feet. The reservoir is a direct-use drinking water supply for over 300,000 consumers in Northglenn, Thornton, and Westminster. The reservoir also provides recreation opportunities as well as water to farms located in Adams and Weld counties. It is owned and operated by the Farmers' Reservoir and Irrigation Company (FRICO) and is the third largest reservoir in the Denver metropolitan area, covering approximately 1,200 acres. Standley Lake receives the majority of its inflows from the Clear Creek Watershed via three canals. Through the Watershed Monitoring Program, the lake is monitored regularly during the ice-free period.

Kayakers enjoying Standley Lake

Canada geese on Standley Lake

MONITORING IN THE UPPER BASIN

Taking a grab sample of Clear Creek at CC26 (Lawson)

Flow measurements are collected at four locations and water-quality samples are collected at 16 stations throughout the watershed to monitor the concentrations of nutrients, select metals, and other key constituents. Upper Basin monitoring activities have been designed to evaluate the relative contributions of various nutrient sources, the effectiveness of BMPs, waste water treatment facility (WWTF) operational changes, and nutrient reductions from WWTF upgrades. The Watershed Monitoring Program uses a combination of ambient grab samples, 24-hour ambient composite samples, and the automated collection of composite event samples to assess water quality. In 2017, a total of 72 samples were collected in the Upper Basin of the watershed (Table 1).

Table 1. Samples Taken in the Upper Basin, 2017

Type of Sample	Total Number of Samples Collected
Grab samples	46
Ambient composites	23
Storm-triggered composites	3

Clear Creek at CC26 (Lawson)

Sample Types for the Upper Basin

***Grab samples** provide a water quality snapshot in time.*

***Composite samples** provide a more complete picture of water quality fluctuations over the course of the 24-hour sampling period. Two types of composite samples are collected:*

- ***Ambient samples** are collected on a periodic basis over a 24-hour period during base flow.*
- ***Event samples** are collected during storm events large enough to trigger the autosamplers.*

WASTEWATER TREATMENT FACILITIES AND REGULATION 85

> *Regulation 85*
>
> *In 2012, the Water Quality Control Commission (WQCC) adopted Regulation 85 (CDPHE, 2012), the Nutrients Management Control Regulation, which establishes numeric standards for nutrient concentrations in WWTF effluent.*

Of the nine wastewater treatment facilities (WWTFs) in the Upper Basin, only the Black Hawk / Central City Sanitation District facility (capacity of 2.0 MGD) is subject to Regulation 85 effluent limits and monthly monitoring requirements. Minor dischargers (less than 1 MGD) are required to sample once every two months at a minimum. This applies to the seven domestic WWTFs in the watershed: Loveland Ski Area, Georgetown, Empire, Central Clear Creek, Idaho Springs, St. Mary's, and Clear Creek High School. Effluent nutrient concentrations for these WWTFs and Henderson Mine are summarized in Table 2. Total inorganic nitrogen and total phosphorus are the constituents WWTFs are required to monitor, but this report focuses on loadings of total nitrogen (TN) and total phosphorus (TP) and thus TN is reported here.

Table 2. Summary of Effluent Nutrient Concentrations and Flows from WWTFs in the Clear Creek Watershed for 2017*

Location	WWTF	Average Flow (MGD)	Total Phosphorus (mg/L)			Total Nitrogen (mg/L)		
			Min	Max	Average	Min	Max	Average
Upstream	Loveland Ski Area	0.010	0.17	7.50	1.27	3.79	55.19	22.89
↓	Henderson Mine	1.93	0.005	0.03	0.007	0.20	1.09	0.76
↓	Georgetown	0.254	0.04	0.73	0.29	1.60	6.50	4.08
↓	Empire	0.026	0.01	2.02	0.55	23.81	37.90	30.79
↓	Central Clear Creek	0.037	1.20	3.33	1.97	33.86	60.53	50.26
↓	Idaho Springs	0.265	0.28	2.06	0.84	0.89	9.10	4.40
↓	Black Hawk/Central City	0.337	0.06	0.13	0.09	4.49	8.46	5.79
Downstream	Clear Creek High School	0.005	11.60	21.90	16.14	10.77	158.69	105.24

* Data for St. Mary's WWTF were not available.

> *WWTF Improvements*
>
> ***The City of Idaho Springs Water Resources Recovery Facility (WRRF)*** *began the design process for an on-site biosolids dewatering facility, scheduled for completion in April 2018. Simultaneously, the City began the design process for an expansion of the WRRF. This expansion will increase facility capacity from 0.6 MGD to 0.995 MGD. The two technologies being investigated include activated granular sludge (AGS) and membrane bio-reactors (MBR). The City piloted an AGS plant on-site from December 2017 to February 2018.*

NONPOINT SOURCE CONTROL

This section highlights key accomplishments in 2017 for nonpoint source pollution control and monitoring in the Upper Basin. It also includes OWTS monitoring / regulation and the remediation of abandoned mines.

The City of Golden (Golden) operates under a Municipal Separate Storm Sewer System (MS4) permit and is designated a Qualifying Local Program by the Water Quality Control Division. Under this permit and designation, the City ensures that erosion and sediment controls are implemented on construction sites. In 2017, the City of Golden administered 33 stormwater quality construction permits and conducted 551 erosion and sediment control inspections. These inspections resulted in 297 written and 63 verbal notifications of violation. Four stop-work orders were issued and performance security was implemented at four sites for corrections.

Golden's Stormwater Maintenance Program performs yearly inspections on all private systems requiring routine cleaning and maintenance. In 2017, approximately 250 inspections of permanent water-quality BMPs were performed resulting in close to 200 letters sent to landowners requesting maintenance. Twice a year, the City's stormwater division cleans and inspects municipal inlets, increasing the efficiency of the system and removing pollutants that would be discharged to the creek. Sumped manholes and sediment traps are utilized to remove solids from the stormwater system. In 2017, 336 yards of sediment and other debris were removed from the system.

The City of Golden and Colorado School of Mines partnered on a full-scale pilot of a Biohydrochemical Enhancements for Streamwater Treatment (BEST) channel. The channel was constructed in 2017 and is paired with an existing detention pond to attenuate flows and settle out suspended solids. As runoff discharges from the pond, it flows into the BEST channel, which is lined and filled with media. A series of baffles within the BEST channel enhance mixing between surface and subsurface flows, increasing hyporheic exchange (water movement in the sediment adjacent to the channel) to achieve a higher level of treatment. Flow monitoring and autosamplers will be installed in 2018 to monitor the effectiveness of the BEST system for pollutant removal. Operation and maintenance data will also be collected.

Jefferson County maintains an erosion and sediment control program as part of their MS4 permit. The County maintains a small-site erosion control manual that explains the basic principles of erosion control and illustrates techniques to control sediment from small development sites. The County's efforts concentrate on construction site runoff control, post-construction site runoff control, and pollution prevention/good housekeeping. In 2017, Jefferson County performed 1,212 construction permit inspections, five post-construction permit inspections, and 33 permit enforcement actions. More information about Jefferson County's municipal stormwater program is contained in their CDPS Stormwater Permit Annual Report.

EMERGENCY RESPONSE AND ILLICIT DISCHARGES

Clear Creek County Office of Emergency Management uses the Code Red Emergency Call-Down System. This system is used to promptly and effectively notify downstream users of Clear Creek water of any potential contamination from an upstream source. The system is initiated when incidents / spills into Clear Creek or its tributaries occur. In 2017, there were no hazardous materials spills into the waterways or tributaries of Clear Creek within the Clear Creek County jurisdictional response area.

Illicit Discharges in The City of Golden and Jefferson County

The City of Golden *responded to 47 reports of illicit discharges to the storm system resulting in:*

- *10 written warnings;*
- *19 verbal warnings; and*
- *3 cases where clean-up costs were levied.*

Jefferson County *responded to 47 reports of illicit discharges to the storm system.*

RESTORATION ACTIVITIES

CDPHE Nonpoint Source Grant; Lower North Empire Creek Restoration Project

Lower North Empire Creek before (left) and after (right) restoration

Post restoration

The Clear Creek Watershed Foundation completed the Lower North Empire Creek Restoration Project in 2017. This was one of several multi-year projects funded through the CDPHE nonpoint source program. Mining activities in Lower North Empire Creek have resulted in steep side slopes with acid mine drainage and significant contamination from heavy metals. Past mining activities have included surface mining, hydraulic placer mining and lode mining. The hydraulic placer mining removed the topsoil and much of the subsoil from many of the west slopes of the north-to-south flowing drainage. Therefore, it would be difficult to restore and revegetate the area using any practical and affordable approaches for reclamation. The Lower North Empire Creek project began in October 2017 and was completed in April 2018. The project was designed to control runoff from severely impacted, virtually un-reclaimable, upland mined lands to the west of the creek. This will aid in minimizing erosion and sediment yield from the mining impacted slopes. Total funding for this restoration project was $477,460 and was performed by Frontier Environmental Services, Inc.

WILDFIRE PROTECTION AND MITIGATION

The Clear Creek County Wildfire Protection Task Force (The Task Force) oversees the Wildfire Risk Mitigation and Preparedness Grant Program, a community-based cost share program that provides matching grants to eligible neighborhood subdivisions, community home/property owner groups, and municipalities in Clear Creek County. The Grant Program assists with actual costs associated with the implementation of hazardous fuel reduction projects, reduction of wildfire risk in their communities, and follows through with the action items identified in the area's Community Wildfire Protection Implementation Plan (CWPIP). Projects include the creation of defensible space to reduce the ignitability of structures throughout the plan area, hazard tree removal, the development of emergency water supplies, and improvements to evacuation routes. Table 3 summarizes projects funded by the grant program to date.

The Task Force

The Task Force was created in 2014 for the purpose of:

- *Mitigating wildfire risk in Clear Creek County through the conceptual endorsement and implementation of the Community Wildfire Protection Plan (CWPP) and the CWPIPs;*
- *Identifying areas where the risk and potential community impact of wildfire is greatest; and*
- *Guiding and coordinating community efforts to mitigate the impacts of wildfire.*

Table 3. Projects Funded by the Wildfire Risk Mitigation and Preparedness Grant Program to Date in the Upper Basin

Clear Creek County Wildfire Protection Taskforce Projects Funded				
Project	Funds	Acres	Properties	Benefit
Echo Hills Wildfire Mitigation Project	$10,780	23.54	N/A	Defensible space, fuel reduction, vegetation treatments*
Echo Hills Wildfire Mitigation Project 2	$8,948	23.54	6	Defensible space
Floyd Hill Area Wildfire Mitigation Project 1	$1,515	N/A	60	Chipping slash
Floyd Hill Area Wildfire Mitigation Project 2	$3,165	N/A	15	Chipping slash

* Vegetation treatment includes removal of dead, unhealthy pine beetle infested standing trees, thinning healthy trees that are too close to road right of ways, chipping and removal of slash, trimming low branches, and the removal of ladder fuels.

A working group of the Task Force (The Watershed / County Right-of-Way Wildfire Mitigation Work Group) identified primary county roadways within Clear Creek County for wildfire mitigation that would serve as main evacuation routes. A total of 362 acres have been identified for critical wildfire mitigation at a cost of roughly $1,086,000. The St. Mary's Area Homeowner's Association and Metro District, both of which are within the Fall River Watershed CWPIP, have shown interest in submitting project proposals to The Task Force for grant funding in the future.

Clear Creek County Community Wildfire Protection Plan

The CWPP was developed in 2008 using guidance from the Healthy Forests Restoration Act (2003) and the Colorado State Forest Service's Minimum Standards for Community Wildfire Protections Plans (2004). The plan was developed collaboratively and prioritizes areas for hazardous fuel reduction treatments, recommends treatment methods to reduce the wildfire threat, and recommends measures to reduce the ignitability of structures. Since then, nine CWPIPs have been developed by community core planning teams in the Echo Hills, Empire, Fall River, Georgetown, Georgetown Loop Railroad, Idaho Springs, Silver Plume, Silver Valley, and Upper Bear Creek areas.

PUBLIC EDUCATION, OUTREACH, AND PARTNERSHIPS

Jefferson County continues to provide opportunities for residents, and visitors to the watershed to learn about and be involved in programs that promote water quality and environmental stewardship. The Jefferson County MS4 and floodplain management program continues to participate in a number of public events to reach diverse audiences.

The Rooney Road Recycling Center provides critical recycling and disposal services for household hazardous waste and electronics. In 2017, the facility collected over 600,000 pounds of household hazardous waste. Support and participation with the Rooney Road facility are provided by both Jefferson County and the City of Golden.

The Clear Creek County Transfer Station held a one-day collection event for receiving material from residents of Clear Creek County. A total of 34 residents utilized the facility for hazardous waste disposal. This was 36 fewer residents than in 2016, likely because the facility is now accepting paint year-round with the implementation of the PaintCare program. The facility collected around 413 gallons of hazardous waste and shipped out 27 4'x4'x4' gaylord boxes of household paints to PaintCare.

MONITORING IN THE CANAL ZONE

To provide information for evaluation of the nutrient loadings from nonpoint sources in the Canal Zone, the Church, Croke, and FHL canals are sampled at the headgates where water is diverted from Clear Creek and again at the inlets into the lake. The KDPL is sampled upstream in Coal Creek and near the inlet into Standley Lake. Figure 2 shows the headgate and inlet monitoring locations for each canal. Routine monitoring for the Canal Zone is described in detail in the Watershed Monitoring Program. A total of 76 samples were taken in the Canal Zone in 2017. Sample types include: grab samples, ambient composites, storm triggered composites (event), and first flush composites. Table 4 breaks down the number of samples collected by type in the Canal Zone in 2017. These samples are important for assessing how water quality changes along each canal as well as quantifying loading into the lake.

Table 4. Samples Taken in the Canal Zone, 2017

Type of Sample	Number of Samples Collected
Grab samples	57
Ambient composites	13
Storm-triggered composites	2
First flush composites	4

First Flush Samples
First flush samples *are collected during the initiation of water delivery to Standley Lake and provide data on the quality of the water entering the lake during the seasonal start-up of the canals.*

Croke Canal

CANAL IMPROVEMENTS

Church Ditch Water Authority (CDWA) completed two projects in 2017 to improve water deliveries to Standley Lake and to agricultural and other water users. During the floods of 2013, the Church Ditch experienced severe bank failure between W. 72nd Avenue and W. 74th Avenue,

Figure 3. Retaining Wall Between W. 72nd Ave. and W. 74th Ave. East of Quaker St. Before (left) and After (right) Repairs

just east of Quaker St. A substantial retaining wall was installed in 2014 to stabilize the uphill bank and it began to fail one year after installation (Figure 3, left). CDWA obtained a loan through the Colorado Water Conservation Board in July 2017 to repair/replace the failing retaining wall as well as four additional projects. CDWA worked with Ecological Resource Consultants and SM&RC Structural Engineers to design and manage the repairs completed by JL Melton Construction. Work was completed just prior to ditch start-up in May 2018 (Figure 3, right).

Figure 4. Leyden Flush Structure Before (left) and After (right) Improvements

The second major project completed in 2017 was the rehabilitation of the Leyden Flush Structure. Improvements included the addition of two new automated slide gates, telemetry, bridges with safety railings, and security fencing. This project will allow staff to safely operate, monitor, and control flows. The new structure will also allow for remote operation of the facility to turn water out just upstream of Standley Lake in the event of contamination upstream or potential flood conditions (Figure 4).

Figure 5. Church Ditch Easement Before (left) and After (right) Improvements

The CDWA actively oversees any projects within the ditch easement or channel to ensure proper care is taken to minimize/eliminate erosion and potential contaminants from entering the ditch and affecting water quality. Those projects include the installation of a retaining wall to re-establish the proper easement width, placement of one pedestrian bridge, one driveway crossing, and multiple utility bores (Figure 5).

MONITORING AT STANDLEY LAKE

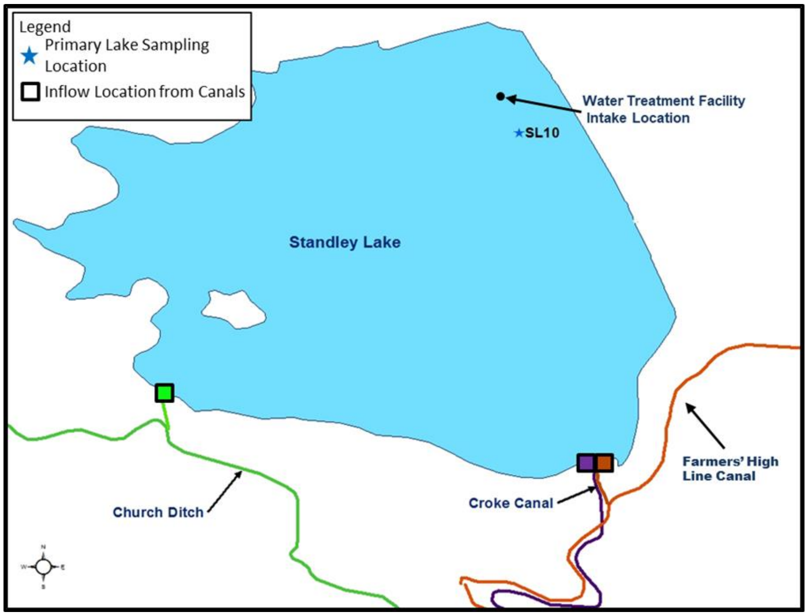


Figure 6. Standley Lake Sampling Location and Locations of Canal Inflows

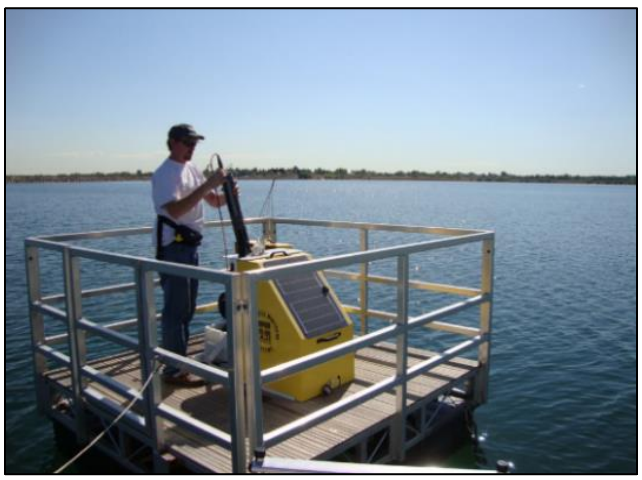
Standley Lake is monitored throughout the year when ice is not present. The lake is sampled in multiple locations, however, SL10 (Figure 6) is the most pertinent to this report because it is the deepest location. This location is located near the municipal supply intakes and is the location of the automated profiler. Daily lake profiles are taken and biweekly samples are also collected at the surface, through the photic zone, and at the bottom.

Standley Lake Monitoring 2017

Daily Profiles: *Standley Lake water quality is measured four times per day for approximately 10 months per year using an automated profiler. Measurements are taken every meter, from the surface to within 2 meters of the bottom.*

Water-Quality Sampling: *samples are collected in the lake at three depths: grab samples are taken at the surface and one meter from the bottom. A composite sample is taken over the extent of the photic zone (at two times the measured Secchi depth). In 2017, 60 water-quality samples were collected on the lake.*

Zooplankton Samples: *zooplankton tows are taken once every two weeks.*



The Standley Lake profiler

The Standley Lake Profiler *is equipped with a multi-probe sonde which provides measurements of water temperature, dissolved oxygen, pH, conductivity, turbidity, oxidation/reduction potential (ORP), and chlorophyll a concentrations.*

AQUATIC INVASIVE SPECIES MANAGEMENT AND PREVENTION

EWM sampling

Eurasian Water Milfoil (EWM) is an aquatic invasive species that established in Standley Lake in 1998 and has been managed with the addition of EWM weevils, an herbivorous insect specialized to EWM. Weevils have been stocked in Standley on five separate occasions from 2002-2007, leading to observed declines in EWM densities. In 2017, an abbreviated survey was performed by City of Westminster personnel. Three sample sites were selected as representative of the 10 sites surveyed in previous years. Two sites had an average density of milfoil, with average weevil damage. One site displayed approximately twice the density of milfoil compared to 2016 data but had the highest occurrence of weevil damage.

How do we sample for mussels?

Zooplankton tows *target the microscopic larval mussel stage and are an early detection method.*

Substrate samples *help detect juvenile mussels that have started the attachment phase of the life cycle.*

Shoreline surveys *are performed when water levels are low and target adult mussels that may be attached to hard surfaces.*

Zebra and Quagga Mussels are a non-native aquatic invasive species that can be introduced to new water bodies by the unintentional transfer of organisms from an infested water body, often via boats or fishing bait. To protect Standley Lake from these species, an intensive boat inspection and decontamination program was implemented in 2008. Additionally, no live aquatic baits are allowed in the reservoir. Standley Lake is monitored for mussels via three methods: zooplankton tows, substrate samplers, and shoreline surveys. Zooplankton tows are performed every two weeks at the lake inlets and the boat ramp/outlet area. Substrate samples are monitored by Colorado Parks and Wildlife and are placed at several locations in the lake. A shoreline survey is performed when water levels are at their lowest. All sampling efforts in 2017 showed that the lake continues to remain free of zebra and quagga mussels.

MODELING

The existing Standley Lake Water-Quality Model characterizes the reservoir as a simple four-layer system that is homogeneous both laterally and longitudinally. In 2017, the Standley Lake Cities initiated an effort to upgrade to a full two-dimensional hydrodynamic water-quality model (CE-QUAL-W2). The upgraded model will provide a greater suite of model uses, including the ability to investigate the impacts of various operational schemes using the different outlet structures. The effort also includes updating the period of simulation to include five more years of recent data. The model will be completed in 2018.

4A. <u>2017 NUTRIENT AND TSS LOADING</u> – THE UPPER BASIN

This section describes the results of the analyses performed in the Upper Basin in 2017. The constituents included in this analysis are total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN). Two sampling locations are included in this analysis: the upper station (CC26) and the lower station (CCAS59/60). Details about these sampling locations are provided in the Watershed Monitoring Program. Ambient grab and autosampler data from these two stations are used to quantify nutrient loadings from upstream to downstream and provide an assessment of water quality in the upper watershed. Loads for TSS, TP, and TN for the Upper Basin locations in 2017 are presented in Figures 7-9. Sampling dates in 2017 may have missed the higher concentrations that typically occur with higher flows resulting in lower concentrations overall. Due to the lower concentrations, loads of TSS, TP, and TN were all lower (12-56% lower) than the 2012-2016 average at both locations.

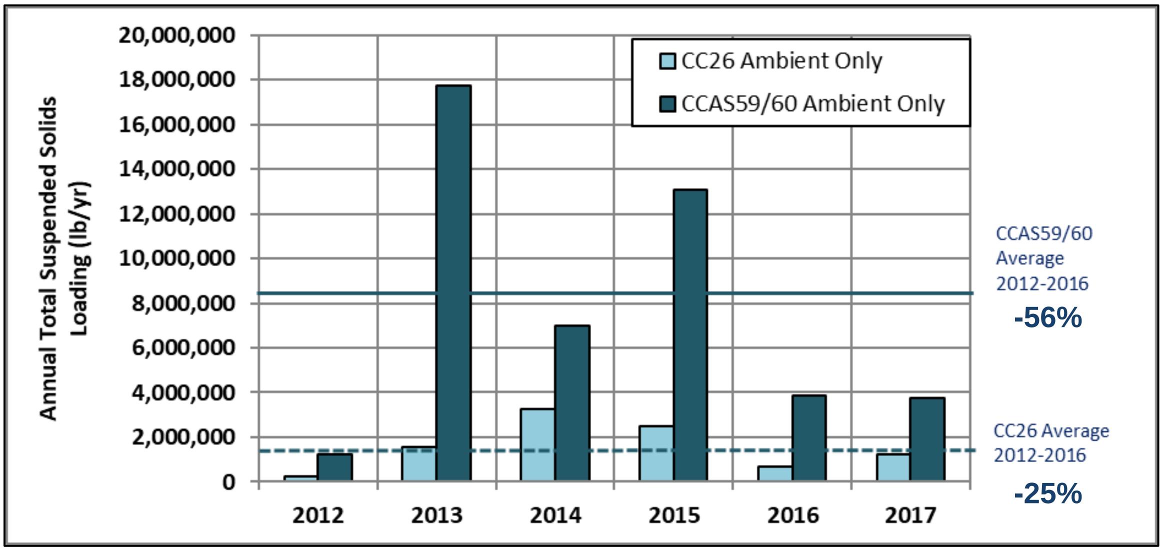


Figure 7. TSS Loads with Percent Change in 2017 for the Upper Station (CC26) and Lower Station (CCAS59/60)

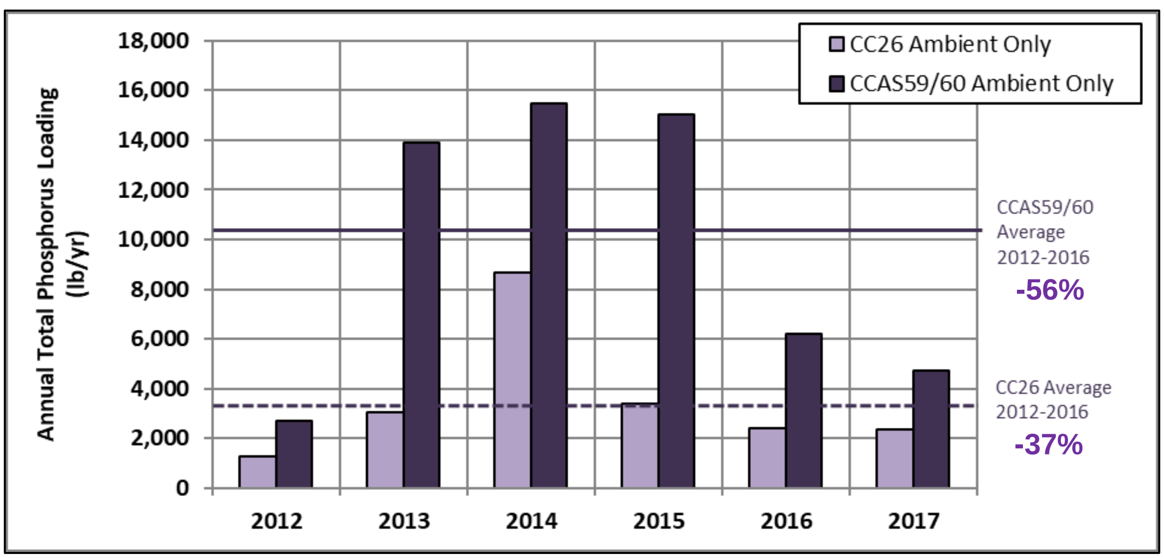


Figure 8. TP Loads with Percent Change in 2017 for the Upper Station (CC26) and Lower Station (CCAS59/60)

4A. 2017 NUTRIENT AND TSS LOADING – THE UPPER BASIN

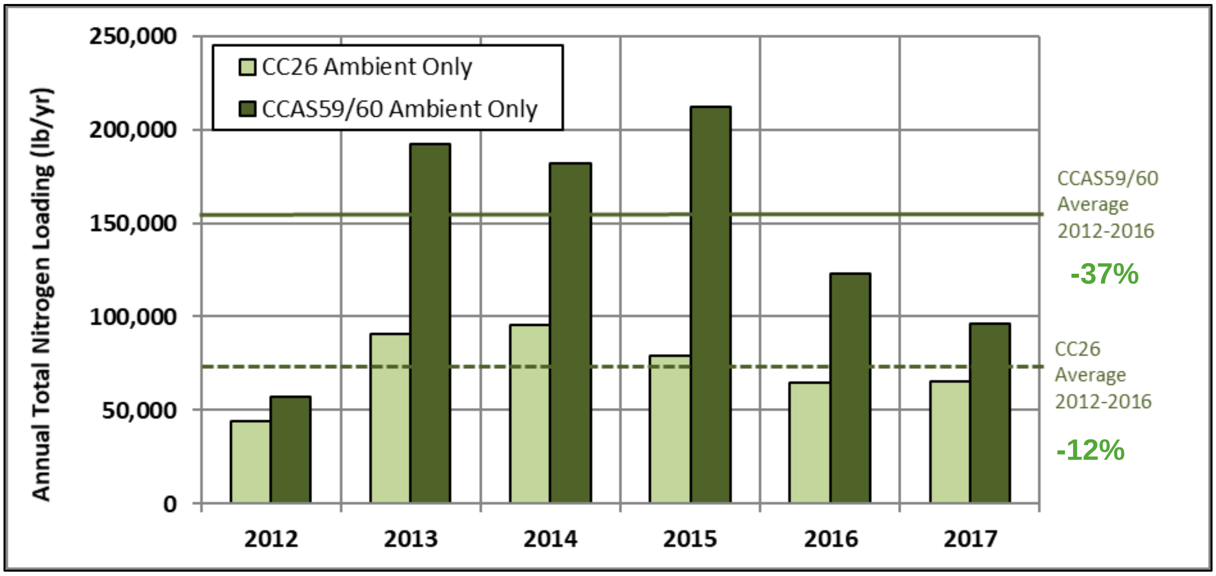


Figure 9. TN Loads with Percent Change in 2017 for the Upper Station (CC26) and Lower Station (CCAS59/60)

4B. 2017 NUTRIENT AND TSS LOADING – THE CANAL ZONE

Loads for total suspended solids, total phosphorus, and total nitrogen from the four canals entering Standley Lake are presented in Figures 10-12. The FHL continues to contribute the largest fraction of the total annual loads to the reservoir for TSS, TP, and TN (51%,51%, and 49% respectively). This contribution is expected as it is the primary canal used during runoff in spring and provides 63% of the total annual inflow to the reservoir. The Croke Canal is the second largest contributor of total annual loads, contributing almost half of the total TSS, TP, and TN loads entering the reservoir (46%, 44%, and 45% respectively). However, the Croke Canal only contributed 29% of the total annual inflow to Standley Lake (Figure 13). Although the canals are close in proximity (Figure 2), the data show that a large amount of nutrient and TSS nonpoint source loading occurs as water flows through the Croke Canal.

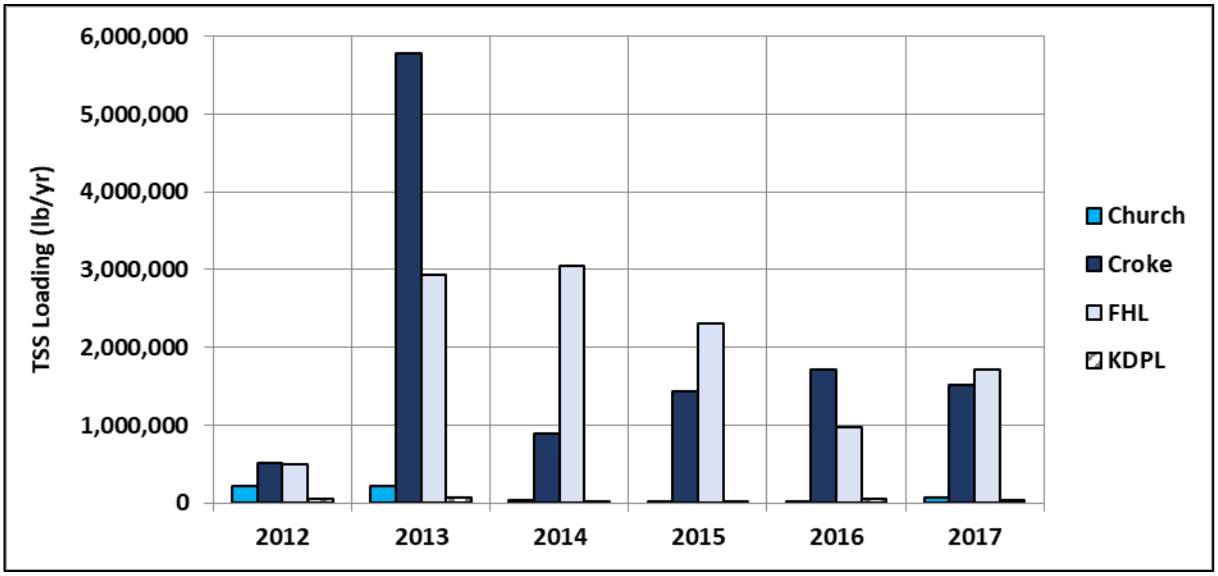


Figure 10. Total Suspended Solids Loading Into Standley Lake by Source, 2012-2017

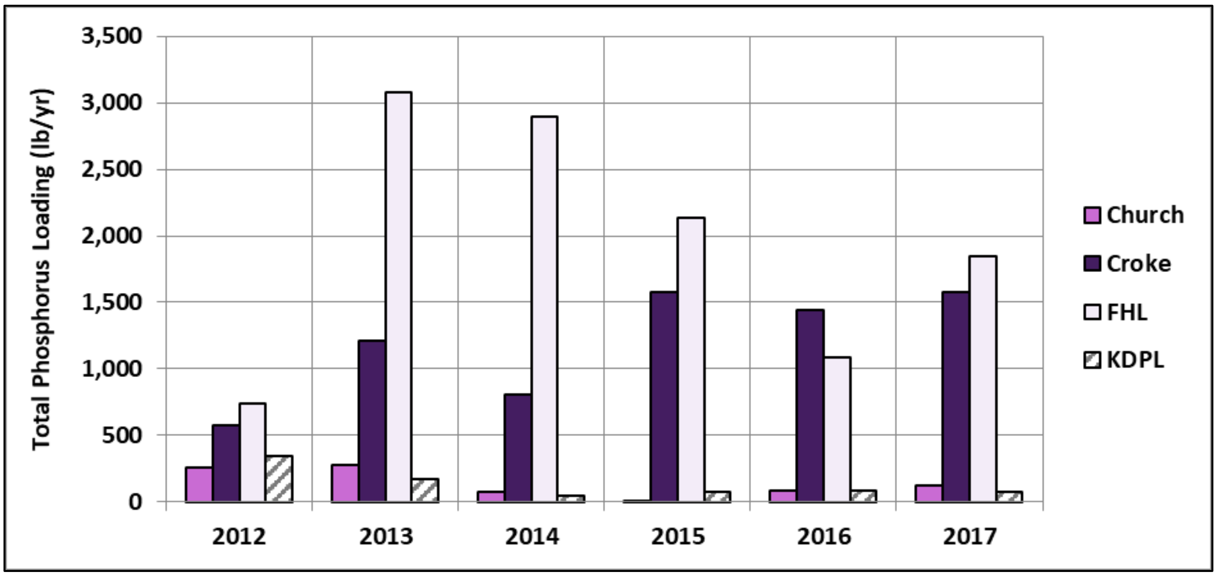


Figure 11. Total Phosphorus Loading Into Standley Lake by Source, 2012-2017

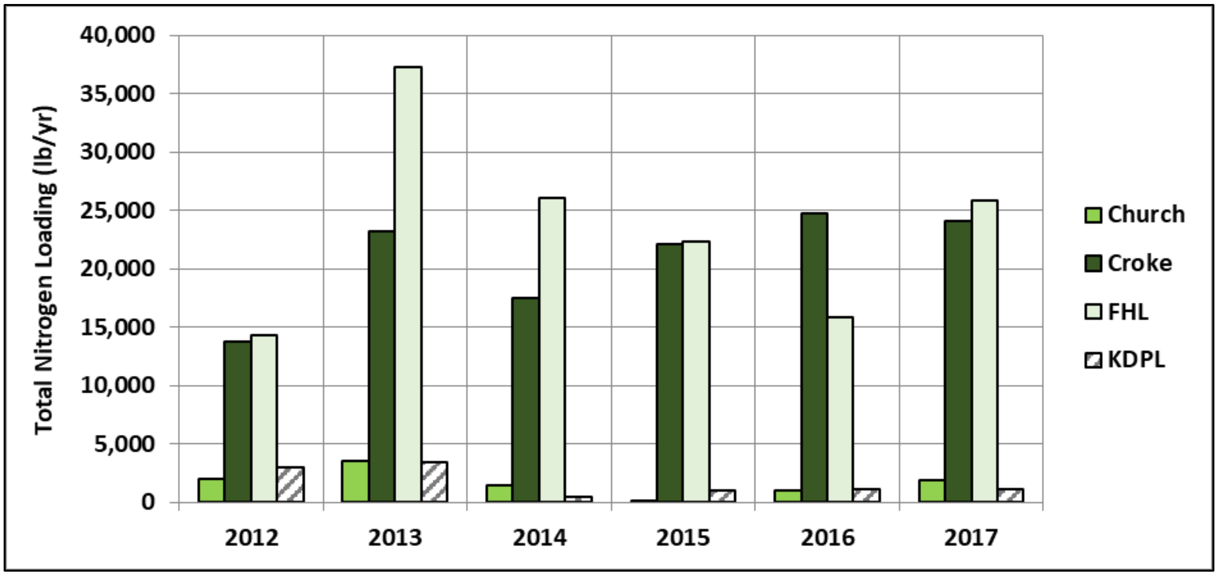


Figure 12. Total Nitrogen Loading Into Standley Lake by Source, 2012-2017

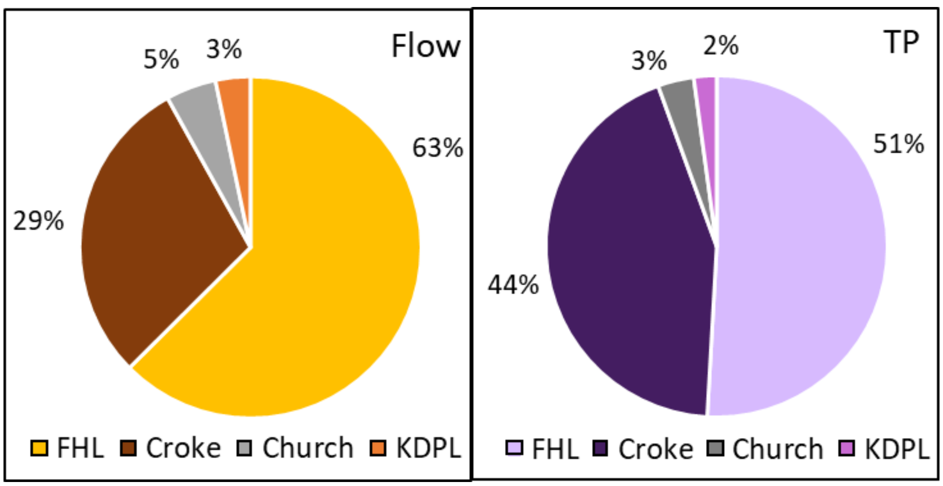


Figure 13. Annual Contributions of Flow and Total Phosphorus by Each of the Four Canals Entering Standley Lake, 2017

TOTAL SUSPENDED SOLIDS, PHOSPHORUS, AND NITROGEN LOADING INTO AND OUT OF STANDLEY LAKE

> **Nutrient Retention in Reservoirs**
>
> ***Phosphorus*** *tends to be closely associated with* ***total suspended solids*** *through particle-associated transport and tends to be retained with sediment.*
>
> ***Nitrogen*** *can be retained through biological uptake and deposition of particulate organic carbon to the bottom sediment.*

Estimated annual total suspended solids loadings into and out of Standley Lake for 2012-2017 are shown in Figure 14. TSS loads into the lake in 2017 were 20% lower than the 2012-2016 average. TSS loads were below average because of the large loads that came into the lake during the 2013 floods, removing this from the average, loadings for TSS were 13% above average. Total phosphorus loads in 2017 into the lake (Figure 15) were 7% above the average of the past five years. As with previous years, loadings of TP and TSS into the lake were greater than outflow, indicating some level of phosphorus and sediment retention. Total nitrogen loads entering the reservoir in 2017 were 12% higher than the 2012-2016 average (Figure 16). Consistent with previous years, loading into the reservoir was higher than loads leaving the reservoir, indicating that nitrogen is also being retained.

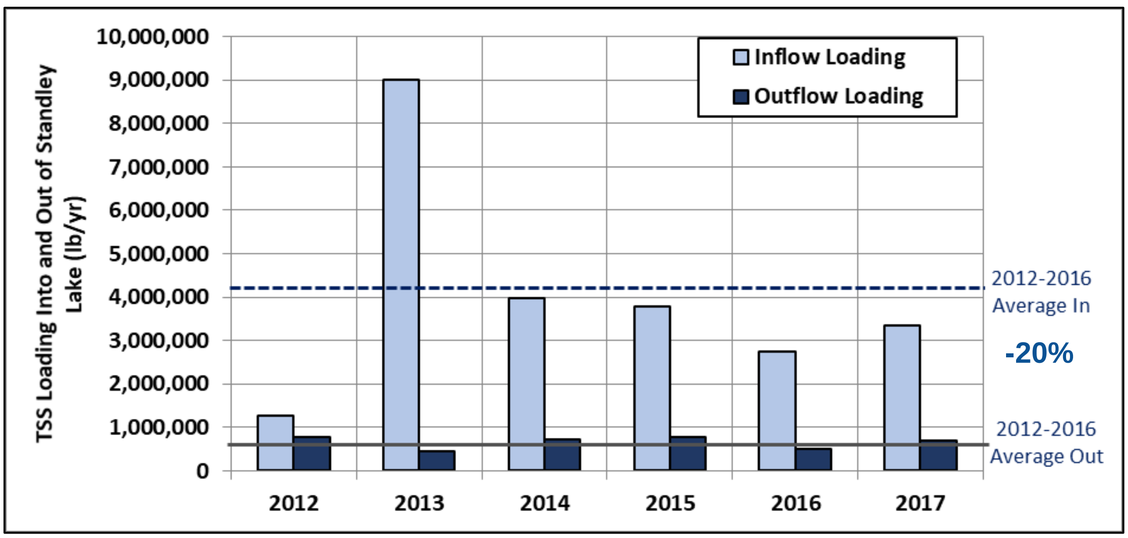


Figure 14. Total Suspended Solids Loading Into and Out of Standley Lake, 2012-2017

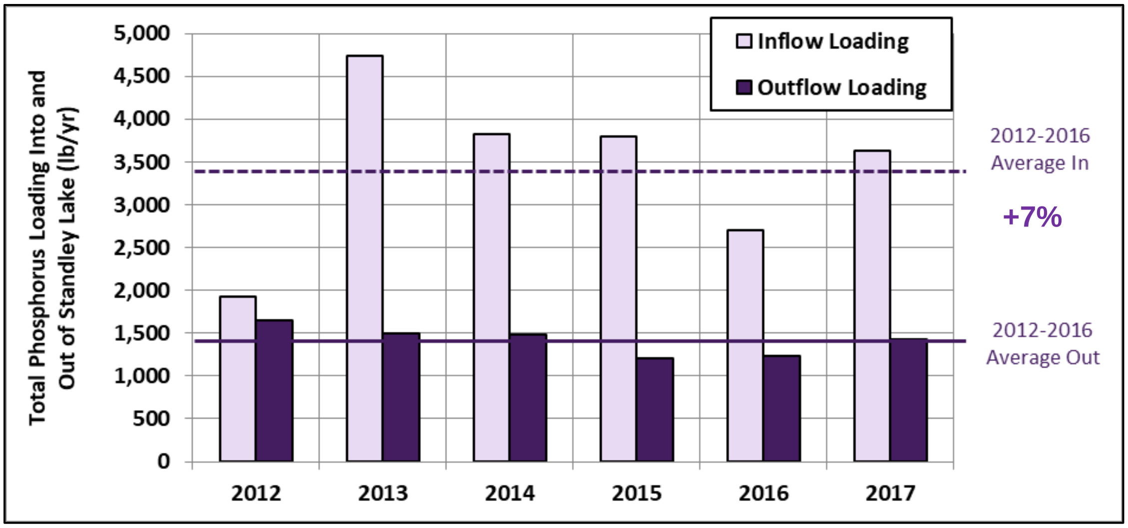


Figure 15. Total Phosphorus Loading Into and Out of Standley Lake, 2012-2017

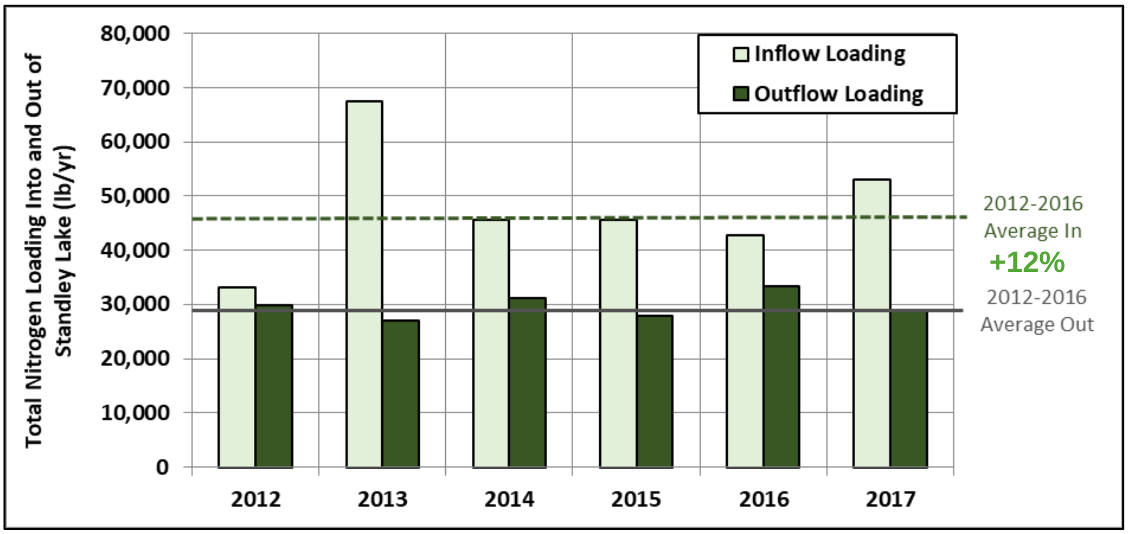


Figure 16. Total Nitrogen Loading Into and Out of Standley Lake, 2012-2017

FLOWS

Hydrographs from Upper Basin locations CC26 (Clear Creek at Lawson Gage) and CC60 (Clear Creek upstream of the Church headgate, Golden, CO) are shown in Figure 17. The snowmelt-dominated pattern is consistent with previous years. Flows in Clear Creek were fairly average in 2017. The annual flows at the upper station were 12% higher than the average of the previous five years. Conversely, the flows at the lower station were 7% below the average of the previous five years. This was due to unusual precipitation patterns in 2017. Precipitation at CC26 was 24% higher than average while CC60 was 7% below average.

> **Twin Peak Flows?**
>
> *The twin peak flows in Figure 17 are driven by a period of lower temperatures that decreased the rate of snowmelt. This is the second year in a row this pattern has been observed (Hydros, 2017).*

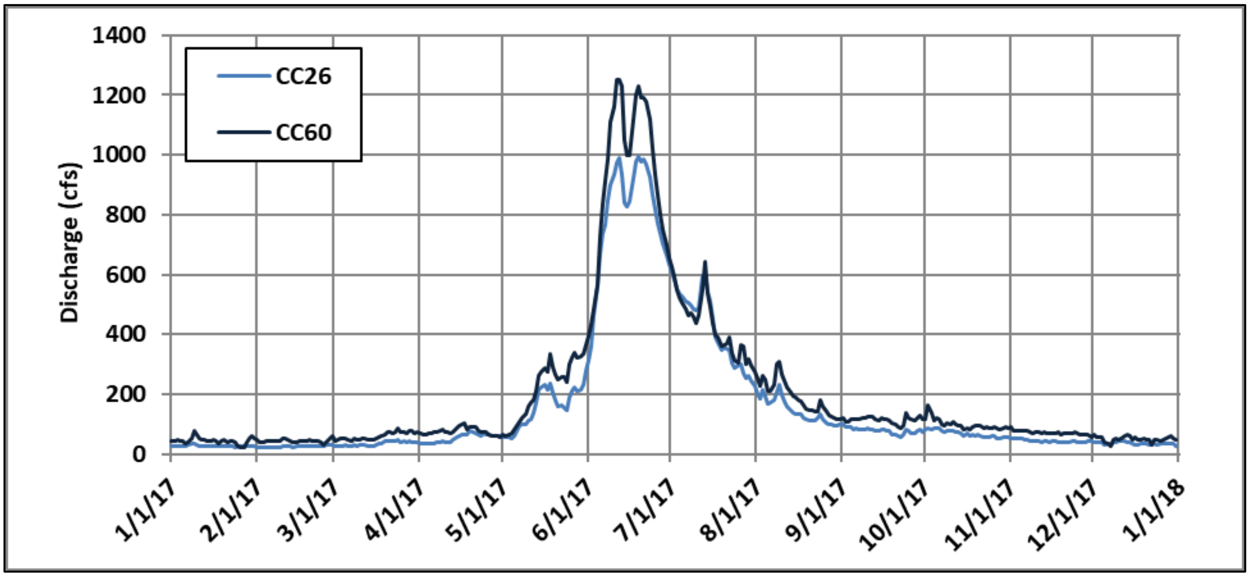


Figure 17. 2017 Clear Creek Hydrographs for the Upper Station (CC26) and the Lower Station (CC60)

CONCENTRATIONS

Upper Basin concentrations for TSS and TP in 2017 followed typical patterns with higher concentrations during runoff conditions. Conversely, TN displayed a pattern opposite of TSS and TP with lower concentrations during runoff conditions due to the dilution of sources during the higher flow periods. Most of the monthly concentrations were below average leading to lower Upper Basin loads overall. This was due to the timing of sample collection and corresponding flow conditions; peak concentrations were potentially missed because samples were not collected during peak flow conditions. Ranges of observed concentrations and volume-weighted concentrations are provided in the Data Analysis and Interpretation Supplement. Volume-weighted concentrations at CC60 were low in 2017 for TSS, TP, and TN.

CANAL ZONE TSS, TP, AND TN CONCENTRATIONS

Results of water-quality analyses for the Canal zone are highlighted in this section. Constituents for the Farmers' Highline and Croke Canals are the focus because they are the largest contributors of flow to Standley Lake (62% and 28%, respectively). Samples taken in the Canal zone in 2017 were consistent with previous years. A substantial increase in TSS and TP concentrations from the headgate to the entry point into the lake continue to be notable in the Croke Canal (Figure 18, Figure 19, right). The FHL shows a smaller difference between the two sampling locations. Total nitrogen for both canals showed little difference between the headgate and entry point to the lake (Figure 20).

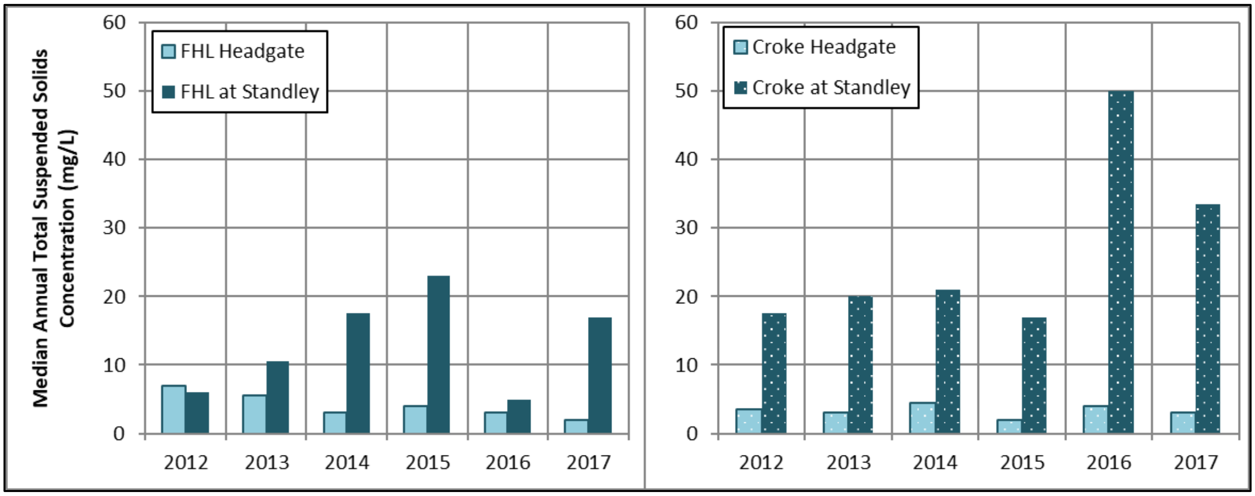


Figure 18. Median Total Suspended Solids in FHL (left) and Croke (right) Canals

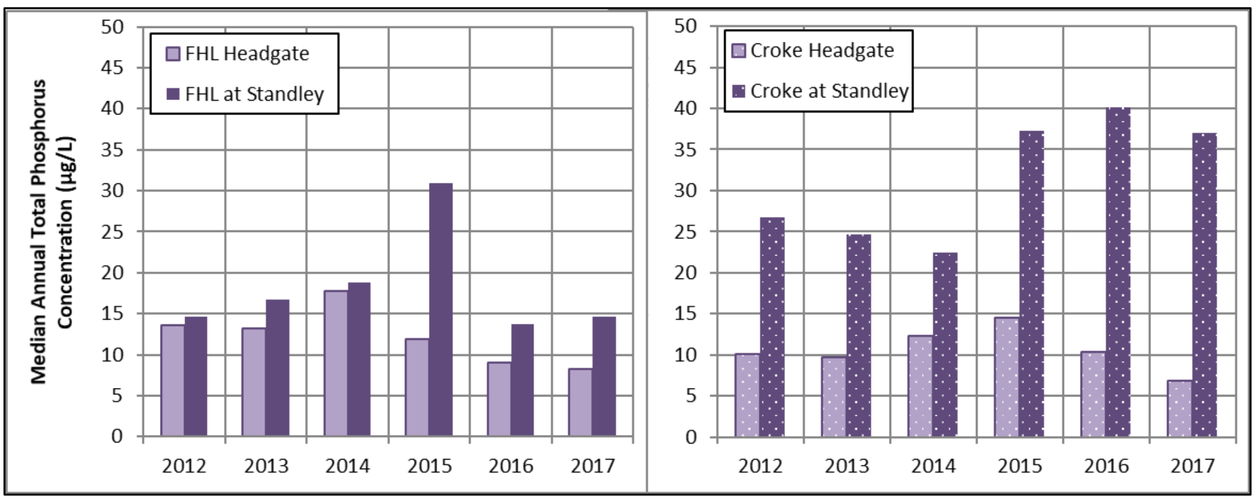


Figure 19. Median Total Phosphorus Concentrations in FHL (left) and Croke (right) Canals

5B. 2017 WATER-QUALITY RESULTS – THE CANAL ZONE

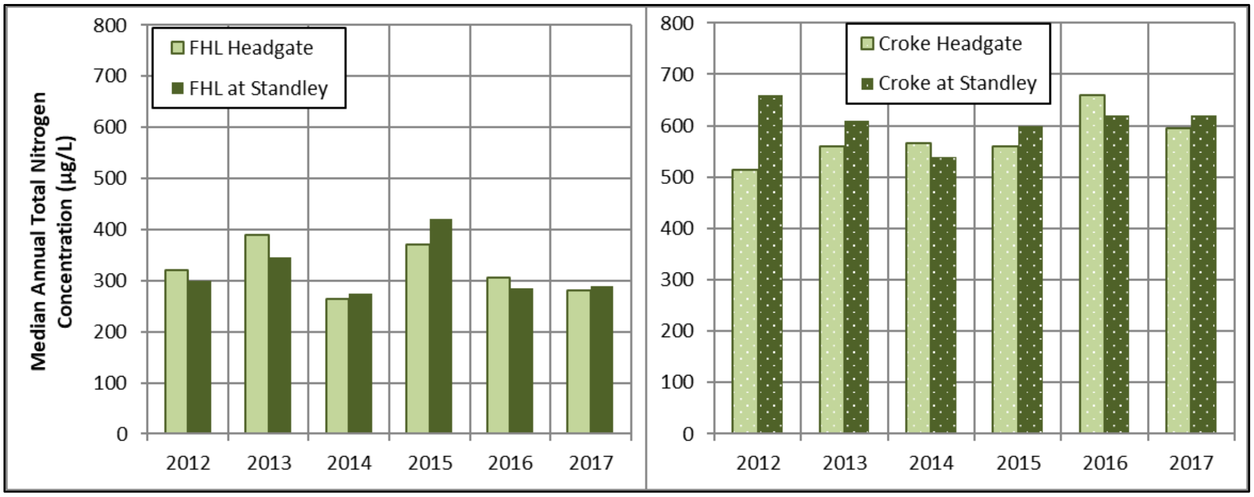


Figure 20. Median Total Nitrogen Concentrations in FHL (left) and Croke (right) Canals

5C. 2017 WATER-QUALITY RESULTS – STANDLEY LAKE

LAKE CONTENTS

Standley Lake began the year with lower water levels and filled to capacity during runoff. Figure 21 shows the contents of Standley Lake over the period of 2012-2017. The lake began to draw down during the higher demands months in the fall but was able to refill to capacity due to water availability and water rights conditions from October and November.

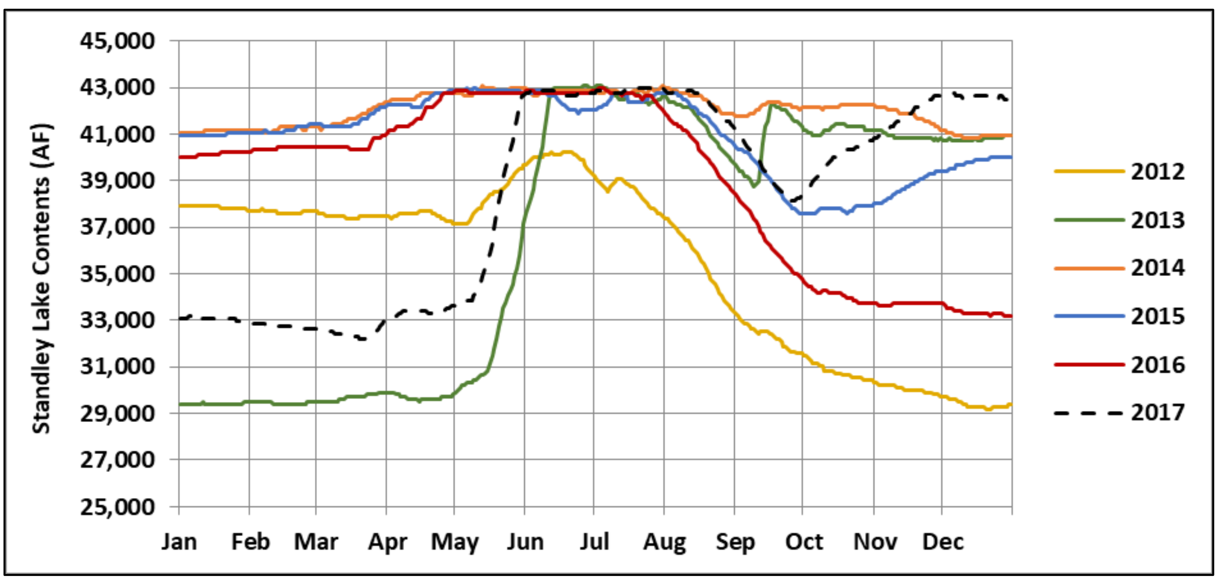


Figure 21. Standley Lake Contents, 2012-2017

TEMPERATURE

Temperature patterns in Standley Lake were unusual in 2017 as shown in Figure 22 where comparisons are made with the more typical year of 2016. In 2016, the lower intake (66 ft, 20 m, below full pool) was used all year, as for previous years. In 2017, water was withdrawn from the upper intake (36 ft, 10m, below full pool), starting on August 1. At this point, warmer water was being released from the reservoir, increasing the amount of thermal energy removed, and lowering overall reservoir temperatures. Since the surface temperatures are similar between the two years, no additional energy was added at the air-water interface in 2017. Therefore, the use of the upper intake appears to have resulted in cooler temperatures in the lower depths of the lake. Turnover occurred on October 9, 2017 which is a typical date for the end of stratification for Standley Lake.

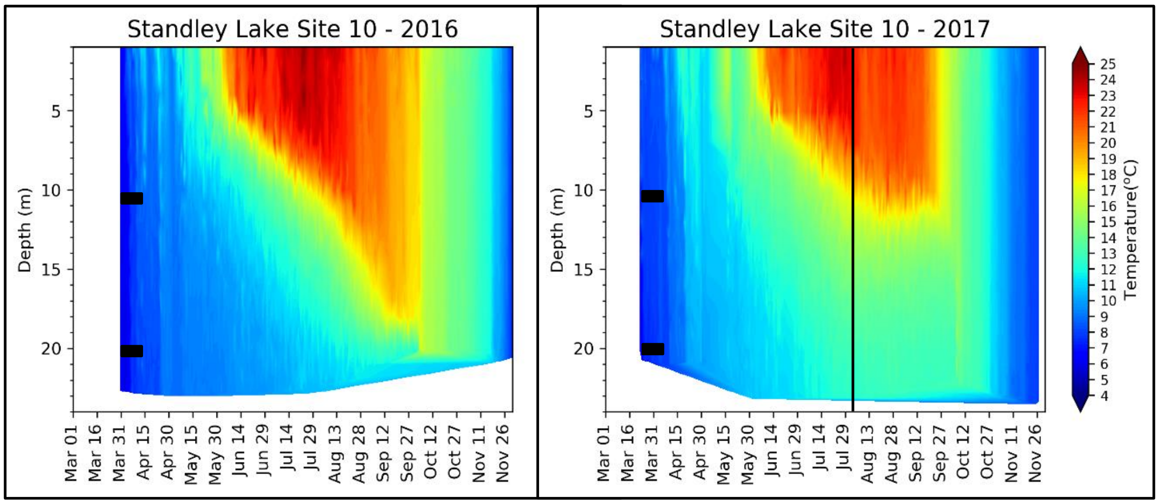


Figure 22. Contour Plots of Temperature in Standley Lake in 2016 and 2017, the Black Line Indicates the Outlet Depth Change on 8/1/2017, the Black Bars Indicate the Approximate Outlet Depths

DISSOLVED OXYGEN

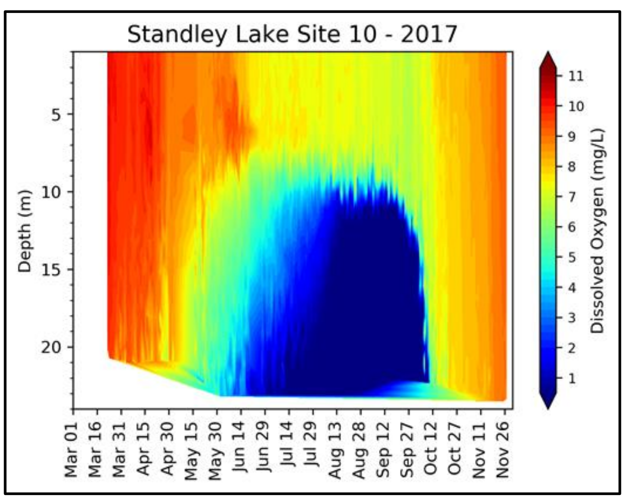


Figure 23. Contour Plot of Dissolved Oxygen in Standley Lake, March-December 2017

Dissolved oxygen concentrations in 2017 are shown in Figure 23. Data from 2017 show a typical pattern of decreased oxygen concentrations in the hypolimnion with the onset of stratification in mid-May. Hypoxic conditions at the bottom started on June 16, which is the earliest date over the period 2002-2017. It is also well before changes were made to the withdrawal elevation. This early on-set of hypoxic (DO <2.0 mg/L) conditions allowed for an above average number of days of hypoxia (Figure 24). Longer periods of hypoxia allow for higher anaerobic internal loads of nutrients. As with previous years, hypoxic conditions end with turnover in early October.

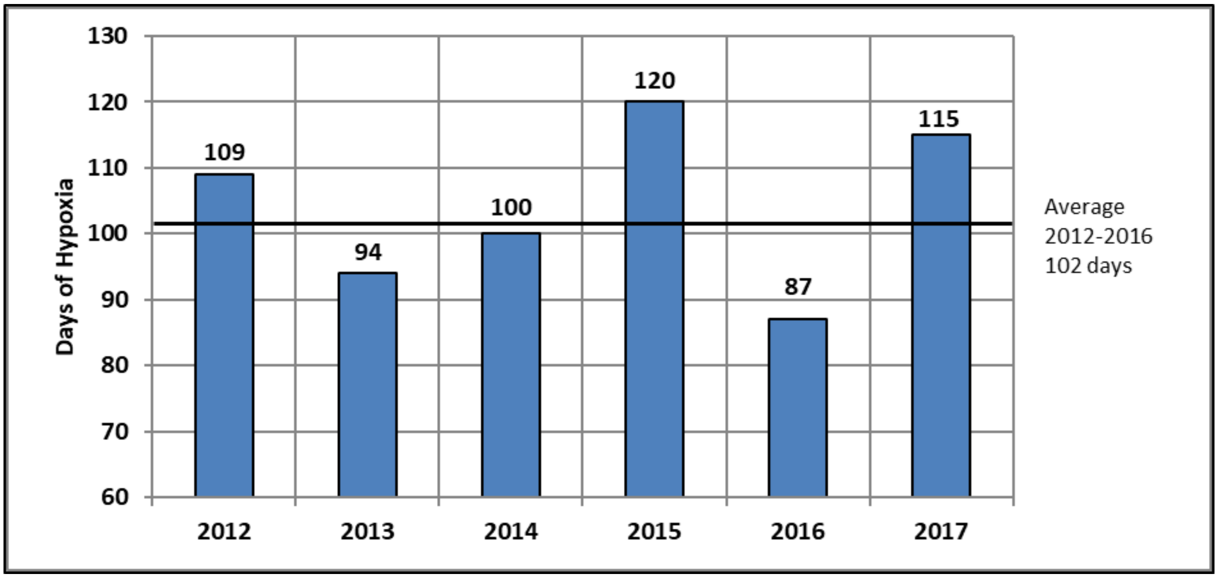


Figure 24. Days of Hypoxia (DO< 2.0 mg/L), 2012-2017

NUTRIENTS

Total Phosphorus

Phosphorus measurements are made in the photic zone and at the bottom of Standley Lake (Figure 25). Measurements in the photic zone were low and displayed little variation throughout the year. The most distinct observation from the time series is the large spike (228 µg/L) of TP at the bottom in late September. An increase in TP concentrations in the fall is typical and indicative of sediment release of nutrients as a result of hypoxia in the hypolimnion. However, the magnitude of this increase was unusually high in 2017, compared to previous years (Figure 26). The longer period of hypoxic conditions likely contributed to this high observation.

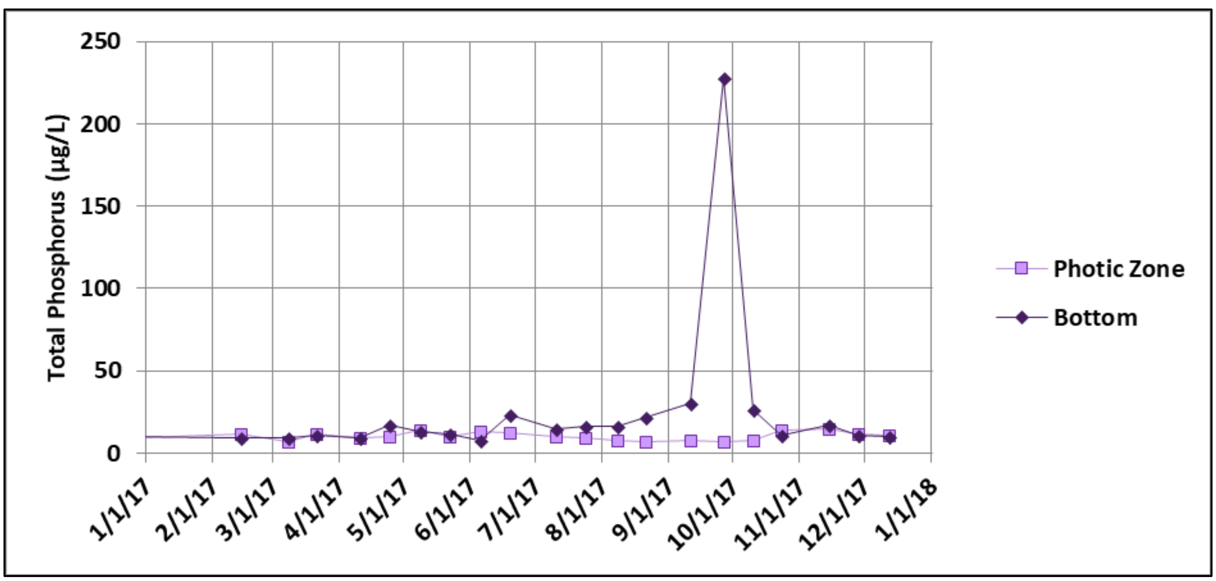


Figure 25. Total Phosphorus Concentrations in Standley Lake, 2017

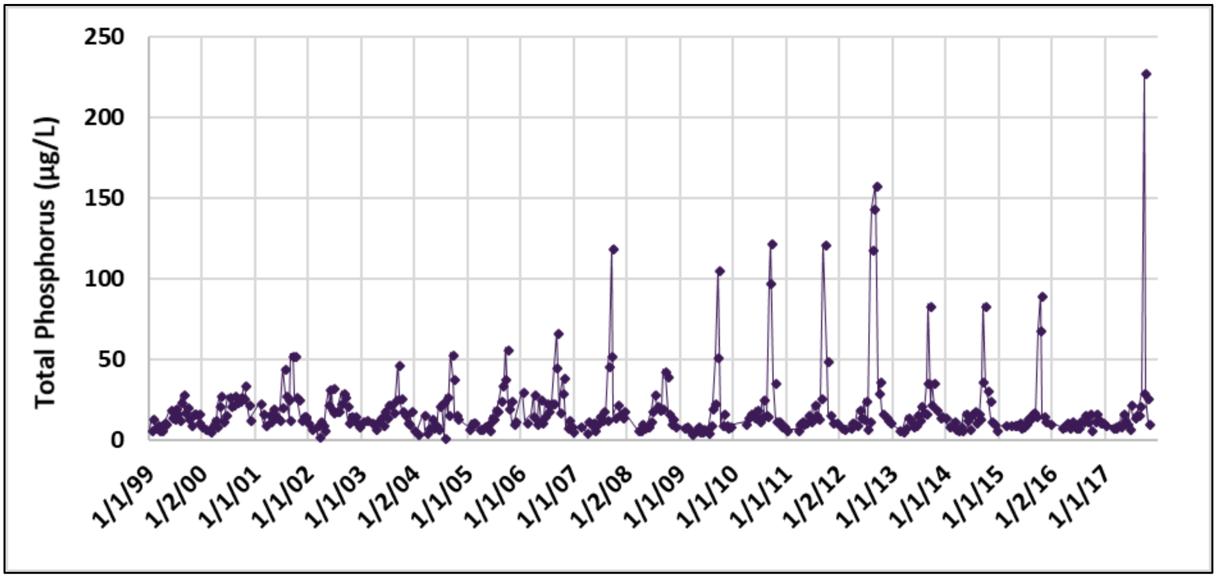


Figure 26. Total Phosphorus Concentrations at the Bottom of Standley Lake, 1999-2017

Note that this increase in TP is only observed in one sample, while previous years have shown a pattern of increase with at least two samples being high. It is also possible that concentrations have reached these levels in the past but have been missed between sampling events.

Total Nitrogen

Total nitrogen concentrations in Standley Lake are displayed in Figure 27. TN concentrations at the bottom of the lake exhibited a sharp increase to 700 µg/L on the same day (September 26, 2017) as the TP increase discussed in the previous sub-section. This is consistent with evidence of internal loading. The pattern of higher concentrations in early summer reflects external loading during the runoff season. The photic zone showed smaller amounts of variability.

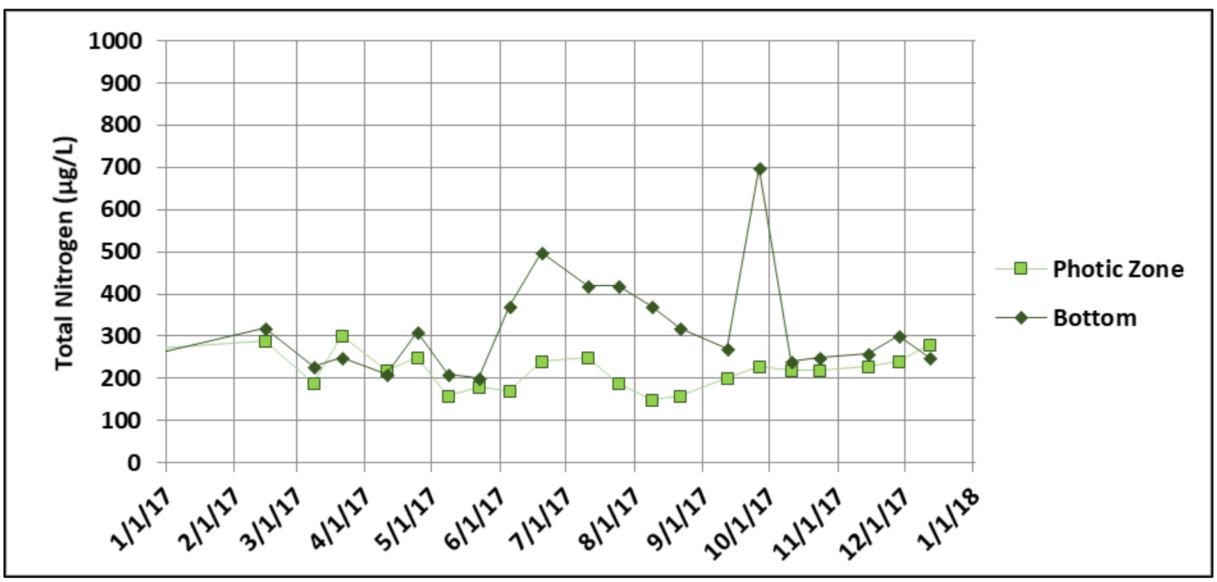


Figure 27. Total Nitrogen Concentrations in Standley Lake, 2017

CHLOROPHYLL *a*

Chlorophyll *a* concentrations measured in the photic zone are shown in Figure 28. March through November is the relevant period for standards assessment and is indicated with the grey box. Standley Lake typically sees two peaks in chlorophyll each year, one in spring and a higher peak post-turnover. In 2017, the peak in the fall was lower than the peak in spring, likely impacted by abundant zooplankton. It was noted that shortly after algal concentrations started to increase in the fall, the population of zooplankton increased sharply. As such, it is likely that zooplankton grazing reduced chlorophyll *a* before the next biweekly sampling occurred.

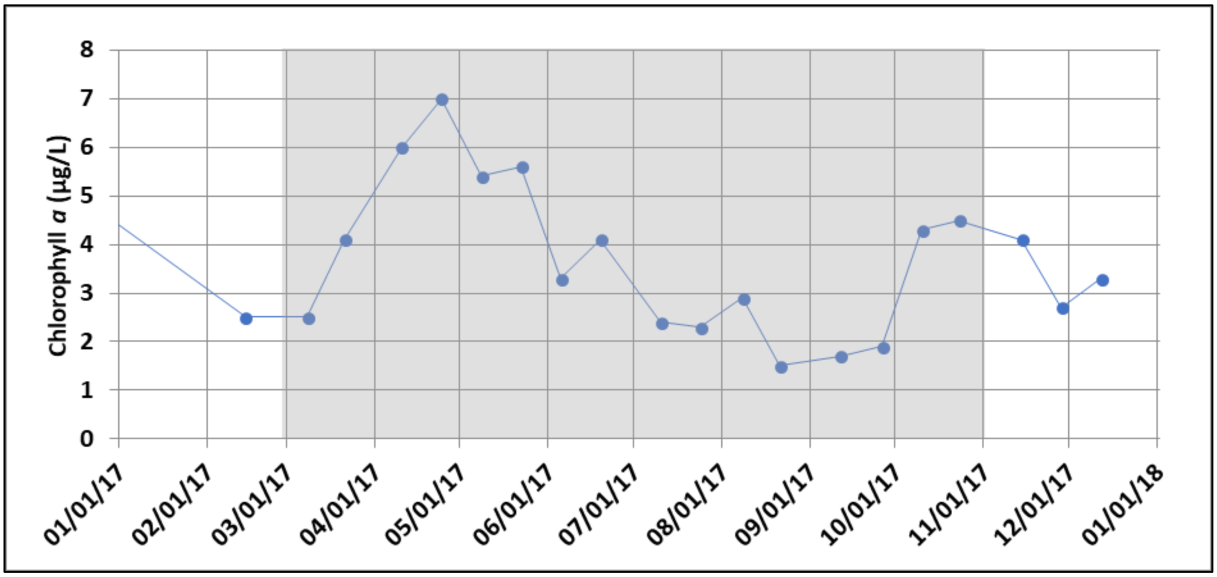


Figure 28. Chlorophyll *a* Concentrations in Standley Lake, 2017 (March-November Assessment Period in Grey)

A chlorophyll *a* standard of 4.0 µg/L was established in 2009 for Standley Lake. This standard is evaluated on an annual basis using the average of observed data for the nine-month period from March through November. To account for the natural variability in chlorophyll *a* concentrations, the standard is assessed using a concentration of 4.4 µg/L. For 2017, the value of the assessment metric was 3.7 ug/L (Figure 29).

Did we meet the chlorophyll a standard?

***Yes,** the standard for chlorophyll a in Standley Lake was met in 2017. The 2017 average is compliant with both the 4.0 µg/L standard and 4.4 µg/L assessment threshold. The standard is met when four out of the five most recent years have a March-though-November average concentration below 4.4 µg/L. Every year in the five-year period from 2013 to 2017 has had a March-November average concentration below 4.0 µg/L.*

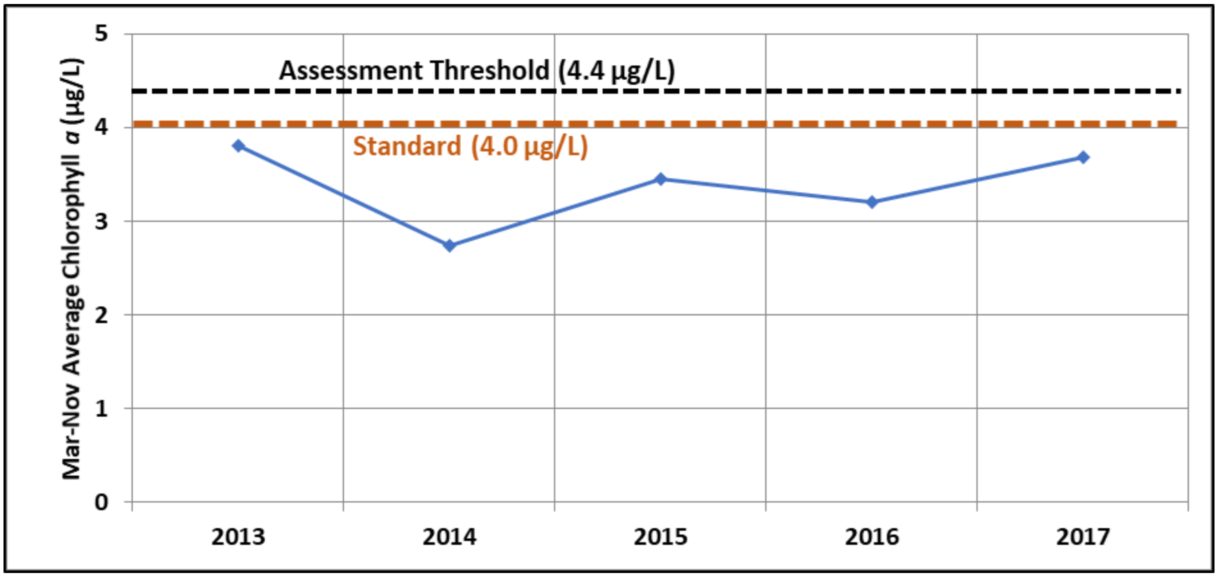


Figure 29. March-November Average Chlorophyll a Concentrations, 2013-2017

6. SUMMARY

Collaborative efforts made by UCCWA members, the Standley Lake Cities, and other parties to the 1993 Agreement continue to be successful in enhancing, protecting, and improving water quality in Standley Lake and Clear Creek. This success is evident based on consistent monitoring indicating good water quality. Wastewater treatment plant upgrades, canal improvements, illicit discharge responses, public outreach events, and a wide host of other BMPs are all ways that the parties to The Agreement continue to contribute to water quality protection and enhancement.

The Clear Creek Watershed showed indications of good water quality in 2017. Flow rates at both the upper station (CC26) and the lower station (CC60) were generally average, showing a typical snowmelt-dominated pattern. Volumes of flow for the year varied between the two stations with CC26 being above average and CC60 being below average due to atypical precipitation patterns in the watershed. Consistent with 2016, twin peaks in flow occurred in June, apparently driven by a period of lower temperatures slowing the rate of snowmelt. Sample timing, coupled with lower peak flows caused concentrations of TSS, TP, and TN to be lower and resulted in lower loadings in the Upper Basin.

Water-quality measurements in the Canal Zone indicate that nonpoint sources provide additional TSS and nutrients to the canals before flowing into Standley Lake. The Croke Canal stands out and the data again indicate that significant amounts of TSS and phosphorus are added to the canal as water flows from Clear Creek to the reservoir. Loadings of phosphorus and nitrogen to the lake from the canals were above the 2012-2016 average.

Standley Lake also had good water quality in 2017. After starting the year with lower water levels than the previous three years, Standley Lake rapidly filled to capacity in May, and was close to the average lake capacity of the previous five years. Water availability and water rights conditions in the fall allowed Standley Lake to reach capacity towards the end of the year during the typical draw-down period. As expected, Standley lake exhibited a period of stratification and hypoxia in the hypolimnion, though temperatures of the hypolimnion were lower than previous years due to changes in outlet operations. In addition, hypoxic conditions started much earlier than has been historically observed leading to a long period of hypoxia and increased internal loading. The peak TP measurement at the bottom of the reservoir was 3 times the average over the period 1999-2016 and 69 ug/L higher than the maximum observed over that period due to increased internal loading.

Despite the long hypoxia and high internal loading, the chlorophyll *a* standard was again met in 2017 with an average March-November chlorophyll *a* concentration of 3.7 µg/L. Zooplankton grazing post-turnover is a likely reason for a less intense algae bloom in the fall than previous years and is indicative of a healthy food web. The results of the analyses performed in 2017 show that Standley Lake and Clear Creek continue to exhibit good water quality, and demonstrate the effectiveness of the efforts to manage, enhance, and protect water quality made by collaborating entities. Further explanations and detailed analyses of 2017 water-quality monitoring results are detailed in the Data Analysis and Interpretation Supplement.

REFERENCES

Colorado Department of Public Health and Environment (CDPHE). 2012. Nutrients Management Control Regulation. 5 CCR 1002-85 (Regulation 85). Water Quality Control Commission. Adopted June 11, 2012; Effective September 30, 2012.

Hydros Consulting 2017. Clear Creek / Standley Lake Watershed Agreement. 2016 Annual Report. September 1, 2017.

SUPPLEMENTAL INFORMATION

Supplemental Information 1 - Clear Creek/Standley Lake Watershed Agreement

Supplemental Information 2 - Upper Clear Creek/Standley Lake Watershed Water Quality Monitoring Plan

Supplemental Information 3 - Clear Creek / Standley Lake Data Analysis and Interpretation - 2017

Supplemental Information 4 - Clear Creek, Canal, and Standley Lake Water Quality Monitoring Data - 2017

ACRONYMS

AF - Acre Feet

AGS - Activated Granular Sludge

BMP - Best Management Practice

CC26 - Clear Creek Sampling Station: Clear Creek at Lawson Gage

CCAS26 - Clear Creek Autosampler Station: Clear Creek at Lawson Gage

CC59 - Clear Creek Autosampler Station: Clear Creek 2 Miles West of Highway 58/US6 in Golden. Storm Location Operated by City of Golden

CCAS59 - Clear Creek Autosampler Station: Clear Creek 2 Miles West of Highway 58/US6 in Golden

CC60 - Clear Creek Sampling Station: Clear Creek upstream of the Church Ditch Headgate

CDPHE - Colorado Department of Public Health and Environment

CDWA - Church Ditch Water Authority

Church - Church Ditch

Croke - Croke Canal

CWPIP - Community Wildfire Protection Implementation Plan

CWPP - Community Wildfire Protection Plan

DBP - Disinfection By-Product

EWM - Eurasian Water Milfoil

FHL - Farmers' Highline Canal

FRICO - Farmers' Reservoir and Irrigation Company

KDPL - Kinnear Ditch Pipeline

MBR - Membrane Bio-Reactor

MGD - Millions of Gallons per Day

MS4 - Municipal Separate Storm Sewer System

ORP - Oxidation-Reduction Potential

OWTS - Onsite Wastewater Treatment System

The Task Force - Clear Creek County Wildfire Protection Task Force

TN - Total Nitrogen

TP - Total Phosphorus

TSS - Total Suspended Solids

UCCWA - Upper Clear Creek Watershed Association

WQCC - Water Quality Control Commission

WRRF - Water Resource Recovery Facility

WWTF - Wastewater Treatment Facility

SUPPLEMENTAL INFORMATION 1

CLEAR CREEK/STANDLEY LAKE WATERSHED AGREEMENT

Clear Creek / Standley Lake Watershed Agreement

AGREEMENT

The undersigned parties hereto agree as follows:

I. Preamble.

This Agreement seeks to address certain water quality issues and concerns within the Clear Creek Basin of Colorado, and specifically, such issues as they affect the water quality of Standley Reservoir, an agricultural and municipal water supply reservoir located in Jefferson County Colorado, which is supplied with water primarily from Clear Creek. For purposes of this Agreement, the Clear Creek Basin is divided into three (3) areas of segments: the Upper Clear Creek Basin ("Upper Basin"), consisting of Clear Creek and its tributaries from its source to and including the headgate of the Croke Canal in Golden, Colorado; the Standley Lake Tributary Basin ("Tributary Basin"), consisting of the lands directly tributary to Standley Lake, the Church Ditch, the Farmers High Line Canal, the Croke Canal, and lands directly tributary to these Canals; and Standley Lake ("Standley Lake"), consisting of the Lake itself.

The parties to this Agreement are governmental agencies and private corporations having land use, water supply, and/or wastewater treatment responsibilities within the Clear Creek Basin. The parties are: (1) UCCBA; (2) City of Golden; (3) City of Arvada; (4) Jefferson County; (5) Jefferson Center Metropolitan District; (6) City of Westminster; (7) City of Northglenn; (8) City of Thornton; (9) City of Idaho Springs; (10) Clear Creek County; (11) Gilpin County; (12) Black Hawk/Central City Sanitation District; (13) Town of Empire; (14) City of Black Hawk; (15) City of Central; (16) Town of Georgetown; (17) Town of Silverplume; (18) Central Clear Creek Sanitation District; (19) Alice/St. Mary's Metropolitan District; (20) Clear Creek Skiing Corporation; (21) Henderson Mine; (22) Coors Brewing Company; (23) Church Ditch Company; (24) Farmers High Line Canal and Reservoir Company; and (25) Farmers Reservoir and Irrigation Company. For purposes of this Agreement, the parties can be divided into four (4) functional groups, as follows: The Upper Basin Entities ("Upper Basin Users" or "UCCBA"), consisting of the members of the Upper Clear Creek Basin Association (generally representing entities with jurisdiction over land use and wastewater treatment activities in the Upper Basin that can affect water quality in the Upper Basin); the Tributary Basin Entities ("Tributary Basin Entities"), consisting of the Cities of Golden, Arvada, and Westminster, and the County of Jefferson and the Jefferson Center Metropolitan District (generally representing entities with jurisdiction over land use activities that can affect water quality in the Tributary Basin); the Standley Lake Cities ("Standley Lake Cities"), consisting of the Cities of Westminster, Northglenn, and Thornton, (representing the municipal water users from Standley Lake); and the three canal companies (the "Canal Companies"), consisting of the Church Ditch Company, the Farmers High Line Canal and Reservoir Company, and the Farmers Reservoir and Irrigation Company (representing the entities that own and operate canals through which water is conveyed to Standley Lake for municipal and agricultural use).

In accordance with the geographical and functional divisions, this Agreement generally sets out rights and obligations with respect to certain water quality matters within the Clear Creek Basin (as above defined) by area or segment and by functional group.

II. Agreement.

1. The parties will submit a joint alternative proposal to the Water Quality Control Commission ("WQCC") in the matter captioned "For Consideration of Revisions to the Water Quality Classifications and Standards, Including Adoption of a Narrative Standard, for Segment 2, Standley Lake, of Big Dry Creek, in the South Platte Basin, and Adoption of a Standley Lake Control Regulation" on or before December 23, 1993. Said alternative proposal shall contain the following points:

    a. Request the WQCC to adopt a narrative standard only for Standley Lake at this time, with further consideration of any control regulation or numeric criteria for implementation of the standard at or after the triennial review of the South Platte River to be held in 1997. The narrative standard shall require maintenance of Standley Lake in a mesotrophic state, as measured by a combination of relevant indicators, as recommended by the parties' consultants prior to December 23, 1993.

    b. Request language in the Rule and in the Statement of Basis and Purpose for the regulation explaining that during the next triennium ending in 1997 ("triennium") the parties hereto will be conducting additional testing and monitoring, as well as implementing certain best management practices and controls on a voluntary basis, the results of which will be reported to the WQCC on an annual basis, and that point-source discharge permits written during the triennium shall not include any new or more stringent nutrient effluent limitations or wasteload allocations to meet the narrative standard. The proposed language will also refer to the intention of the parties and the Commission that should the narrative standard not be met at the end of the triennium, and substantial progress has not been made in reducing the nutrient loads to Standley Lake, additional measures may be required, including numeric standards or effluent limitations for phosphorous and/or nitrogen in the Upper Basin, and for additional best management controls in Standley Lake to be considered.

2. Should the WQCC fail to approve and adopt the substance of the proposed alternative described in paragraphs 1.a. and 1.b. above, this agreement shall automatically terminate and the parties shall be released from all other obligations and rights hereunder.

3. At or after the triennial review in 1997, the UCCBA and Standley Lake Cities agree that if substantial progress has not been made by the UCCBA in reducing its portion of nutrient loading and in developing controls to maintain appropriate reductions in nutrient loads to Standley Lake sufficient to maintain the narrative standard, they

will jointly petition the Commission to adopt a control regulation for Standley Lake containing the following points:

a. Total Phosphorous effluent limitation of 1.0 mg/l as P as a thirty (30) day average at the Upper Clear Creek Wastewater Treatment Plants, or such other numeric standard(s) or effluent limitations (s) for phosphorous or nitrogen, or in combination, with opportunity for point to point source and nonpoint source to point source trading among the entities that operate the UCCBA treatment plants, as has been determined will be effective in achieving and maintaining the narrative standard for Standley lake. Such numeric standard(s) or effluent limitation(s) shall be implemented over a three year period to allow time for the affected entities to fund, design and construct improvements necessary to meet the standards.

b. In-lake treatment to reduce internal phosphorous loading by 50% from the 1989-90 measured loadings in the 1993 USGS report by Mueller and Ruddy, or such other standards for reduction of internal phosphorous and nitrogen loading as has been determined will be effective in achieving and maintaining the narrative standard for Standley Lake, within three (3) years.

4. The UCCBA, in consultation with the Standley Lake Cities and Tributary Basin Entities will prepare a Best Management Practices Manual by December 31, 1994 for nonpoint sources that will cover disturbed areas of 1 acre or more and use its best efforts to have it approved and adopted for implementation by all jurisdictions within the Upper Basin by July 1, 1995. This Manual will be prepared to deal with the geologic, topographic and weather conditions existing within the Upper Basin to facilitate the reduction of nutrient loading from the various activities of the Upper Basin. This Manual will be coordinated with the Standley Lake Cities and Tributary Basin entities. The plan will include a program for monitoring representative results, to be included in the overall basin monitoring plan. For purposes of development of BMPs, Jeffco will not be considered to be part of the UCCBA.

5. The UCCBA, in consultation with the Standley Lake Cities and the Tributary Basin Entities, will examine the costs and effects of nutrient removal at UCCBA wastewater treatment plants, including operational controls or modifications which would decrease nutrient loads. Recommendations of such review shall be furnished to all the parties hereto by June 30, 1994. The UCCBA will use its best efforts to have its members implement operational modifications which can be implemented without significant capital improvements as quickly as reasonably practical.

6. The Standley Lake Cities, in consultation with the other parties, will develop a Standley Lake Management Plan by December 31, 1994 which will address in-lake nutrient loading and potential nutrient loading from lake activities, water supply operations, recreational activities, and activities in the watershed. The Standley Lake Cities will use their best efforts to implement the Lake Management Plan by

June, 1995. It is understood that the water rights implications of the plan must be considered.

7. The parties will jointly design, implement, and fund in such allocations as they shall agree a monitoring program to evaluate (1) nutrient loadings from point sources; (2) nutrient loadings from non-point sources in the Upper Basin; (3) nutrient loadings from non-point sources in the Tributary Basin; (4) internal Lake loading; and (5) the effect of nutrient reduction measures implemented by the various parties on the trophic status of Standley Lake. The results of the monitoring program will be provided to the Water Quality Control Commission for informational purposes annually. A description of the monitoring program will be included with the Annual Reports.

8. The Tributary Basin Entities and the Standley Lake Cities, in consultation with the other parties, will develop Best Management Practices (BMPs) for each of their jurisdictions by December 31, 1994, and shall use their best efforts to have them adopted as regulations by July, 1995. The BMPs will be designed to remove pollutants to the maximum extent practical considering the costs and benefits of possible measures; provided, however that no retro-fitting of existing construction or development will be required.

9. The Tributary Basin Entities, the Standley Lake Cities and the Canal Companies will develop a Management Plan for the Tributary Basin, addressing stormwater quality and quantity, hazardous substance spills, canal flushing, crossing permits, the Canal Companies' stormwater concerns, and the water rights implications of the above by December, 1994, and use their best efforts to achieve adoption of the portions of the Plan under the control of each entity by July, 1995. If not all affected parties adopt the agreed measures, then the parties that have adopted such measures will determine whether or not to implement the Plan despite such non-adoption by one or more parties.

10. Each functional group (The UCCBA, The Tributary Entities, The Standley Lake Cities, and the Canal Companies) shall provide each other group with semi-annual reports detailing the progress made on the implementation of its responsibilities herein, including development of any BMPs, nutrient reduction programs or controls, or other items required by this agreement, beginning in June, 1994. The parties shall also meet periodically after each report is completed to discuss progress by the parties. It is anticipated that the various functional groups may assign or appoint task groups or committees to address specific tasks or areas of concern (e.g. BMPs; ISDS; Wastewater Plant operational changes; monitoring, etc). If so, then the task groups shall provide the appropriate reports and participate in follow-up meetings.

11. This agreement may be enforced as a contract according to the laws of the State of Colorado; however, this agreement shall not create any right to claim or recover monetary damages for a breach thereof.

12. It is anticipated that other regional agencies with land use and/or water quality responsibilities or impacts within the Clear Creek Basin (as above defined) may join in the parties' monitoring and other efforts pursuant to this Agreement.

13. This Agreement may be executed in counterparts.

SUPPLEMENTAL INFORMATION 2

UPPER CLEAR CREEK/STANDLEY LAKE WATERSHED WATER QUALITY MONITORING PLAN

Upper Clear Creek/Standley Lake Watershed

Water Quality Monitoring Plan

Standley Lake courtesy of Eric Scott

December 2017

TABLE OF CONTENTS

APPENDICES

Abbreviations and Acronyms

BH/CC	Blackhawk/Central City
C	Centigrade
CC	Clear Creek
cfs	cubic feet per second
COC	chain of custody
CWQCC	Colorado Water Quality Control Commission
DI	Deionized Water
DO	Dissolved Oxygen
DRP	Dissolved Reactive Phosphorus (ortho-Phosphate-P)
EPA	U.S. Environmental Protection Agency
FHL	Farmers Highline Canal
FRICO	Farmers Reservoir and Irrigation Company
HCl	Hydrochloric acid
KDPL	Kinnear Ditch Pipe Line
LDMS	Laboratory Data Management System
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
m	meter
mgd	million gallons per day
mg/L	milligrams per liter
MSCC	Mainstem Clear Creek
mv	millivolt
N	Nitrogen
NFCC	North Fork Clear Creek
NG	City of Northglenn
NPS	Nonpoint Source
NTU	Nephelometric Turbidity Units
ORP	Oxidation Reduction Potential
OWTS	Onsite Wastewater Treatment System
pCi/L	picocuries per liter
P	Phosphorus
QC	Quality Control
SDWA	Safe Drinking Water Act
SFCC	South Fork Clear Creek
SLC	Standley Lake Cities
SLWQIGA	Standley Lake Water Quality Intergovernmental Agreement
SM	Standard Methods for the Examination of Water and Wastewater
TH	City of Thornton
TOC	Total Organic Carbon
TSS	Total Suspended Solids
TVSS	Total Volatile Suspended Solids
UCC	Upper Clear Creek
USGS	United States Geological Survey
Westy	City of Westminster
WFCC	West Fork Clear Creek
WMA	Upper Clear Creek Watershed Management Agreement
WQIGA	Water Quality Intergovernmental Agreement (Standley Lake)
WQS	Colorado Water Quality Standards (Regs #31 and #38)
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

MONITORING PROGRAMS OVERVIEW

Introduction

The quality of the water in Standley Lake has been monitored for more than two decades. Efforts to protect Standley Lake through State water quality regulations culminated in adoption of the numeric chlorophyll *a* standard for the lake in 2009. The Colorado Water Quality Control Commission ("CWQCC") established the chlorophyll *a* standard at 4.0 µg/L with a statistically derived assessment threshold of 4.4 µg/L. The standard is based on the arithmetic average of the individual monthly average chlorophyll *a* data for samples collected during March through November in each year. Exceedance of the standard would occur if the yearly 9-month average of the monthly chlorophyll *a* average results is greater than 4.4 µg/L more frequently than once in five years. In addition, a version of the narrative standard adopted in 1993 was also retained stating that the trophic status of Standley Lake shall be maintained as mesotrophic as measured by a combination of common indicator parameters such as total phosphorus, chlorophyll *a*, secchi depth and dissolved oxygen. The voluntary implementation of best management practices clause included in the 1993 version of the standard was eliminated from the 2009 narrative standard.

The Standley Lake Cities ("SLC") of Northglenn, Thornton and Westminster remain committed to effective and efficient water quality monitoring in the watershed as originally agreed to in the 1993 Watershed Management Agreement. The Standley Lake Water Quality Intergovernmental Agreement ("SLWQIGA" or "WQIGA"), entered into between the SLC, details the provisions for costs sharing related to cooperative efforts regarding water quality issues in the Clear Creek Basin and Standley Lake. The WQIGA monitoring program is subdivided into three inter-related programs for which the SLC provide field sampling, laboratory analyses and data management support: the Upper Clear Creek Monitoring Program, the Tributary Basin Monitoring Program and the Standley Lake Monitoring Program.

The Monitoring Committee was formed to periodically evaluate the monitoring programs and propose appropriate modifications as necessary. The proposals are evaluated by the SLWQIGA committee prior to implementation. Representatives from the SLC, Upper Clear Creek Basin and the Tributary Basin are actively involved in committee activities as appropriate. This document details the specific requirements and responsibilities of the SLC and outlines the commitments of additional entities involved in the Standley Lake watershed monitoring programs.

Standley Lake serves as the sole drinking water source for the cities of Northglenn and Westminster and is one of several drinking water sources for the City of Thornton. The monitoring program is designed to collect samples from a variety of locations in the watershed with varying anthropogenic and natural sources of pollutants. The data is used for trend analysis, modeling and for numerous other applications. Interpretation of the results allows the upstream and downstream communities to work cooperatively to minimize impacts to water quality.

Safety Considerations

The personal safety of the sampling team members is paramount in the decision making process for collection of water quality samples. At no time should personal safety be jeopardized in order to collect a sample. Environmental conditions may change suddenly and are variable throughout the watershed.

The following safety measures should be observed during all sampling activities:

- Sample collection should be performed by a two person team whenever possible.
- Weather conditions at the sampling sites should be evaluated prior to leaving the laboratory.
- Personal flotation devices should be worn if the creek water level is greater than twelve inches deep. Hydrostatically triggered, self-inflating personal flotation devices are recommended for non-lake sampling, as the device will automatically inflate if the sensor is submerged below six inches of water.
- Personal flotation devices are mandatory on Standley Lake. Lake sampling team members should be experienced swimmers.
- Wear waterproof gloves and sock liners, as appropriate.
- Exercise caution on slippery rocks, river banks and boat docks.
- Cell phones must be available during sampling, but be aware that cell phone signals are not reliable in all areas of Clear Creek Canyon.
- First aid kits must be available in all sampling vehicles, including boats. It is recommended that sampling team members be trained in basic first aid techniques.
- Supervisors are notified of the sampling team's itinerary and the expected return time to the lab. Sampling teams will notify supervisors of any delay in the expected return time.

UPPER CLEAR CREEK MONITORING PROGRAM

The Upper Clear Creek ("UCC") Monitoring Program is designed to provide water quality information in order to evaluate nutrient loadings from both point sources (discrete) and non-point sources (dispersed) within the Upper Clear Creek Basin.

The UCC Monitoring Program includes three distinct sub-programs, each designed to obtain water quality data during specified conditions:

- ambient grab samples;
- continuous stream monitoring and the automated collection of 24-hour ambient samples, and
- the automated collection of event samples.

UCC – AMBIENT GRAB SAMPLES

Program Coordination and Sampling Team: Thornton

Grab samples are single, point-in-time samples collected in-stream throughout the Upper Clear Creek Basin. Grab sample locations were selected to correspond with established USGS gage stations and additional sites have been included over the years as the monitoring program has evolved. Refer to the table below for sample site locations. The rationale for selection of the specific sampling sites is included in Appendix A. A map of the watershed is included in Appendix B.

Grab samples are collected five times during the year to correspond with seasonally varying flow conditions in Clear Creek. The *Short Schedule* is collected three times per year (February, April and December) and includes four stream locations. The *Long Schedule* is collected twice per year (May and October) and includes 15 stream locations. Laboratory analytical protocols limit sample collection to Monday through Thursday. Sampling is performed each year on approximately the same schedule. The specific sampling dates for the year are predetermined at the beginning of the year.

Since 2013, Wastewater Treatment Plant (WWTP) effluent samples collected by treatment plant staff are analyzed for nutrients (nitrogen and phosphorus) by commercial laboratories in accordance with Colorado Regulation 85. Sampling and analysis plans were developed by each WWTP outlining the monitoring locations, frequency and analytical parameters for testing. The analytical data reported by the WWTPs to the Colorado Water Quality Control Division will be included in the watershed annual reports.

WWTP Effluent Sample ID	Sample Location
CC1A	Loveland WWTP
CC3A	Georgetown WWTP
CC5A	Empire WWTP
CC7A	Central Clear Creek WWTP
CC8A	St Mary's WWTP
CC12A	Idaho Springs WWTP
CC13B	Black Hawk/Central City WWTP
CC14A	Henderson Mine WWTP
CC15A	Eisenhower Tunnel WWTP

UCC – AMBIENT GRAB SAMPLES

Locations and Sample Schedule

Clear Creek Sample ID	Flow Gage	Sample Location *	Feb	Apr	May	Oct	Dec
CC05	Staff gage	MSCC at Bakerville			X	X	
CC10	Recording gage	SFCC upstream of the lake			X	X	
CC15	Staff gage	WFCC below Berthoud			X	X	
CC20	Recording gage	WFCC below Empire			X	X	
CC25	Recording gage	MSCC above WFCC			X	X	
CC26	Recording gage	MSCC at Lawson Gage	X	X	X	X	X
CC30	Staff gage	Fall River above MSCC			X	X	
CC34	----	MSCC above Chicago Creek			X	X	
CC35	Recording gage	Chicago Creek above Idaho Springs WTP			X	X	
CC40	Recording gage	MSCC below Idaho Springs WWTP (US 6 and I-70))	X	X	X	X	X
CC44	Staff gage	NFCC above BH/CC WTP intake			X	X	
CC50	Recording gage	NFCC at the mouth	X	X	X	X	X
CC52	----	Beaver Brook at the mouth			X	X	
CC53	----	Soda Creek at the mouth			X	X	
CC60	----	MSCC at Church Ditch Headgate	X	X	X	X	X

* MSCC = Mainstem Clear Creek	WFCC = West Fork Clear Creek	WTP = Water Treatment Plant
SFCC = South Fork Clear Creek	NFCC = North Fork Clear Creek	WWTP = Wastewater Treatment Plan

UCC – AMBIENT GRAB SAMPLES

Analytical Parameters for Creek samples – includes parameters for both Short and Long Schedules

Analyte	Analytical Method Reference	Reporting Limit Goal	Responsible Laboratory
Total Nitrogen	SM 4500-NO3 I	0.02 mg/L	Westminster
Nitrate/Nitrite as N	SM 4500-NO3 I	0.01 mg/L	Westminster
Ammonia as N	SM 4500-NH3 H	0.01 mg/L	Westminster
Total Phosphorus	SM 4500-P E	0.0025 mg/L	Northglenn
Ortho-phosphate as P (dissolved) or DRP	SM 4500-P E	0.0025 mg/L	Northglenn
Total Organic Carbon (TOC)	SM 5310 B	0.5 mg/L	Thornton
Total Suspended Solids	SM 2540 D	1 mg/L	Thornton
Temperature (field)	SM 2550 B	1.0 °C	Thornton
pH (field)	SM 4500-H+ B-2000	1.0 Std Units	Thornton
Conductivity (field)	SM 2510 B-1997	10 µS/cm	Thornton
Turbidity (field)	ASTM D7315	1.0 NTU	Thornton
Dissolved Oxygen (field)	ASTM D888-09 (C)	1.0 mg/L	Thornton
Stream Depth	Staff gage reading	0.1 ft	Thornton

Table Notes:
1) SM refers to the 23rd Edition of Standard Methods for the Examination of Water and Wastewater.
2) Reporting limit goals are matrix dependent and may be increased for complex matrices and may be lower depending on laboratory capability.
3) TOC is analyzed on samples from sites CC05, CC20, CC26, CC35, CC40, CC50, CC52, CC53, and CC60 during the Long Schedule events. TOC is analyzed on all four creek grab samples during the Short Schedule events.
4) YSI/Xylem ProDSS or 6-series sondes are used for field measurements.

UCC – AMBIENT GRAB SAMPLES

Flow Monitoring

Various mechanisms are employed throughout the watershed for monitoring the hydrologic conditions at strategic locations. USGS real-time recording gages are installed at CC10, CC20, CC25, CC26, CC35, CC50 and CC61 (Clear Creek at Golden). USGS staff gages are in place at CC05, CC15, CC30 and CC44. The staff gage readings are recorded to the nearest 0.1 foot and may be converted to stream flow using the USGS calibration rating curve established for the location.

The recording gage at CC40 (Clear Creek at US 6 and I-70) is operated and maintained by Clear Creek Consultants on behalf of UCCWA. The SLC provide financial support for the USGS gages at CC05 at Bakerville (staff gage), CC15 on the West Fork below Berthoud (staff gage), and CC26 at Lawson (recording gage). The SLC provide financial support for the Department of Natural Resources staff gage at CC30 on Fall River at the mouth. The City of Golden provides financial support for the USGS gage on the West Fork of Clear Creek at Empire.

UCC – AMBIENT GRAB SAMPLES

Program Coordination and Sampling Team - Short Schedule:Thornton

Two weeks before the scheduled Clear Creek sampling date:

- Contact Westminster and Northglenn to request adequate supply of sample bottles from each lab.
- Prepare four sample kits as directed below. Each sample bottle kit includes the containers for sampling at one location.

Sample Bottle Kit Prep- Short Schedule

Destination	**Quantity**	**Volume**	**Bottle Type**	**Parameter**	**Laboratory**	**Additional Documentation**
Clear Creek Team – Feb, April and Dec **ONLY** (Collect samples at CC26, CC40, CC50 and CC60)	4	500 mL	Rectangular plastic	Phosphorus series	Northglenn	Instructions, COCs and one field data sheet
	4	500 mL	Plastic jug	TSS	Thornton	
	4	125 mL	Rectangular brown plastic	Nitrogen series	Westminster	
	4	40 mL	Glass vial	TOC	Thornton	

Table Notes:
1) Phosphorus series includes total P and dissolved ortho-phosphate-P (also referred to as DRP).
2) Nitrogen series includes total N, ammonia-N and nitrate/nitrite-N.
3) The additional documentation forms are included in Appendix C.

<u>On Clear Creek sampling day (Short Schedule):</u>

- Calibrate field equipment in the lab. Ensure all probes and meters are working properly before leaving the lab. Take aliquots of the standards into the field to check instrument calibration if necessary.

- At each sample location, collect samples and analyze for field parameters (pH, temperature, DO, conductivity, and turbidity). Complete the COC and record all results on the Field Data Sheet (refer to Appendix C).

- The field samples are returned to the Thornton Lab and refrigerated until pickup by Westminster and Northglenn personnel. The samples are relinquished to Westminster (nitrogen) and Northglenn (phosphorus) and the COCs are signed appropriately. The original copies of the COCs are retained by Westminster and Northglenn. Original field data sheets and copies of the COCs are retained by the City of Thornton for permanent archive.

<u>UCC – AMBIENT GRAB SAMPLES</u>

<u>Sampling Locations Directions and Narrative Descriptions - Short Schedule</u>

Sampling Frequency: Feb, April, Dec

POINT	DIRECTIONS AND DESCRIPTION OF LOCATION
CC26	Travel westbound I-70 to exit at Lawson. Travel frontage road through Lawson. Immediately before the I-70 overpass, on your right, is a parking area. Sample creek at gage and USGS sampling station by bridge. [RECORDING GAGE] (39-45-57N/105-37-32W) **Sample TOC**
CC40	Traveling eastbound on I-70 take US 6 exit. Pull off in parking area just east of the off ramp. (Tributary Restaurant is across the road) Sample approx. 100 yards east of stop sign below recording gage. (39-44-47N/105-26-08W) [RECORDING GAGE] **Sample TOC**
CC50	Travel Hwy 119 eastbound toward US 6. Approximately 2 miles downstream of the Black Hawk/Central City WWTP and ¼ mile upstream from intersection is a pullout area to the right immediately before the junction. Sample at the recording gage. (39-44-56N/105-23-57W) [RECORDING GAGE] **Sample TOC**
CC60	Approximately 1 mile west of the intersection of Hwy 58 and US 6. Park in the pullout on the south side of highway and walk down (or drive) downhill to the Church Ditch diversion structure. Go across the bridge and sample from the main stem of Clear Creek. Do <u>not</u> sample from Church Ditch. (39-45-11N/105-14-40W) **Sample TOC**

Photographs of the sampling locations and GPS coordinates are included in Appendix D.

UCC – AMBIENT GRAB SAMPLES

Program Coordination and Sampling Teams - Long Schedule: Thornton

Two weeks before the scheduled Clear Creek sampling date:

- Contact Westminster and Northglenn to request adequate supply of sample bottles from each lab.
- Prepare sample kits as directed below. Each sample bottle kit includes the containers for sampling at one location.

Prepare sample bottle kits as directed below. Each sample bottle kit contains the prepared sample bottles to collect samples at one location. Prepare 15 bottle kits: 8 kits Creek Team A and 7 kits for Creek Team B.

Sample Bottle Kit Prep- Long Schedule

Destination	Quantity	Volume	Bottle Type	Parameter	Laboratory	Additional Documentation
Clear Creek Team A (Collects samples at CC25, CC05, CC10, CC26, CC34, CC35, CC52 and CC53)	8	500 mL	Rectangular plastic	Phosphorus series	Northglenn	One set of: Instructions, COCs and one field data sheet
	8	500 mL	Plastic jug	TSS	Thornton	
	8	125 mL	Rectangular plastic	Nitrogen series	Westminster	
	5	40 mL	Glass vial	TOC	Thornton	
Clear Creek Team B (Collects samples at CC15, CC20, CC30, CC40, CC44, CC50 and CC60)	7	500 mL	Rectangular plastic	Phosphorus series	Northglenn	One set of: Instructions, COCs and one field data sheet
	7	500 mL	Plastic jug	TSS	Thornton	
	7	125 mL	Rectangular plastic	Nitrogen series	Westminster	
	4	40 mL	Glass vial	TOC	Thornton	
QC	4	2 L	1:1 HCl rinsed Rectangular plastic	QC spikes and dups for Golden	Thornton	QC sampling completed by Team A in May and Team B in October.
	1 (blank)	1 L	Rectangular plastic	Phosphorus series	Northglenn	
	1 (blank)	250 mL	Rectangular plastic	Nitrogen series	Westminster	

Table Notes:
1) Phosphorus series includes total P and dissolved ortho-phosphate-P (also referred to as DRP).
2) Nitrogen series includes total N, ammonia-N and nitrate/nitrite-N.
3) The additional documentation forms are included in Appendix C.

On Clear Creek sampling day (Long Schedule):

- Calibrate field equipment in the lab. Ensure all probes and meters are working properly before leaving the lab. Take aliquots of the standards into the field to check instrument calibration if necessary.

- Prepare coolers with ice and sample bottle kits. The Creek Team chosen for QC sampling must also include in the field sample bottle kit: field blank bottles (nitrogen and phosphorus), one field duplicate cubitainer, and at least 4 two-liter bottles for QC samples. Thornton prepares both sample kits for Clear Creek Teams A and B and will provide the extra materials needed for the QC sampling in the appropriate sample kit.

- At each sample location, collect samples and analyze for field parameters (pH, temperature, DO, conductivity, and turbidity). Complete the COC and record all results on the Field Data Sheet (refer to Appendix C). Samples will be collected at all creek sites for nitrogen series, phosphorus series and TSS. TOC samples are collected only at designated creek sites: CC05, CC20, CC26, CC35, CC40, CC50, CC52, CC53, and CC60.

- The Clear Creek Team selected for QC sampling will randomly select four creek sites. Collect one sample (2-liter HCl rinsed bottle) at four randomly selected creek sites for preparation of the spike and duplicate nutrient QC samples by Thornton staff.

- Complete the COC for the QC samples.

- Return to the Thornton Lab when sampling is completed. Relinquish the QC samples to the Thornton Lab staff.

- Thornton's Lab staff prepares one duplicate and one spike sample for total nitrogen and total phosphorus from the four QC samples.

- Analyze and complete any missed field parameters as allowable.

- Make one copy of each team's field data sheet for Westminster to use for logging in the samples to the electronic spreadsheet.

- The field samples and prepared QC samples are relinquished to Westminster (nitrogen) and Northglenn (phosphorus) and the COCs are signed appropriately. The original copies of the COCs are retained by Westminster and Northglenn. Original field data sheets and copies of the COCs are retained by the City of Thornton for permanent archive.

UCC – AMBIENT GRAB SAMPLES

Sampling Locations Directions and Narrative Descriptions - Long Schedule

Clear Creek Team A

Sampling frequency: May, Oct

Sample bottles: Creek sites: One 500mL rectangular (phosphorus series), one 500 mL (TSS), one 125 mL (nitrogen series) and one 40 mL amber glass vial (TOC) as required.

POINT	DIRECTIONS AND DESCRIPTION OF LOCATION
CC05	1-70 westbound to Exit 221 (Bakerville); go south back over Interstate (left). Park at call box. Take sample upstream of parking area, read gage located downstream. [STAFF GAGE] (39-41-31N/105-48-15W) **Sample TOC**
CC10	I-70 eastbound to Georgetown. Begin at intersection of 6th and Rose in Georgetown. Go 2.2 miles up Guanella Pass Road (go to the first lake). U-turn by the inlet and park on the right side of road. Sample from stream above lake inlet point. [RECORDING GAGE] (39-41-11N/105-42-00W)
CC25	Return towards but do not enter I-70. Instead take the frontage road (Alvarado Road) back towards Empire. Travel on the road approximately 3.3 miles until you see a large dirt pull off on the left, across the road from the cemetery. You'll need to hop the barb wire fence to access the creek. Sample near the culvert under I-70. (39-45-05N/105-39-45W)
CC26	Continue approximately 2.3 miles down Alvarado Road towards and through Lawson. Immediately before the road curves left under I-70 is a parking area straight ahead through an opening at the end of a guardrail. Sample creek at gage and USGS sampling station by the bridge over the creek. [RECORDING GAGE] (39-45-57N/105-37-32W) **Sample TOC**
CC34	From I-70 (either direction) Exit 240 (Chicago Creek), pull off in the small parking area on the other side of the bridge. Sample the main stem of Clear Creek upstream of Chicago Creek across from the Forest Service Building. (39-44-26N/105-31-17W)
CC35	Continue approx. 3.7 miles on Hwy 103. Pull off on the right shoulder just past the green roofed house that looks like a barn (on the left). Cross road and sample creek at recording gage. DO NOT PARK BY COVERED WAGON!!! [RECORDING GAGE] (39-42-58N/105-34-15W) **Sample TOC**
CC52	Exit I-70 eastbound at Beaver Brook/Floyd Hill (Exit #247). Turn Left to the north frontage road (US Hwy 40). Travel east approximately 2.4 miles. Pull off to the side of road and sample Beaver Brook at this point.(39-43-7N/105-22-4W) **Sample TOC**
CC53	Continue travelling east bound 0.3 miles and cross the second white bridge. Exit immediately on the right to Soda Creek Drive. Park on the right. Sample Soda Creek upstream of the bridge. (39-42-50N/105-21-42W) **Sample TOC**

Photographs of the sampling locations and GPS coordinates are included in Appendix D.

UCC – AMBIENT GRAB SAMPLES
Sampling Locations Directions and Narrative Descriptions - Long Schedule

Clear Creek Team B

Sampling frequency: May, Oct

Sample bottles: Creek sites: One 500 mL rectangular (phosphorus series), one 500 mL (TSS), one 125 mL (nitrogen series) and one 40 mL amber glass vial (TOC) as required.

POINT	DIRECTIONS AND DESCRIPTION OF LOCATION
CC15	Travel west on US 40 through Empire. Begin at Empire Dairy King and continue 6.0 miles west on US 40. There is a large pullout on the creek side of highway with a large stump in the middle of the pullout located a ¼ mile past mile marker 250. Sample directly below the stump at the creek. Staff gage is along the north bank of stream next to a tree at the stream's edge. (39-46-05N/105-47-36W) [Read the STAFF GAGE and record on the field data sheet]
CC20	Returning back through Empire eastbound, travel along the road\ramp from US 40 to Westbound I-70. Immediately after turning onto road/ramp, there is a large open space on right side of road\ramp. Park in open space and cross road to the Colorado Dept. of Transportation (CDOT) fence enclosing their maintenance yard. Enter fence and sample approximately 100 feet downstream of bridge at recording gage. (39-45-23N/105-39-34W) [RECORDING GAGE] **Sample TOC**
CC30	East on 1-70. Exit 238 (Fall River Road/St. Mary's Glacier). Approximately 100 yards up Fall River Road, there is a small turnout on right by a wooden support wall. Cross road and sample creek at staff gage. (39-45-23N/105-33-20W) [Read the STAFF GAGE and record on the field data sheet]
CC40	Traveling eastbound on I-70 take US 6 exit. Pull off in parking area just east of the off ramp. (Tributary Restaurant is across the road) Sample approximately 100 yards east of stop sign below recording gage. (39-44-47N/105-26-08W) [RECORDING GAGE] **Sample TOC**
CC44	Continue east on US 6 to 119. Drive west on 119 to Black Hawk. From the Black Hawk intersection travel westbound approximately 1 mile on Hwy 119. There is a small wooden building and parking area on the left side of the road. This is the Black Hawk water intake. Walk approximately 100 feet upstream and sample at staff gage. (39-44-56N/105-23-57W) [STAFF GAGE] Record the staff gage and sample near there.
CC50	Continue on Hwy 119 eastbound toward US 6. Approximately 1 mile downstream of the Black Hawk/Central City WWTP and ¼ mile upstream from intersection is a pullout area to the right immediately before the junction. Sample at the recording gage. (39-44-56N/105-23-57W) [RECORDING GAGE] **Sample TOC**

CC60 Site is approximately 1 mile west of intersection of Hwy 58 and US 6. Park in the pullout on the south side of highway and walk down (or drive) downhill to the Church Ditch diversion structure. Go across the bridge and sample from the main stem of Clear Creek. Do not sample from Church Ditch. (39-45-11N/105-14-40W) **Sample TOC**

Photographs of the sampling locations and GPS coordinates are included in Appendix D.

UCC – AMBIENT GRAB SAMPLES

QA/QC Program - Long Schedule Only

Duplicate and spike quality control samples are prepared from creek samples collected during the Clear Creek Long Schedule sampling events for selected nutrients and are analyzed by Westminster (total nitrogen) and Northglenn (total phosphorus). The QC samples are prepared by the City of Thornton at their laboratory on the day of sampling. Four creek locations are randomly selected for preparation of the QC samples. One duplicate and one spike are submitted to each laboratory. The analytical procedure for QC preparation is detailed below:

SOP - QC Preparation for Clear Creek Studies

Night before:

- Soak 2 1-Liter Class A volumetric flasks with 1:1 HCl. One flask will be used to make up fresh Nitrate standard and the other will be used for spiking the selected Clear Creek sample (with both nitrate and phosphorus spikes).

The Morning of Sampling Day:

- Remove 5 mg/L Phosphorus standard from fridge to warm to room temperature. This standard is prepared by the City of Northglenn. It is usually in a 125 ml brown glass bottle.
- Remove 100 mg/L Nitrate-N standard from fridge. It is stored in a 125 ml brown Nalgene bottle. This standard is prepared fresh each time. The method to prepare a 100 mg/L NO3-N standard is in Standard Methods, 21st Ed., page 4-120 and described below.

- **To Prepare Fresh Nitrate-N Standard**
  - Thoroughly rinse out one of the HCl acid soaked 1-Liter flasks to prepare the fresh standard in.
  - Fill flask with 200-300 mL DI water.
  - Weigh out 0.7218 grams of KNO3 and add to flask. (KNO3 is stored in the desiccator).
  - Dilute to 1-Liter volume with DI and mix thoroughly.
  - Discard old standard and refill bottle with fresh standard. Rinse bottle out with fresh standard 2-3 times before filling. Record new prep date on bottle.

- Prepare 4 sample bottles for spike and duplicate samples. Bottles used for spike and duplicate prep are provided by the City of Thornton and are the plastic HCl-washed, 16-ounce “milk type” bottles.

  Two labs receive spike and duplicate samples from this program:
  - Northglenn for low level total phosphorus analysis.
  - Westminster for total nitrogen analysis.

  Starting 2018, the bottles are marked with (##) corresponding to the date of the sampling (for example, “051418” for May 14, 2018). Mark the 4 bottles with the following information:

  - City of Northglenn - P(##) - Spike for Phosphorus, Date of sampling.
  - City of Northglenn - D(##) - Duplicate for Phosphorus, Date of sampling.

  - City of Westminster - N(##) - Spike for Nitrogen, Date of Sampling.
  - City of Westminster - D(##) - Duplicate for Nitrogen, Date of sampling.

  <u>When Samples Arrive in Thornton's Lab:</u>

  Certain <u>2 Liter</u> samples from Clear Creek sites will have been randomly selected by the sampling team as "QC" samples.

  - Select ONE of these as the QC sample (**spike and duplicate)** and set aside. Record which site was chosen in the QC log book.

  This sample will be spiked with <u>both</u> Nitrogen and Phosphorus at concentrations within the analytical ranges of Northglenn's and Westminster's labs.

  The "**spiked sample"** will be made in the remaining HCl rinsed volumetric flask and will use up 1 liter from the 2 liter bottle.
  The remaining 1 liter volume will be split into the "**duplicate sample**" bottles for both labs.

  - **<u>To Prepare Spiked Sample</u>**

    - Rinse out the remaining 1-Liter volumetric flask with DI.
    - Then rinse flask with a <u>small</u> portion of the selected QC Creek sample - 2 times.
    - Refer to the last sampling to determine new spike volumes.

    **Spike amounts for Phosphorus are usually within the 1.75 to 3.0 ml volume range for a total spiked concentration of 0.00875 mg/L to 0.015 mg/L, i.e.,*

    1.75 mL of 5 mg/L phosphorus standard in 1 liter = 0.00875 mg/L concentration spiked
    **Spike amounts for Nitrogen are usually within a 1.5 to 3.0 ml volume range for a total spiked concentration of 0.15 mg/L to 0.3 mg/L, i.e.,*

    1.5 mL of 100 mg/L nitrogen-N standard in 1 liter = 0.15 mg/L concentration spiked

- Mix the Clear Creek sample well and pour approximately 500 mL into pre-rinsed flask.
- Add determined spike volumes of both standards to flask. Mix well.
- Dilute to volume with additional Creek sample finalizing volume with a pipet. (It is too hard to bring it to volume by pouring from the 2 liter container!)
- Mix well and pour into 2 bottles labeled for spike samples ("N" and "P").

To Prepare Duplicate Sample

- Thoroughly mix remaining Clear Creek sample.
- Pour into 2 bottles labeled for duplicates ("D").

Record the following information:

1. the new (##) number discussed earlier
2. the Clear Creek sample site number that was selected for preparation of the QC samples
3. the volumes spiked for phosphorus and nitrogen

Generate new chain of custody forms for the 4 new samples. One form can be filled out for both Westminster and Northglenn labs. The respective labs will collect their samples from Thornton.

UCC AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Program Coordination and Sampling Team: Westminster

Autosampler sites were selected at strategic locations in the watershed in order to assess diurnal variations in water quality in Clear Creek. The 24-hour ambient composites are collected with programmable automatic sampling devices. Each of the 12 sample bottles represents a two hour time period, resulting from collecting equal volumes of sample in each of two consecutive hours; therefore, 24 hours of samples are collected in 12 bottles. The 12 discrete samples are composited into one 24-hour sample on a time weighted basis (i.e. equal sample volumes are taken from 12 discrete autosampler bottles and combined into a single composite sample). Additional discrete or composite samples may be submitted for analysis based on anomalies noted in field observations for the individual autosampler bottles.

Ambient samples are collected approximately seven times per year on a monthly schedule starting in April and ending in October. The schedule for the ambient sampling is based on clear weather predictions and is staggered at different times during the week, including weekends.

Analytical probes and data logging equipment are active at most of the autosampler sites year-round to continuously monitor in-stream conditions for temperature, conductivity, pH, ORP and turbidity. From April through October, or as weather conditions permit, a depth/pressure probe may be installed at some locations. YSI/Xylem multi-probe sondes are deployed at each autosampler location. The sample locations are equipped with data loggers and cellular telephone modems for remote monitoring of water quality conditions in the watershed and to remotely control activation of the autosamplers.

UCC AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Sample Locations

CCAS26	Mainstem of CC at USGS Lawson gage
CCAS49	Mainstem of CC above the confluence with the North Fork
CCAS50	North Fork of CC above confluence with Mainstem of CC at USGS gage
CCAS59*	Mainstem of CC above Golden and Church Ditch diversions

*In 2016, Westminster assumed responsibility for sample collection at and maintenance of the new autosampler location at CCAS59 installed approximately 100 feet upstream of the City of Golden's CC59 station.

UCC AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Flow Monitoring

USGS gages provide the average daily flow associated with the 24-hour composite samples for the ambient autosamplers. Flow data is obtained directly from the gage stations at CC26 and CC50 to correlate with CCAS26 and CCAS50, respectively. Flow data from the gage at CC40 is used to correlate to CCAS49 because there are rarely significant inflows to or diversions from Clear Creek between CC40 and CCAS49.

The flow data associated with CCAS59 is considered to be an estimated flow. The flows diverted to the City of Golden water treatment plant and the Church Ditch will be added to the gage flows recorded at the USGS gage at CC61 (Clear Creek at Golden) to estimate the flow at CCAS59.

UCC AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Analytical Parameters

Analyte	Analytical Method Reference	Reporting Limit Goal	Responsible Laboratory
Total Nitrogen	SM 4500-NO3 I	0.02 mg/L	Westminster
Nitrate/Nitrite-N	SM 4500-NO3 I	0.01 mg/L	Westminster
Ammonia-N	SM 4500-NH3 H	0.01 mg/L	Westminster
Total Phosphorus	SM 4500-P E	0.0025 mg/L	Northglenn
Ortho-phosphate-P (dissolved) or DRP	SM 4500-P E	0.0025 mg/L	Northglenn
Total Suspended Solids (TSS)	SM 2540 D	1 mg/L	Thornton
Total Organic Carbon (TOC)	SM 5310 B	0.5 mg/L	Thornton
pH (field)	SM 4500-H+ B-2000	1.0 Std Units	Westminster
Temperature (field)	SM 2550 B	1.0 °C	Westminster
Conductivity (field)	SM 2510 B-1997	10 µS/cm	Westminster
Turbidity (field)	ASTM D7315	1.0 NTU	Westminster
Total and Dissolved Cadmium	EPA 200.8	0.0005 mg/L	Westminster Contract Laboratory
Total and Dissolved Copper	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Iron	EPA 200.7	0.02 mg/L	Westminster Contract Laboratory
Total and Dissolved Lead	EPA 200.8	0.0005 mg/L	Westminster Contract Laboratory
Total and Dissolved Manganese	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Zinc	EPA 200.8	0.02 mg/L	Westminster Contract Laboratory

Table Notes: 1) SM refers to the 23rd Edition of Standard Methods for the Examination of Water and Wastewater.

2) Reporting limit goals are matrix dependent and may be increased for complex matrices and may be lower depending on laboratory capability.

3) EPA recommended holding times less than 72 hours may not be met due to the extended sampling routine.

4) Samples collected for nutrients (nitrogen and phosphorus) with a turbidity reading of greater than 100 NTU may be analyzed by commercial laboratories that have demonstrated proficiency in analyzing complex matrices for nutrients.

5) Metals will be analyzed in May, July and October on the Creek intended to capture low, medium and high ambient canal flows delivered to Standley Lake.

6) YSI/Xylem 6-series or EXO sondes are used for field measurements.

UCC AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Field Equipment

Equipment Installed At Autosampler Locations

- Permanent and tamper-proof enclosure box with lock
- American Sigma 900, 900 Max or other automated sampler
- Power supply – solar panel, rechargeable battery or direct power
- Sample tubing long enough to reach from the autosampler to the streambed. Probes must be contained in protective piping secured in the creek bed
- Dedicated sonde with field probes for turbidity, temperature, conductivity and pH

- Depth/pressure sensor
- Recording gage at CC26 – Operated and maintained by USGS
- Staff gage and recording gage at CC50 – Operated and maintained by USGS
- Rain gage at CC59 – Operated and maintained by Clear Creek Consultants for the City of Golden
- 24 discrete HCl rinsed autosampler bottles with caps. Bottles must be numbered and inserted in the designated position in autosampler (positions numbered 1 through 24). Though samples will only be collected in bottles 1-12, a full rack of sample bottles is required to secure sample bottles in place.
- Continuous recording datalogger
- Cellular modem and antenna at CC26, CC50 and CCAS59

UCC AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Autosampler Operation

On a monthly basis between April and October, autosamplers are set to collect time-weighted discrete samples for a 24-hour period. The autosamplers are strategically located in order to correlate stream flow with the chemical water quality data collected on the samples. In order to associate the relative impacts of the point and nonpoint pollutant sources located between the sample stations, it is advisable to observe the same "slug" of water at both the upstream and downstream locations. Using the "time of travel" study conducted by USGS in 1999, activation of the downstream autosamplers on Clear Creek are delayed for a predetermined time based on in-stream flow at the Lawson stream gage.

The time of travel estimates tables are included in Appendix E.

Autosampler Setup:

Equipment required:

- 24 discrete HCl rinsed autosampler bottles with caps
- Keys and/or tools to access autosampler enclosure
- Field data collection/station audit sheets

Setup Procedure:

1. Unlock sample enclosure and remove sampler head. Set aside without disturbing or bumping the distributor arm.
2. Load uncapped bottles in the correct positions in the bottom of the sampler.
3. Secure bottles in place with the retaining ring. Store caps in a ziplock bag inside the autosampler until sample collection.
4. Program the sampler according to manufacturer's instructions to collect two 450 mL storm samples per bottle, one sample per pulse.
5. After starting the autosampler, ensure that the distributer arm is positioned above bottle #1.

6. Replace sampler head and lock in place.
7. Record station/equipment information on field sheet.
8. Make sure the autosampler program is ***RUNNING*** before locking the enclosure.
9. The autosampler may be set up ahead of a scheduled start time.

Sample Collection

Additional equipment required:

- Keys and/or tools to access autosampler enclosures
- Large cooler with ice to collect sample bottles
- 12 pre-cleaned, HCl rinsed, discrete sample replacement bottles
- Field data sheets/station audit sheets
- Chain of custody forms
- Laptop with Loggernet software and data cable (9 pin serial cable with SC32B adapter) if retrieving data directly from datalogger
- One 3-liter or larger Nalgene bottles (clean and rinsed with 1:1 hydrochloric acid) for compositing samples
- 250 mL graduated cylinder (clean and rinsed with 1:1 hydrochloric acid) for compositing samples
- Prepared sample bottles provided by participating Cities for nutrients, solids and metals analyses
    - 500mL square plastic – phosphorus series (Northglenn)
    - 125 mL brown plastic – nitrogen series (Westminster)
    - 500 mL plastic bottle – TSS (Thornton)
    - 40 mL amber glass vial with septa cap – TOC (Thornton)
    - 500 mL round plastic – total metals (Westminster)
    - 500 mL round plastic – dissolved metals (Westminster)
- Chain of Custody forms – Refer to Appendix C
- Field Sampling form - Refer to Appendix C

Sample Collection Procedure:

1. Unlock enclosure and remove sampler head.
2. Retrieve date/time information from autosampler if required. To collect sample history on American Sigma samplers, press <Change/ Halt> button, press <time/read> button for 5 seconds. The sample collection time for the first sample will appear. Record data on the field sheet. Press <yes> for next sample time to appear. Continue until all data is recorded.
3. Date and time information for samples is also automatically stored in a data file by the dataloggers at all sites.
4. Record station/equipment information on field sheet.

5. Make note of any samples with high turbidity determined by visual observance or data obtained from the datalogger.
6. Compositing of samples in the field is performed by pouring off equal volumes into a 3-liter (or larger) pre-cleaned bottle. Refer to the Sample Compositing Procedure Step 1 below. Aliquot the composited sample into the individual sample bottles that correspond to the analytes to be tested. Save the remaining volume of any individual high turbidity samples to take back to the lab for possible further testing. Discard remaining sample in the remaining autosampler bottles. Return used autosampler bottles to the lab for cleaning.
7. Clean out autosampler base and reload with a new set of pre-cleaned bottles.
8. Reset the autosampler by pressing the START button (Sigma 900 autosampler). Ensure that the distributor arm is parked over bottle #1 and the display reads "Program Running" before closing the autosampler and placing it back in the enclosure. .
9. Take all samples to the Westminster Semper Water Quality Laboratory for splitting and distribution.

UCC AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Sample Compositing

1. Composite samples in the laboratory if compositing was not performed in field. Shake sample bottles and pour equal volumes of sample from the 12 bottles into a composite bottle.
2. Perform turbidity, temperature, pH and conductivity measurements on composited samples. Enter data on the Sampling Form.
3. Use the well mixed composited sample to fill the appropriate sample bottles.
4. If any discrete bottle(s) appears to have an unusually high turbidity and enough sample is available, analyze for turbidity and conductivity. Record on Sampling Form. If there is enough sample, pour the high turbidity discreet samples into separate nutrient and solids bottles for individual analysis.
5. Complete the COCs.
6. Relinquish to each city their respective samples (Westminster-nitrogen series, Thornton-TSS and TOC, Northglenn-phosphorus series) and sign COCs as appropriate.
7. Original field data sheets and COCs are retained by the City of Westminster for permanent archive.
8. Samples are created in the web-accessible Excel spreadsheet by Westminster for data entry and results archive.

UCC AUTOSAMPLERS – EVENT SAMPLES
Sample Locations

CCAS49 Event	Mainstem of CC above the confluence with the North Fork
CCAS50 Event	North Fork of CC above confluence with Mainstem of CC at USGS gage
CCAS59 Event	Mainstem of CC above Golden and Church Ditch diversions

UCC AUTOSAMPLERS – EVENT SAMPLES
Flow Monitoring

Westminster will obtain the 15 minute interval flow data from the USGS gage at CC61 (Clear Creek at Golden) to correlate to CCAS59. The average event flow will be calculated to correspond to the specific time-event composited samples. If the 15 minute interval flow data is not available, the average daily flow will be associated with the event. The average daily flow at UCCWA gage CC40 will be used to correlate with CCAS49. Flow at CC50 is measured by a USGS gage at that site.

UCC AUTOSAMPLERS – EVENT SAMPLES
Analytical Parameters

Storm event samples are analyzed for the same suite of analytical parameters listed in the previous section for the 24-hour ambient samples. Westminster will collect storm samples triggered at CCAS49, CCAS50, and CCAS59 and send them out to their contract laboratory for metals analysis. Independently from this Monitoring Plan, the City of Golden will perform metals analyses collected at CC59 event samples using EPA Method 200.8. Some samples may be analyzed outside the EPA recommended holding time for some parameters based on the random nature of the storm event triggering. Golden and the Standley Lake cities have agreed to share their data.The SLC will submit all other autosampler event samples to a commercial lab for metals testing.

UCC AUTOSAMPLERS – EVENT SAMPLES
Program Coordination: Westminster (and Golden)

Field Sampling Teams: Westminster (and Golden)

The event autosampler program was initiated in 2006 to assess the pollutant concentrations mobilized during significant snow melt (runoff) or rain events at the 24-hour ambient locations CCAS49, CCAS50 and CCAS59. Automated sample collection of stormwater is triggered based on changes in ambient turbidity, conductivity, stage height, or rain gage readings, depending on the autosampler location. The autosamplers are currently set to trigger when the 25 minute running average exceeds a predetermined turbidity level (for example, 100 NTU). The autosampler at CCAS50 triggers based on a combination of change in stream depth, precipitation and turbidity in order to eliminate triggering autosampler event sampling that might be associated with localized human disturbances in the creek (e.g. sluice mining). Autosamplers trigger independently depending on the localized conditions in the watershed. The autosampler collects discrete samples every 15 minutes until the parameter that triggered the event returns to the ambient condition or until the maximum number of samples is collected. The discrete samples may be analyzed individually or multiple discrete samples may be composited based on the field observations. As necessary, refer to the previous section for instructions on compositing samples from autosamplers. Event sampling can also be started remotely in the event of a spill or other event that might not cause the triggering parameters to be met. Westminster coordinates sampling at CCAS49, CCAS50 and CCAS59. Golden is in charge of CC59, independently from this Monitoring Plan. Golden and the Standley Lake cities have agreed to share their data.

UCC AUTOSAMPLERS - EVENT SAMPLES

Field Equipment

Storm event sampling utilizes the same equipment listed in the previous section for the 24-hr ambient samples.

Autosampler Operation

Field equipment used for storm event sampling is operated using the same techniques as described in the previous section for 24-hr ambient sampling.

Sample Compositing

Sample compositing is performed similarly to the procedure described in the previous section for 24-hr ambient sampling; however, fewer or more samples may be composited based on the intensity and duration of a storm event.

TRIBUTARY BASIN MONITORING PROGRAM

The Standley Lake Tributary Basin Monitoring Program is designed to provide water quality information for evaluation of the nutrient loadings from non-point sources in the Standley Lake Tributary Basin. The only point source discharge between CC60 on the main stem of Clear Creek and the canal diversions to Standley Lake is the Coors cooling basin return flow.

Three tributaries (the terms trib and canal are interchangeable) divert Clear Creek water to Standley Lake: the Church Ditch, the Farmers Highline ("FHL") Canal and the Croke Canal. The trib monitoring locations were selected to assess the relative loadings to the canals from areas within unincorporated Jefferson County and the city limits of Golden and Arvada. Denver Water supplies Westminster with a small quantity of water via the Kinnear Ditch Pipeline ("KDPL") which enters Standley Lake after passing through a wetlands area located west of 96th Ave and Alkire Street. The upstream and downstream locations near the wetlands are monitored when there is flow through the pipeline. The Denver Water raw water sources include Gross Reservoir and Coal Creek.

Trib samples are collected year-round on a monthly basis. All tributaries flowing at a rate that allows collection of a representative sample are monitored.

The Church Ditch delivery structure at Standley Lake was relocated in 2008 from the west side of the lake to the south side of the lake in order to avoid the potential for significant stormwater impacts to the lake. The former Church Ditch monitoring location at Standley Lake (T-09) was abandoned in 2009 when the new delivery structure (T-27) became operational.

The raw water pipeline at Semper (T-24) is monitored monthly to provide lake outflow data used to determine lake outflow loadings. The raw water pipeline at NWWTP (T-25) is monitored only when the Semper facility is offline.

TRIB SAMPLES

Locations and Sample Schedule

Sample ID	Sample Location *	Every month of the year when flowing**
T-01	Church Ditch at Headgate on MSCC	X
T-02	FHL at Headgate on MSCC	X
T-03	Croke Canal at Headgate on MSCC	X
T-04	Croke Canal at Standley Lake	X
T-11	FHL at Standley Lake	X
T-22A	Kinnear Ditch Pipeline (KDPL) – at Coal Creek entry point into pipeline	X
T-22D	Kinnear Ditch Pipeline (KDPL) downstream of wetlands	X
T-24	Raw Water Pipeline at Semper	X
T-25	Raw Water Pipeline at NWWTP	X
T-27	Church Ditch delivery structure at SL (est. 2009)	X

*MSCC = Mainstem Clear Creek

** Exceptions noted in paragraph above the table.

TRIB SAMPLES

Analytical Parameters and Analytical Scheme

Analyte	Analytical Method Reference	Reporting Limit Goal	Responsible Laboratory	Monitoring Frequency
Temperature (field)	SM 2550 B	1.0 °C	Northglenn	Monthly
pH (field)	SM 4500-H+ B-2000	1.0 Std Units	Northglenn	Monthly
Conductivity (field)	SM 2510 B-1997	10 µS/cm	Northglenn	Monthly
Turbidity (field)	ASTM D7315	1.0 NTU	Northglenn	Monthly
Dissolved Oxygen (field)	ASTM D888-09 (C)	1.0 mg/L	Northglenn	Monthly
Total Phosphorus	SM 4500-P E	0.0025 mg/L	Northglenn	Monthly
Ortho-phosphate as P (dissolved) or DRP	SM 4500-P E	0.0025 mg/L	Northglenn	Monthly
Total Suspended Solids (TSS)	SM 2540 D	1 mg/L	Thornton	Monthly
Total Organic Carbon	SM 5310	0.5 mg/L	Thornton	Monthly
E. coli	SM 9221 D	1 cfu/100mL	Thornton	Monthly
Total and Dissolved Iron	EPA 200.7	0.05 mg/L	Westminster Contract Lab	Monthly
Total and Dissolved Manganese	EPA 200.8	0.002 mg/L	Westminster Contract Lab	Monthly
Total and Dissolved Zinc	EPA 200.8	0.020 mg/L	Westminster Contract Lab	Monthly
Total Nitrogen	SM 4500-NO3 I	0.02 mg/L	Westminster	Monthly
Nitrate/Nitrite as N	SM 4500-NO3 I	0.01 mg/L	Westminster	Monthly
Ammonia as N	SM 4500-NH3 H	0.01 mg/L	Westminster	Monthly
Gross Alpha and Gross Beta	EPA 901.1	0.1 pCi/L	Westminster Contract Lab	Quarterly
Total and Dissolved Arsenic	EPA 200.8	0.001 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Barium	EPA 200.8	0.002 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Beryllium	EPA 200.8	0.002 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Cadmium	EPA 200.8	0.0005 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Chromium	EPA 200.8	0.001 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Copper	EPA 200.8	0.002 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Lead	EPA 200.8	0.0005 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Molybdenum	EPA 200.8	0.002 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Nickel	EPA 200.8	0.002 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Selenium	EPA 200.8	0.005 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Silver	EPA 200.8	0.002 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Strontium	EPA 200.7	0.002 mg/L	Westminster Contract Lab	Quarterly
Total and Dissolved Vanadium	EPA 200.8	0.0005 mg/L	Westminster Contract Lab	Quarterly
Chloride	SM 4110 A	5 mg/L	Thornton	Quarterly
Sulfate	SM 4110 A	10 mg/L	Thornton	Quarterly
Total Hardness (as $CaCO_3$)	EPA 130.2	5 mg/L	Thornton	Quarterly

Table Notes: 1) SM refers to the 23rd Edition of Standard Methods for the Examination of Water and Wastewater.

2) Reporting limit goals are matrix dependent and may be increased for complex matrices and may be lower depending on laboratory capability.

3) Quarterly parameters are analyzed in March, June, September and December at all sampled locations.

4) Samples collected for nutrients (nitrogen and phosphorus) with a turbidity reading of greater than 100 NTU may be analyzed by commercial laboratories that have demonstrated proficiency in analyzing complex matrices for nutrients.

5) YSI/Xylem ProDSS used for field measurements.

TRIB SAMPLES

Program Coordination and Sampling Team (Northglenn)

Before the scheduled Tributary sampling date:

- Ensure an adequate supply of sample containers is available from Thornton. Westminster's bottles will be picked up at Westminster on sampling day before the start of sampling at T-24.
- Label the Trip blank bottle and fill with laboratory DI water.
- Calibrate the field equipment.
- Analyze the Trip Blank for field parameters.
- Pack Trip Blank in cooler to monitor field activities for phosphorus contamination.

Sample Bottle Kit – Tribs Monthly and Quarterly

Quantity	Volume	Bottle Type	Parameter	Laboratory
9	500 mL	Rectangular plastic	Phosphorus series	Northglenn
1 (Trip blank)	500 mL	Rectangular plastic	Phosphorus series	Northglenn
9	500 mL	Plastic	TSS, Total Hardness, Chloride, Sulfate	Thornton
9	40 mL	Glass vial	TOC	Thornton
9	125 mL	Plastic	E. coli	Thornton
9	500 mL	Plastic	Total Metals	Westminster
9	500 mL	Plastic	Dissolved Metals	Westminster
9	125 mL	Brown plastic	Nitrogen series	Westminster
9	1 L	Plastic	Rads	Westminster

Sample Collection

Equipment required:

- Key to access T-2
- Key to access T-27
- Gate Code for access at T-22A
- Field data book
- Cooler with blue ice or ice
- Trip blank filled with DI
- Sample bottles as detailed above
- Bucket for sample collection
- YSI/Xylem ProDSS and probes
- Ballpoint pen

- Waterproof marker
- Chain of custody forms
- NOTE – Four wheel drive vehicle recommended for sampling due to steep inclines at some locations and potentially rugged or muddy conditions.

Sample collection procedure:

1. Meet with Westminster staff at Semper. Drop off bottles for Westminster staff to collect sample at T-25, if necessary.
2. Starting with T-24, collect field samples in the order detailed in the next sectionat each location where water is flowing.
3. Rinse the sample bucket with the field sample water repeatedly at each location before collecting the sample.
4. Collect enough volume of the field sample in the bucket to fill all sample bottles for the location.
5. Fill the appropriate sample bottles from the bucket.
6. Label the sample bottles with location, date and time of collection.
7. Analyze the field parameters and record data in the field notebook.
8. Repeat the process at each location.
9. Return to Westminster's Semper WTP. Receive T-25 sample from Westminster staff if necessary. Sign COC and keep the original copy of the COC.
10. Leave an unsigned copy of the Thornton COC at Westminster so the samples can be logged into the Excel spreadsheet by Westminster staff.
11. Complete the COCs and relinquish custody of the samples to Westminster staff. Sign COC and keep a copy of the COC. Leave the original COC with the samples.
12. Return to Northglenn Lab.
13. Contact Thornton to pick up collected field samples. Request replenishment of bottles for the next sampling event as needed.
14. Relinquish samples to Thornton and sign COCs. Retain a copy of the COC. Thornton takes possession of the original COC.
15. Northglenn retains a copy of all COCs and field documentation for permanent archive.

TRIB SAMPLES

Sampling Locations Directions and Narrative Descriptions

Tributary sampling occurs generally in an upstream to downstream fashion. Samples are collected at designated locations when water is flowing.

Trib 24
T-24 is located at Westminster's Semper Water Treatment Plant at 8900 Pierce Street. The sample is collected from the RAW water tap in the Operator's Laboratory. Do **NOT** increase the flow at the tap at this location. First tap on the left labeled 24.

Trib 22A
T-22A is the upstream sample point on the Kinnear Ditch pipeline. It is accessed through a gate located at Hwy. 72 and Plainview Rd. A key is required to access the location. The sample point is approximately 0.2 miles from Plainview Rd. Sample is taken at the flume where Coal Creek enters the pipeline.

Trib 1
T-01 is located at the Church Ditch headgate on Clear Creek. This site is accessed via Hwy 6 approximately 0.5 miles west of Hwy 93. There is a diversion from Clear Creek above this location which diverts water from Clear Creek and runs it parallel to the Creek. There are two gates at this location one sends water back into Clear Creek and the other is the Church Ditch headgate. Sample is taken from the bridge just above both gates.

Trib 2
T-2 is located at the Farmers Highline headgate on Clear Creek.
The site is accessed behind the Coors office building at the end of Archer St. Sample is taken from the bridge just inside the gate. Sample the downstream side of the headgate if it is open or on the upstream side if the headgate is closed (Clear Creek side).

Trib 3
T-3 is located at the Croke Canal headgate on Clear Creek.
This site is on Coors property. It is along the frontage road through Coors, on the east side of a small "pond". Sample the downstream side of the headgate if it is open or on the upstream side if the headgate is closed (Clear Creek side).

Trib 22D
T-22D is on the Kinnear Ditch Pipeline between 96th Ave and 88th Ave on Alkire St.
The sample is taken just downstream of the culvert on the east side of Alkire St.

Trib 04 and Trib 11
The Croke Canal (T-04) passes UNDER the Farmers Highline (T-11) in the area just west of 86th and Kipling prior to entering Standley Lake. The Farmers Highline passes OVER the Croke in a concrete structure. Sample the Croke on the south side of the Farmers Highline concrete structure. Sample the Farmers next to the white autosampler housing box.

Trib 25
Located at Westminster's Northwest Water Treatment Plant located at 104th & Wadsworth. The sample is collected by Westminster from the raw water tap on the west wall in the membrane filter gallery. Sample only if T-24 is not running.

Trib 27
T-27 is located on the south side of Standley Lake at the Church Ditch delivery structure. From Alkire, take 88th Ave east. Open Standley Lake Park gate number 23-D using a master lock key number 2006. Drive north down the trail; it curves east and intersects with a trail going south. Drive down the south trail to the delivery structure.

Photographs of the sampling locations and GPS coordinates are included in Appendix D.

TRIB CONTINUOUS MONITORING
Program Coordination and Sampling Team (Westminster)

At least one YSI multi-parameter sonde and data logging equipment are deployed year-round at the trib location where the Farmers Highline Canal (T-11) crosses over the Croke Canal (T-04), provided there is sufficient flow in one of the canals. Sondes were installed at the new Church Ditch inlet (T-27) in 2009, the FHL headgate (T-02) in 2014 and the Croke headgate (T-03) in 2015 to provide continuous in-stream monitoring of pH, ORP, turbidity, temperature and conductivity during the winter months when the canal is diverting water. Remote access to the data logger data facilitates monitoring of water quality at these inflow locations to Standley Lake. The FHL headgate station is also equipped with a tipping-bucket rain gauge.

TRIB CONTINUOUS MONITORING
Sample Locations

CCAST02	FHL at Headgate on MSCC
CCAST03	Croke Canal at Headgate on MSCC
CCAST04	Croke Canal approximately 0.5 mile from Standley Lake inlet
CCAST11	Farmers Highline Canal approximately 0.5 mile from Standley Lake inlet
CCAST27	Church Ditch at Standley Lake inlet

Table Note: Limited historical data from these locations are available as part of the Clear Creek Canal Program that was eliminated in 2008. The sample location identifications associated with the Clear Creek Canal Program have been retained.

TRIB AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Program Coordination: Westminster
Field Sampling Teams: Westminster

Autosampler sites in the Tributary Basin are located at the canal headgates and inlets to Standley Lake. The 24-hour ambient composites are collected with programmable automatic sampling devices as described in the UCC autosampler 24-hr ambient program section of this plan in order to assess any water quality impacts introduced to or removed from the canals.

Ambient samples are collected approximately seven times per year on a monthly schedule starting in April and ending in October as a continuation of the UCC autosampler 24-hr ambient sample program.

Time of travel is estimated between CCAS59 and T-02, then a time of travel table is used to set the start time for sample collection at T-11 in order to capture the same slug of water collected at the upstream sites. Composite samples are not collected on the Croke Canal or Church Ditch due to season of operation or limited flow volumes.

TRIB AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Sample Locations

CCAST02	FHL at Headgate on MSCC
CCAST03	Croke Canal at Headgate on MSCC
CCAST04	Croke Canal approximately 0.5 mile from Standley Lake inlet
CCAST11	Farmers Highline Canal approximately 0.5 mile from Standley Lake inlet
CCAST27	Church Ditch at Standley Lake inlet

TRIB AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Flow Monitoring

Flow in the canals is tracked by the ditch operators and water accountants.

TRIB AUTOSAMPLER 24-HOUR AMBIENT SAMPLES

Analytical Parameters

Analyte	Analytical Method Reference	Reporting Limit Goal	Responsible Laboratory
Total Nitrogen	SM 4500-NO3 I	0.02 mg/L	Westminster
Nitrate/Nitrite-N	SM 4500-NO3 I	0.01 mg/L	Westminster
Ammonia-N	SM 4500-NH3 H	0.01 mg/L	Westminster
Total Phosphorus	SM 4500-P E	0.0025 mg/L	Northglenn
Ortho-phosphate-P (dissolved) or DRP	SM 4500-P E	0.0025 mg/L	Northglenn
Total Suspended Solids (TSS)	SM 2540 D	1 mg/L	Thornton
Total Organic Carbon (TOC)	SM 5310 B	0.5 mg/L	Thornton
Total and Dissolved Cadmium	EPA 200.8	0.0005 mg/L	Westminster Contract Lab
Total and Dissolved Copper	EPA 200.8	0.002 mg/L	Westminster Contract Lab
Total and Dissolved Iron	EPA 200.7	0.05 mg/L	Westminster Contract Lab
Total and Dissolved Lead	EPA 200.8	0.0005 mg/L	Westminster Contract Lab
Total and Dissolved Manganese	EPA 200.8	0.002 mg/L	Westminster Contract Lab
Total and Dissolved Zinc	EPA 200.8	0.020 mg/L	Westminster Contract Lab
pH (field)	SM 4500-H+ B-2000	1.0 Std Units	Westminster
Temperature (field)	SM 2550 B	1.0 °C	Westminster
Conductivity (field)	SM 2510 B-1997	10 µS/cm	Westminster
Turbidity (field)	ASTM D7315	1.0 NTU	Westminster

Table Notes:
1) SM refers to the 23rd Edition of Standard Methods for the Examination of Water and Wastewater.
2) Reporting limit goals are matrix dependent and may be increased for complex matrices and may be lower depending on laboratory capability.
3) EPA recommended holding times less than 72 hours may not be met due to the extended sampling routine.
4) Samples collected for nutrients (nitrogen and phosphorus) with a turbidity reading of greater than 100 NTU may be analyzed by commercial laboratories that have demonstrated proficiency in analyzing complex sample matrices for nutrients.
5) Metals will be analyzed in May, July and October on the canals operating at that time intended to capture low, medium and high canal flows delivered to Standley Lake.
6) YSI/Xylem 6-series or EXO sondes are used for field measurements.

TRIB AUTOSAMPLER 24-HOUR AMBIENT SAMPLES
Program Coordination and Sampling Team (Westminster)

Field Equipment

Equipment Installed At Autosampler Locations

- Permanent and tamper-proof enclosure box with lock
- American Sigma 900, 900 Max or other automated sampler
- Power supply – solar panel, rechargeable battery or direct power
- Sample tubing long enough to reach from the autosampler to the streambed. Probes must be contained in protective piping secured in the creek bed
- Sondes equipped with dedicated field probes for turbidity, temperature, conductivity and pH
- Depth/pressure sensor
- Rain gage at T-02 and T-04/T-11
- 24 discrete HCl rinsed autosampler bottles with caps. Bottles must be numbered and inserted in the designated position in autosampler (positions numbered 1 through 12). Though samples will only be collected in bottles 1-12, a full rack of sample bottles is required to secure sample bottles in place.
- Continuous recording datalogger
- Cellular modem and antenna at T-02, T-03 (to be installed Fall 2015),T-04/T-11 and T27
- Weather conditions collected at T-27 include air temperature, relative humidity, wind speed and wind direction.

TRIB AUTOSAMPLER 24-HOUR AMBIENT SAMPLES
Autosampler Operation

On a monthly basis between April and October, autosamplers are set to collect time-weighted discrete samples for a 24 hour period. The autosamplers are located at the canal headgates and inlets to Standley Lake. In order to associate the relative impacts of the point and nonpoint pollutant sources located between the last autosampler location on Clear Creek (CCAS59), it is advisable to observe the same "slug" of water at the canal inlets to Standley Lake. The time of travel in the Farmer's Highline canal is calculated from the inflows to the canal at the headgate on Clear Creek.

The time of travel estimates table for the Farmer's Highline Canal is included in Appendix E. Time of travel estimates have not been established for the Croke Canal. The Ditch operators assist in estimating when water will arrive at Standley Lake after the ditch is turned on.

Autosampler Setup:

Equipment required:

- 24 discrete HCl rinsed autosampler bottles with caps. Though samples will only be collected in bottles 1-12, a full rack of sample bottles is required to secure sample bottles in place.
- Keys and/or tools to access autosampler enclosure.
- Field data collection/station audit sheets.

Setup Procedure:

1. Unlock sample enclosure and remove sampler head. Set aside without disturbing or bumping the distributor arm.
2. Load uncapped bottles in the correct positions in the bottom of the sampler.
3. Secure bottles in place with the retaining ring. Store caps in a ziplock bag inside the autosampler until sample collection.
4. Program the sampler according to manufacturer's instructions to collect two 450 ml storm samples per bottle, one sample per pulse.
5. After starting the autosampler, ensure that the distributer arm is positioned above bottle #1.
6. Replace sampler head and lock in place.
7. Record station/equipment information on field sheet.
8. Make sure the autosampler program is ***RUNNING*** before locking the enclosure.
9. The autosampler may be set up ahead of a scheduled start time.

Sample Collection

Additional equipment required:

- Keys and/or tools to access autosampler enclosures
- Large cooler with ice to collect sample bottles
- 24 pre-cleaned, HCl rinsed, discrete sample replacement bottles
- Field data sheets/station audit sheets
- Chain of custody forms
- Laptop with Loggernet software and data cable (9 pin serial cable with SC32B adapter) if retrieving data directly from datalogger
- One 3-liter Nalgene bottle (clean and rinsed with 1:1 hydrochloric acid) for compositing samples
- 250 mL graduated cylinder (clean and rinsed with 1:1 hydrochloric acid) for compositing samples
- Prepared sample bottles provided by participating Cities for nutrients, solids and metals analyses
    - 500 mL square plastic – phosphorus series (Northglenn)
    - 125 mL brown plastic – nitrogen series (Westminster)
    - 500 mL plastic bottle – TSS (Thornton)

- 40 mL amber glass vial with septa cap – TOC (Thornton)
- 500 mL non-preserved total metals (Westminster)
- 500 mL non-preserved bottle – dissolved metals (Westminster)

- Chain of Custody forms – Refer to Appendix C
- Field Sampling form - Refer to Appendix C

Sample Collection Procedure:

1. Unlock enclosure and remove sampler head.
2. Retrieve date/time information from autosampler if required. To collect sample history on American Sigma samplers, press <Change/ Halt> button, press <time/read> button for 5 seconds. The sample collection time for the first sample will appear. Record data on the field sheet. Press <yes> for next sample time to appear. Continue until all data is recorded.
3. Date and time information for samples is also automatically stored in a data file by the dataloggers at all sites.
4. Record station/equipment information on field sheet.
5. Make note of any samples with high turbidity determined by visual observance or data obtained from the datalogger.
6. Optional compositing of samples in the field is performed by pouring off equal volumes into a 3-liter (or larger) pre-cleaned bottle. The 12 sample bottles may also be brought back to a laboratory for compositing. Refer to the Sample Compositing Procedure Step 1. Save remaining volume of any high turbidity samples to take back to the lab. Discard remaining sample.
7. Clean out autosampler base and reload with a new set of pre-cleaned bottles.
8. Reset the autosampler by pressing the START button (Sigma 900 autosampler). Ensure that the distributor arm is parked over bottle #1 and the display reads "Program Running" before closing the autosampler and placing it back in the enclosure.
9. Return to the Westminster Water Quality Laboratory for sample splitting and distribution.

TRIB AUTOSAMPLER 24-HOUR AMBIENT SAMPLES
Sample Compositing

1. Composite samples in the laboratory if compositing was not performed in field. Shake sample bottles and pour equal volumes of sample from the first 12 bottles into a composite bottle.
2. Perform turbidity, temperature, pH and conductivity measurements on the composited sample. Enter data on the Sampling Form.
3. Use the well mixed composite sample to fill the appropriate bottles for the Northglenn, Thornton and Westminster labs.
4. If any discreet bottle(s) appears to have an unusually high turbidity and enough sample is available, analyze for turbidity and conductivity. Record on Sampling Form. If there is enough sample, pour the high turbidity discreet samples into separate nutrient and solids bottles for individual analysis.
5. Complete the COCs.
6. Relinquish to each city their respective samples (Westminster-nitrogen series and metals, Thornton-TSS and TOC, Northglenn-phosphorus series) and sign COCs as appropriate.
7. Original field data sheets and COCs are retained by the Cities of Westminster for permanent archive.
8. Samples are created in the web-accessible Excel spreadsheet by Westminster for data entry and results archive.

TRIB AUTOSAMPLER EVENT SAMPLES
Program Coordination and Sampling Team (Westminster)

The event autosampler program was initiated on the Tributaries in 2009 at CCAST11 to assess the pollutant concentrations mobilized during significant snow melt (runoff) or rain events at the location closest to Standley Lake. Automated sample collection of stormwater is triggered based on a turbidity reading of 100 NTU. The autosampler may also be activated remotely to begin sampling immediately or programmed to start sampling at a designated time in an attempt to capture the downstream effects of a storm in the upper watershed based on time of travel. The autosampler collects discrete samples every 15 minutes until the ambient condition drops below the trigger level or until the maximum number of samples is collected. The discrete samples may be analyzed individually or multiple discrete samples may be composited based on the field observations. Automated collection of storm event samples was initiated in 2014 at the headgates for the FHL and in 2015 in the Croke Canal. These locations trigger sample collection when the turbidity is 200 NTU or greater. The events samples primarily collected on the Croke Canal and Church Ditch are considered first flush samples when water is first delivered to the lake during seasonal startup of the canal/ditch.

TRIB AUTOSAMPLERS EVENT MONITORING
Sample Locations

Localized events may trigger sample collection at any of the Trib Autosampler Continuous Monitoring locations.

CCAST02 Event	FHL at Headgate on MSCC
CCAST03 Event	Croke Canal at Headgate on MSCC
CCAST04 Event	Croke Canal approximately 0.5 mile from Standley Lake inlet
CCAST11 Event	Farmers Highline Canal approximately 0.5 mile from Standley Lake inlet
CCAST27 Event	Church Ditch at Standley Lake inlet

Table Note: Historical data from these locations may be available as part of the Clear Creek Canal Program which was eliminated in 2008. The sample location identifications associated with the Clear Creek Canal Program have been retained.

TRIB AUTOSAMPLER EVENT SAMPLES
Flow Monitoring

Flow in the canals is tracked by the ditch operators and water accountants. The average daily flow data corresponding with the time-event composited samples will be used for loadings calculations for storm events.

Refer to Appendix E for the time of travel data for the Farmers Highline Canal. Time of travel studies have not been performed from the canal headgates on Clear Creek to Standley Lake for the Croke Canal or the relocated Church Ditch inlet structure.

TRIB AUTOSAMPLER EVENT SAMPLES
Analytical Parameters

Storm event samples are analyzed for the suite of analytical parameters listed below.

Analyte	Analytical Method Reference	Reporting Limit Goal	Responsible Laboratory
Temperature (field)	SM 2550 B	1.0 °C	Westminster
pH (field)	SM 4500-H+ B-2000	1.0 Std Units	Westminster
Conductivity (field)	SM 2510 B-1997	10 µS/cm	Westminster
Turbidity (field)	ASTM D7315	1.0 NTU	Westminster
Total Nitrogen	SM 4500-NO3 I	0.02 mg/L	Westminster
Nitrate/Nitrite as N	SM 4500-NO3 I	0.01 mg/L	Westminster
Ammonia as N	SM 4500-NH3 H	0.01 mg/L	Westminster
Gross Alpha and Gross Beta	EPA 900.0	0.1 pCi/L	Westminster
Total Phosphorus	SM 4500-P E	0.0025 mg/L	Northglenn
Ortho-phosphate as P (dissolved) or DRP	SM 4500-P E	0.0025 mg/L	Northglenn
Total Organic Carbon	SM 5310 B	0.5 mg/L	Thornton
Total Suspended Solids	SM 2540 D	1 mg/L	Thornton
Total and Dissolved Arsenic	EPA 200.8	0.001 mg/L	Westminster Contract Laboratory
Total and Dissolved Barium	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Beryllium	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Cadmium	EPA 200.8	0.0005 mg/L	Westminster Contract Laboratory
Total and Dissolved Chromium	EPA 200.8	0.001 mg/L	Westminster Contract Laboratory
Total and Dissolved Copper	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Iron	EPA 200.7	0.05 mg/L	Westminster Contract Laboratory
Total and Dissolved Lead	EPA 200.8	0.0005 mg/L	Westminster Contract Laboratory
Total and Dissolved Manganese	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Molybdenum	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Nickel	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Selenium	EPA 200.8	0.005 mg/L	Westminster Contract Laboratory
Total and Dissolved Silver	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Strontium	EPA 200.7	0.001 mg/L	Westminster Contract Laboratory
Total and Dissolved Vanadium	EPA 200.8	0.0005 mg/L	Westminster Contract Laboratory
Total and Dissolved Zinc	EPA 200.8	0.020 mg/L	Westminster Contract Laboratory
Total Hardness (as $CaCO_3$)	EPA 130.2	5 mg/L	Thornton
E. coli	SM 9221 D	1 cfu/100mL	Thornton

Table Notes:
1) SM refers to the 23rd Edition of Standard Methods for the Examination of Water and Wastewater.
2) Reporting limit goals are matrix dependent and may be increased for complex matrices and may be lower depending on laboratory capability.
3) EPA recommended holding times less than 72 hours may not be met due to the extended sampling routine.
4) Samples collected for nutrients (nitrogen and phosphorus) with a turbidity reading of greater than 100 NTU are analyzed by commercial laboratories that have demonstrated proficiency in analyzing complex matrices for nutrients.
5) YSI/Xylem 6-series or EXO sondes are used for field measurements.

TRIB AUTOSAMPLER EVENT SAMPLES

Field Equipment

Storm event sampling utilizes the same equipment listed in the previous section for the 24-hr ambient samples.

Autosampler Operation

Field equipment used for storm event sampling is operated using the same techniques as described in the previous section for 24-hr ambient sampling.

Sample Compositing

Sample compositing is performed similarly to the procedure described in the previous section for 24-hr ambient sampling; however, fewer samples are typically composited based on the intensity and/or duration of a storm event.

STANDLEY LAKE MONITORING PROGRAM

Standley Lake is a storage reservoir that serves as the raw drinking water source for the SLC. Over 250,000 consumers rely on Standley Lake for their drinking water. The Standley Lake ("SL") Monitoring Program is designed to provide water quality information in order to evaluate internal loadings in Standley Lake and the effects of nutrient reduction measures and best management practices on the trophic status of Standley Lake. Regularly spaced and frequent sampling is necessary to provide sufficient data for monitoring trends for the analytes used to evaluate trophic status including dissolved oxygen, chlorophyll and nutrients.

The main water quality monitoring efforts on Standley Lake include:

- Daily top to bottom lake profiles
- Bimonthly grab samples
- Zooplankton tows
- Invasive species monitoring and control

SL – DAILY LAKE PROFILES

Program Coordination (Westminster)

The sampling location in Standley Lake (Site 10-00) is situated 225 meters south of the lower lake outlet structure, between the lake outlets and the two main inlets to the lake. The lake site was selected based on the lengthy historical record of water quality monitoring data and because the water is drawn from the lake near this location via pipelines to the SLC's water treatment plants. Sampling at varying depths in the lake provides extensive information for use in drinking water treatment process decisions and evaluating water resource management options.

Standley Lake is monitored at Site 10-00 using an automated profiler equipped with a multi-probe sonde four times each day from early spring to late fall for the analytes listed in the following table. The profiler is removed from the lake prior to freezing of the lake surface. Refer to the watershed map in Appendix B for the location of the SL monitoring location. The solar powered unit collects data from the surface of the lake to within 2 meters off the bottom and every meter in between. The profiler data is telemetered using a cellular telephone modem and provides a depth-integrated profile of the lake water quality.

SL – DAILY LAKE PROFILES

Analytical Parameters

Analyte	Analytical Method Reference	Reporting Limit Goal
Temperature	SM 2550 B	1.0 °C
pH	SM 4500-H+ B-2000	1.0 Std Units
Conductivity	SM 2510 B-1997	10 µS/cm
Turbidity	ASTM D7315	1.0 NTU
Dissolved Oxygen	ASTM D888-09 (C)	1.0 mg/L
Chlorophyll	YSI (optical probe)	1.0 µg/L
ORP	SM 2580 A	1.0 mv

Table Notes: 1) SM refers to the 23rd Edition of Standard Methods for the Examination of Water and Wastewater.
2) Reporting limits are matrix dependent and may be increased for complex matrices.
3) YSI/Xylem EXO sondes are used for all lake profile measurements.

SL – BIMONTHLY GRAB SAMPLES
Program Coordination and Sampling Team: Westminster

The same sampling location in Standley Lake (Site 10-00) is used for both the daily lake profiles and the bimonthly grab samples. Sampling at varying depths in the lake provides extensive information for use in drinking water treatment process decisions and evaluating water resource management options. Refer to the watershed map in Appendix B for the location of the SL monitoring location.

SL – BIMONTHLY GRAB SAMPLES
Locations

Grab samples are collected twice each month as long as the lake is not frozen and weather permits. The raw water pipeline at Semper (T-24) may be sampled for a subset of the routine analytical parameters when the lake is frozen or when safety of the sampling team is a concern (i.e. high winds, frozen boat ramp, etc.).

Sample Identification	Sample Location
SL 10-00	SL surface
SL 10-PZ	SL at two times the Secchi depth
SL 10-70	SL at two meters above the lake bottom. (The depth of the lake is 23.7 meters (77.75 ft) when the lake is full at gage height 96)
SL 69-00	SL surface at the boat dock
T-24	The lower lake outlet (T-24) is located at an elevation approximately 2 meters higher than sample point SL 10-70

SL – BIMONTHLY GRAB SAMPLES

Analytical Parameters

Analyte	Analytical Method Reference	Reporting Limit Goal	Responsible Laboratory
Temperature (field)	SM 2550 B	1.0 °C	Westminster
pH (field)	SM 4500-H+ B-2000	1.0 Std Units	Westminster
Conductivity (field)	SM 2510 B-1997	10 µS/cm	Westminster
Turbidity (field)	ASTM D7315	1.0 NTU	Westminster
Dissolved Oxygen (field)	ASTM D888-09 (C)	1.0 mg/L	Westminster
ORP (field)	YSI (electrode)	1 mv	Westminster
Chlorophyll (field)	YSI (electrode)	1.0 µg/L	Westminster
Secchi Depth (field)	Secchi disk	0.1 meter	Westminster
Total Nitrogen	SM 4500-NO3 I	0.02 mg/L	Westminster
Nitrate/Nitrite as N	SM 4500-NO3 I	0.01 mg/L	Westminster
Ammonia as N	SM 4500-NH3 H	0.01 mg/L	Westminster
Gross Alpha and Gross Beta	EPA 900.0	0.1 pCi/L	Westminster
Zooplankton	SM 10900	1 per L	Westminster
Algae	SM 10900	1 per mL	Westminster
Chlorophyll *a*	SM 10200-H	1.0 µg/L	Westminster
Total Phosphorus	SM 4500-P E	0.0025 mg/L	Northglenn
Ortho-phosphate as P (dissolved) or DRP	SM 4500-P E	0.0025 mg/L	Northglenn
Total Organic Carbon	SM 5310 B	0.5 mg/L	Thornton
Total Suspended Solids	SM 2540 D	1 mg/L	Thornton
Total Hardness (as $CaCO_3$)	EPA 130.2	5 mg/L	Thornton
E. coli	SM 9221 D	1 cfu/100mL	Thornton
BTEX	EPA 524.2	0.0005 mg/L	Thornton
Total and Dissolved Arsenic	EPA 200.8	0.001 mg/L	Westminster Contract Laboratory
Total and Dissolved Barium	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Beryllium	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Cadmium	EPA 200.8	0.0005 mg/L	Westminster Contract Laboratory
Total and Dissolved Chromium	EPA 200.8	0.001 mg/L	Westminster Contract Laboratory
Total and Dissolved Copper	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Iron	EPA 200.7	0.05 mg/L	Westminster Contract Laboratory
Total and Dissolved Lead	EPA 200.8	0.0005 mg/L	Westminster Contract Laboratory
Total and Dissolved Manganese	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Molybdenum	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Nickel	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Selenium	EPA 200.8	0.005 mg/L	Westminster Contract Laboratory
Total and Dissolved Silver	EPA 200.8	0.002 mg/L	Westminster Contract Laboratory
Total and Dissolved Strontium	EPA 200.7	0.001 mg/L	Westminster Contract Laboratory
Total and Dissolved Vanadium	EPA 200.8	0.0005 mg/L	Westminster Contract Laboratory
Total and Dissolved Zinc	EPA 200.8	0.020 mg/L	Westminster Contract Laboratory
Dissolved Silica	EPA 200.8	0.1 mg/L	Westminster Contract Laboratory
Total Mercury	EPA 245.1	0.0002 mg/L	Westminster Contract Laboratory

Table Notes: 1) SM refers to the 23rd Edition of Standard Methods for the Examination of Water and Wastewater.
2) Reporting limit goals are matrix dependent and may be increased for complex matrices and may be lower depending on laboratory capability.
3) YSI/Xylem EXO sondes are used for all lake field measurements except for secchi depth.

SL – BIMONTHLY GRAB SAMPLES
Analytical Scheme

The analytical scheme for Standley Lake was designed to capture the biological, physical and chemical changes occurring in the lake ecosystem throughout the year. Seasonality plays an important role in lake dynamics and subsequently, on the water treatment processes. The table below details the variable analytical scheme, with the caveat that weather patterns may require modification to the plan.

Month	**Lake Sample Location**	**Analytes**												
		Hand Profile	Secchi depth	Rads	E coli	Zooplankton	Nutrients	Metals	Algae	Chlorophyll *a*	TOC	TSS	Total Hardness	BTEX
January 1st week	10-00	X	X		X	X								
	10-PZ						X	X	X	X	X	X	X	
	10-70	X			X		X	X			X	X	X	
January 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							
February 1st week	10-00	X	X		X	X								
	10-PZ						X		X	X	X	X		
	10-70	X			X		X				X	X		
February 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							
March 1st week	10-00	X	X	X	X	X								
	10-PZ			X			X	X	X	X	X	X	X	
	10-70	X		X	X		X	X			X	X	X	
March 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							
April 1st week	10-00	X	X		X	X								
	10-PZ						X		X	X	X	X		
	10-70	X			X		X				X	X		
April 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							

Month	Lake Sample Location	Analytes												
		Hand Profile	Secchi depth	Rads	E coli	Zooplankton	Nutrients	Metals	Algae	Chlorophyll *a*	TOC	TSS	Total Hardness	BTEX
May 1st week	10-00	X	X		X	X								
	10-PZ						X		X	X	X	X		
	10-70	X			X		X				X	X		
May 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							
June 1st week	10-00	X	X	X	X	X								
	10-PZ			X			X	X	X	X	X	X	X	
	10-70	X		X	X		X	X			X	X	X	
June 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							
July 1st week	10-00	X	X		X	X								
	10-PZ						X		X	X	X	X		
	10-70	X			X		X				X	X		
July 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							
	69-00													X
August 1st week	10-00	X	X		X	X								
	10-PZ						X		X	X	X	X		
	10-70	X			X		X				X	X		
August 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							
September 1st week	10-00	X	X	X	X	X								
	10-PZ			X			X	X	X	X	X	X	X	
	10-70	X		X	X		X	X			X	X		

Month	Lake Sample Location	Analytes												
		Hand Profile	Secchi depth	Rads	E coli	Zooplankton	Nutrients	Metals	Algae	Chlorophyll *a*	TOC	TSS	Total Hardness	BTEX
September 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							
October 1st week	10-00	X	X		X	X								
	10-PZ						X		X	X	X	X		
	10-70	X			X		X				X	X		
October 3rd week	10-00	X	X			X								
	10-PZ						X	X	X	X			X	
	10-70	X					X	X					X	
November 1st week	10-00	X	X		X	X								
	10-PZ						X		X	X	X	X		
	10-70	X			X		X				X	X		
November 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							
December 1st week	10-00	X	X	X	X	X								
	10-PZ			X			X	X	X	X	X	X	X	
	10-70	X		X	X		X	X			X	X	X	
December 3rd week	10-00	X	X			X								
	10-PZ						X		X	X				
	10-70	X					X							

Table notes:
1) Hand Profile includes collecting data using the sonde for temperature, pH, conductivity, turbidity, DO, chlorophyll and ORP at 0.1 meter intervals from the surface of the lake to 10 meters depth, then at 1 meter internals to the bottom of the lake.
2) Rads includes Gross Alpha and Gross Beta.
3) The full list of metals will be analyzed during the first week of Jan, Mar, June, Sept and Dec and the third week in October (after turnover).
4) Only total and dissolved arsenic will be analyzed during the first week of October.
5) Nutrients include the phosphorus series and the nitrogen series analytes. Phosphorus series includes total P and dissolved ortho-phosphate-P (also referred to as DRP). Nitrogen series includes total N, ammonia-N and nitrate/nitrite-N.
6) Total Hardness is reported as $CaCO_3$.

SL – BIMONTHLY GRAB SAMPLES
Program Coordination (Westminster)

SL Sample bottle kit

The sample containers required for each monitoring event varies depending on the parameters to be analyzed. Westminster will assemble sample bottle kits for each event. The following table details the sample containers for various parameters.

Parameter	**Volume**	**Bottle Type**	**Laboratory**
Phosphorus series	500 mL	Rectangular plastic	Northglenn
Nitrogen series, UV-254	125 mL	Rectangular brown plastic	Westminster
Rads	1 L	Plastic	Westminster
Zooplankton	250 mL	Plastic	Westminster
Algae	1 L	Plastic	Westminster
Chlorophyll *a*	1 L	Brown plastic	Westminster
Total metals, Total Hg	500 mL	Plastic	Westminster
Dissolved metals	500 mL	Plastic	Westminster
TOC	40 mL	Glass vial	Thornton
TSS, Total Hardness	500 mL	Plastic jug	Thornton
E. coli	125 mL	Plastic	Thornton
BTEX	3 x 40 mL	Glass vial	Thornton
BTEX trip blank	40 mL	Glass vial	Thornton

Table Notes:
1) A trip blank is required to be prepared when field samples are collected for BTEX. The trip blank is comprised of a pre-cleaned glass vial filled with DI by the laboratory and is used to monitor for volatile organic contamination during transport and lab storage prior to analysis. Analysis of the trip blank is only required when any of the BTEX analytes are detectable in the field samples.
2) Phosphorus series includes total P and dissolved ortho-phosphate-P (also referred to as DRP).
3) Nitrogen series includes total N, ammonia-N and nitrate/nitrite-N.
4) Rads includes Gross Alpha and Gross Beta
5) BTEX includes benzene, toluene, ethyl benzene and total xylenes

SL – BIMONTHLY GRAB SAMPLES

Sample Collection

Equipment

Pontoon Boat
Marking Pen – Waterproof
Depth Finder
Secchi Disk
Log book and pen
Van Dorn bottle
Labeled sample bottles (refer to individual monitoring plans)
Churn sample splitter
PZ tube sampler
Ice packs
Coolers
Chain of custody forms
YSI EXO2 Sonde – calibrated for hand profile
YSI 6600 Sonde - calibrated
YSI 650 Meter and cable
Handheld anemometer/%Relative humidity meter
Cellular phone
GPS unit
Digital camera
Boat Tool Kit
Laptop computer – fully charged with communication cable and Loggernet application installed
Water pitcher and wide bristle brush for cleaning sonde cage
Jackets, hats, gloves or other protective clothing as appropriate for the weather conditions
First aid kit
Personal flotation devices (one per person)
Survival Suits – yellow (1 hr protection) and orange (1/2 hr protection) -as appropriate
Profiler enclosure key
Boat Anchor(s)
Key for boat ramp during off-season
Zooplankton tow net – 63 µm

Sample collection procedure

At Laboratory

- Prepare and label all required sampling containers.
- Complete basic information on the chain of custody (COC) forms.
- Update the YSI EXO2 file names using the format XXMMDDYY, where XX denotes the field sampling program identification (e.g. SL, CC, RC, etc.), MM denotes the month, DD denotes the day and YY denotes the year.
- Notify laboratories about the sampling event and schedule sample pickup.
- Assemble the sampling equipment and load into the truck.
- Calibrate a YSI EXO2 sonde for the hand profile. While the Profiler is deployed, also calibrate a YSI 6600 sonde to swap out.

Sampling on Standley Lake

Van Dorn Bottle

- The Van Dorn bottle provides a means of collecting water samples at selected depths below the surface. It is made of an open-ended plastic cylinder that is attached to a rope, and lowered to any desired depth.
- Each end of the cylinder is fitted with a rubber cover. The Van Dorn bottle is attached to the length of rope, marked in 0.1 m increments, with the covers pulled out and attached to the trigger device.
- The depth of the lake is determined using the sonde. The bottle is lowered to a depth one meter above the bottom of the lake.
- A metal weight called a "messenger" is attached to the rope above the bottle. The water sample is taken by dropping a weighted “messenger" down the rope. When the weight hits the triggering device on the upper Van Dorn bottle, the catch releases the rubber end covers. The two covers are pulled together and seal off the ends.
- When the bottle has been closed, it is pulled to the surface.
- Water samples from the Van Dorn bottle are transferred to the appropriate sample containers.
- The Van Dorn sampler has a four liter capacity. If the volume of sample required is greater than the Van Dorn sampler can hold, multiple sample volumes can be collected and combined in the churn. The churn and churn spigot should be rinsed out with new sample water prior to sample collection in order to prevent cross-contamination from prior samples. Once the churn contains enough sample, it is thoroughly mixed and the sample is dispensed into the required sample containers.
- Sample containers are labeled with sample location, date and time of sample collection and the sampler’s initials. The label should indicate any preservative in the sample container.
- Full sample containers are placed in coolers with ice packs until they are returned to the laboratory.

PZ Tube Sampler

- The PZ (photic zone) sampler is used to sample a column of water from the surface of the lake to the depth of the photic zone. Photic zone is defined as twice the secchi depth. The PZ sampler is comprised of a churn sample splitter connected to a polypropylene tube equipped with a quick release connector on one end and a check valve on the other end.
- Measure the secchi depth through the floor port on the pontoon boat. Do not wear sunglasses. Record data in the logbook.
- Connect the end of the tube to the hose barb on the churn.
- The tube is marked in 0.5 meter lengths. Lower the end of the tube with the check valve into the water until it is at the depth of the photic zone.
- Pull the tube up out of the water and hold the end with the check valve upside-down at a height over your head, until the tube drains down to floor level, then quickly drop the check-valve end of the tube back into the water vertically to the depth of the photic zone. The water entering the end of the tube will push the air bubble and prior sample into the churn as the tube is lowered into the water. Use the first collected volume of sample to rinse the tube and churn. Waste the sample back to

the lake. Start collecting the second volume of sample. Repeat this step until sufficient quantity of sample has been collected in the churn. The capacity of the churn is 12 liters.

- Once the churn contains enough sample, it is thoroughly mixed and the sample is dispensed into the required sample containers.
- Sample containers are labeled with sample location, date and time of sample location and the sampler's initials. The label should indicate any preservative in the sample container.
- Sample containers are placed in a cooler with ice packs until they are returned to the laboratory.

Surface Sampling

- Surface sampling is accomplished through the floor port of the pontoon boat. Sample containers are dipped into the water until full to collect samples.
- Sample containers are labeled with sample location, date and time of sample collection and the sampler's initials. The label should indicate any preservative in the sample container.
- Sample containers are placed in a cooler with ice packs until they are returned to the laboratory.

Zooplankton Tows

- Zooplankton samples are collected at SL-10 using a 63 µm tow net.
- A vertical tow sampling methodology involves lowering the tow net to the bottom of the lake and retrieving it at a slow speed of approximately one foot per second up to the surface.
- The zooplankton collected in the net are washed into a 250 mL sample bottle using multiple DI water rinses to ensure all organisms in the net are transferred to the sample container. The final volume in the bottle is not required to be consistent.
- The sample depth is recorded on the sample bottle along with date and location.

SL – AQUATIC INVASIVE SPECIES MANAGEMENT

Eurasian Watermilfoil

Eurasian Watermilfoil ("EWM"), *Myriophyllum spicatum L*, is a non-native, aquatic, noxious weed that grows rapidly and to a depth of 35 feet. EWM grows in dense mats that severely interfere with recreation and has been known to provide a substrate for blue-green algae growth. Blue-green algae blooms can ultimately cause taste and odor events in drinking water supplies. EWM was first observed in Standley Lake in 1998. It was positively identified in 2000. In 2012, it was confirmed that the Eurasian watermilfoil hybridized with a native Colorado species Northern watermilfoil (Myriophillum sibiricum). The hybrid species is more robust and grows even quicker than the Eurasian watermilfoil.

Annual surveys of weevil populations in the lake were performed by contractors until 2013, but beginning in 2014 will be performed by the City of Westminster.

Eurasian milfoil weevils have been stocked in the lake (on the west side) on four occasions from 2004 through 2011. The weevil larva bore into the stem of the milfoil which damages the plant. When an adequate weevil population is sustained, the weevils may be able to control the spread of the milfoil.

As lake conditions permit, bathymetric studies are performed on Standley Lake during the early summer for mapping the submerged aquatic vegetation in order to assess milfoil growth and the effectiveness of the remedies.

Zebra and Quagga Mussels

Zebra and quagga mussels are non-native, aquatic invasive species that are introduced to new water bodies by the unintentional transfer of organisms from an infested water body via boats or fishing bait. Aquatic mussels cause serious damage to the ecosystem and result in costly control procedures for drinking water treatment facilities. Both zebra and quagga mussels were discovered in 2008 in a few of Colorado's lakes. Prevention of aquatic mussel infestation is key to protecting Standley Lake. An intensive boat inspection and decontamination program was initiated in 2008 to protect the lake from new invasive species. No live aquatic baits are allowed at Standley Lake.

Standley Lake is monitored for aquatic mussels every two weeks using the zooplankton tow procedure described previously. The tows are performed at the lake inlets, SL-10, and the boat ramp/outlet area. Several invasive species have a planktonic life stage and sampling with the plankton nets will provide early warning of infestation. In addition, substrate samplers, constructed and monitored by Colorado Parks and Wildlife are placed throughout the lake. Substrate samplers are made up of a float, rope, plastic plates and an anchor weight. A plate is located at every 10 feet of depth from the surface to the bottom of the lake at various locations. The plates and ropes are checked periodically for aquatic mussel growth. A plate or rope that feels like sand paper will be scraped and examined under the microscope for veligers (zebra or quagga mussel larvae).

Shoreline surveys are performed when the water level is at the lowest for the year. A shoreline survey consists of walking the shoreline in teams looking for adult mussels attached to any hard substrate.

DATA MANAGEMENT AND REPORTING

The City of Westminster is responsible for management of the data collected in support of the IGA monitoring efforts. A Microsoft Excel spreadsheet is used for archival of monitoring data collected for all programs detailed in this document except the lake profile data. The IGA partners have access to the system via a secure internet host site. The City of Thornton is responsible for backing up the data.

The City of Westminster logs in all samples collected by the various sampling teams. The coordinated sample creation effort reduces interpretation errors and subsequent reporting inconsistencies. Each IGA partner is responsible for data entry of the analytical results for their assigned analyses into the spreadsheet. On a semi-annual basis, a peer review team comprised of at least one representative from each of the SLC, evaluates the data and identifies possible errors or data anomalies. Each city makes corrections to the spreadsheet and submits a final version of the data.

Data results from this program, along with other reporting requirements as stated in the Joint Agreement, will be reported to the Colorado Water Quality Control Commission on an annual basis. Only data collected during the normal sampling schedule is included in the annual report. The data is reported in tabular and graphic formats.

Each laboratory must retain all records (i.e. field notebooks and logs, instrument logs, bench sheets, instrument printouts, electronic data files, chain of custody forms, etc.) pertaining to the monitoring programs until the SLC IGA representatives jointly, in writing, authorize disposal of the records.

The periods of record for monitoring data formats are summarized in the following table:

Program	Period of Record	Available Format
Clear Creek Grabs	1994 – 2001	MS Access/Excel
	2002 – current	MS Excel
Clear Creek Grabs - EPA Metals Data	1994 – current	MS Excel
Clear Creek Autosamplers Ambient	2006 – current	MS Excel
Clear Creek Autosamplers Event	2006 – current	MS Excel
Standley Lake Tributaries – grabs and autosamplers (includes data for the program formerly called Clear Creek Canals)	1988 – 2001	MS Access/Excel
	2002 - current	MS Excel
Standley Lake	1988 – 2001	MS Access/Excel
	2002 - current	MS Excel

Table Notes: The data archive includes phosphorus data from 1999-current, all Thornton data from 2001-current and all Westminster data from 2002-current.

SUPPLEMENTAL INFORMATION - 3

CLEAR CREEK / STANDLEY LAKE DATA ANALYSIS AND INTERPRETATION - 2017

TABLE OF CONTENTS

I. INTRODUCTION

This document serves as a supplement to the 2017 Clear Creek / Standley Lake Watershed Annual Report. It describes an analysis of 2017 water-quality data in the Upper Basin, Canal Zone, and Standley Lake, and compares data from 2017 to data from the previous five years (2012-2016). Constituents included in this analysis are discharge (flow), total suspended solids, total phosphorus, and total nitrogen. Constituent concentrations that are below the detection limit are analyzed and reported at ½ the detection limit.

II. UPPER BASIN FLOWS AND WATER QUALITY

This section describes an analysis of water-quality data in the Upper Basin in 2017. The analysis is based on data from two sampling locations CC26 (the upper station - Clear Creek at Lawson Gage) and CCAS59/60 (the lower station - Clear Creek upstream of the Church Ditch headgate). The data from each location include both grab samples and composite samples. Grab samples represent the conditions at a single point of time. Composite samples, comprised of multiple samples collected over 24 hours, represent conditions occurring over the entire collection period. The data presentation and discussion in this section focus on ambient (non-event) samples. However, loading estimates are presented including and excluding the event samples (e.g. storm event samples).

DISCHARGE

The annual hydrographs for Upper Basin locations CC26 and CC60 (Figure 1) both show a snowmelt-dominated pattern with the rising limb beginning in early May and the falling limb extending through summer. The hydrographs exhibit twin peaks in early and late June, similar to that observed in 2016 (Hydros, 2017), with the first peak being slightly higher than the second peak. This pattern is driven by a period of lower air temperatures decreasing the rate of snowmelt. Both hydrographs have intermittent periods of increased streamflow due to precipitation events.

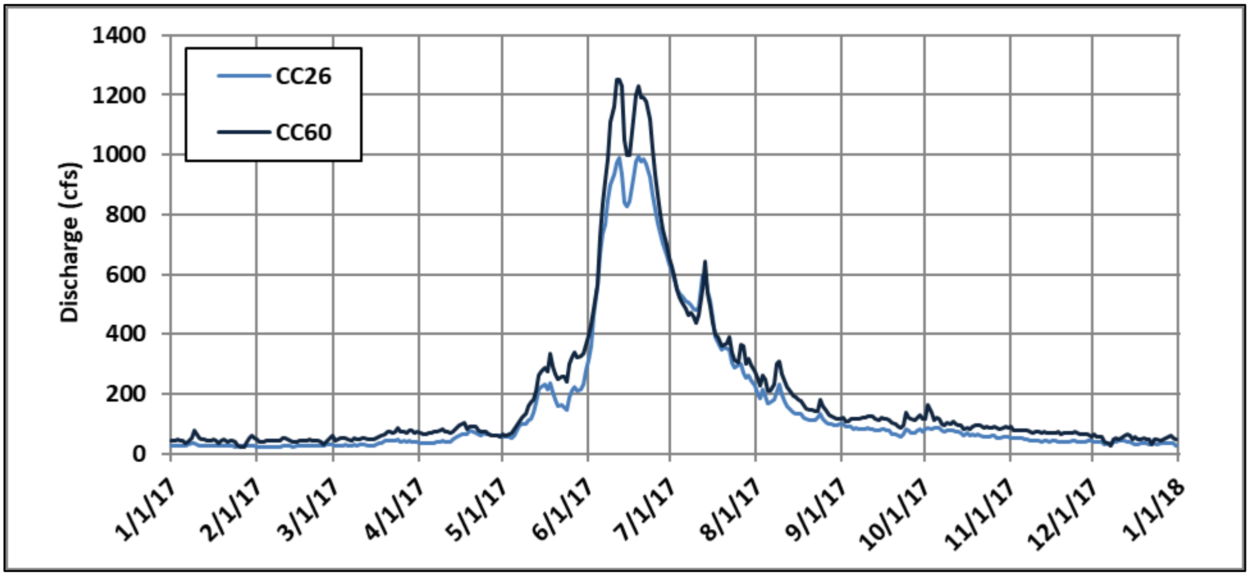


Figure 1. 2017 Clear Creek Hydrographs for the Upper Station (CC26) and the Lower Station (CC60)

Total annual flows at the upper station (CC26) of 113,704 AF were 12% above the 2012-2016 average of 101,537 AF. Total annual flows at the lower station (CC60) of 141,280 AF were 7% below the 2012-2016 average of 152,066 AF. This discrepancy in flow patterns for 2017 (one station above average and the other below average) was affected by an unusual precipitation distribution. Comparing total precipitation in 2017 at the two locations to average total annual precipitation in 2012-2016 shows similar departures from average. Precipitation[1] at CC26 was 24% higher than average. Precipitation[2] at CC60 was 7% lower than average. Total annual flow volumes for the two locations (2012-2017) are presented in Figure 2. The 2012-2016 average flow volume is included for reference.

---

[1] Precipitation data from the upper station are from Cabin Creek weather station located southwest of Georgetown, CO. NOAA station ID: GHCND: USC00051186 (National Weather Service, 2018).
[2] Precipitation data from the lower station are from Golden 3SW weather station located southwest of Golden, CO. CSU station ID: 053387 (National Weather Service, 2018).

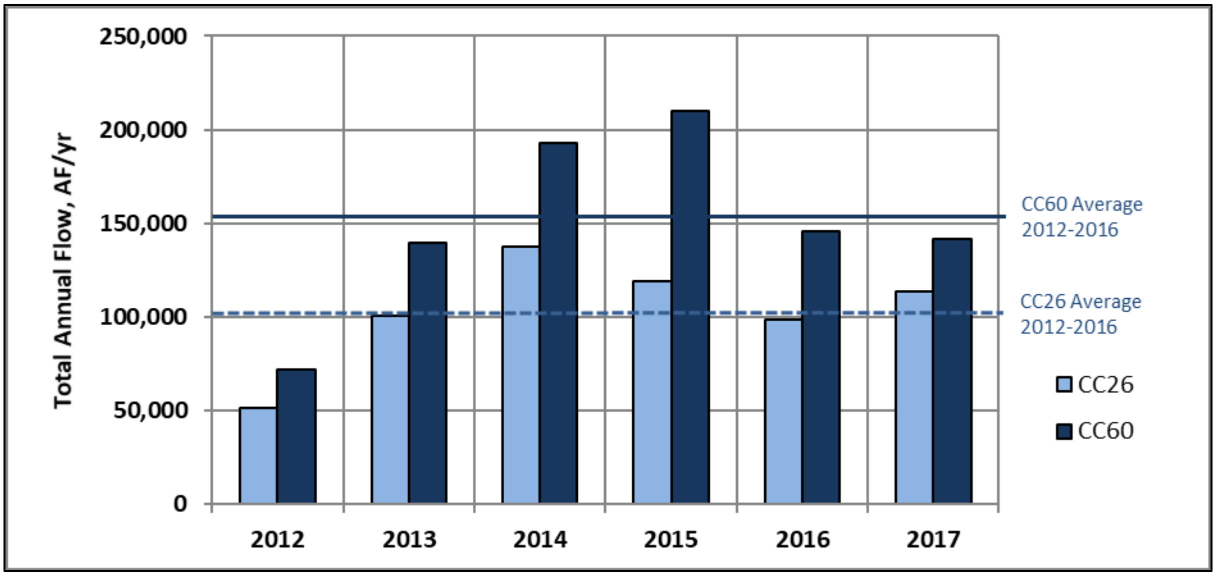


Figure 2. Total Annual Flow in Clear Creek at CC26 and CC60, 2012-2017

Hydrographs from CC60 for 2012-2016 are shown in Figure 3. The patterns and timing of yearly snowmelt-driven flows are consistent with previous years, but the magnitude of the flows is lower than the previous three years. Runoff also began later in 2017, with the hydrograph beginning to rise in May rather than April.

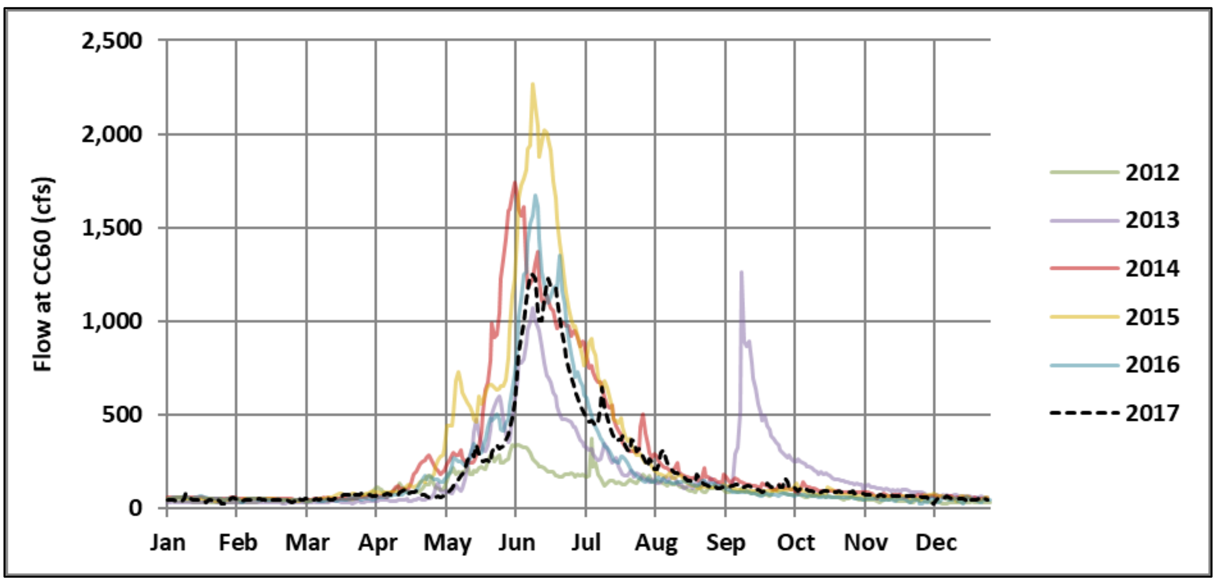


Figure 3. Annual Clear Creek Hydrographs for 2012-2017 (CC60)

WATER QUALITY AND NUTRIENT LOADING

Total Suspended Solids

Total suspended solids concentrations from 2017 ambient composite and grab samples for CCAS59/60 and CC26 are displayed in Figure 4. The maximum observed concentration for the upper station was 16 mg/L on July 18. The maximum observed concentration of TSS was 21 mg/L at the lower station (CC60) on May 10. Consistent with previous years, TSS concentrations at the upper station (CC26) were lower than concentrations observed at the lower station.

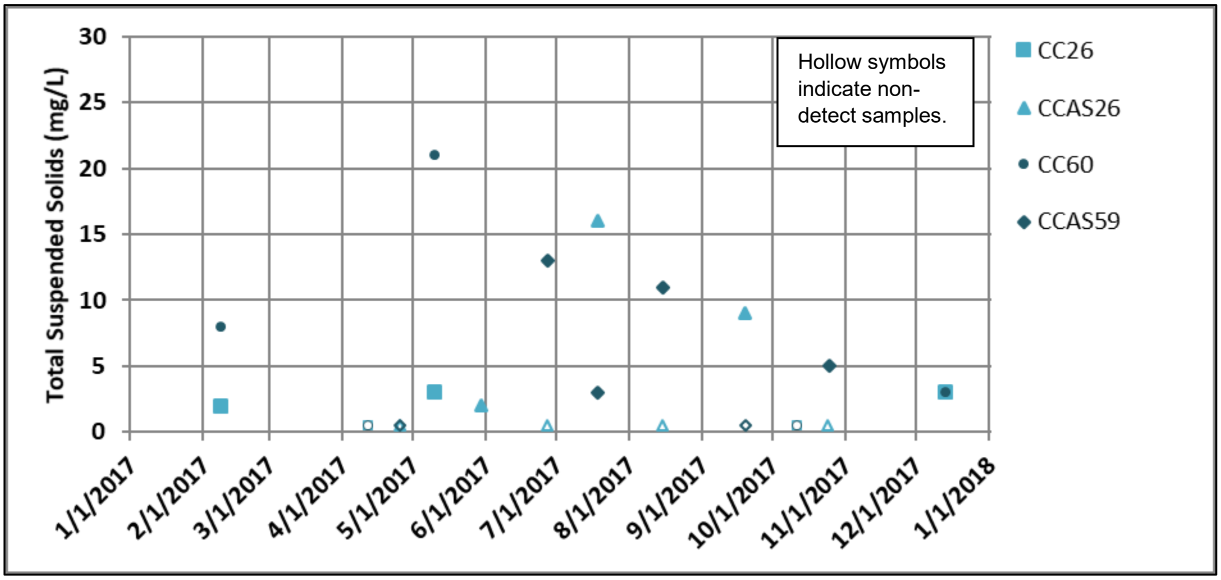


Figure 4. Total Suspended Solids Concentrations (Non-Event) in the Upper Basin, 2017

TSS sample results from the previous six years are presented in Figure 5. In this figure, and subsequent related figures for TP and TN, the November to March period is highlighted in grey. This is done to emphasize the seasonality of the observed water-quality patterns. Peak concentrations in 2017 for CCAS59/60 were lower than previous years. However, peak concentrations at the upper station were higher than the previous two years.

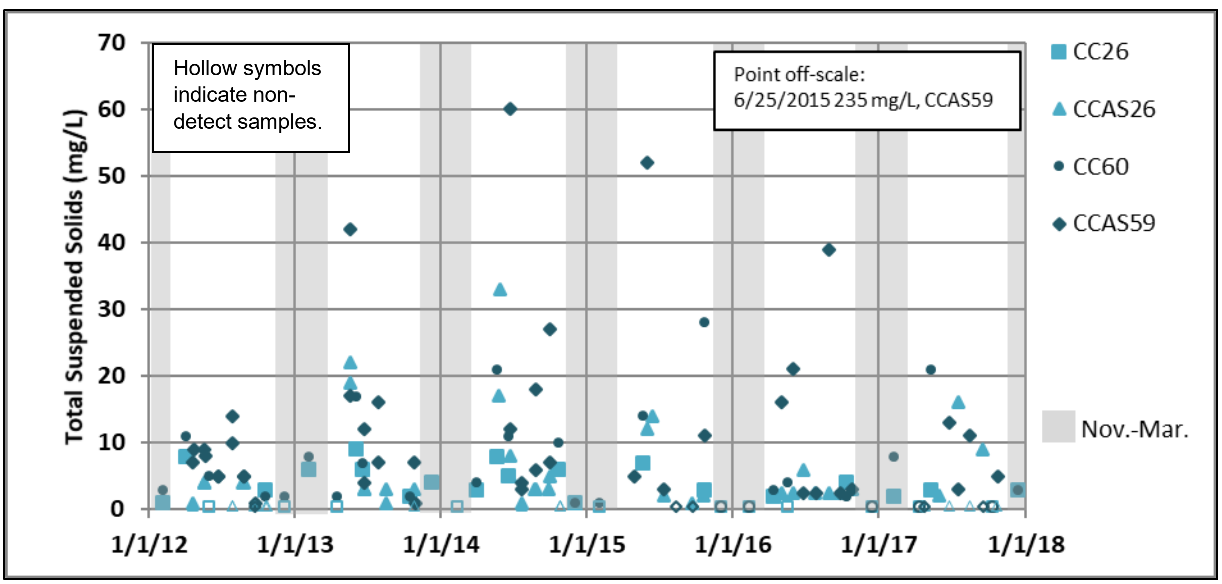


Figure 5. Total Suspended Solid Concentrations (Non-Event) in the Upper Basin, 2012-2017

Average monthly TSS concentrations at the lower station in 2017 are compared to the average and range of the previous five years (2012-2016) for the runoff season in Table 1. The runoff season (April-July) is displayed because these are the months that typically have the highest flows and subsequently higher concentrations. All concentrations were within the range observed in the previous five years with the exception of April, which had unusually low concentrations, all below detection limits. Low concentrations in April can be explained by lower than average flow conditions (-25%) during the month of April (Figure 3). These data show how the timing of runoff can influence constituent concentrations.

Table 1. Monthly Average Total Suspended Solids Concentrations (Non-Event) in the Upper Basin at CCAS59/60, Red Values are Below Detection Limit and are Reported as ½ the Detection Limit (0.5 mg/L)

Month	2017 Average TSS (mg/L)	2012-2016 Average TSS (mg/L)	2012-2016 Range of TSS (mg/L)
April	0.5	5.9	2.0 – 11.0
May	21.0*	15.1	4.0 – 42.0
June	13.0*	34.1	2.5 – 235.0
July	3.0*	7.4	2.5 – 16.0

* "Average" based on one observed value

Loads were calculated using daily flows from USGS gage measurements and concentration data from samples collected as part of the Upper Clear Creek/Standley Lake Watershed Water Quality Monitoring Program. Consistent with previous analyses, a mid-point step function was used to fill in daily concentrations between available sample data. Annual loads are then calculated as the sum of individual daily loads. Non-storm-event TSS loading at CC26 and CCAS59/60 was calculated for 2017 and compared to estimates from 2012-2016 (Figure 6). Loads at the upper station were 25% lower than the average of the previous five years. Loads at the lower station were 56% below average, this is expected given the lower than average TSS concentrations observed.

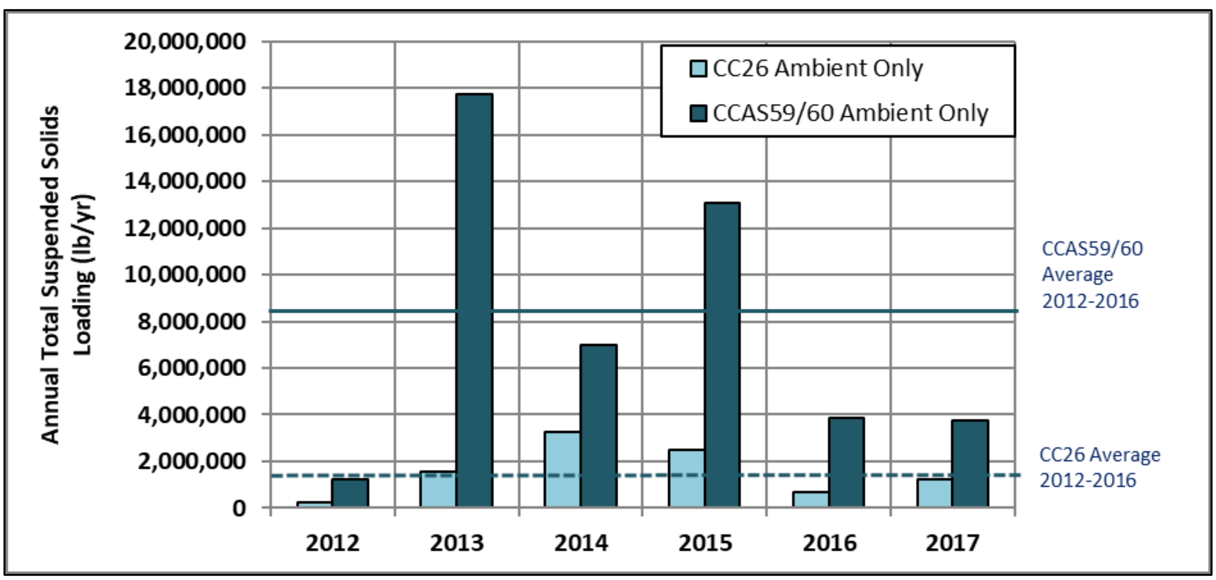


Figure 6. Total Suspended Solids Load Estimates in the Upper Basin, 2012-2017

Volume-weighted concentrations were computed at the two key locations for the past six years (Figure 7). They were calculated by summing the annual load and dividing by the annual flow volume. Volume-weighted concentrations in 2017 were similar to those from 2016.

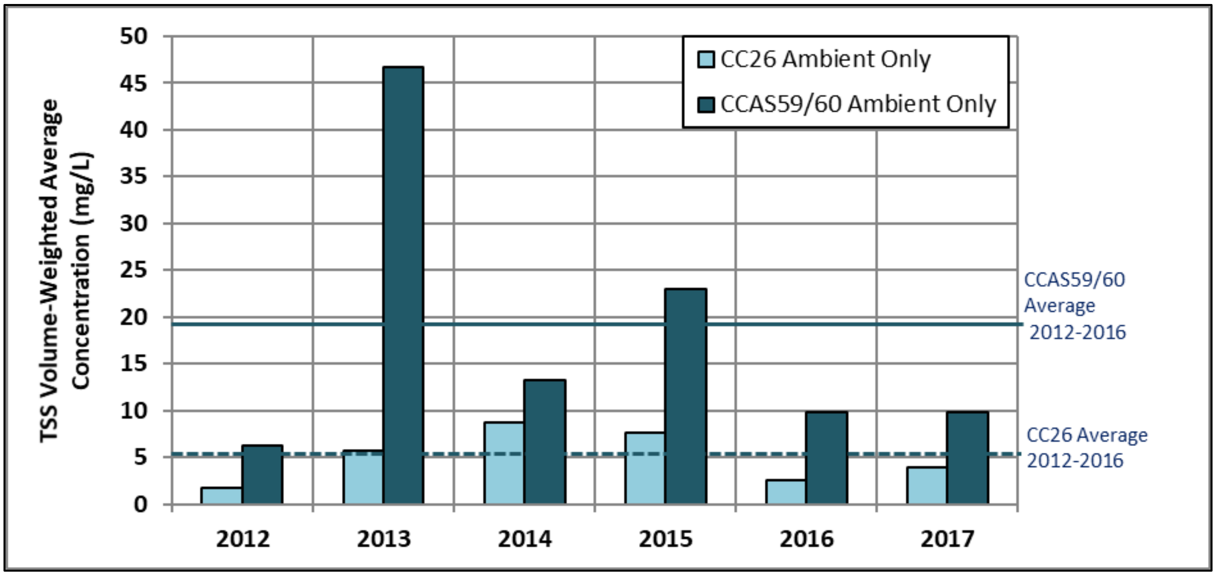


Figure 7. Total Suspended Solids Volume-Weighted Concentration Estimates in the Upper Basin, 2012-2017

Consistent with 2016, one possible explanation of the lower TSS loadings is the sample timing. Figure 8 shows the sample timing in relation to the hydrograph, it is apparent that peak flows occurred between sampling events. Samples on the rising limb of the hydrograph are crucial to improving the accuracy of loading estimates as the rising limb typically have higher concentrations. Sample timing coupled with lower peak flows (Figure 3) could explain why computed loadings were low this year.

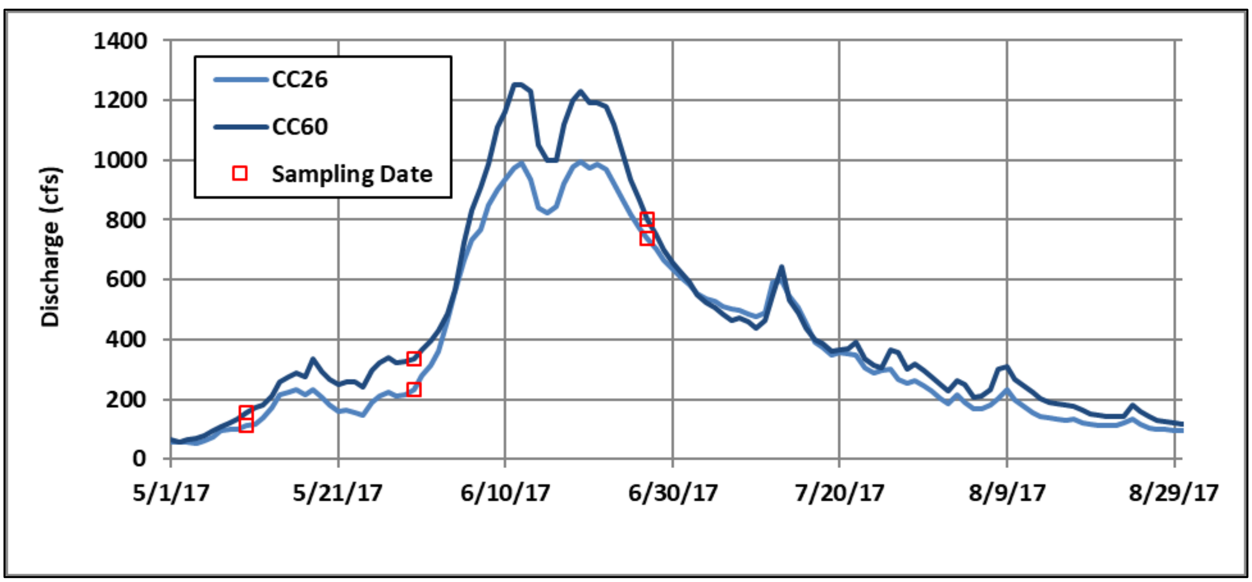


Figure 8. Sample Timing and Flow at CC26 and CC60

Total Phosphorus

Total phosphorus concentrations from grab samples and ambient composites in the Upper Basin are displayed in Figure 9. For both stations, most of the concentrations throughout the year remained relatively consistent. At CC60, there were increases in February, May, and November with May having the highest measured concentration (31.1 µg/L on May 10).

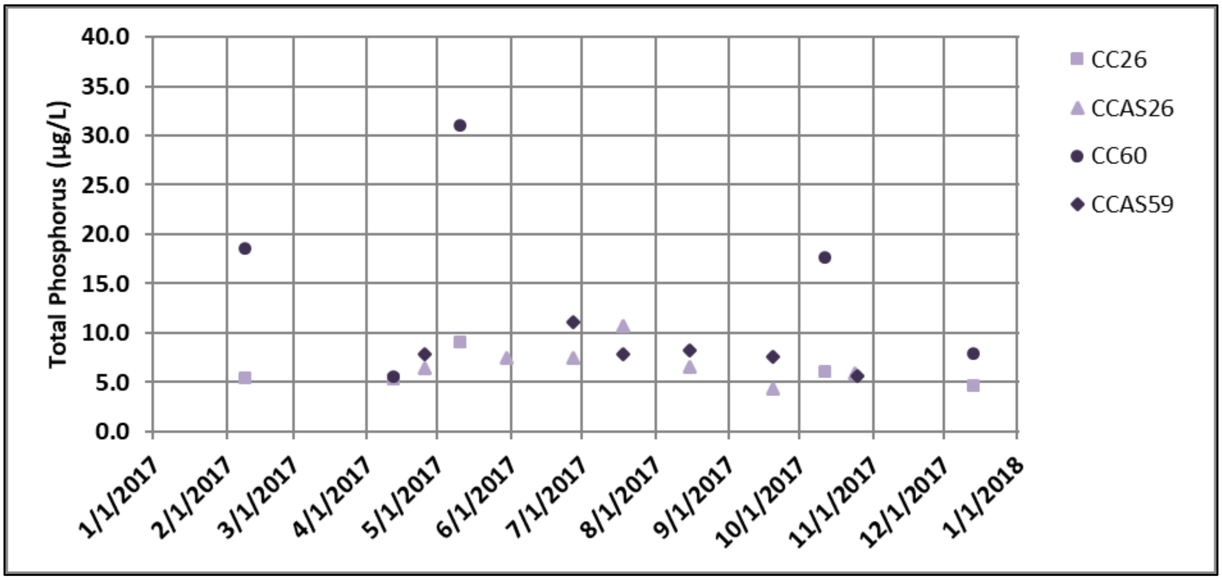


Figure 9. Total Phosphorus Concentrations (Non-Event) in the Upper Basin, 2017

Total phosphorus concentrations from ambient and grab samples for the period of 2012-2017 are displayed in Figure 10. Previous years have shown TP concentrations increasing during the snowmelt period. Similar to 2016, 2017 did not exhibit this pattern as strongly. This is similar to the patterns shown with TSS concentrations because TP concentrations are often closely linked to TSS concentrations due to particle-associated transport. The patterns shown for TSS and TP in 2016 and 2017 are consistent with this understanding.

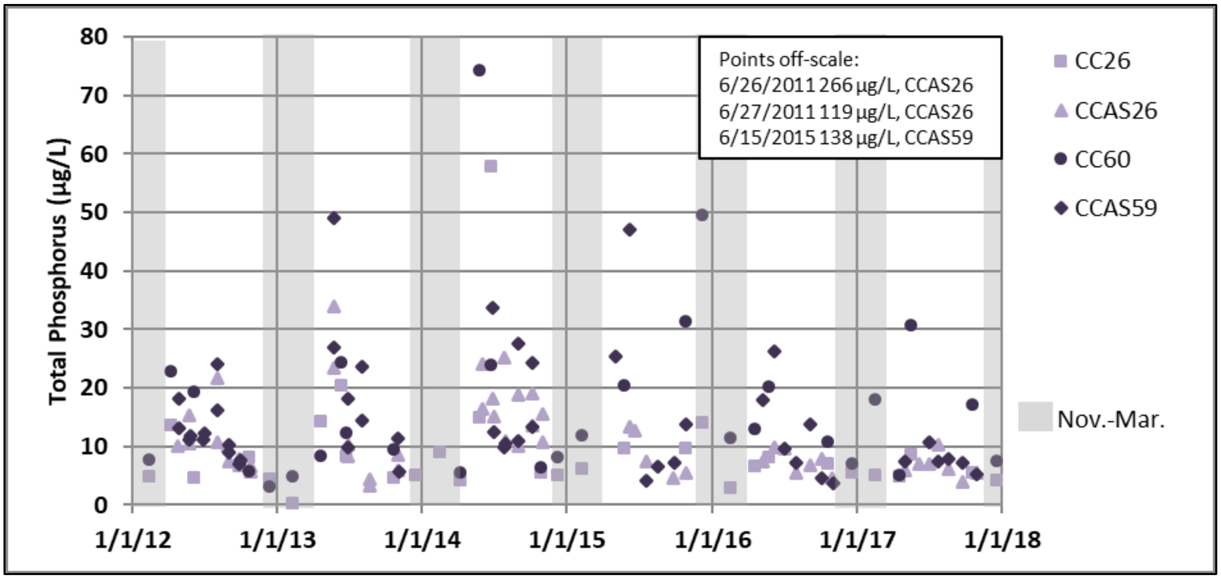


Figure 10. Total Phosphorus Concentrations (Non-Event) in the Upper Basin, 2012-2017

Monthly average TP concentrations for April-July 2017 and the 2012-2016 average and range are shown in Table 2. All runoff months were within the observed range of the last five years.

Table 2. Monthly Average Total Phosphorus Concentrations (Non-Event) in the Upper Basin at CCAS59/60

Month	2017 Average TP (µg/L)	2012-2016 Average TP (µg/L)	2012-2016 Range of TP (µg/L)
April	6.8	15.6	5.9 – 25.8
May	31.1*	28.3	11.5 – 74.7
June	11.1*	29.6	10.3 – 138
July	7.9*	14.2	4.5 – 24.5

∗ "Average" based on one observed value

Non-storm event TP loading at CC26 and CCAS59/60 was calculated for 2017 and compared to estimates from 2012-2016 (Figure 11). Loads in 2017 were lower than the 2012-2016 average, consistent with TSS loads. Loads for CC26 and CCAS59/60 were 37% and 56% lower than the average, respectively. This load decrease is similar to 2016 and is expected given the generally lower concentrations measured. As with the TSS observations, this pattern of lower concentrations may be driven by sample timing. Lower peak flows could also be contributing to the lower than average loads.

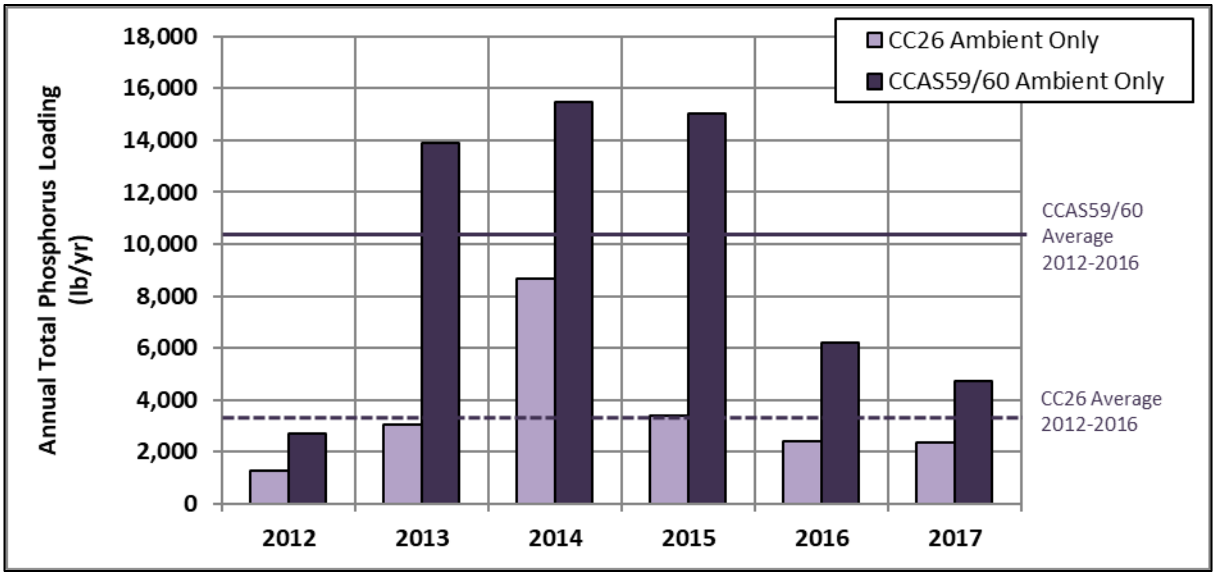


Figure 11. Annual Total Phosphorus Loading Estimates in the Upper Basin, 2012-2017

Volume-weighted concentrations (annual load divided by annual volume) of TP at CC26 and CCAS59/60 are presented in Figure 12 for 2012-2017. In 2017, volume-weighted concentrations at CCAS59/60 were lower than the average of the previous five years.

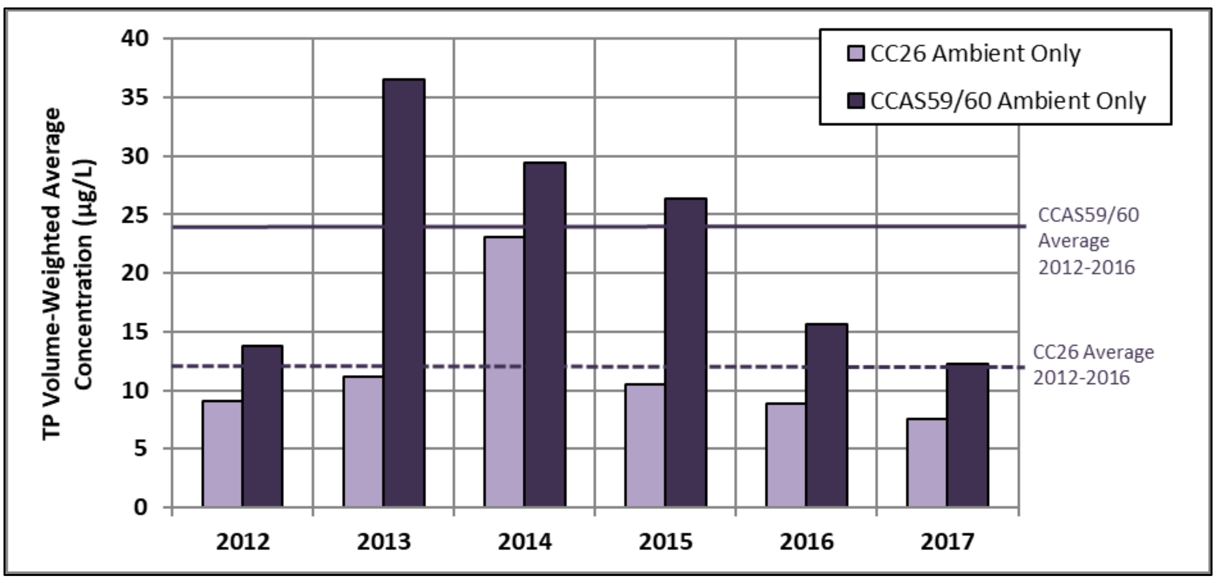


Figure 12. Volume-Weighted Total Phosphorus Concentration Estimates in the Upper Basin, 2012-2017

Total Nitrogen

Total nitrogen concentrations from grab and composite sample data collected in the Upper Basin for 2017 are presented in Figure 13. Both stations follow a seasonal pattern with higher concentrations in the winter and early spring months. This pattern is the opposite of patterns observed in TSS and TP; this is due to differences in the mechanisms of nitrogen loading. The maximum ambient concentration of 640 µg/L was observed on February 8 at CC60. The maximum concentration at CC26 of 380 µg/L was observed on December 13.

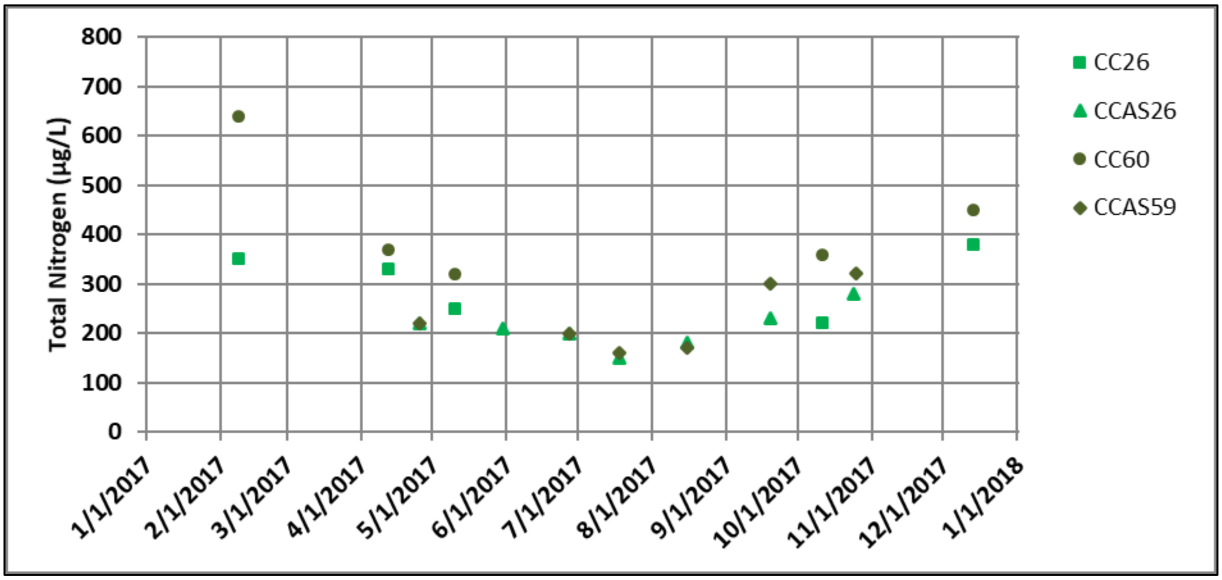


Figure 13. Total Nitrogen Concentrations (Non-Event) in the Upper Basin, 2017

A temporal pattern of lower TN concentrations in summer and higher concentrations during the winter low-flow period (typically November to March) was observed in 2017. This pattern is consistent with previous years (Figure 14) and is driven by the dilution of sources during periods of higher flow.

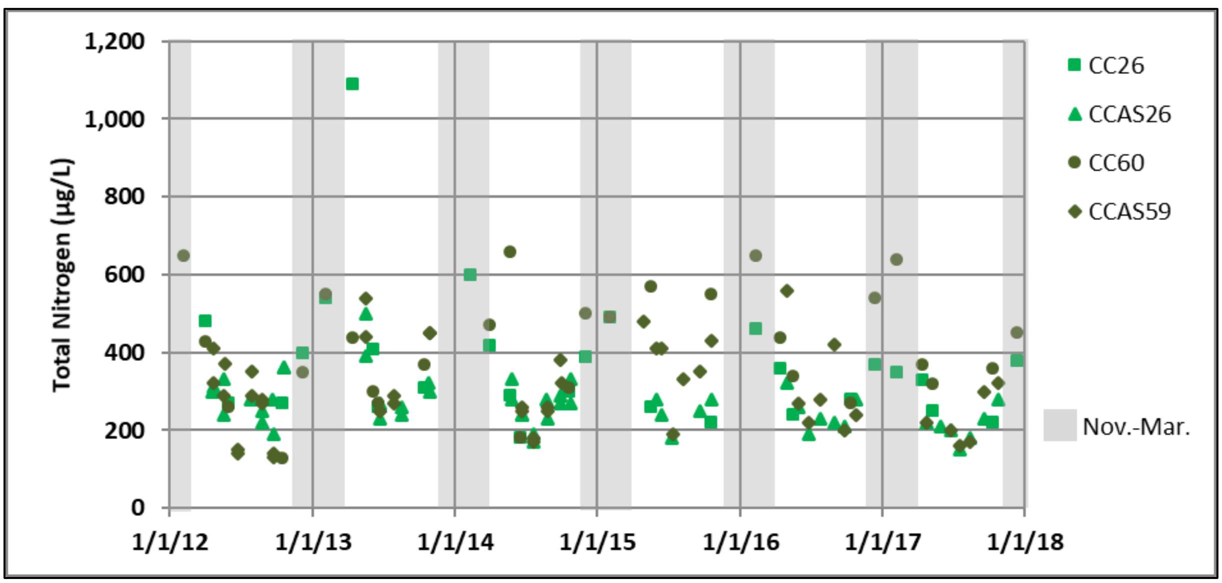


Figure 14. Total Nitrogen Concentrations (Non-Event) in the Upper Basin, 2012-2017

A comparison of monthly average TN concentrations at CCAS59/60 for 2017 and the 2012-2016 average for the runoff period is displayed in Table 3. February and December are included in this table because TN concentrations tend to be highest during the winter months.

The ambient results for TN are all generally lower than the average of previous years, with the exception of February, where the single observation was 9% above average. Most of the months were lower than average, but within the observed 2012-2016 concentrations. April and July were the only two months that had concentrations lower than the 2012-2016 range.

Table 3. Monthly Average Total Nitrogen Concentrations (Non-Event) in the Upper Basin at CCAS59/60

Month	2017 Average TN (µg/L)	2012-2016 Average of TN (µg/L)	2012-2016 Range of TN (µg/L)
February	640*	585	490 – 650
April	295	427	320 – 480
May	320*	448	260 – 660
June	200*	259	140 – 410
July	160*	253	170 – 350
December	340	352	130 – 550

* “Average” based on one observed value

Loads in 2017 for CC26 and CCAS59/60 were lower (-12% and -37% respectively) than the average of the previous five years (Figure 15). This is expected due to the decrease in ambient concentrations.

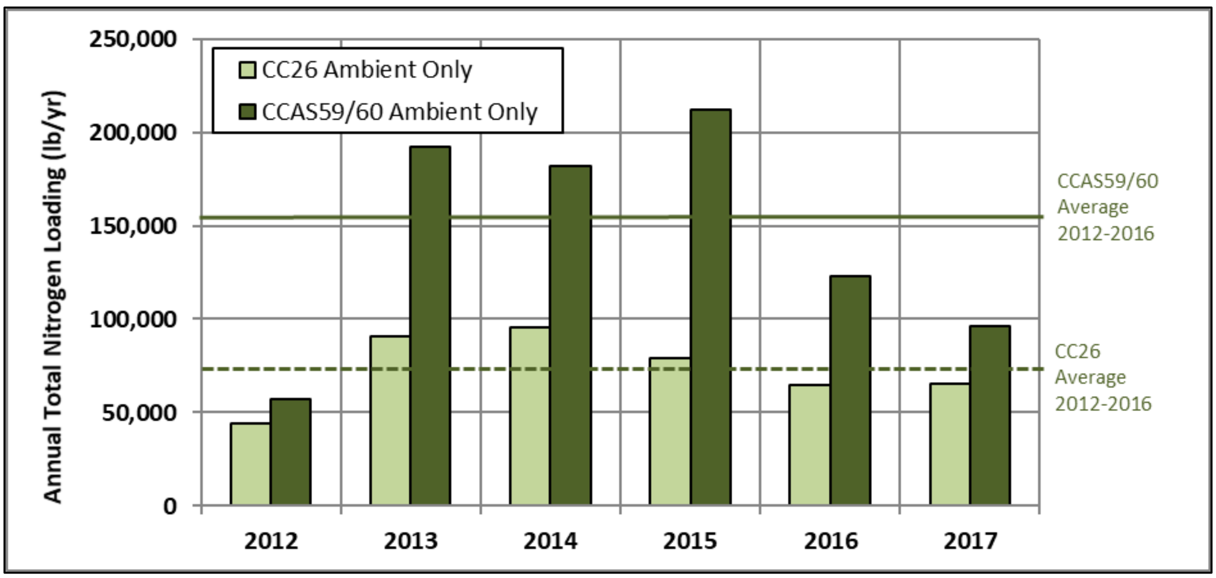


Figure 15. Total Nitrogen Loading Estimates in the Upper Basin, 2012-2017

Volume-weighted concentrations (annual load divided by annual volume) of TN at CC26 and CCAS59/60 are presented in Figure 16 for 2012-2017. Volume weighted concentrations of TN at both stations are below the averages of the previous five years.

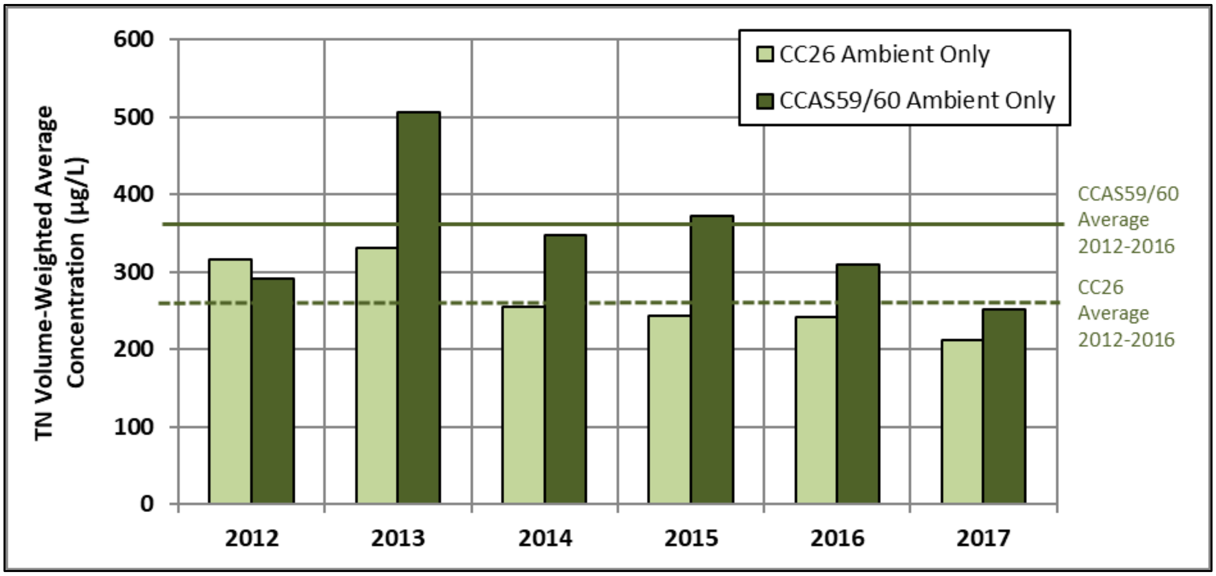


Figure 16. Volume-Weighted Total Nitrogen Concentration Estimates in the Upper Basin, 2012-2017

STORM LOADING EVENTS

The loading calculation results described earlier in this section include grab samples and ambient composite data. These types of samples, which are taken at regular intervals, are not intended to capture the water quality response to storm events. It is widely recognized, however, that precipitation events can result in substantial changes to water quality. As such, event-triggered sampling results at station CC59 are included for analysis in this section. For the event-triggered samples, the storm-event concentrations were assumed to represent concentrations for the full day of the composite sample, though runoff events can cover longer or shorter periods. The storm-event data were collected at station CC59 and the ambient data were collected at CCAS59.

In July and August 2017, three event-triggered samples were collected at CC59. The effects of these storms on loading estimates are presented in Table 4 and Figure 17. Incorporating these event samples into the loading calculations increases the annual loads of TN (12%), TP (112%), and TSS (142%). The effects are even more apparent in loading estimates for the individual months (Table 4).

The effects of a single storm event are exemplified by the July 27, 2017 event. This single-day event is estimated to have contributed 6,005 lbs of TN, 3,654 lbs of TP, and 3,547,191 lbs of TSS loading. These amounts represent a substantial fraction of the annual loading (TN: 6%, TP: 78%, TSS: 94%); and represent a substantial fraction of the loading differences seen in Figure 17. The large loading estimates for this event are the result of the high concentrations measured on this date (TN: 3,295 µg/L; TP: 1,900 µg/L, and TSS: 1,840 mg/L). While not all storm events have such high concentrations, and correspondingly large impact on annual totals, this event demonstrates the importance of understanding the effects of storm events on water quality. For context, the previous three years of event load TSS graphs (with and without storm events) are provided in Figure 18. 2015 had a proportionately similar large increase in TSS loads (187%) with the inclusion of event samples. This large percentage was based upon five event-triggered samples. 2016 TSS loads increased 45% based upon three storm events. The differences in percentages highlight the variability within storm events and make comparisons of the effects of storm events on a year-to-year basis not straight forward. The effects of storm events on loading estimates are highly dependent on the number of storm events captured by sampling and by the concentrations observed during each individual event.

Table 4. Effect of Storm Events on Annual and Monthly Loading at CCAS59/60 Compared to Non-Event Loading

Time Period	Increase in TN Loading with Storm Events	Increase in TP Loading with Storm Events	Increase in TSS Loading with Storm Events
2017 (Annual Load)	12%	112%	142%
July 2017 (Monthly Load)	85%	765%	1,277%
August 2017 (Monthly Load)	17%	185%	93%

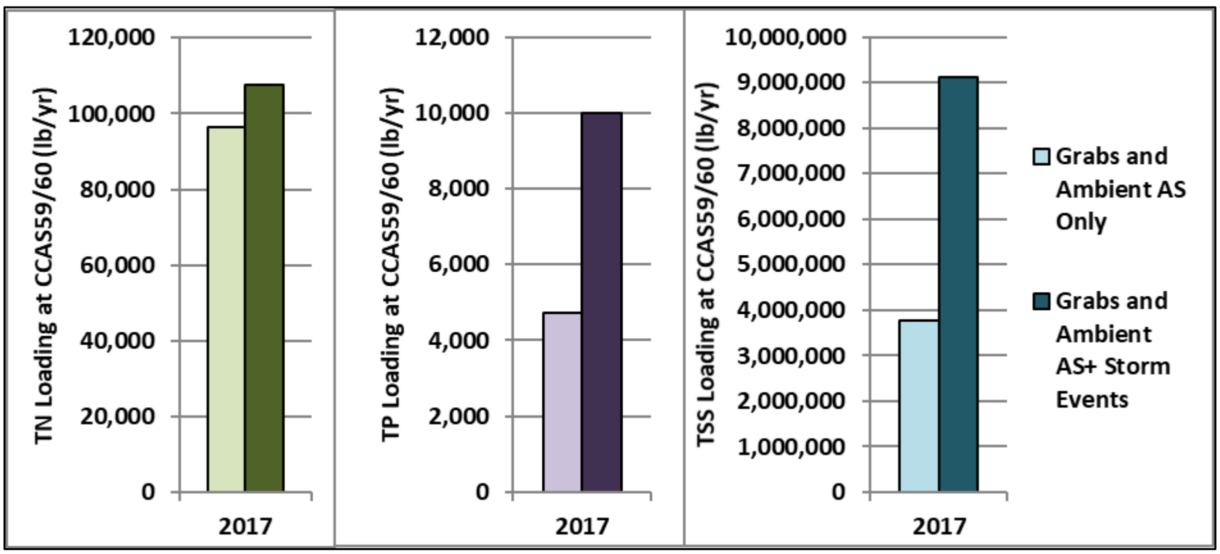


Figure 17. Total Nitrogen, Total Phosphorus, and Total Suspended Solids Loading in 2017 With and Without Storm Events (Ambient Samples Collected at CCAS59/CC60, Storm Event Samples Collected at CC59)

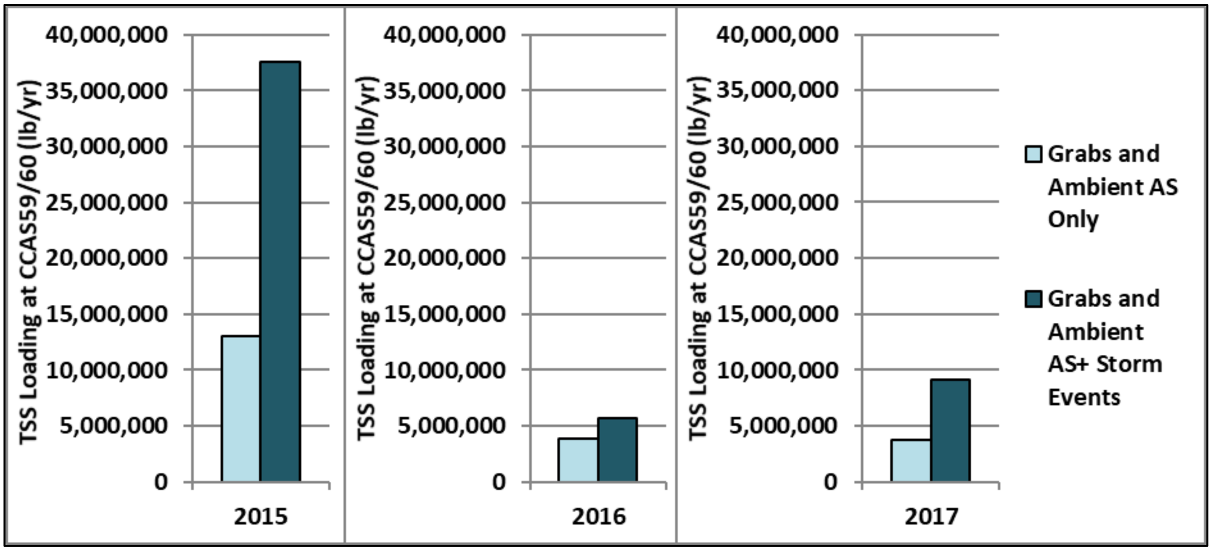


Figure 18. Total Suspended Solids Loading in 2015, 2016, and 2017 With and Without Storm Events

III.CANAL ZONE FLOWS AND WATER QUALITY

The Upper Basin is the source for the water diverted into the inflow canals that lead to Standley Lake. This section presents the timing and volume of flows for the inflow canals. In addition, a description of water quality changes along the two major inflow (FHL and Croke) canals from their points of diversion on Clear Creek to the reservoir are included.

FLOWS FROM CANALS AND KDPL

Water enters Standley Lake via four conveyances: Church Ditch, Croke Canal, Farmers' High Line Canal (FHL), and Kinnear Ditch Pipeline (KDPL). Inflows for 2017 from each of these sources are shown in Figure 19. During the irrigation season (April to October), the FHL Canal was the dominant source of inflows. Starting in May, additional water was delivered by the Church Ditch. The KDPL began delivering water in late August. The Croke Canal has the most senior rights in the Clear Creek Basin during the non-irrigation season (November – March). As is typical, following the curtailment of flows from FHL in early November the Croke Canal provided the only inflow to Standley Lake until early April. While the Croke canal typically ceases flow to the lake in April, occasionally it will be put to use during the "free-river" period (period where there is more water than all water rights on a river, Colorado River District, 2018). During 2017 the Croke was used concurrently with the FHL to aid in filling the lake when "free-river" was initiated in May.

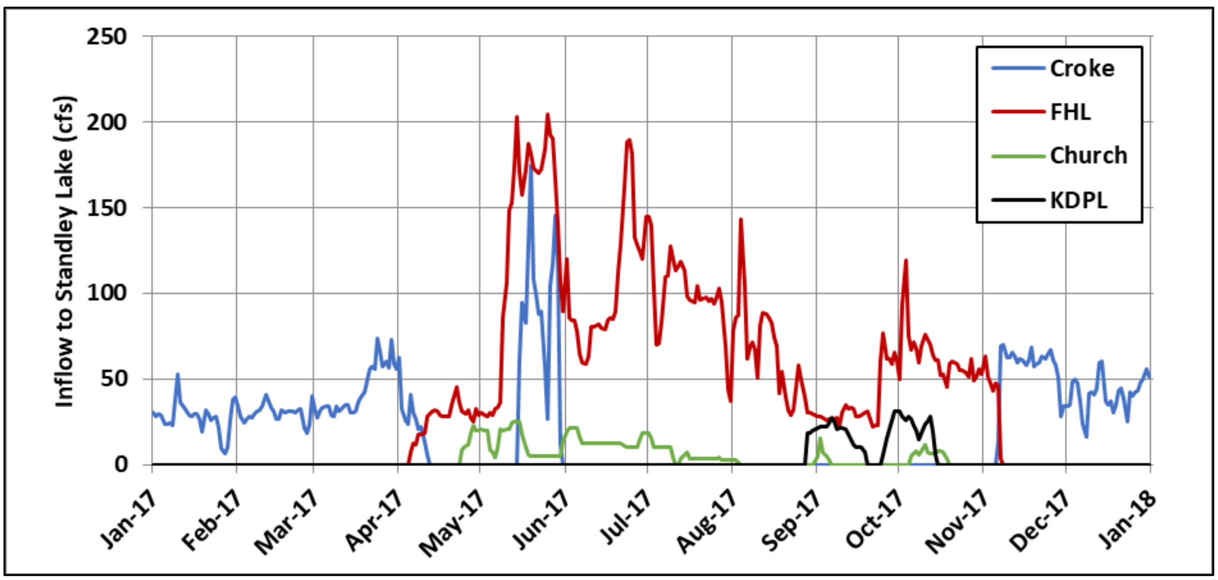


Figure 19. Inflow to Standley Lake, 2017

CHANGES IN WATER QUALITY FOR THE FHL AND CROKE CANALS

The Croke Canal and the FHL Canal are the dominant sources of water to Standley Lake. These canals follow parallel paths for approximately 15 miles between their headgates at Clear Creek and their turnouts to Standley Lake. Over this distance the canals pass through a diverse range of land uses. When a canal is in use, water-quality samples are collected at both the headgate and at the release point to Standley Lake. To better understand the effects of the

Canal Zone on water quality, an analysis of concentration differences observed between the canal headgates and turnouts was performed. As with the Upper Basin and Standley Lake water quality discussions, this analysis focused on TSS, TP, and TN. Median annual concentrations were calculated for TSS, TP, and TN. These medians were calculated for the canal headgate and at the release points into the lake for the Croke and FHL. For the Croke Canal, there is substantial increase in TSS concentrations between the headgate and the release point (Figure 20, right). The increase in TSS is associated with a corresponding increase in TP (Figure 21, Figure 20, right). However, there is little difference between locations for TN (Figure 22, right). In contrast, less difference is observed in the FHL between headgate and turnout for TSS, TP, or TN (Figures 20-22, left). The specific sources of TSS and associated TP along the Croke Canal are unknown at this time.

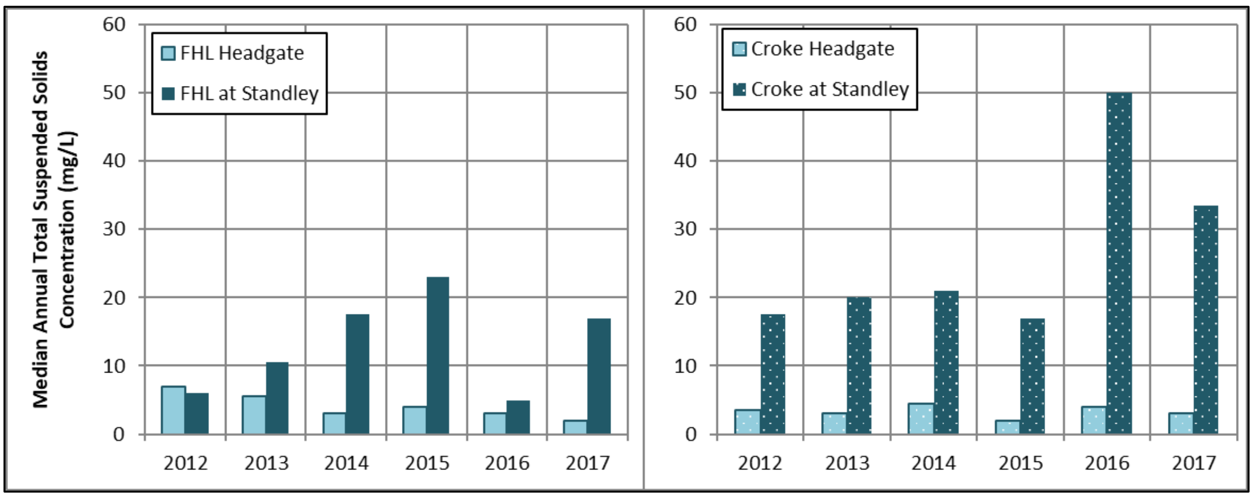


Figure 20. Median Total Suspended Solids in FHL (left) and Croke (right) Canals

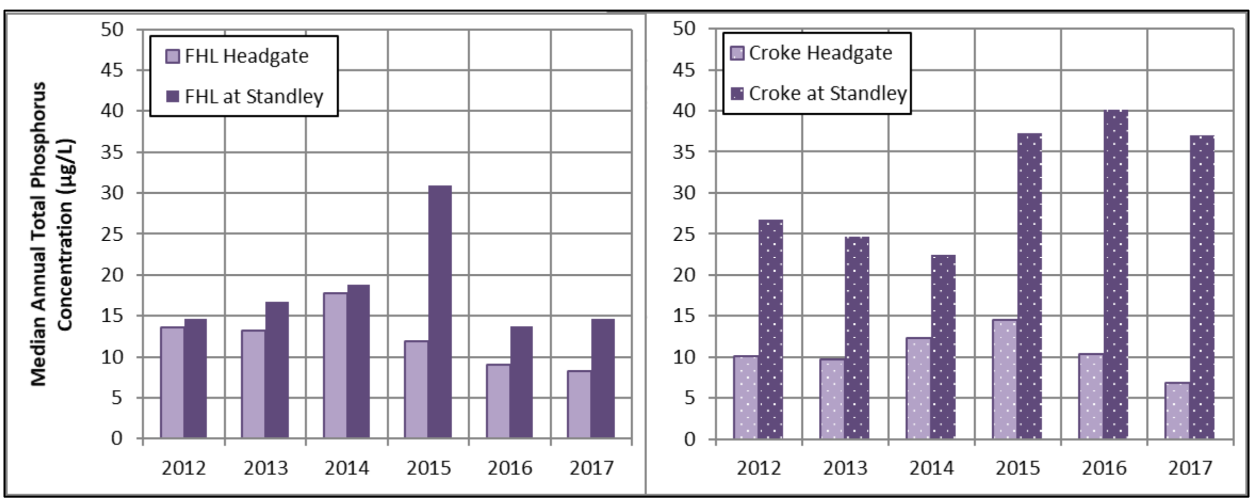


Figure 21. Median Total Phosphorus Concentrations in FHL (left) and Croke (right) Canals

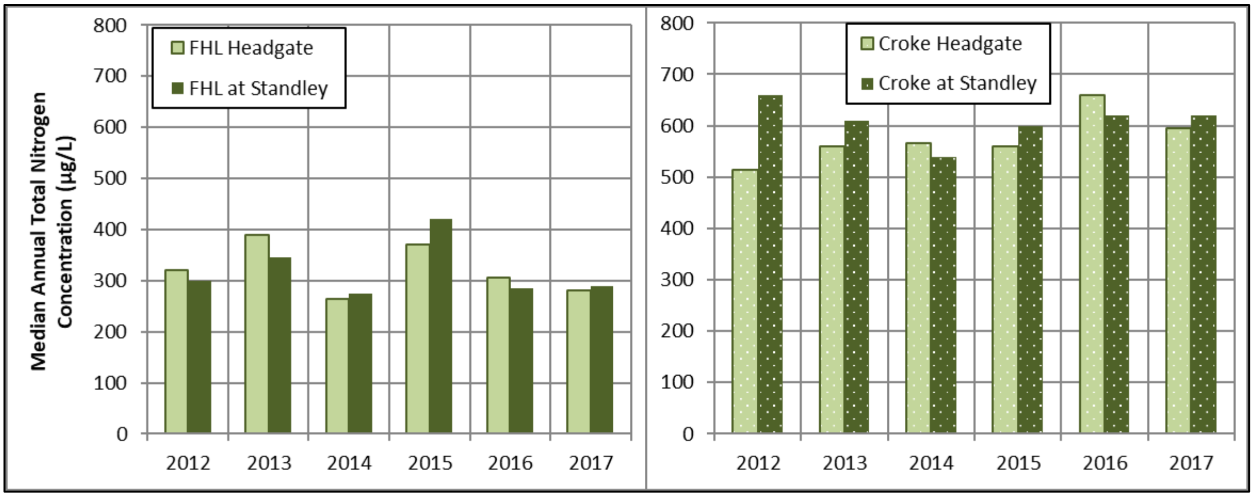


Figure 22. Median Total Nitrogen Concentrations in FHL (left) and Croke (right) Canals

2017 loadings per unit of discharge (AF) for the Croke and FHL canals are shown in Table 5. Total loads for TN, TP, and TSS were summed and divided by total inflows for the year (AF), providing the amount of loading (lbs) attributed to one AF of discharge. Comparing the two canals, it is apparent that the Croke Canal contributed approximately twice the amount of each constituent per unit of discharge. This adds to the evidence that a larger amount of nonpoint source loading is occurring as water is moving through the Croke Canal.

Table 5. Comparison of the Croke Canal and the FHL Canal, Loading (lbs) Per Unit of Discharge (AF), 2017

Croke Canal vs. FHL Canal (lbs of loading/AF)			
Location	**TN**	**TP**	**TSS**
Croke Canal	1.6	0.11	101.5
FHL Canal	0.8	0.06	53.6

IV. STANDLEY LAKE FLOWS, CONTENTS, AND LOADINGS

This section provides a discussion of the quantity and quality of the inflows to and outflows from Standley Lake. In addition, the loadings of TSS, TN and TP are described along with the lake contents.

FLOWS AND CONTENTS

Seasonal patterns and daily flow rates for the four inflows to Standley Lake were presented previously (Figure 19). Annual flow volumes for each source during the period of 2012 to 2017 are shown in Figure 23. The FHL and Croke Canals are the largest sources of water to Standley Lake providing 63% and 29%, respectively, of the total inflows. Church Ditch and KDPL inflows provide a smaller percentage of the total inflows (10% combined).

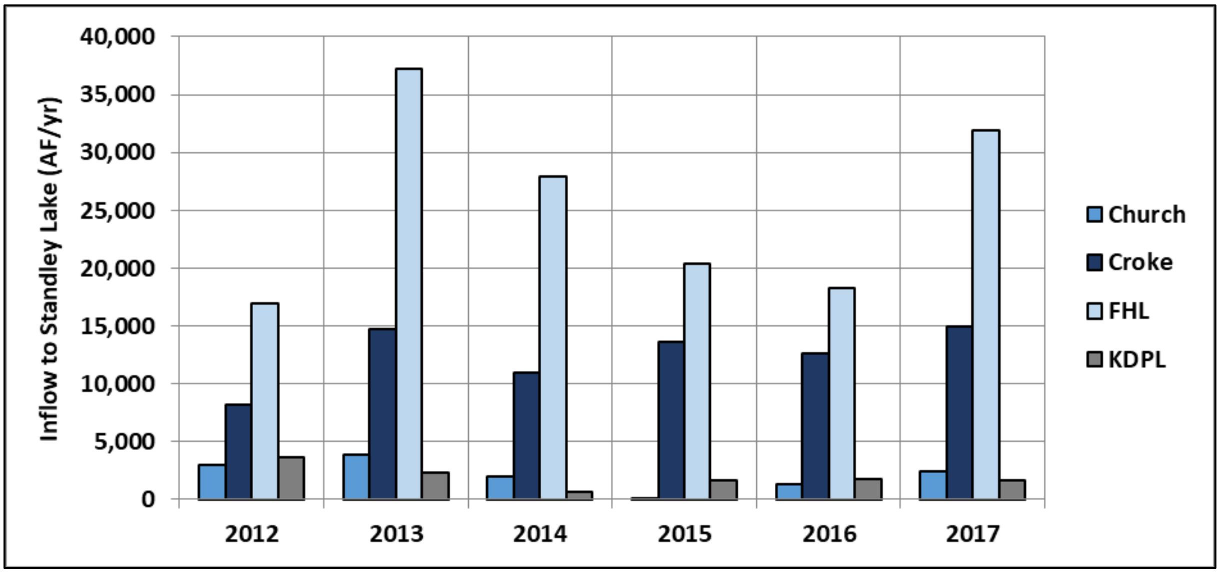


Figure 23. Inflow Volumes to Standley Lake by Source, 2012-2017

Standley Lake contents for the period of 2012-2017 are displayed in Figure 24. Contents were calculated from gage-height measurements using the elevation-area-volume relationship for the lake. In the beginning of 2017, lake contents were lower than the previous three years. This led to the lake filling to capacity as soon as water was available and included the use of the Croke Canal in May to aid in filling the reservoir quickly (Figure 19). In contrast to recent years, Standley Lake ended the year at full capacity due to water availability and water rights conditions from October and November.

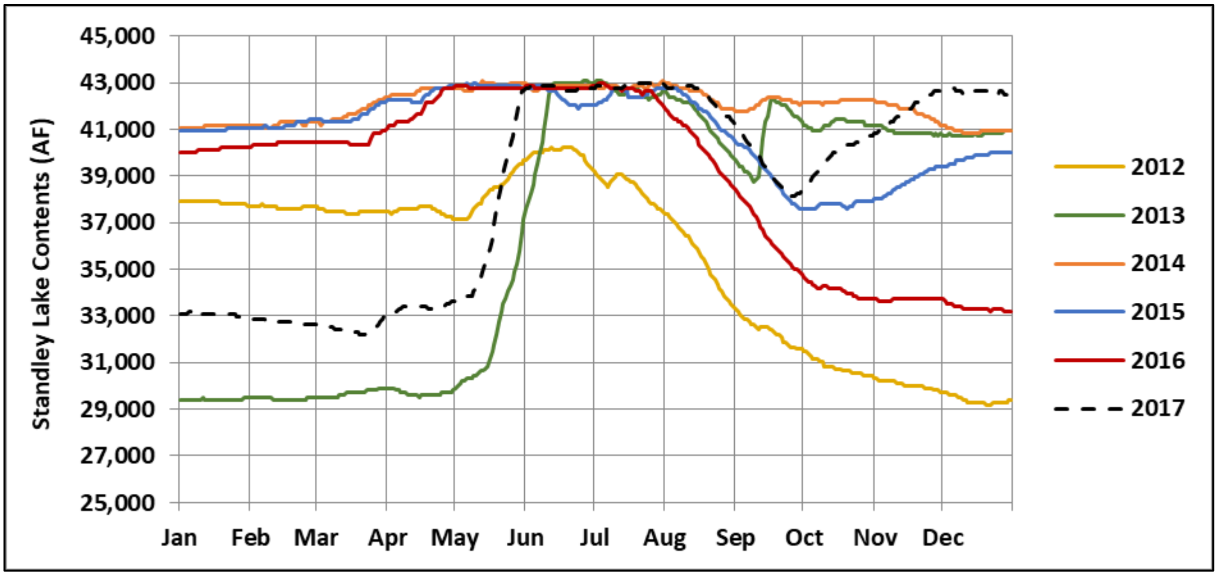


Figure 24. Standley Lake Contents, 2012-2017

Total inflow and outflow rates to/from the lake in 2017 are presented in Figure 25. Inflows are less than outflows from the beginning of the year until May when inflows increased during the runoff period. Because outflow in Standley Lake is dependent on drinking water demands, it is relatively consistent over the years barring unusual weather patterns. In 2017, outflows in Standley Lake were only 4% higher than the previous five years.

Figure 25. Inflows to and Outflows from Standley Lake, 2017

During the month of May, 23% of the total annual inflow came into the lake. Figure 26 shows most of the water used to fill Standley Lake in 2017 came in during the beginning of the runoff period. Water coming in at the beginning of the hydrograph typically has higher concentrations of nutrients and could contribute to larger nutrient loads to the lake.

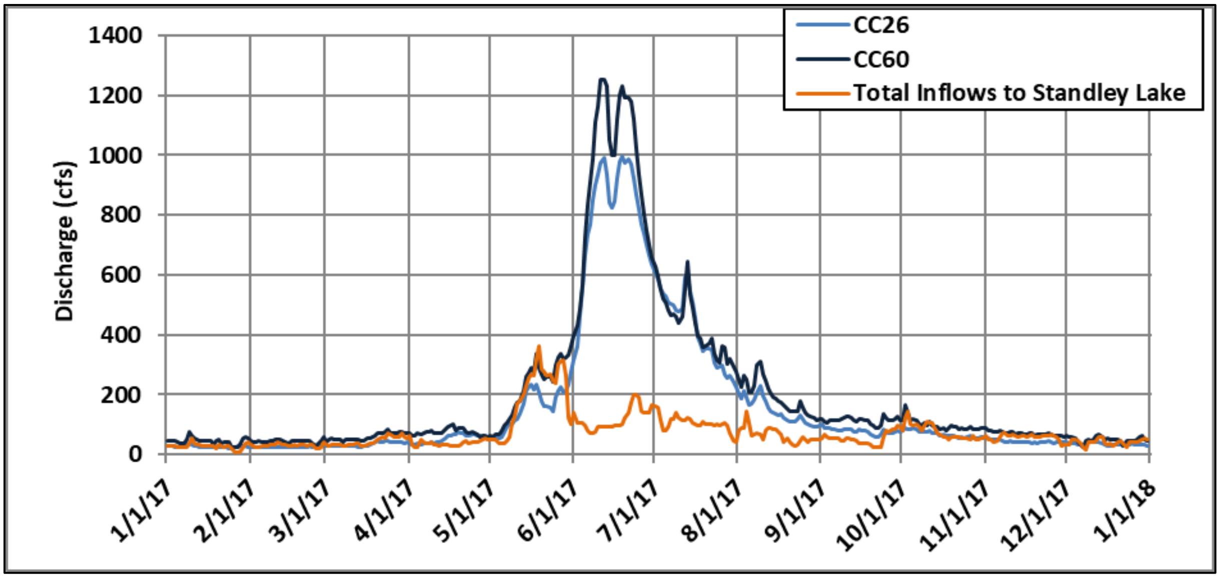


Figure 26. Hydrographs of CC26 and CC60 with Inflows to Standley Lake

Overall, the largest outflows occurred during the summer and fall. Total measured annual inflow (the sum of all four sources) and outflow for 2012-2017 are presented in Figure 27. In 2017, total inflows were 27% higher than the 2012-2016 average.

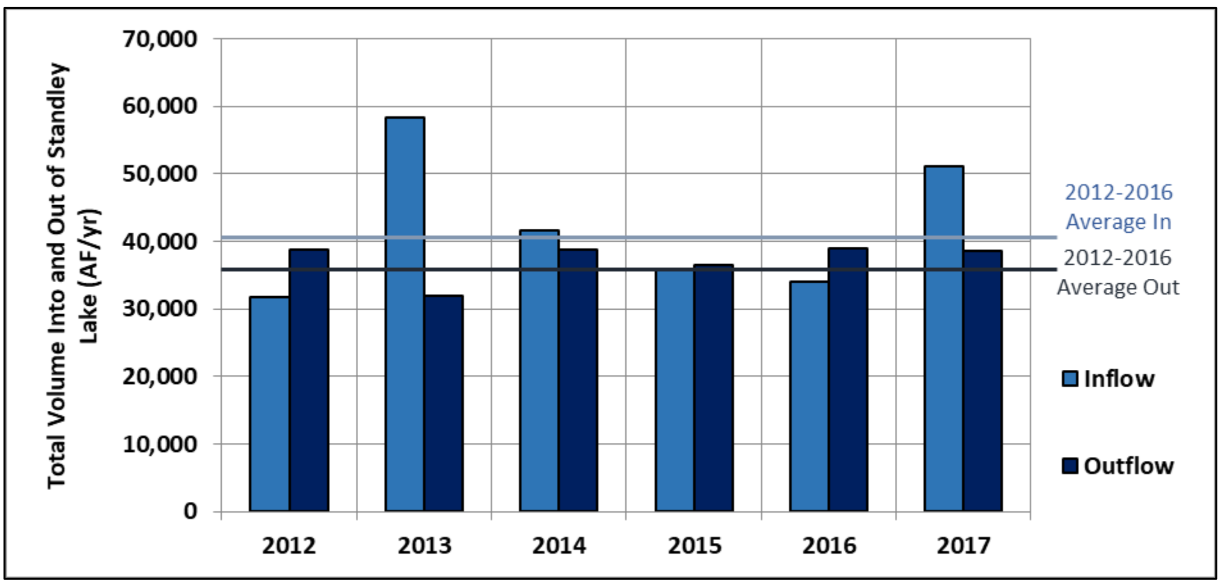


Figure 27. Total Measured Annual Standley Lake Inflow and Outflow, 2012-2017

LOADING INTO AND OUT OF STANDLEY LAKE AND INFLOW WATER QUALITY

Estimates of nutrient loading into and out of the lake are described in this sub-section. The concentration data are from samples collected as part of the Upper Clear Creek/Standley Lake Watershed Water Quality Monitoring Program. The sampling data used for inflows includes ambient grab samples and 24-hour ambient composites. Loads are calculated using flows and concentrations on a daily basis. To compute daily concentrations, a mid-point function was used to fill concentrations between the available sample data. Event samples collected on the canals include storm event samples and first flush samples. These types of samples provide an indication of the effects of different events on loading to the reservoir.

Total Suspended Solids

Total suspended solids loading into Standley Lake for the 2012-2017 period is presented by source in Figure 28. The Croke and FHL canals, the largest contributors of water to the reservoir, delivered the largest TSS loads (Figure 28). Consistent with most years, the FHL contributed the largest (51%) portion of the annual TSS load. This is expected as the canal provided 63% of the total annual inflow to the reservoir. Interestingly, the Croke Canal contributed 46% of the annual TSS load in only 29% of the total annual inflow to the reservoir. This is reflective of the higher TSS concentrations observed in the Croke Canal at the lake compared to the headgate (Figure 20).

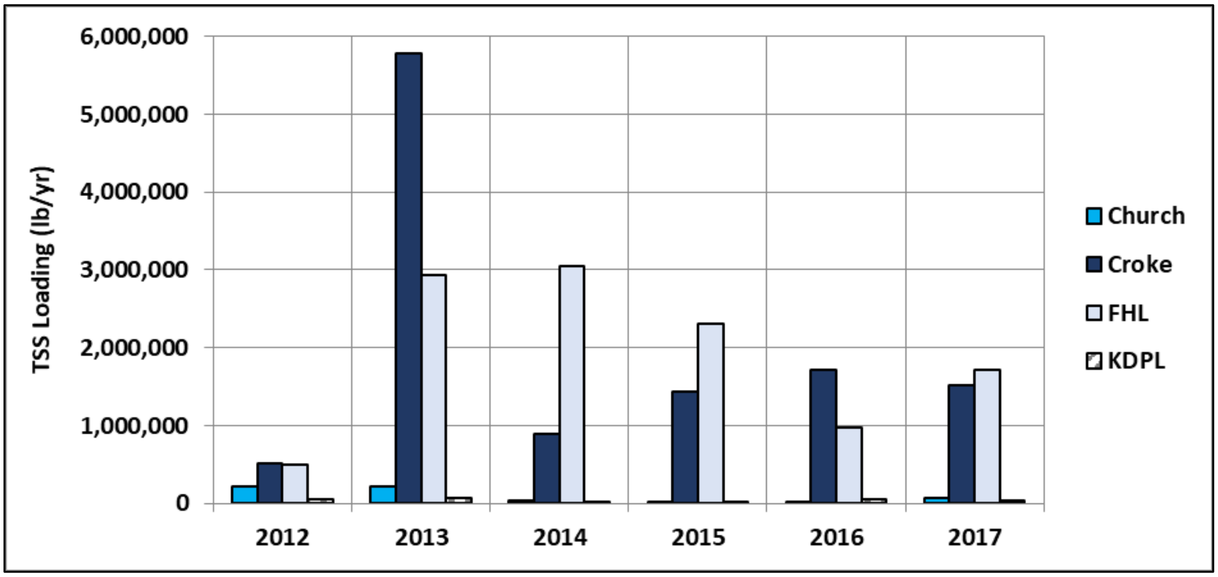


Figure 28. Total Suspended Solids Loading Into Standley Lake by Source, 2012-2017

Estimated annual TSS loadings into and out of Standley Lake for 2012-2017 are shown in Figure 29. Non-storm event loading of total suspended solids in 2017 was below (20%) the average of the past five years, however, this is due to the large contributions of TSS from the 2013 flood. When removing 2013 from the average calculations, 2017 TSS loads are 13% above average. Loadings of total suspended solids into the lake were greater than outflow, indicating some level of solids retention. Loads leaving the reservoir were 10% higher than the previous five years.

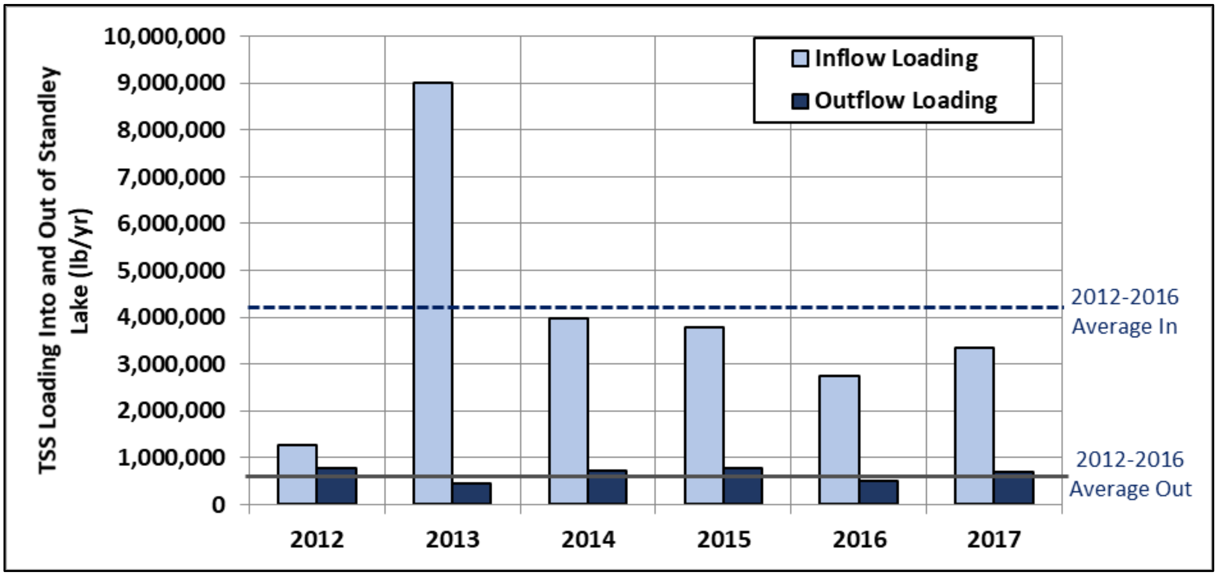


Figure 29. Total Suspended Solids Loading Into and Out of Standley Lake, 2012-2017

Volume-weighted TSS concentrations into Standley Lake are presented in Figure 30 by source. The Croke had the highest volume-weighted concentration and KDPL the lowest. The combined average of the canals (24 mg/L) in 2017 was 21% lower than the 2012-2016 average.

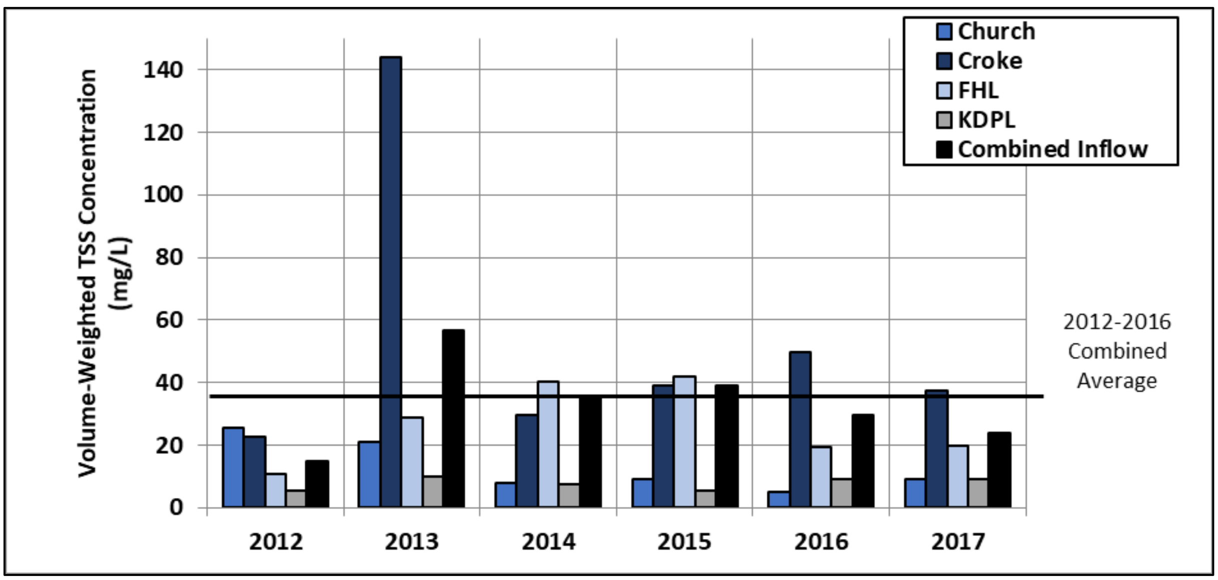


Figure 30. Volume-Weighted Total Suspended Solids Concentrations Into Standley Lake by Source, 2012-2017

Total Phosphorus

Total phosphorus loading into Standley Lake for the 2012-2016 time period is presented by source in Figure 31. Similar to TSS loadings, the FHL and Croke Canals contributed the largest TP loads (51% and 44% respectively). The similarity between the two canal load contributions and differences in flow mentioned previously indicate that the Croke Canal is contributing more sediment and phosphorus per unit of discharge than the FHL Canal.

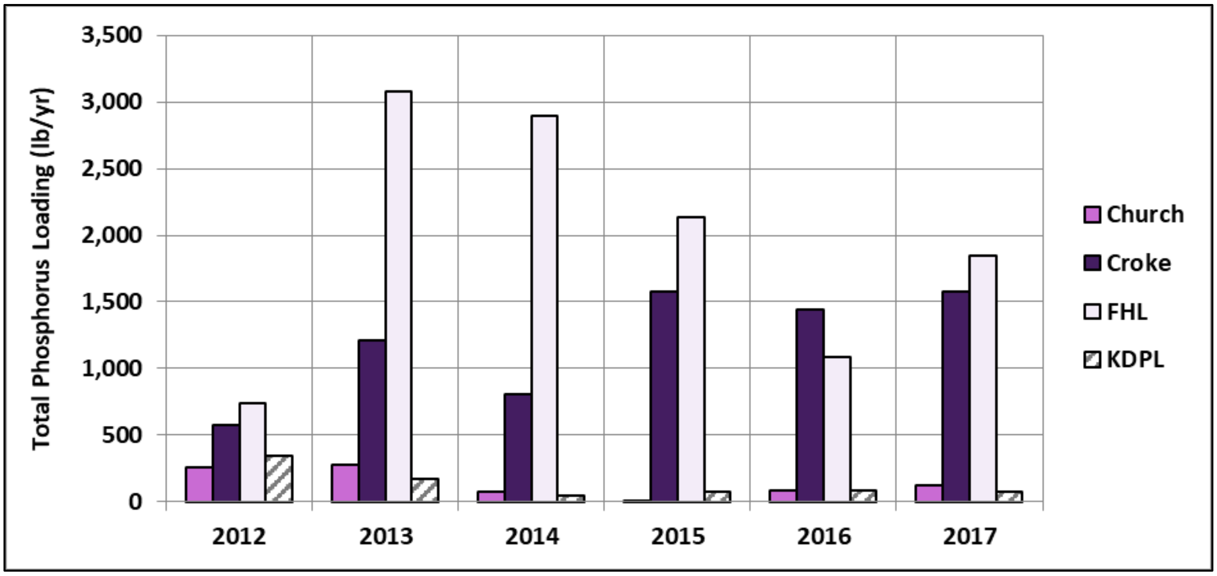


Figure 31. Total Phosphorus Loading Into Standley Lake by Source, 2012-2017

Estimated annual TP loadings into and out of Standley Lake for 2012-2017 are shown in Figure 32. Non-storm event loading of total phosphorus in 2017 was above (7%) the average of the past five years. As with previous years, loadings of total phosphorus into the lake were greater than outflow, indicating some level of phosphorus retention.

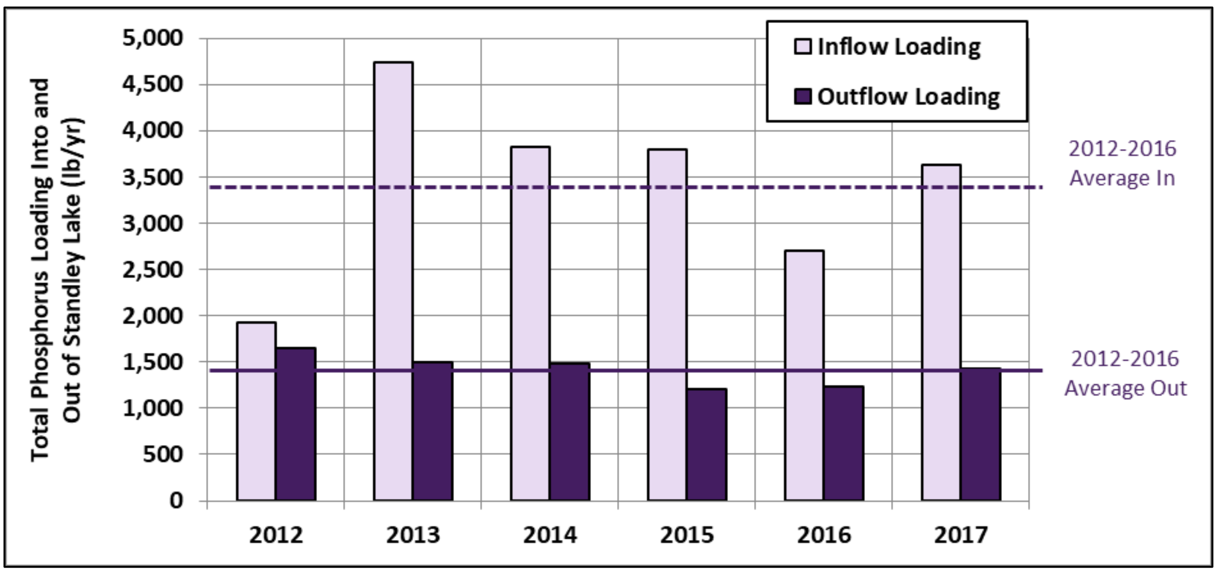


Figure 32. Total Phosphorus Loading Into and Out of Standley Lake, 2012-2017

The volume-weighted TP concentrations into Standley Lake are presented in Figure 33 by source. The Croke had the highest volume-weighted concentration and KDPL the lowest. The combined average of the canals (26 µg/L) in 2017 was 15% lower than the 2012-2016 average.

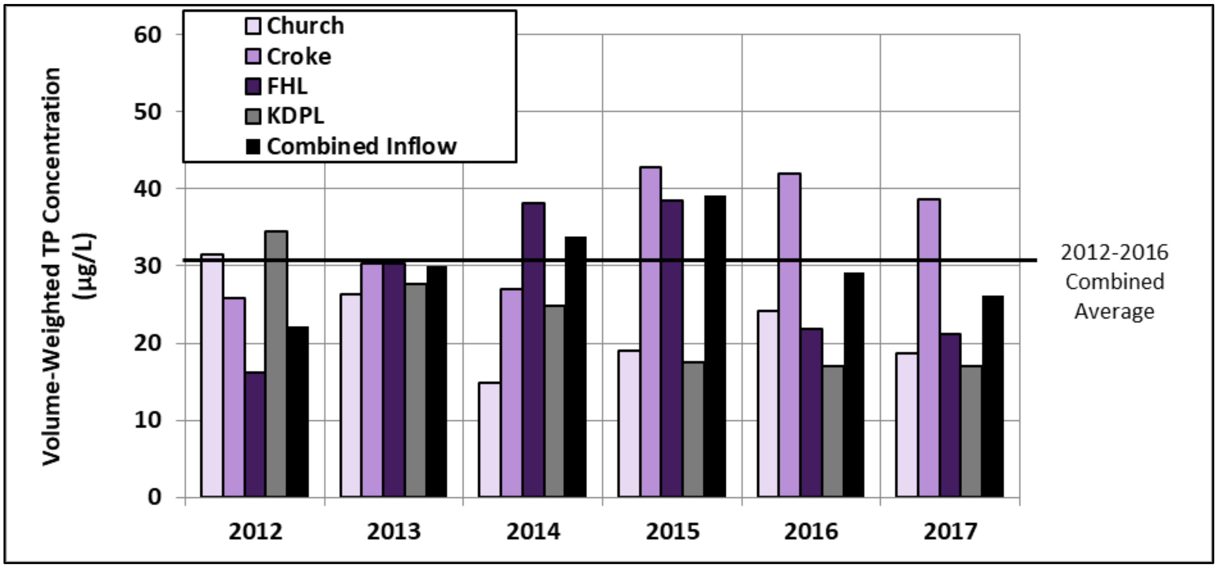


Figure 33. Volume-Weighted Total Phosphorus Concentrations Into Standley Lake by Source, 2012-2017

Total Nitrogen

Total nitrogen loading into Standley Lake, based on data from ambient grab and ambient composite samples, is grouped by source and displayed in Figure 34. Combined TN loading into and out of the lake is presented in Figure 35. The FHL contributed the largest portion of the annual TN load (49%). As noted with TSS, though the Croke canal only contributed 29% of the total inflow to the lake, it contributed a higher percentage (45%) of the annual TN load. TN loads entering the reservoir in 2017 were 13% higher than the 2012-2016 average. The outflow TN load in 2017 was slightly lower (-4%) than the 2012-2016 average. Consistent with previous years, loading into the reservoir was higher than loads leaving the reservoir, indicating that nitrogen is being retained. Nitrogen can be retained in a reservoir through biological uptake and deposition of particulate organic carbon to the bottom sediment.

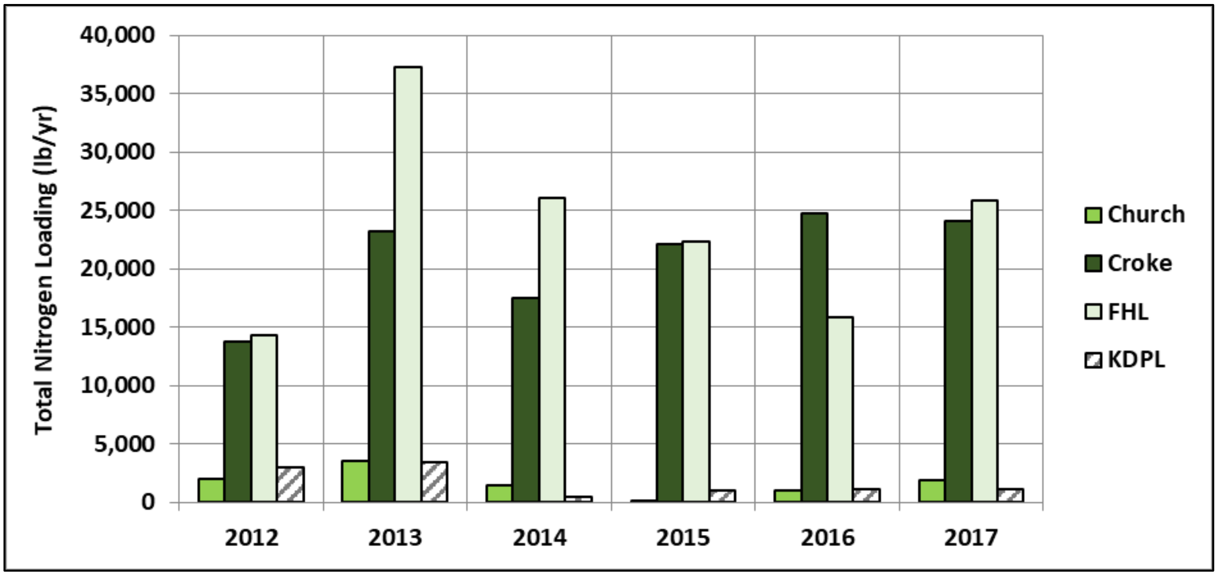


Figure 34. Total Nitrogen Loading Into Standley Lake by Source, 2012-2017

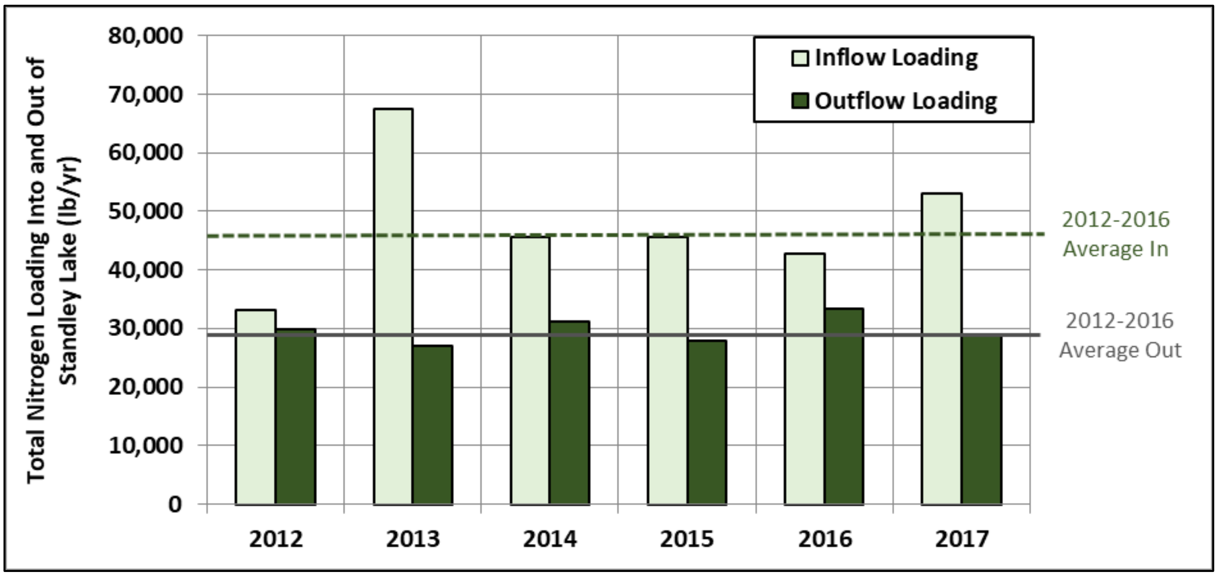


Figure 35. Total Nitrogen Loading Into and Out of Standley Lake, 2012-2017

Volume-weighted total nitrogen concentrations into the lake are presented in Figure 36. The combined average from all sources in 2017 (381 µg/L) was lower (-11%) than the 2012-2016 average of 429 µg/L.

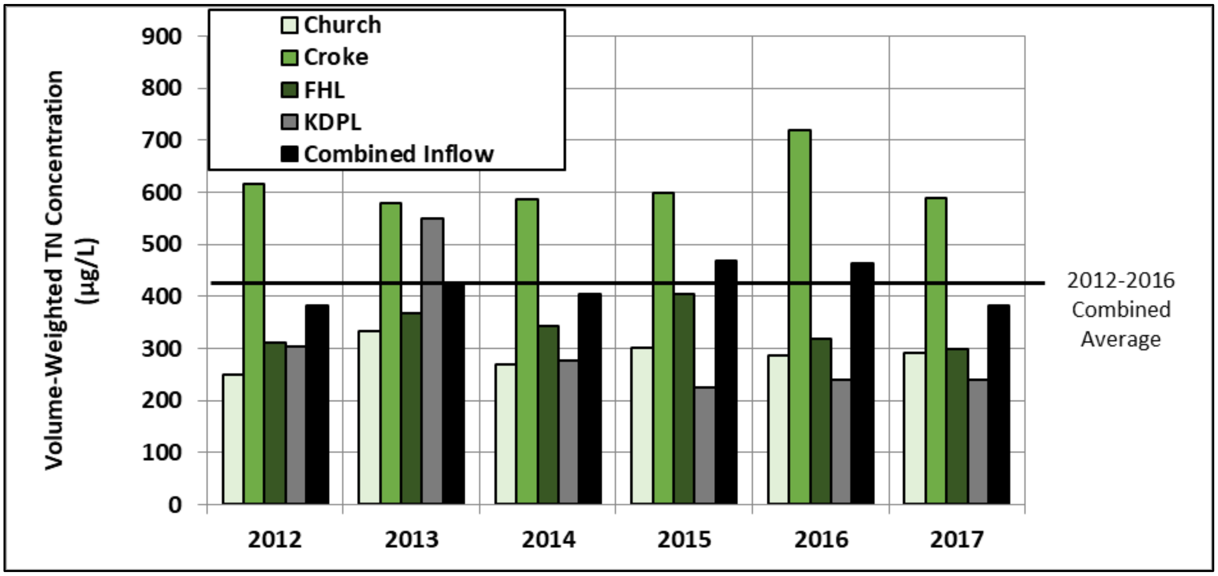


Figure 36. Volume-Weighted Total Nitrogen Concentrations Into Standley Lake by Source, 2012-2017

STORM EVENT LOADS TO THE LAKE

Load estimates to the lake that include storm-event-triggered autosampler data are described in this section. In 2017, there was only one instance where an autosampler was triggered by a storm event. It occurred on July 27 on the FHL canal at the inflow location to the reservoir. Storm event samples were assumed to represent conditions for the full 24-hour period on the sample date.

A comparison of nutrient loading into Standley Lake from FHL in 2017 with and without the sampled storm event is shown in Figure 37. The lighter bars in the figure represent the estimated loading, excluding storm-event autosampler data. The darker bars include the storm event listed above. Incorporation of the observed storm event yields a 23% increase for TSS, a 2% increase in loading for TN, and an 8% increase for TP. These estimates are based on a single storm event and are underestimates of the actual loading.

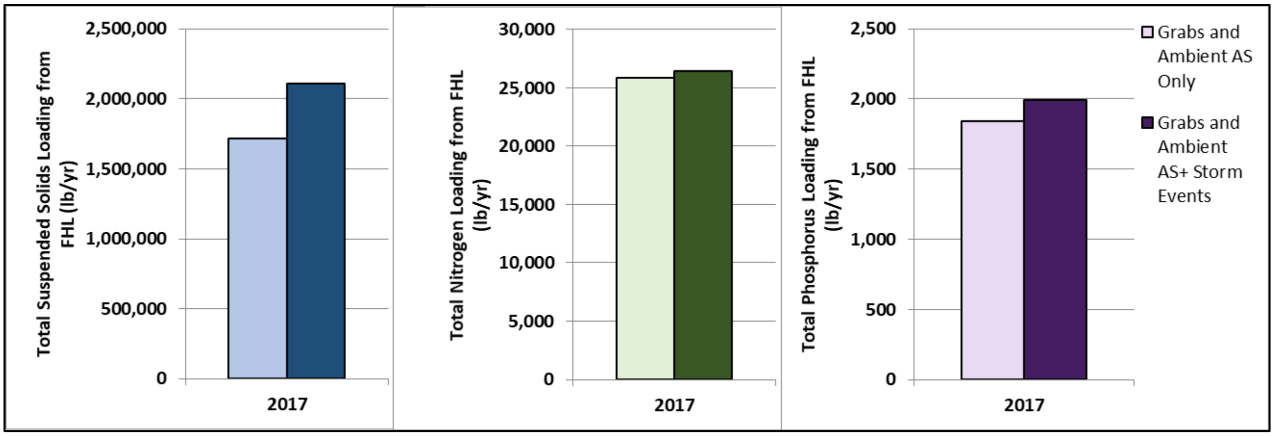


Figure 37. Total Suspended Solids, Total Nitrogen, and Total Phosphorus Loading in 2017 With and Without Storm Events

V. STANDLEY LAKE WATER QUALITY

In this section, the in-reservoir water quality responses at sampling location SL-10 to the hydrology and nutrient loads are discussed. This sampling location was selected as it has an extensive sampling history, is directly relevant to water treatment plant operations, and is the location of the automated lake profiler station. The water-quality indicators discussed here include temperature, dissolved oxygen (DO), TP, TN, chlorophyll *a*, and water clarity.

TEMPERATURE

Temperature is crucial in water quality monitoring in reservoirs because it drives stratification patterns. It is typical for deep reservoirs to experience stratification during the summer and this stratification can lead to lowered dissolved oxygen levels in the hypolimnion. While Standley Lake experienced stratification in 2017, there is a noteworthy difference in the temperature in the hypolimnion of the lake. Typical years show the thermocline gradually deepening as the summer progresses, reaching the lower depths of the reservoir (~ 20 m) until fall turnover. In 2017, however, the deepening of the metalimnion stops around early August at about 10 meters (Figure 38). At this time, the outlet used for water withdrawals was switched from the lower intake (66 ft, 20 m, below full pool) to the upper intake (36 ft, 10m, below full pool). When this occurred, warmer water was being released from the reservoir, increasing the amount of thermal energy removed, and lowering overall reservoir temperatures. Since the surface temperatures are similar between the two years, no additional energy was added at the air-water interface in 2017. This results in cooler temperatures in the lower depths of the lake. Turnover occurred on October 9, 2017 which is a typical date for the end of stratification for Standley Lake.

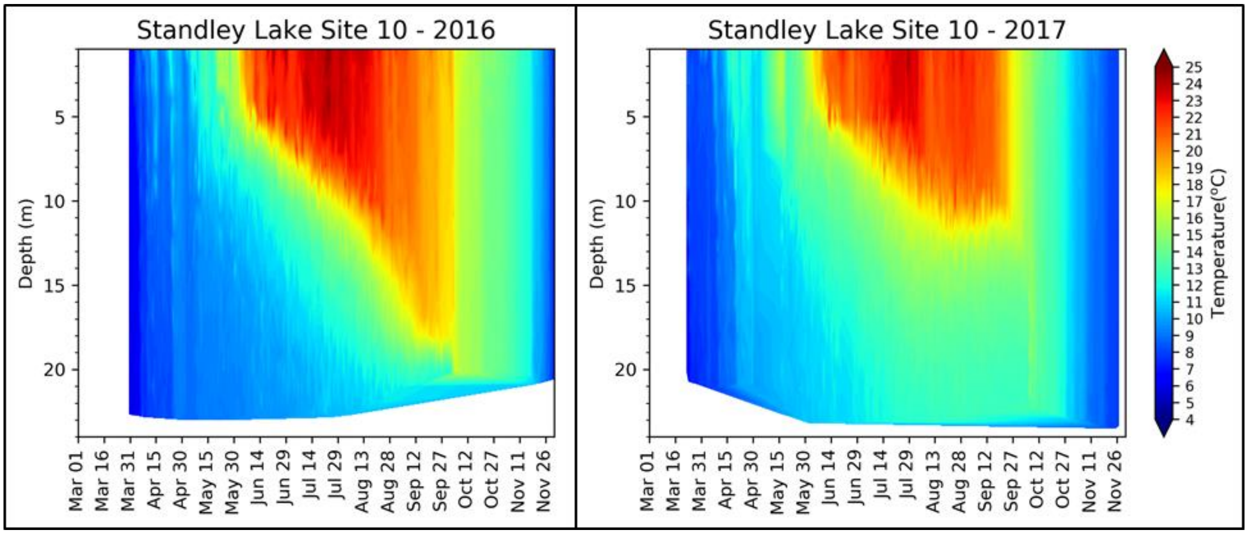


Figure 38. Contour Plots of Temperature in Standley Lake in 2016 and 2017

DISSOLVED OXYGEN

Dissolved oxygen is an important water quality constituent because of its effect on aquatic life and drinking water treatment. Dissolved oxygen at the sediment-water interface (i.e. the bottom of the lake) is of particular relevance. Low DO at this location can result in the loading of nutrients and certain metals from the sediment to the water column. These releases can lead to increases in water treatment costs and the potential for taste and odor events in drinking water.

Each year, Standley Lake experiences hypoxia (DO concentrations ≤ 2.0 mg/L) at the bottom. This is common for stratified reservoirs in Colorado. In 2017, DO concentrations started dropping at the bottom earlier than typical (mid-May) and hypoxic conditions were well developed by the beginning of August. These hypoxic conditions were maintained until turnover in early October. A contour plot of dissolved oxygen concentrations in Standley Lake for March through early December 2017 is provided in Figure 39.

Dissolved oxygen concentrations measured at the top and bottom of Standley Lake through 2017 are displayed in Figure 40. At the surface, the cyclical patterns in DO concentrations are driven by the decrease in oxygen solubility with increasing temperatures. The onset of stratification is observed to occur in mid-May, as indicated by the divergence of lake-bottom DO concentrations from surface concentrations. This divergence increases in magnitude as dissolved oxygen is depleted in the hypolimnion and is maintained by continued stratification. Consistent with the contour plot (Figure 39), the divergence between surface and bottom DO concentrations is extinguished with turnover in early October.

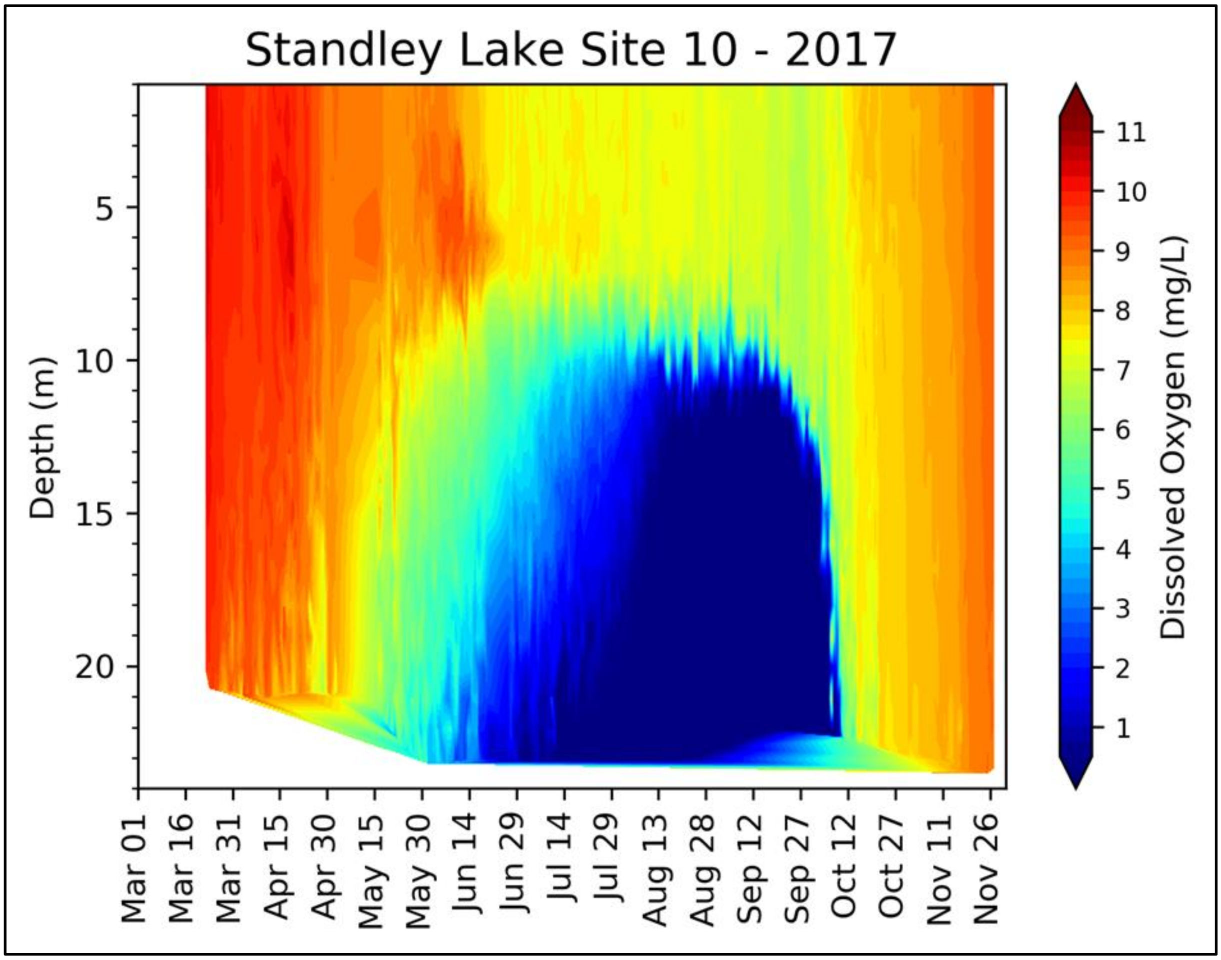


Figure 39. Contour Plot of Dissolved Oxygen in Standley Lake, March-December 2017

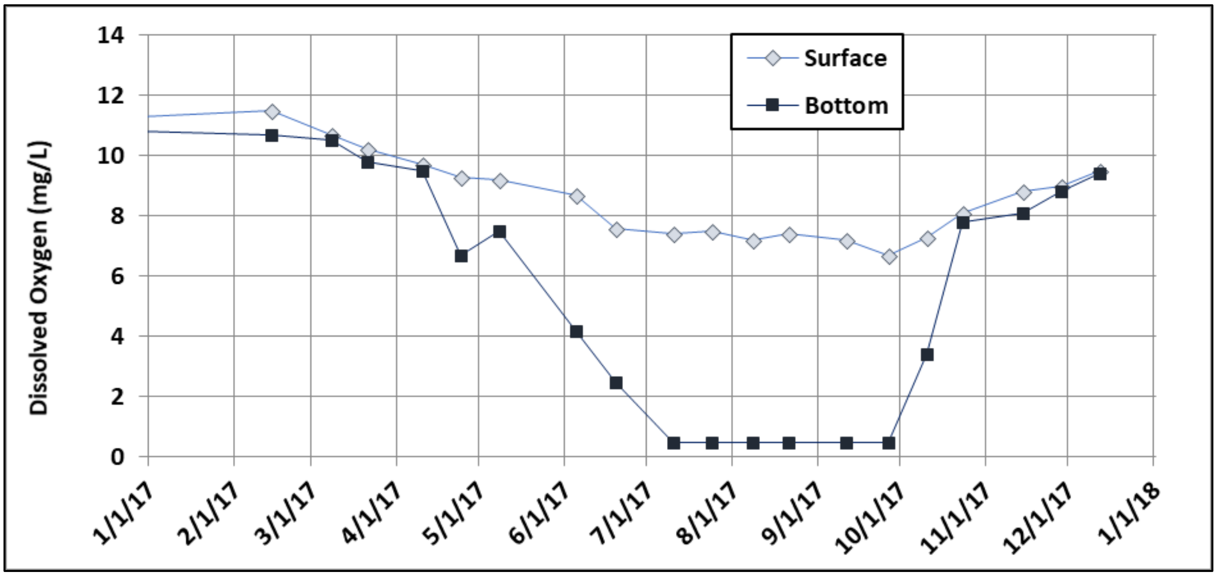


Figure 40. Dissolved Oxygen Concentrations in Standley Lake from Manual Profiles, 2017

Although hypoxic conditions at the reservoir bottom started early, the 2017 seasonal dissolved oxygen patterns closely match those observed in previous years in Standley Lake, as shown in Figure 41.

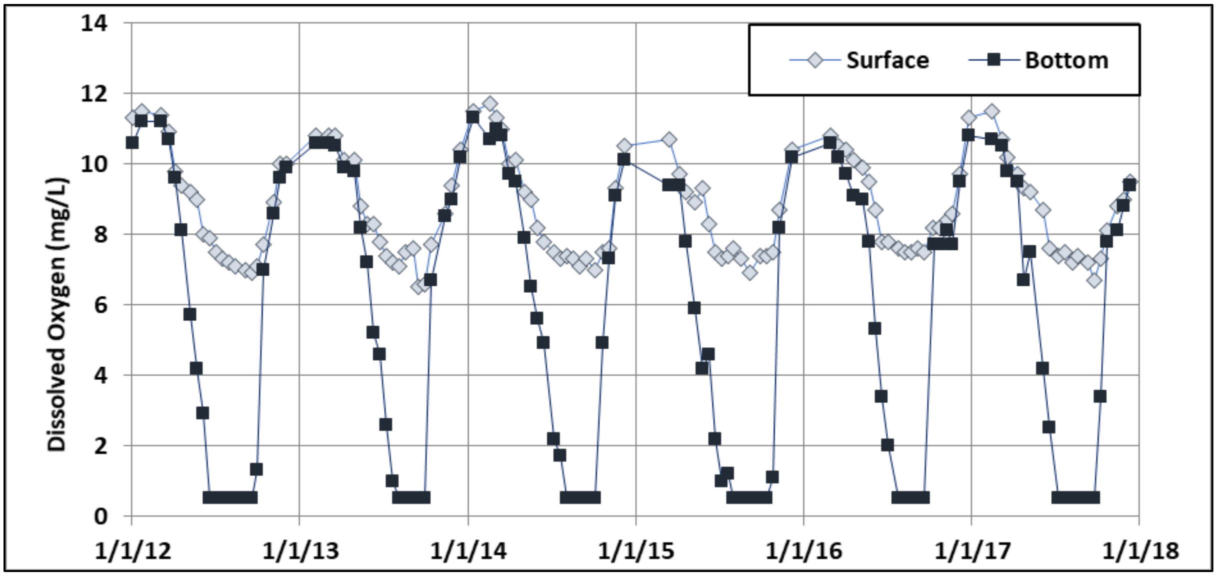


Figure 41. Dissolved Oxygen Concentrations in Standley Lake from Manual Profiles, 2012-2017

DAYS OF HYPOXIA

Hypoxia occurs each year in the hypolimnion of Standley Lake, but the start date, end date, and duration vary from year-to-year. The pattern of hypoxia extending well into the higher levels of the water column as observed in Figure 39, and starting early allowed for an increased number of days of hypoxia. In 2017, the hypoxic period started June 17th and lasted 115 days until turnover on October 9th (Figure 42). The period of hypoxia was above the 2012-2016 average of 102 days. Longer periods of hypoxia allow for higher anaerobic internal loads of nutrients.

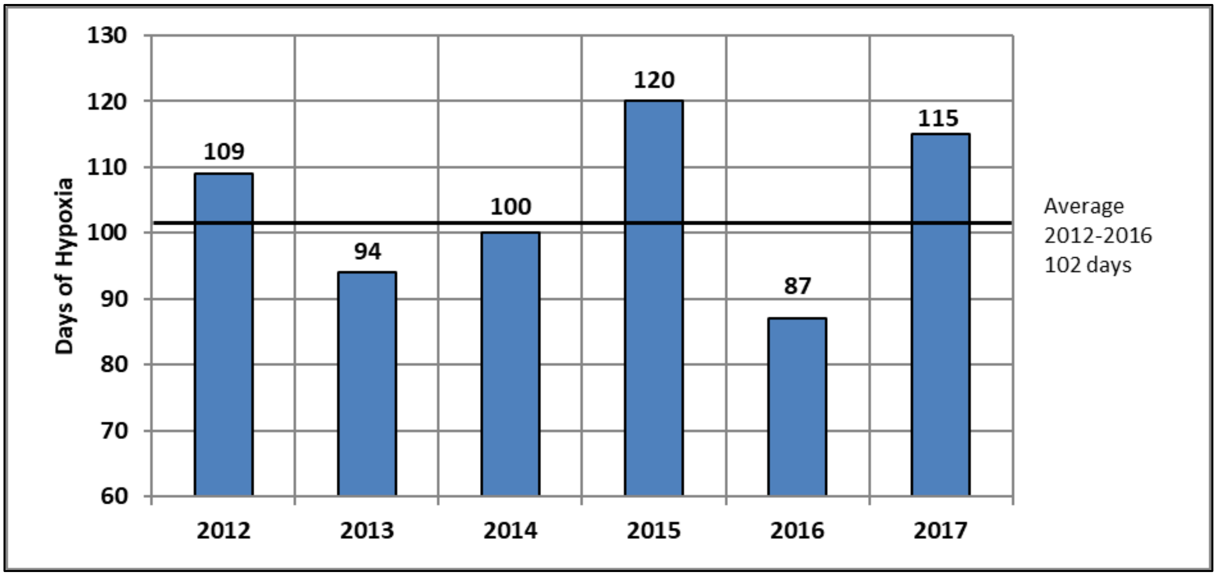


Figure 42. Days of Hypoxia (DO< 2.0 mg/l), 2012-2017

NUTRIENTS

Total Phosphorus

Total phosphorus concentrations observed in Standley Lake in 2017 are displayed in Figure 43. Measurements are made in the photic zone, defined as twice the Secchi depth, and at the bottom of Standley Lake. The most distinct observation from the time series is the large spike (228 µg/L) of TP in the hypolimnion in late September. This increase in TP concentrations in fall is indicative of sediment release of nutrients as a result of hypoxia in the hypolimnion. Dissolved phosphorus (DP) data compared to TP data collected on the same dates are displayed in Figure 44 and reinforce sediment releases as the source. The photic zone displayed little variation throughout the year.

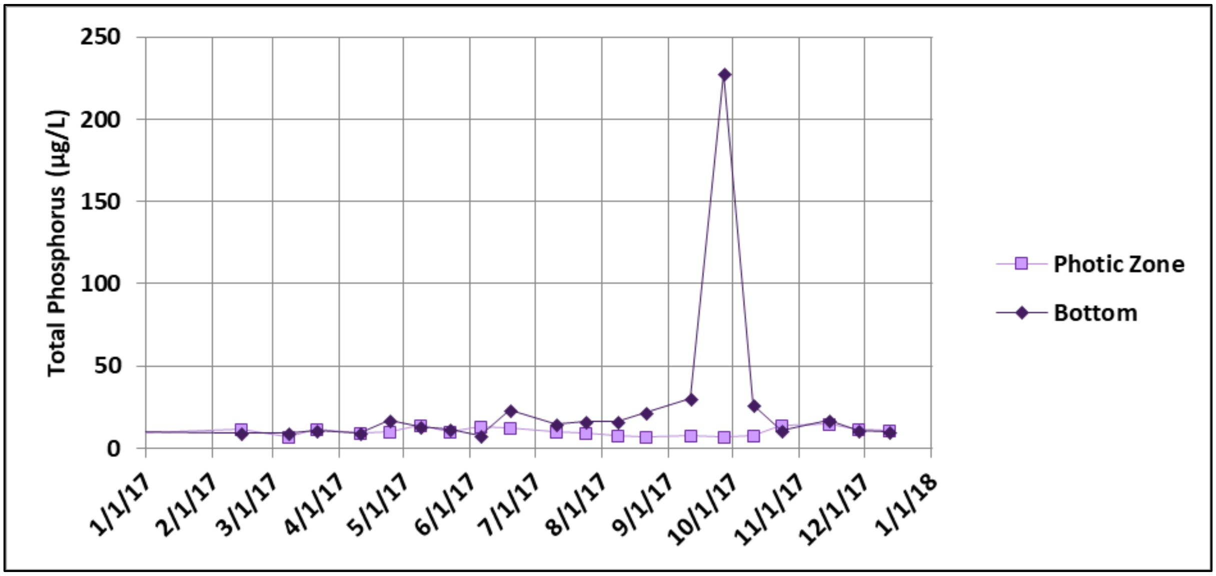


Figure 43. Total Phosphorus Concentrations in Standley Lake, 2017

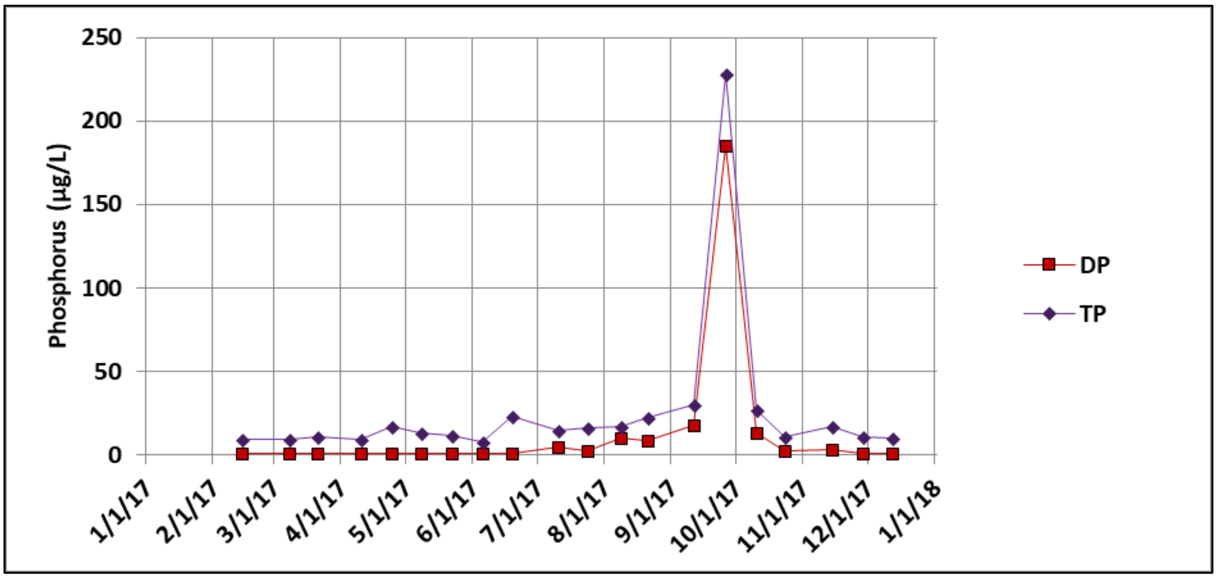


Figure 44. Total and Dissolved Phosphorus Concentrations in Standley Lake, 2017

The observed pattern of sediment releases in late summer/fall is typical of previous years, excluding 2016 where high nitrate concentrations may have prevented sediment release (Hydros, 2017). The sudden increase in TP observed in 2017 is higher than any of the peak concentrations observed since 1999 (Figure 45). Comparing oxidation-reduction potential (ORP) of 2017 to the next highest peak concentration (159 µg/L in 2012) observed in the previous five years (Figure 46) shows that reducing conditions (low ORP) were more prevalent in 2017 and could be driving the observed increase in TP concentrations. It should be noted that this increase is only observed in one sample, while previous years have shown a pattern of increase with at least two samples being high. It is also possible that concentrations have reached these levels in the past but have been missed between sampling events.

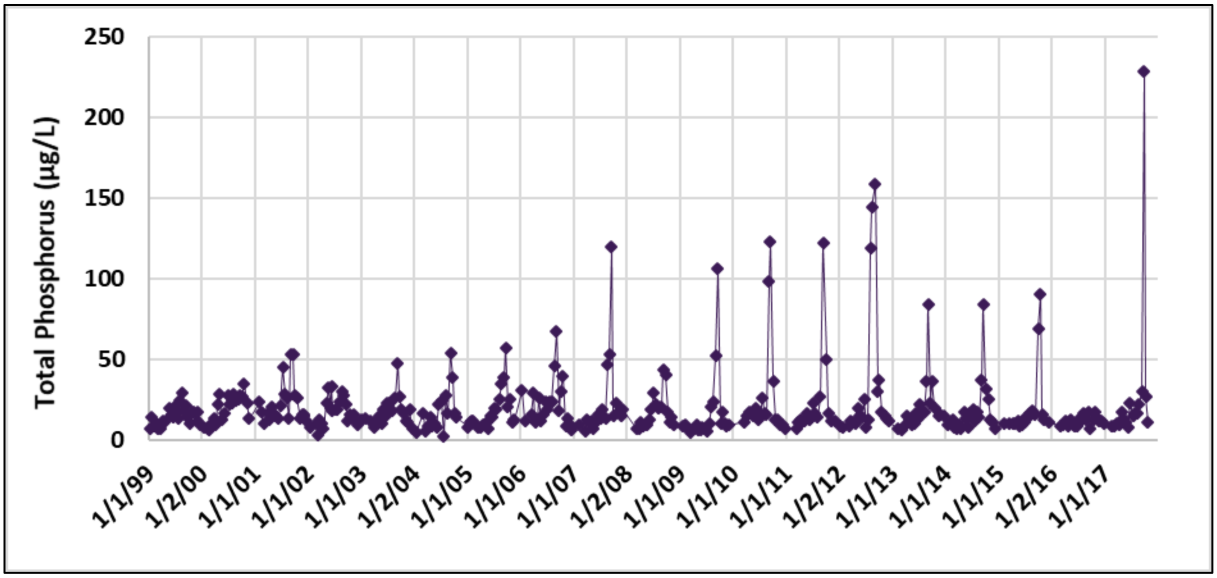


Figure 45. Total Phosphorus Concentrations in Standley Lake, 1999-2017

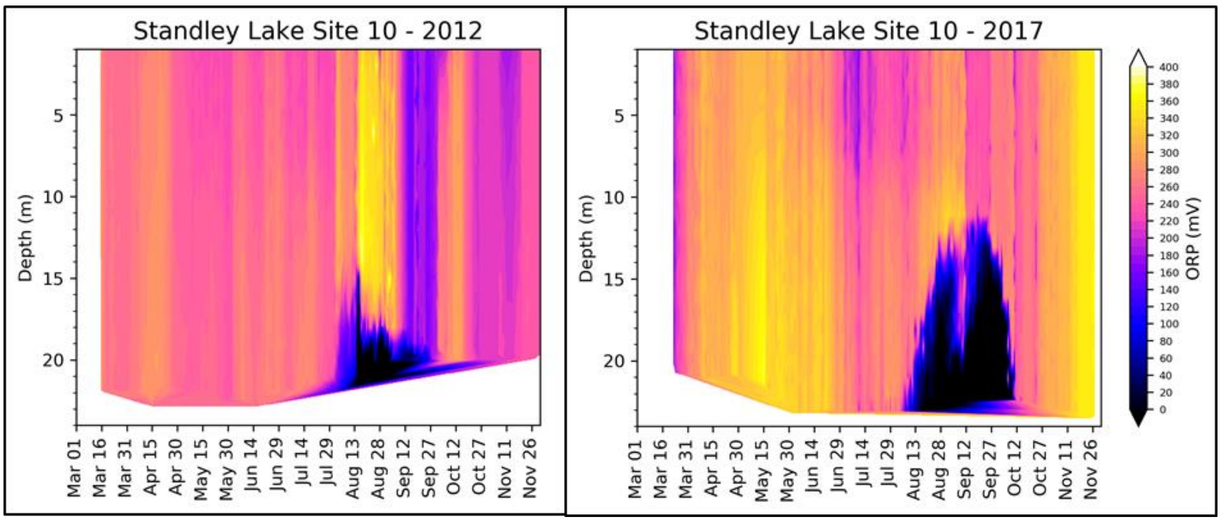


Figure 46. Contour Plots of ORP for Standley Lake in 2012 and 2017

Total Nitrogen

Total nitrogen concentrations in Standley Lake are displayed in Figure 47. TN concentrations at the bottom of the lake exhibited a sharp increase to 700 µg/L on the same day (September 26, 2017) as the TP increase discussed in the previous sub-section. This is consistent with evidence of internal loading. The pattern of higher concentrations in early summer reflects external loading during the runoff season. The photic zone showed smaller amounts of variability.

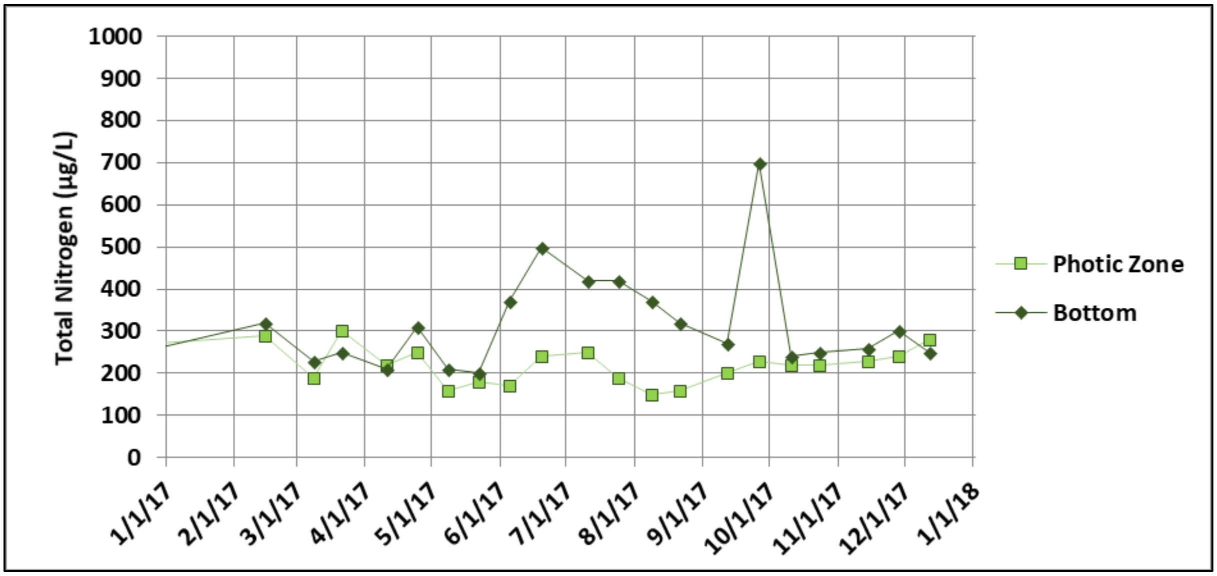


Figure 47. Total Nitrogen Concentrations in Standley Lake, 2017

Concentrations of TN in the lake for 2012-2017 are shown in Figure 48. Overall, TN concentration ranges observed in 2017 at the bottom and in the photic zone were comparable to previous years. The 2017 average TN concentrations (320 µg/L hypolimnion, 216 µg/L photic zone) were 16% lower in the hypolimnion and 17% lower in the photic zone when compared with the 2012-2016 annual average concentrations.

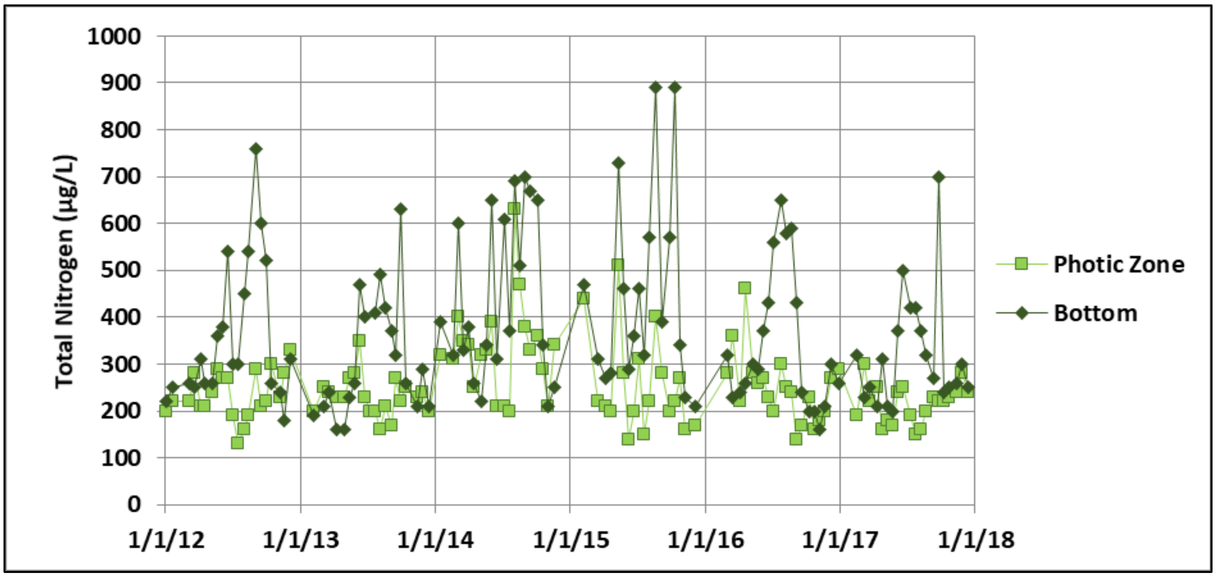


Figure 48. Total Nitrogen Concentrations in Standley Lake, 2012-2017

CHLOROPHYLL *a*

Chlorophyll *a* concentrations observed in Standley Lake in 2017 are presented in Figure 49. March through November is the relevant period for standards assessment and this period is indicated by the grey box. The maximum concentration measured in 2017 was 7.0 µg/L and occurred on April 24, 2017.

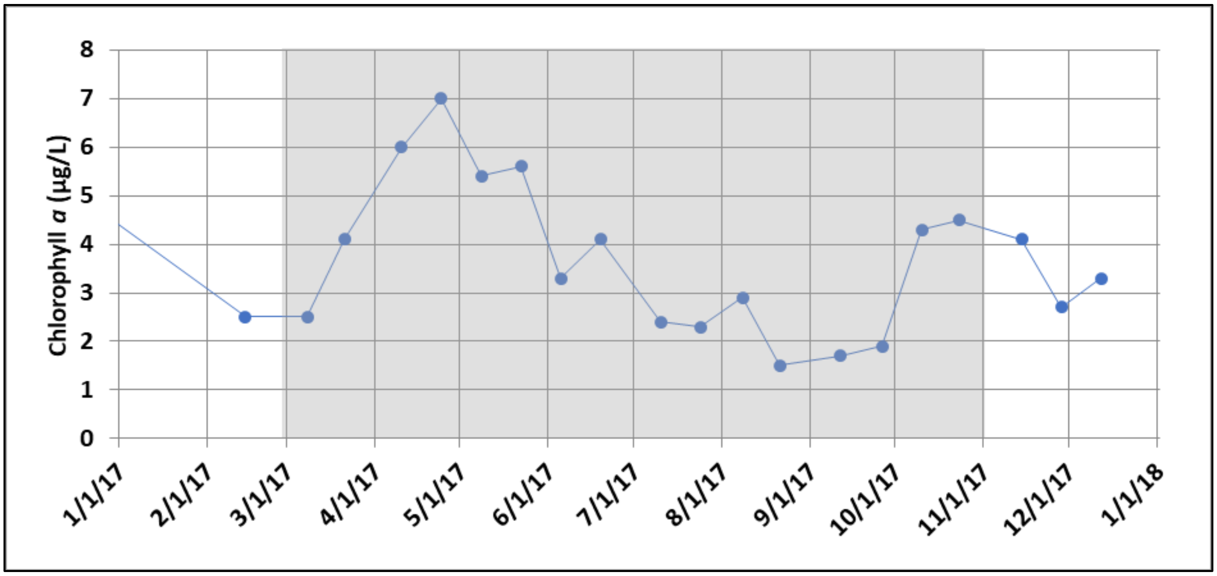


Figure 49. Chlorophyll *a* Concentrations in Standley Lake, 2017 (March-November Assessment Period in Grey)

Chlorophyll *a* observations from 2012-2017 are shown in Figure 50. In addition, a contour plot of chlorophyll *a* concentrations in Standley Lake for March to December 2017 is shown in Figure 51. Temporally, the patterns were consistent with previous years with a peak in the spring and after fall turnover. However, this year the peak concentration in the fall was lower than the spring peak, and differs somewhat from other years in terms of magnitude, likely impacted by abundant zooplankton. It was noted that shortly after algal concentrations started to increase in the fall, the population of zooplankton increased sharply. As such, it is believed that zooplankton grazing reduced chlorophyll *a* concentrations before the next biweekly sampling occurred.

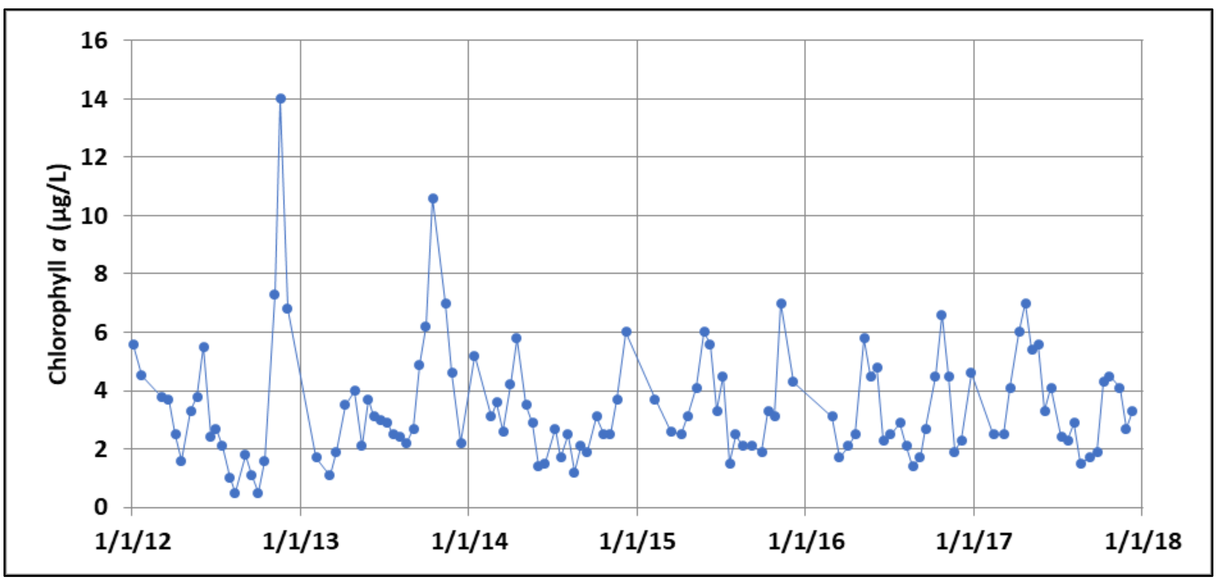


Figure 50. Chlorophyll *a* Concentrations in Standley Lake, 2012-2017

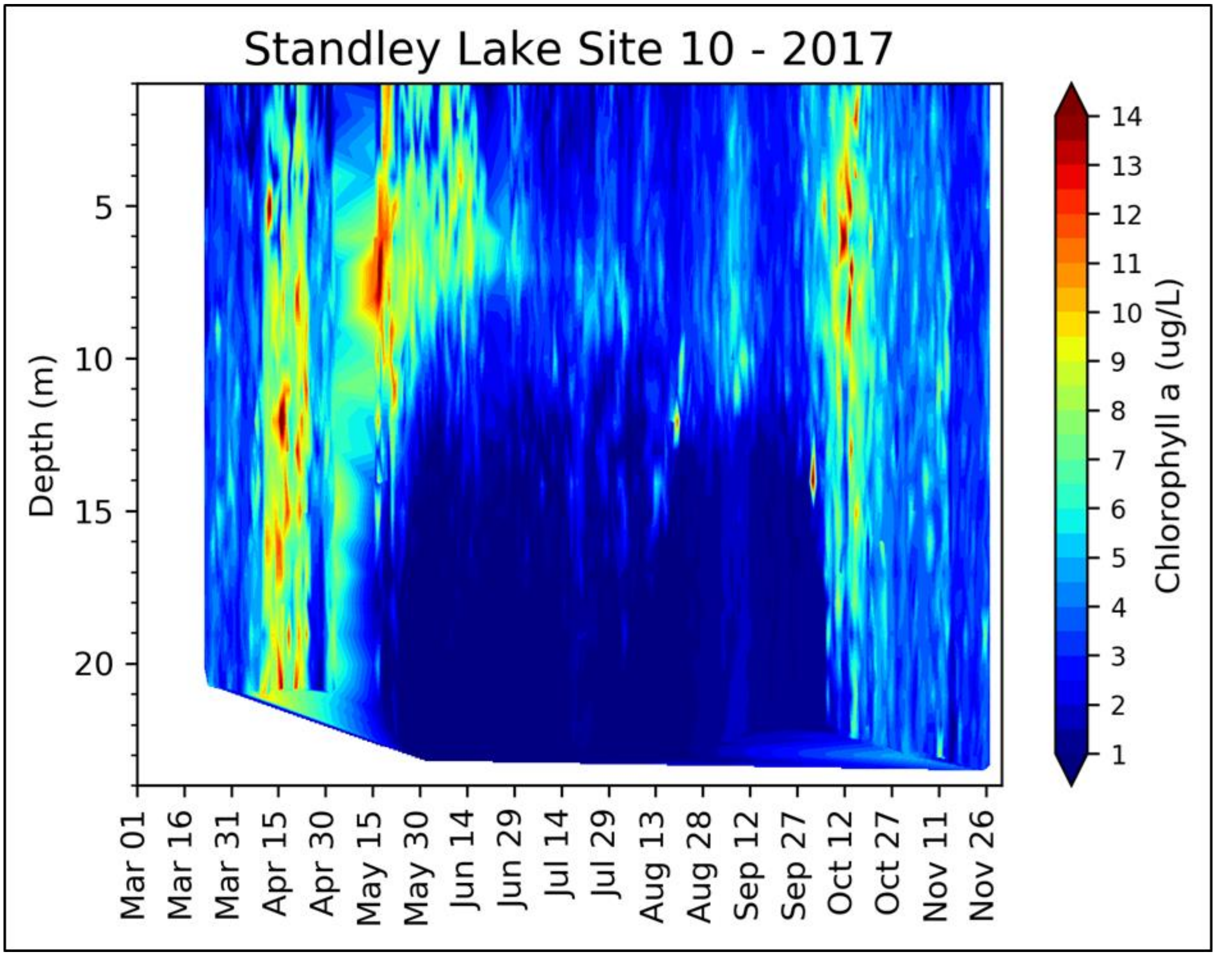


Figure 51. Contour Plot of Chlorophyll *a* Concentrations in Standley Lake, 2017

A chlorophyll *a* standard of 4.0 µg/L was established in 2009 for Standley Lake. This standard is evaluated on an annual basis using the average of observed data for the nine-month period from March through November. To account for the natural variability in chlorophyll *a* concentrations, the standard is assessed using a concentration of 4.4 µg/L. The 2017 average was 3.7 ug/L (Figure 52). This average is calculated as the average of all measurements from the photic zone for the period of March through November.

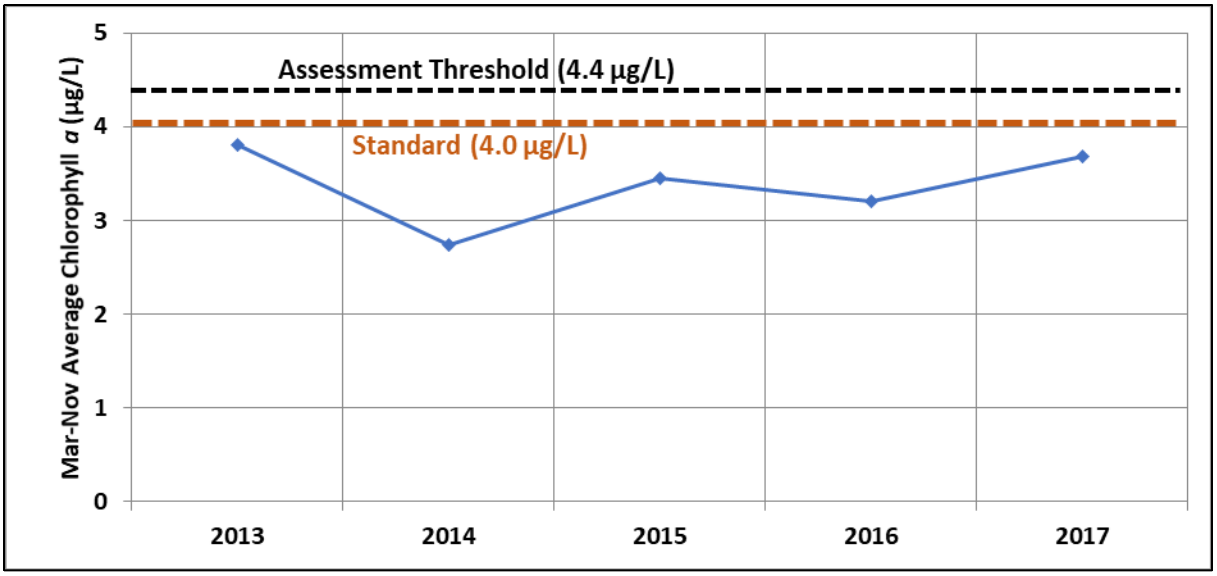


Figure 52. March-November Average Chlorophyll *a* Concentrations, 2013-2017

The standard for chlorophyll *a* in Standley Lake was met in 2017. The 2017 average is compliant with both the 4.0 µg/L standard and 4.4 µg/L assessment threshold. The standard is met when four out of the five most recent years have a March-though-November average concentration below 4.4 µg/L. Every year in the five-year period from 2013 to 2017 has had a March-November average concentration below 4.0 µg/L. Of the last ten years, only one year (2007, at 4.8 µg/L) had a March-November average concentration above 4.0 µg/L. This occurred prior to the implementation of the relevant standard in 2009.

SECCHI DEPTH

Clarity in Standley Lake is measured using a Secchi disk. When taking this measurement, a black-and-white disk is lowered vertically into the lake until the disk is no longer visible. The resulting depth, termed the Secchi depth, provides a measure of the scattering and absorption of light in the upper portion of the water column. This includes the effects of algae, non-algal organic particulate matter, inorganic suspended solids, dissolved organic matter, and the water molecules themselves. Secchi-depth measurements for Standley Lake in 2017 are shown in Figure 53. The measure of clarity with the greatest depth (7.0 m) occurred on August 21, 2017. Through the year clarity is variable, reflecting a combination of effects such as inflowing suspended solids, algal growth, particle settling, and stratification.

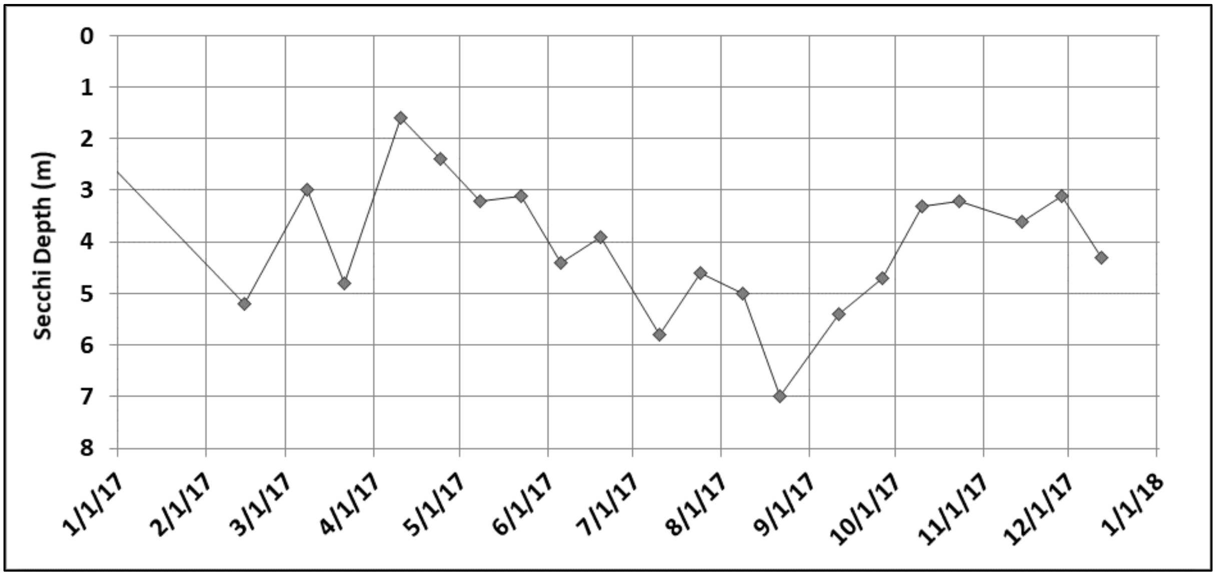


Figure 53. Clarity as Measured by Secchi Depth in Standley Lake, 2017

Individual Secchi-depth measurements for the past six years are shown in Figure 54. The observation on August 21, 2017 was the highest Secchi depth recorded for Standley Lake over the period 2002-2017. This date corresponds to the minimum chlorophyll *a* measurement of 1.5 ug/L. Average annual Secchi depths for 2012-2017 can be found in Figure 55. The annual average (4.1 m) and range of Secchi depths observed in 2017 were consistent with the range of those observed in recent years.

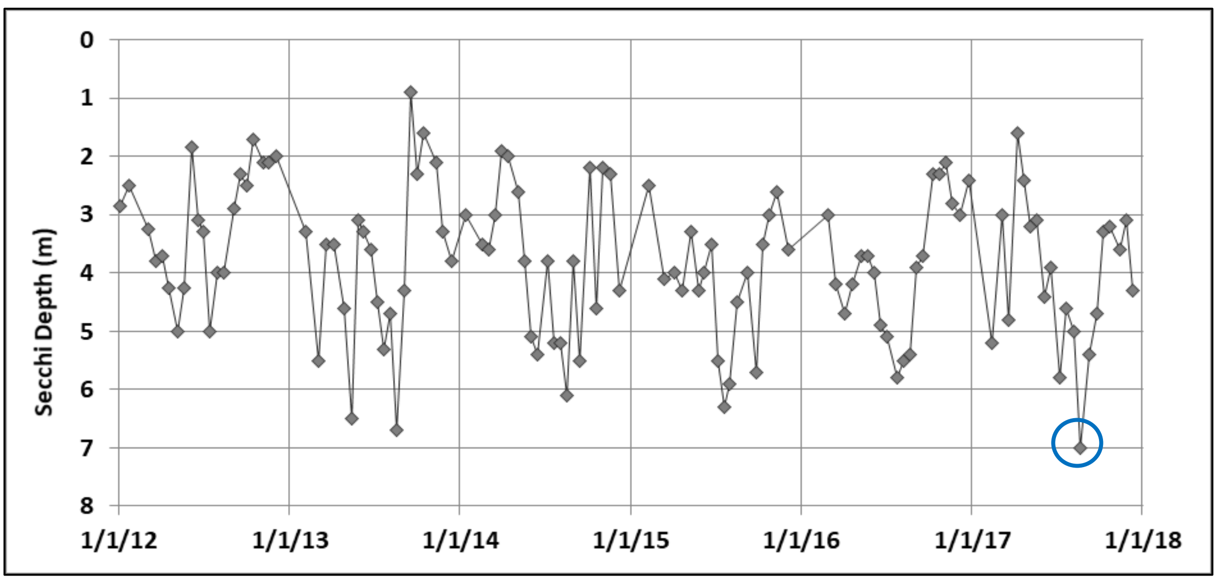


Figure 54. Clarity as Measured by Secchi Depth in Standley Lake, 2012-2017

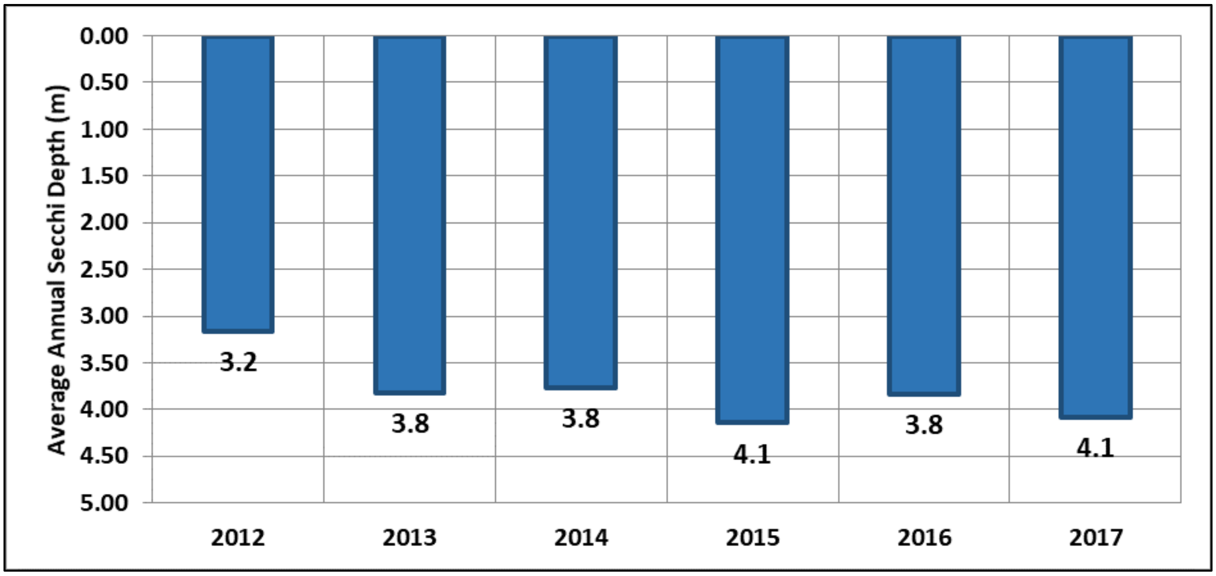


Figure 55. Average Annual Secchi Depth in Standley Lake, 2012-2017

REFERENCES

Colorado River District 2018. Water Glossary. https://www.coloradoriverdistrict.org/water-glossary/

Hydros Consulting 2017. Clear Creek/ Standley Lake Watershed Agreement. 2016 Annual Report. September 1, 2017.

National Weather Service 2018. NOAA Online Weather Data. https://w2.weather.gov/climate/xmacis.php?wfo=bou

ACRONYMS

AF - Acre Feet

CC26 - Clear Creek Sampling Station: Clear Creek at Lawson Gage

CCAS26 - Clear Creek Autosampler Station: Clear Creek at Lawson Gage

CC59 - Clear Creek Autosampler Station: Clear Creek 2 Miles West of Highway 58/US6 in Golden. Storm water-Only Location Operated by City of Golden

CCAS59 - Clear Creek Autosampler Station: Clear Creek 2 Miles West of Highway 58/US6 in Golden

CC60 - Clear Creek Sampling Station: Clear Creek at Church Ditch Headgate

CFS - Cubic Feet per Second

FHL - Farmers' Highline Canal

Church - Church Ditch

Croke - Croke Canal

DO - Dissolved Oxygen

DP - Dissolved Phosphorus

KDPL - Kinnear Ditch Pipeline

NOAA - National Oceanic and Atmospheric Administration

ORP - Oxidation-Reduction Potential

TN - Total Nitrogen

TP - Total Phosphorus

ADDITIONAL INFORMATION

TSS - Total Suspended Solids

USGS - United States Geological Survey

SUPPLEMENTAL INFORMATION 4

CLEAR CREEK, CANAL, AND STANDLEY LAKE WATER-QUALITY MONITORING DATA - 2017

Clear Creek Grabs

Method				SM2550B	SM4500H+B	SM2510B	SM4500OG	SM2130B	SM5310B	SM2540D	SM4500NH3H	SM4500NO3I	SM4500NO3I	SM4500PE	SM4500PE				
DL				1.0	1.0	10	1.0	1	0.5	1	0.01	0.01	0.02	0.0025	0.0025				
Max Sig figs				3	3	3	3	3	3	3	3	3	3	3	3				
Max decimals				1	1	0	1	1	1	0	2	2	2	4	4				
Reporting Units				°C	s.u.	µS/cm	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
Sample Date	Sample Time	Sample Type	Location ID	Temp	pH	Conductivity, Specific	Oxygen, Dissolved	Turbidity	Carbon, Total Organic	Solids, Total Suspended	Nitrogen, Ammonia (Salicylate)	Nitrogen, Nitrate+Nitrite	Nitrogen, Total Nitrogen	Phosphorus, Dissolved (DRP)	Phosphorus, Total	Notes	Conclusion	Field Notes	Lab Notes
02/08/17	9:40	G	CC 26	1.9	7.8	359	9.8	1.5	0.9	2	0.02	0.31	0.35	< 0.0025	0.0055				
02/08/17	10:00	G	CC 40	2.2	7.9	406	10.1	2.2	1.2	8	0.01	0.37	0.47	< 0.0025	0.0156				
02/08/17	10:22	G	CC 50	4	7.9	718	9.7	36.5	1.5	14	0.03	0.33	0.44	< 0.0025	0.0109				
02/08/17	11:05	G	CC 60	1.3	7.2	404	10.7	6.7	1	8	0.02	0.4	0.64	< 0.0025	0.0186				
04/12/17	10:19	G	CC 26	5	7.7	564	9.6	<1	1.5	<1	0.02	0.19	0.33	< 0.0025	0.0053				
04/12/17	10:48	G	CC 40	5.8	7.6	494	9.6	<1	1.4	2	< 0.01	0.21	0.34	< 0.0025	0.0081				
04/12/17	11:11	G	CC 50	7.7	9.6	499	9.4	8.5	2	8	0.01	0.23	0.39	< 0.0025	0.0103				
04/12/17	11:45	G	CC 60	7.8	7.7	534	9.8	<1	1.5	<1	<0.01	0.24	0.37	< 0.0025	0.0056				
05/10/17	10:05	G	CC 05	4	6.7	268	NT	11.5	4	4	0.01	0.1	0.23	0.0027	0.0072			Staff gage = 4.24	
05/10/17	10:32	G	CC 10	5.2	6.9	132	NT	10.3		<1	0.01	0.12	0.22	< 0.0025	0.0042				
05/10/17	10:18	G	CC 15	5	7	451	8.7	2.3		3	0.04	0.1	0.22	0.0045	0.0064				
05/10/17	10:39	G	CC 20	6.1	7.1	363	8.9	3.5	2.2	4	0.03	0.1	0.21	0.0033	0.0104				
05/10/17	10:50	G	CC 25	8.4	6.8	267	9.2	11.4		12	<0.01	0.1	0.21	< 0.0025	0.0086				
05/10/17	11:05	G	CC 26	7.7	7.1	306	9.2	15.7	2.4	3	0.01	0.1	0.25	< 0.0025	0.0091				
05/10/17	9:54	G	CC 30	5.3	7.3	88	9.5	2.3		3	0.01	0.04	0.18	0.0026	0.0135			staff gage = 1.2	
05/10/17	11:45	G	CC 34	8.2	7.2	278	9.3	12.5		2	0.01	0.11	0.24	< 0.0025	0.0114				
05/10/17	11:30	G	CC 35	5.5	7.4	90	9.7	11.9	3.7	5	<0.01	0.06	0.2	0.0044	0.0108				
05/10/17	9:30	G	CC 40	0:00	7.1	302	9.2	10.9	2.6	21	0.02	0.12	0.28	0.0029	0.0215			staff gage = 4.1	
05/10/17	11:39	G	CC 44	4.4	7.6	90	9.8	16.8		16	<0.01	0.02	0.15	0.0083	0.037				
NS	NS	G	CC 45																
05/10/17	12:01	G	CC 50	6.8	7.3	195	9.4	68.3	3.4	102	<0.01	0.06	0.32	0.0049	0.0642				
05/10/17	12:05	G	CC 52	8.5	7.2	286	9.1	295	3.5	332	0.03	0.22	0.76	0.0031	0.131				
05/10/17	12:20	G	CC 53	9.9	7.1	476	8.8	62.3	4.4	78	0.02	0.33	0.67	0.0067	0.07				
05/10/17	12:34	G	CC 60	9.5	7.3	302	9.3	16.3	2.6	21	0.01	0.15	0.32	0.0027	0.0311				
05/10/17		QC	CCP110												0.0049				
05/10/17		QC	CCD110										0.17		0.0259				
05/10/17		QC	CCN110										0.35						
10/11/17	10:20	G	CC 05	2.1	8.2	200	9	< 1	1.5	3	<0.01	0.23	0.32	0.0032	0.0052			Staff Gage 3.85	
10/11/17	10:56	G	CC 10	1.9	7.9	128	8.9	1		<1	0.02	0.1	0.2	0.0035	0.004			Staff Gage 3.65	
10/11/17	10:10	G	CC 15	8.4	7.5	628	8.8	1.2		<1	0.06	0.14	0.3	0.0025	0.0034			Staff Gage 3.9	
10/11/17	10:35	G	CC 20	8	7.6	390	8.9	1.1	4.4	<1	0.03	0.14	0.26	0.0027	0.01				
10/11/17	11:15	G	CC 25	5.4	7.7	184	8.9	1		<1	0.02	0.11	0.23	< 0.0025	0.0048				
10/11/17	11:33	G	CC 26	4.7	7.7	248	9	1.3	1.5	<1	0.01	0.13	0.22	0.0025	0.0061				
10/11/17	9:45	G	CC 30	8.3	8	64	9.4	1.5		3	<0.01	0.07	0.17	0.0027	0.0101			Staff Gage 1.2	
10/11/17	11:57	G	CC 34	4.7	7.8	224	9	1		<1	0.01	0.13	0.24	< 0.0025	0.0064				
10/11/17	11:45	G	CC 35	2.6	8.1	71	9	4.1	5.4	4	0.02	0.11	0.49	0.0125	0.0174				

Clear Creek Grabs

Method				SM2550B	SM4500H+B	SM2510B	SM4500OG	SM2130B	SM5310B	SM2540D	SM4500NH3H	SM4500NO3I	SM4500NO3I	SM4500PE	SM4500PE				
DL				1.0	1.0	10	1.0	1	0.5	1	0.01	0.01	0.02	0.0025	0.0025				
Max Sig figs				3	3	3	3	3	3	3	3	3	3	3	3				
Max decimals				1	1	0	1	1	1	0	2	2	2	4	4				
Reporting Units				°C	s.u.	µS/cm	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
Sample Date	**Sample Time**	**Sample Type**	**Location ID**	**Temp**	**pH**	**Conductivity, Specific**	**Oxygen, Dissolved**	**Turbidity**	**Carbon, Total Organic**	**Solids, Total Suspended**	**Nitrogen, Ammonia (Salicylate)**	**Nitrogen, Nitrate+Nitrite**	**Nitrogen, Total Nitrogen**	**Phosphorus, Dissolved (DRP)**	**Phosphorus, Total**	**Notes**	**Conclusion**	**Field Notes**	**Lab Notes**
10/11/17	9:22	G	CC 40	6.3	7.7	271	9.5	1.2	1.6	<1	0.01	0.13	0.26	0.0025	0.0068			Staff Gage 3.75	
10/11/17	11:05	G	CC 44	7.4	8	117	8.9	1.1		2	<0.01	0.02	0.1	0.0032	0.0052				
10/11/17		G	CC 45																
10/11/17	11:25	G	CC 50	11.3	7.5	572	8.7	3.4	2.4	<1	0.01	0.22	0.39	0.003	0.0089			Staff Gage 4	
10/11/17	12:10	G	CC 52	6.1	7.6	777	8.7	3.1	3.6	3	0.01	0.37	0.54	0.0027	0.0089				
10/11/17	12:22	G	CC 53	7.7	7.8	665	8.5	4.2	4	<1	<0.01	0.31	0.54	0.0025	0.0202				
10/11/17	12:00	G	CC 60	13.2	7.8	313	9.5	1.9	1.7	<1	<0.01	0.22	0.36	0.0029	0.0176				
10/11/17		QC	CCP111												0.0055				
10/11/17		QC	CCD111										0.09		0.0186				
10/11/17		QC	CCN111										0.4						
12/13/17	10:22	G	CC 26	2.5	7.1	333	9.3	< 1	NT	3	0.03	0.25	0.38	< 0.0025	0.0047				
12/13/17	10:50	G	CC 40	1.3	7.2	342	9.4	< 1	1.1	<1	0.02	0.3	0.45	< 0.0025	0.0065				
12/13/17	11:30	G	CC 50	3.5	7.4	826	9.2	< 1	1.8	3	0.01	0.3	0.48	< 0.0025	0.0068				
12/13/17	12:00	G	CC 60	1.4	7.7	391	10	1.2	1.2	3	< 0.01	0.32	0.45	< 0.0025	0.0079				

Tribs

Method				SM2510B	SM4500OG	SM2550B	SM4500PE	SM4500PE	SM4500NH3H	SM4500NO3I	SM4500NO3I	SM5310B	SM2540D					
Reporting Limit Goal				10	1.0	1.0	0.0025	0.0025	0.01	0.01	0.02	0.5	1					
Max Sig figs				3	3	3	3	3	3	3	3	3	3					
Max decimals				0	1	1	4	4	2	2	2	1	0					
Reporting Units				µS/cm	mg/L	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L					
Sample Date	Sample Time	Sample Type	Location ID	Conductivity, Specific	Oxygen, Dissolved	Temp	Phosphorus, Dissolved (DRP)	Phosphorus, Total	Nitrogen, Ammonia (Salicylate)	Nitrogen, Nitrate+Nitrite	Nitrogen, Total Nitrogen	Carbon, Total Organic	Solids, Total Suspended	Notes	Conclusion	Field Notes	Lab Notes	Notes_conc
01/04/17	9:05	G	Trib 01	421	9.8	1.8	< 0.0025	0.0055	0.06	0.47	0.81	1	3					- - -
NS	NS	G	Trib 02											Not sampled				Not sampled - - -
01/04/17	9:25	G	Trib 03	438	8.2	5.9	0.003	0.0086	0.08	0.51	0.83	1.1	5					- - -
01/04/17	10:00	G	Trib 04	449	9.4	1.7	0.0059	0.0426	0.05	0.47	0.87	1.2	51					- - -
NS	NS	G	Trib 11											Not sampled				Not sampled - - -
NS	NS	G	Trib 22a											Not sampled				Not sampled - - -
NS	NS	G	Trib 22d											Not sampled				Not sampled - - -
01/04/17	8:20	G	Trib 24	349	8.8	8	0.0028	0.0091	0.03	0.05	0.39	1.9	4					- - -
NS	NS	G	Trib 25											Not sampled				Not sampled - - -
NS	NS	G	Trib 27 (New C											Not sampled				Not sampled - - -
02/01/17	9:10	G	Trib 01	449	9.8	1.8	0.0026	0.0063	0.02	0.42	0.51	1	5	Not sampled				Not sampled - - -
02/01/17	9:50	G	Trib 02	470	8.9	4.8	0.0035	0.0068	0.02	0.46	0.6	1.1	<1	Not sampled				Not sampled - - -
02/01/17	10:05	G	Trib 03	463	8.2	5.6	0.0029	0.0068	0.03	0.46	0.64	1	3					- - -
02/01/17	10:35	G	Trib 04	473	8.6	4.5	0.003	0.0223	0.04	0.44	0.64	1.2	25					- - -
NS	NS	G	Trib 11											Not sampled				Not sampled - - -
NS	NS	G	Trib 22a											Not sampled				Not sampled - - -
NS	NS	G	Trib 22d											Not sampled				Not sampled - - -
02/01/17	8:30	G	Trib 24	422	9	7.4	0.0029	0.0117	0.05	0.12	0.28	1.8	2					- - -
NS	NS	G	Trib 25											Not sampled				Not sampled - - -
NS	NS	G	Trib 27 (New Church Ditch Inlet)											Not sampled				Not sampled - - -
NS	NS	G	Trib 01											Not sampled				Not sampled - - -
03/01/17	9:50	G	Trib 02	492	8.5	5.8	0.0025	0.0055	0.01	0.49	0.58	1.2	3					- - -
03/01/17	10:05	G	Trib 03	456	8	7.5	0.0025	0.0065	0.01	0.43	0.55	1.1	3					- - -
03/01/17	10:35	G	Trib 04	445	8.9	4	0.0045	0.0313	0.02	0.43	0.6	1.3	34					- - -
NS	NS	G	Trib 11											Not sampled				Not sampled - - -
NS	NS	G	Trib 22a											Not sampled				Not sampled - - -
NS	NS	G	Trib 22d											Not sampled				Not sampled - - -
03/01/17	8:30	G	Trib 24	343	8.1	8.7	< 0.0025	0.0104	0.02	0.05	0.26	2	5					- - -
NS	NS	G	Trib 25											Not sampled				Not sampled - - -
NS	NS	G	Trib 27 (New Church Ditch Inlet)											Not sampled				Not sampled - - -
04/05/17	9:10	G	Trib 01	716	10	3.5	< 0.0025	0.0079	0.01	0.31	0.42	1.5	6					- - -
04/05/17	9:30	G	Trib 02	747	8.5	8.8	0.0025	0.0074	0.02	0.3	0.42	1.6	<1					- - -
04/05/17	9:45	G	Trib 03	741	8.4	7.7	0.0053	0.0123	0.02	0.31	0.43	1.9	<1					- - -
04/05/17	10:20	G	Trib 04	862	7.7	7.1	0.0094	0.0428	0.05	0.3	0.57	2.8	33					- - -
04/05/17	10:15	G	Trib 11	587	8	7.7	0.0043	0.0146	0.02	0.31	0.47	2.5	<1					- - -
NS	NS	G	Trib 22a											Not sampled				Not sampled - - -
NS	NS	G	Trib 22d											Not sampled				Not sampled - - -
04/05/17	8:35	G	Trib 24	402	7.2	10.9	< 0.0025	0.0125	0.01	0.05	0.21	1.9	<1					- - -
NS	NS	G	Trib 25											Not sampled				Not sampled - - -
NS	NS	G	Trib 27 (New Church Ditch Inlet)											Not sampled				Not sampled - - -
05/03/17	9:10	G	Trib 01	391	9.7	7.5	< 0.0025	0.009	< 0.01	0.16	0.24	1.8	4					- - -
05/03/17	9:30	G	Trib 02	402	8.5	10.4	< 0.0025	0.0083	0.01	0.17	0.28	1.9	2					- - -
05/03/17	9:50	G	Trib 03	520	7.8	10.7	0.0049	0.0149	0.04	0.22	0.42	2.4	2					- - -

Tribs

Method				SM2510B	SM4500OG	SM2550B	SM4500PE	SM4500PE	SM4500NH3H	SM4500NO3I	SM4500NO3I	SM5310B	SM2540D					
Reporting Limit Goal				10	1.0	1.0	0.0025	0.0025	0.01	0.01	0.02	0.5	1					
Max Sig figs				3	3	3	3	3	3	3	3	3	3					
Max decimals				0	1	1	4	4	2	2	2	1	0					
Reporting Units				µS/cm	mg/L	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L					
Sample Date	Sample Time	Sample Type	Location ID	Conductivity, Specific	Oxygen, Dissolved	Temp	Phosphorus, Dissolved (DRP)	Phosphorus, Total	Nitrogen, Ammonia (Salicylate)	Nitrogen, Nitrate+Nitrite	Nitrogen, Total Nitrogen	Carbon, Total Organic	Solids, Total Suspended	Notes	Conclusion	Field Notes	Lab Notes	Notes_conc
NS	NS	G	Trib 04											Not sampled				Not sampled - - -
05/03/17	10:55	G	Trib 11	421	7.8	11.3	0.0042	0.013	0.02	0.17	0.33	2.4	3					- - -
NS	NS	G	Trib 22a											Not sampled				Not sampled - - -
NS	NS	G	Trib 22d											Not sampled				Not sampled - - -
05/03/17	8:25	G	Trib 24	397	6.8	12.8	< 0.0025	0.013	0.02	0.04	0.22	2	2					- - -
NS	NS	G	Trib 25											Not sampled				Not sampled - - -
05/03/17	10:35	G	Trib 27 (New C	392	8.7	8.6	0.0069	0.0168	< 0.01	0.13	0.27	2.3	5					- - -
06/07/17	9:15	G	Trib 01	131	9.4	11.5	0.0051	0.0296	0.04	0.14	0.41	4.1	31					- - -
06/07/17	9:30	G	Trib 02	141	8.6	11.1	0.0047	0.0299	0.03	0.14	0.42	4.1	24					- - -
06/07/17	9:45	G	Trib 03	128	9.2	11.6	0.0044	0.0292	0.01	0.13	0.36	4.1	34					- - -
NS	NS	G	Trib 04											Not sampled				Not sampled - - -
06/07/17	10:40	G	Trib 11	154	7.2	15.7	0.0046	0.0201	0.01	0.12	0.31	3.5	26					- - -
NS	NS	G	Trib 22a											Not sampled				Not sampled - - -
NS	NS	G	Trib 22d											Not sampled				Not sampled - - -
06/07/17	8:35	G	Trib 24	392	4.6	15.4	0.0033	0.0098	0.03	0.17	0.34	2	5					- - -
NS	NS	G	Trib 25											Not sampled				Not sampled - - -
06/07/17	10:20	G	Trib 27 (New C	146	7.5	15.1	0.0067	0.022	0.02	0.11	0.37	3.7	18					- - -
07/05/17	9:15	G	Trib 01	125	8.5	14.5	0.0039	0.0095	0.01	0.11	0.27	1.9	2					- - -
07/05/17	9:30	G	Trib 02	121	8.8	14.1	0.003	0.0061	< 0.01	0.1	0.21	1.7	7					- - -
07/05/17	9:45	G	Trib 03	128	7.9	14.8	0.0027	0.0072	< 0.01	0.11	0.2	1.9	<1					- - -
NS	NS	G	Trib 04											Not sampled				Not sampled - - -
07/05/17	10:40	G	Trib 11	127	7.4	16.7	0.0043	0.0145	< 0.01	0.09	0.24	2	24					- - -
NS	NS	G	Trib 22a											Not sampled				Not sampled - - -
NS	NS	G	Trib 22d											Not sampled				Not sampled - - -
07/05/17	8:40	G	Trib 24	380	1.8	15.3	0.0053	0.0249	< 0.01	0.23	0.39	1.9	6					- - -
NS	NS	G	Trib 25											Not sampled				Not sampled - - -
07/05/17	10:20	G	Trib 27 (New C	127	7.2	17.1	0.0055	0.0161	< 0.01	0.09	0.25	2.1	<1					- - -
08/02/17	9:15	G	Trib 01	176	7.2	16.2	0.0042	0.0109	0.02	0.12	0.26	1.6	5					- - -
08/02/17	9:25	G	Trib 02	173	6.8	16.8	0.0035	0.0128	0.02	0.12	0.22	1.6	3					- - -
08/02/17	9:40	G	Trib 03	191	6	18.6	0.0045	0.0137	0.02	0.13	0.3	1.7	11					- - -
NS	NS	G	Trib 04											Not sampled				Not sampled - - -
08/02/17	10:35	G	Trib 11	171	6	19.4	0.0036	0.0245	0.02	0.09	0.25	1.7	24					- - -
NS	NS	G	Trib 22a											Not sampled				Not sampled - - -
NS	NS	G	Trib 22d											Not sampled				Not sampled - - -
08/02/17	8:25	G	Trib 24	325	2.5	19	0.004	0.014	0.02	0.05	0.23	2	17					- - -
NS	NS	G	Trib 25											Not sampled				Not sampled - - -
08/02/17	10:15	G	Trib 27 (New C	179	5.5	19.2	0.0057	0.0201	0.02	0.06	0.25	1.9	11					- - -
09/06/17	9:40	G	Trib 01	254	8.4	14.2	0.0031	0.0071	0.02	0.12	0.25	1.5	4					- - -
09/06/17	10:00	G	Trib 02	253	6.2	18.8	0.0029	0.0067	0.02	0.12	0.29	1.6	2					- - -
09/06/17	10:30	G	Trib 03	275	6.4	17.5	0.0029	0.0071	0.02	0.13	0.29	1.7	5					- - -
NS	NS	G	Trib 04											Not sampled				Not sampled - - -
09/06/17	11:10	G	Trib 11	261	7.3	18.5	0.0031	0.0085	0.02	0.1	0.28	1.6	3					- - -
NS	NS	G	Trib 22a											Not sampled				Not sampled - - -
NS	NS	G	Trib 22d											Not sampled				Not sampled - - -
09/06/17	8:55	G	Trib 24	291	3.3	20	0.0032	0.0122	0.02	0.03	0.22	2	8					- - -

Tribs

Method				**SM2510B**	**SM4500OG**	**SM2550B**	**SM4500PE**	**SM4500PE**	**SM4500NH3H**	**SM4500NO3I**	**SM4500NO3I**	**SM5310B**	**SM2540D**					
Reporting Limit Goal				**10**	**1.0**	**1.0**	**0.0025**	**0.0025**	**0.01**	**0.01**	**0.02**	**0.5**	**1**					
Max Sig figs				**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**					
Max decimals				**0**	**1**	**1**	**4**	**4**	**2**	**2**	**2**	**1**	**0**					
Reporting Units				**µS/cm**	**mg/L**	**°C**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**					
Sample Date	**Sample Time**	**Sample Type**	**Location ID**	**Conductivity, Specific**	**Oxygen, Dissolved**	**Temp**	**Phosphorus, Dissolved (DRP)**	**Phosphorus, Total**	**Nitrogen, Ammonia (Salicylate)**	**Nitrogen, Nitrate+Nitrite**	**Nitrogen, Total Nitrogen**	**Carbon, Total Organic**	**Solids, Total Suspended**	**Notes**	**Conclusion**	**Field Notes**	**Lab Notes**	Notes_conc
NS	NS	**G**	**Trib 25**											Not sampled				Not sampled - - -
09/06/17	NS	**G**	**Trib 27 (New Church Ditch Inlet)**											Not sampled				Not sampled - - -
10/04/17	9:55	**G**	**Trib 01**	295	13.3	9.7	0.0031	0.0072	< 0.01	0.14	0.27	1.7	<1					- - -
10/04/17	10:45	**G**	**Trib 02**	309	10.8	14.5	0.003	0.0074	0.01	0.16	0.27	1.6	<1					- - -
10/04/17	11:00	**G**	**Trib 03**	351	11.6	11.4	0.0052	0.0153	0.01	0.19	0.36	1.8	12					- - -
NS	NS	**G**	**Trib 04**											Not sampled				Not sampled - - -
10/04/17	11:25	**G**	**Trib 11**	310	10.3	12.4	0.0036	0.0222	< 0.01	0.16	0.32	1.7	18					- - -
NS	NS	**G**	**Trib 22a**											Not sampled				Not sampled - - -
NS	NS	**G**	**Trib 22d**											Not sampled		Road construction samplers couldn't get to site		Not sampled - - Road cor
10/04/17	8:25	**G**	**Trib 24**	298	7	16.5	0.0055	0.0116	0.02	0.04	0.18	1.9	<1					- - -
NS	NS	**G**	**Trib 25**											Not sampled				Not sampled - - -
NS	NS	**G**	**Trib 27 (New Church Ditch Inlet)**											Not sampled				Not sampled - - -
11/01/17	9:25	**G**	**Trib 01**	333	11.9	5.6	< 0.0025	0.0058	0.01	0.2	0.39	1.5	8					- - -
11/01/17	9:40	**G**	**Trib 02**	333	8.6	10.8	< 0.0025	0.0061	0.02	0.23	0.5	1.5	<1					- - -
11/01/17	9:55	**G**	**Trib 03**	394	9.8	7.2	0.0039	0.1002	0.08	0.24	0.89	2.7	168					- - -
NS	NS	**G**	**Trib 04**											Not sampled				Not sampled - - -
11/01/17	10:30	**G**	**Trib 11**	333	9.1	8.6	< 0.0025	0.0098	0.01	0.27	0.43	1.7	5					- - -
NS	NS	**G**	**Trib 22a**											Not sampled				Not sampled - - -
NS	NS	**G**	**Trib 22d**											Not sampled				Not sampled - - -
11/01/17	8:40	**G**	**Trib 24**	301	6.7	14	0.0035	0.0107	0.01	0.04	0.24	1.9	5					- - -
NS	NS	**G**	**Trib 25**											Not sampled				Not sampled - - -
NS	NS	**G**	**Trib 27 (New Church Ditch Inlet)**											Not sampled				Not sampled - - -
12/06/17	9:15	**G**	**Trib 01**	463	15.2	1.9	< 0.0025	0.0052	0.01	0.41	0.59	1.5	<1	Send dup TSS to Eurofin				Send dup TSS to Eurofin -
12/06/17	9:35	**G**	**Trib 02**	469	14.8	3.2	< 0.0025	0.0088	0.02	0.42	0.64	1.5	<1	Send dup TSS to Eurofin				Send dup TSS to Eurofin -
12/06/17	9:45	**G**	**Trib 03**	455	11.2	7.6	< 0.0025	0.0103	0.02	0.43	0.61	1.5	21	Send dup TSS to Eurofin				Send dup TSS to Eurofin -
12/06/17	10:25	**G**	**Trib 04**	423	13.5	4.2	< 0.0025	0.0409	0.01	0.32	0.54	1.4	43	Send dup TSS to Eurofin				Send dup TSS to Eurofin -
NS	NS	**G**	**Trib 11**											Not sampled				Not sampled - - -
NS	NS	**G**	**Trib 22a**											Not sampled				Not sampled - - -
NS	NS	**G**	**Trib 22d**											Not sampled				Not sampled - - -
12/06/17	8:30	**G**	**Trib 24**	320	10	11.1	< 0.0025	0.0098	0.02	0.06	0.28	1.9	9	Send dup TSS to Eurofin				Send dup TSS to Eurofin -
NS	NS	**G**	**Trib 25**											Not sampled				Not sampled - - -
NS	NS	**G**	**Trib 27 (New Church Ditch Inlet)**											Not sampled				Not sampled - - -

Ambient Autosamplers (with TH metals)

Method				SM2550B	SM4500H+E	SM2510B	SM2130B	SM4500NH3H	SM4500NO3	SM4500NO3	SM4500PE	SM4500PE	SM5310B	SM2540D	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8
Reporting Limit Goal				1.0	1.0	10	1.0	0.01	0.01	0.02	0.0025	0.0025	0.5	1	0.00015	0.00015	0.00010	0.00010	0.00005
Max Sig figs				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Max decimals				1	1	0	1	2	2	2	4	4	1	0	5	5	5	5	5
Reporting Units				°C	s.u.	µS/cm	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sample Date	**Sample Time**	**Sample Type**	**Location ID**	**Temp**	**pH**	**Conductivity, Specific**	**Turbidity**	**Nitrogen, Ammonia (Salicylate)**	**Nitrogen, Nitrate+Nitrite**	**Nitrogen, Total Nitrogen**	**Phosphorus, Dissolved (DRP)**	**Phosphorus, Total**	**Carbon, Total Organic**	**Solids, Total Suspended**	**Arsenic, Dissolved**	**Arsenic, Total**	**Barium, Dissolved**	**Barium, Total**	**Beryllium dissolved**
04/25/17	3:00	24C	CC AS 26	8.7	7.5	397	1.9	0.01	0.12	0.22	< 0.0025	0.0064	2.3	<1					
04/25/17	11:40	24C	CC AS 49	10	7.5	361	2.3	< 0.01	0.14	0.22	< 0.0025	0.0081	2.4	3					
04/25/17	11:40	24C	CC AS 50	9.9	7.5	328	9	< 0.01	0.13	0.25	< 0.0025	0.0109	2.5	6					
04/25/17	22:00	24C	CC AS 59	10.9	7.7	370	2.1	< 0.01	0.14	0.22	< 0.0025	0.0079	2.5	<1					
04/26/17	1:00	24C	CC AS T2	12.9	7.7	382	2.6	< 0.01	0.15	0.24	< 0.0025	0.01	2.4	<1					
04/26/17	11:00	24C	CC AS T11	11.8	7.8	399	2.2	0.01	0.13	0.26	< 0.0025	0.0116	2.2	5					
05/30/17	7:00	24C	CC AS 26	13.1	7.8	200	3	< 0.01	0.08	0.21	< 0.0025	0.0074	3.1	2					
05/30/17	12:30	24C	CC AS 49	14.9	7.7	192	7.2	< 0.01	0.09	0.27	0.0028	0.0125	3.3	6					
05/30/17	12:30	24C	CC AS 50	15.8	7.7	166	20.8	< 0.01	0.08	0.25	0.0051	0.0213	3.3	18					
		24C	CC AS 59																
05/31/17	21:00	24C	CC AS T2	21.8	7.6	214	5.9	< 0.01	0.1	0.29	0.0028	0.0112	3.2	4					
05/31/17	2:40	24C	CC AS T11	18.2	7.6	224	23.4	< 0.01	0.11	0.29	0.0038	0.0191	3	23					
06/27/17	7:30	24C	CC AS 26	15.7	7.2	95	2	< 0.01	0.1	0.2	0.0032	0.0075	2.1	<1					
06/27/17	10:30	24C	CC AS 49	20.4	7.4	97	4.9	< 0.01	0.09	0.17	0.0032	0.0172	2.3	2					
06/27/17	10:30	24C	CC AS 50	20.5	7.2	86	**S** 464	< 0.01	0.06	0.18	0.0043	0.0102	3	16					
06/27/17	14:30	G	CC AS 59	12.8	7	104	2.5	0.01	0.08	0.2	0.0069	0.0111	1.9	13					
06/28/17	15:00	24C	CC AS T2	26.5	7.5	106	2.2	< 0.01	0.09	0.22	0.0027	0.0067	2.2	17					
06/28/17	22:00	24C	CC AS T11	25.3	7.2	108	16.1	0.06	0.12	0.38	0.0086	0.056	2.4	44					
07/18/17	8:30	24C	CC AS 26	17.8	7.5	125	4.8	< 0.01	0.1	0.15	< 0.0025	0.0107	1.7	16					
07/18/17	12:35	24C	CC AS 49	18.8	7.5	126	7.3	< 0.01	0.11	0.21	0.0028	0.0167	1.9	9					
07/18/17	12:35	24C	CC AS 50	19.1	7.5	316	14.5	0.03	0.19	0.39	0.0031	0.0253	3.1	14					
07/18/17	10:40	G	CC AS 59	16.5	7.5	136	3	< 0.01	0.11	0.16	0.0026	0.0079	1.6	3					
07/19/17	18:45	24C	CC AS T2	27.4	7.7	138	3.5	< 0.01	0.12	0.21	0.0028	0.0092	1.8	<1					
07/19/17	2:00	24C	CC AS T11	25.5	7.6	141	7.8	< 0.01	0.11	0.22	< 0.0025	0.0126	1.7	20					
08/15/17	7:15	24C	CC AS 26	16.2	7.7	180	3.3	0.01	0.12	0.18	0.0029	0.0065	1.6	<1					
08/15/17	13:50	24C	CC AS 49	17.8	7.7	180	8.5	0.02	0.14	0.28	0.0036	0.0227	1.9	28					
08/15/17	13:50	24C	CC AS 50	18.3	7.7	515	4.8	< 0.01	0.25	0.42	0.0035	0.0125	2.8	2					
08/15/17	14:00	G	CC AS 59	15.9	7.8	197	2	< 0.01	0.12	0.17	0.0029	0.0083	1.5	11					
08/15/17	11:00	G	CC AS T2	14.5	7.9	206	5.8	< 0.01	0.13	0.21	0.0032	0.0106	1.6	5					

Ambient Autosamplers (with TH metals)

Method				SM2550B	SM4500H+	SM2510B	SM2130B	SM4500NH3H	SM4500NO3	SM4500NO3	SM4500PE	SM4500PE	SM5310B	SM2540D	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8
Reporting Limit Goal				1.0	1.0	10	1.0	0.01	0.01	0.02	0.0025	0.0025	0.5	1	0.00015	0.00015	0.00010	0.00010	0.00005
Max Sig figs				3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Max decimals				1	1	0	1	2	2	2	4	4	1	0	5	5	5	5	5
Reporting Units				°C	s.u.	µS/cm	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sample Date	Sample Time	Sample Type	Location ID	Temp	pH	Conductivity, Specific	Turbidity	Nitrogen, Ammonia (Salicylate)	Nitrogen, Nitrate+Nitrite	Nitrogen, Total Nitrogen	Phosphorus, Dissolved (DRP)	Phosphorus, Total	Carbon, Total Organic	Solids, Total Suspended	Arsenic, Dissolved	Arsenic, Total	Barium, Dissolved	Barium, Total	Beryllium dissolved
08/16/17	7:35	24C	CC AS T11	19.5	7.9	200	7.9	< 0.01	0.13	0.25	0.0034	0.0182	1.7	13					
09/19/17	4:00	24C	CC AS 26	14.8	6.5	290	<1	< 0.01	0.11	0.23	< 0.0025	0.0044	1.5	9					
09/19/17	12:15	24C	CC AS 49	17.6	6.8	257	1.6	0.02	0.13	0.3	< 0.0025	0.0153	1.7	5					
09/19/17	12:15	24C	CC AS 50	16.9	7.1	723	2	< 0.01	0.5	0.79	< 0.0025	0.0154	2.6	14					
09/19/17	22:00	24C	CC AS 59	17.2	7.9	222	**S** 28.5	0.02	0.14	0.3	< 0.0025	0.0076	2.3	<1					
09/20/17	0:55	24C	CC AS T2	20.7	8	247	5.5	0.01	0.14	0.29	< 0.0025	0.006	1.6	<1					
09/20/17	10:40	24C	CC AS T11	17.8	8	238	6.7	< 0.01	0.11	0.26	< 0.0025	0.0129	1.5	4					
10/24/17	3:00	24C	CC AS 26	8.2	6	262	2.1	< 0.01	0.17	0.28	< 0.0025	0.0059	1.4	<1					
10/24/17	12:40	24C	CC AS 49	9.9	6.2	271	5	< 0.01	0.17	0.3	< 0.0025	0.014	1.7	10					
10/24/17	12:40	G	CC AS 50	8.6	6	662	1.8	< 0.01	0.3	0.47	< 0.0025	0.0066	2.2	10					
10/25/17	0:10	24C	CC AS 59	14.5	7.8	302	1.9	< 0.01	0.19	0.32	< 0.0025	0.0057	2.2	5					
10/25/17	3:30	24C	CC AS T2	18.1	7.8	269	3.8	< 0.01	0.19	0.33	< 0.0025	0.0118	1.6	5					
10/25/17	12:30	24C	CC AS T11	14.8	7.8	319	14.1	< 0.01	0.14	0.3	< 0.0025	0.0155	1.8	17					

EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.7	EPA200.7	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8
0.00005	0.00010	0.00010	0.00050	0.00050	0.00025	0.00025	0.01	0.01	0.00020	0.00020	0.00025	0.00025	0.00050	0.00050	0.00032	0.00032	0.00050	0.00050
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Beryllium Total	**Cadmium, Dissolved**	**Cadmium, Total**	**Chromium, Dissolved**	**Chromium, Total**	**Copper, Dissolved**	**Copper, Total**	**Iron, Dissolved**	**Iron, Total**	**Lead, Dissolved**	**Lead, Total**	**Manganese, Dissolved**	**Manganese, Total**	**Molybdenum, Dissolved**	**Molybdenum, Total**	**Nickel dissolved**	**Nickel Total**	**Selenium, Dissolved**	**Selenium, Total**
	0.00019	0.00029			0.0023	0.004	0.084	0.26	0.00054	0.0015	0.081	0.12						
	0.00046	0.00063			0.0079	0.014	0.083	0.44	0.0004	0.0021	0.13	0.21						
	0.00095	0.0014			0.012	0.039	0.14	2.4	0.00028	0.0056	0.25	0.42						
	0.00045	0.0006			0.0077	0.014	0.079	0.49	0.0003	0.0017	0.11	0.17						
	0.00021	0.00053			0.0057	0.016	0.072	1.2	0.00026	0.0043	0.013	0.17						
	0.000075	0.00014			0.00086	0.0017	0.043	0.34	0.0003	0.0015	0.031	0.055						
	0.00014	0.00024			0.002	0.0044	0.036	0.56	0.00023	0.0025	0.023	0.094						
	0.00028	0.00096			0.0045	0.027	0.19	4.2	ND	0.0071	0.81	0.92						
	0.00039	0.00023			0.0026	0.0042	0.044	0.26	0.00047	0.0014	0.04	0.064						
	0.000035	0.00014			0.0019	0.0037	0.036	0.31	0.000058	0.0011	0.03	0.052						
	ND	0.0002			0.002	0.006	0.033	0.62	0.000087	0.0027	0.0042	0.084						

EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.7	EPA200.7	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8
0.00005	**0.00010**	**0.00010**	**0.00050**	**0.00050**	**0.00025**	**0.00025**	**0.01**	**0.01**	**0.00020**	**0.00020**	**0.00025**	**0.00025**	**0.00050**	**0.00050**	**0.00032**	**0.00032**	**0.00050**	**0.00050**
3	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
5	**5**	**5**	**5**	**5**	**5**	**5**	**3**	**3**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Beryllium Total	**Cadmium, Dissolved**	**Cadmium, Total**	**Chromium, Dissolved**	**Chromium, Total**	**Copper, Dissolved**	**Copper, Total**	**Iron, Dissolved**	**Iron, Total**	**Lead, Dissolved**	**Lead, Total**	**Manganese, Dissolved**	**Manganese, Total**	**Molybdenum, Dissolved**	**Molybdenum, Total**	**Nickel dissolved**	**Nickel Total**	**Selenium, Dissolved**	**Selenium, Total**
	0.00016	0.00019			0.0011	0.0013	0.07	0.15	0.00036	0.0008	0.091	0.099						
	0.00047	0.00051			0.0036	0.0067	0.048	0.17	0.00028	0.00097	0.1	0.15						
	0.0017	0.0017			0.01	0.014	0.018	0.11	0.00014	0.00081	0.36	0.35						
	0.0004	0.0004			0.0034	0.004	0.031	0.075	0.00018	0.00045	0.077	0.081						
	0.00026	0.00034			0.0071	0.022	0.02	0.22	0.00014	0.0019	0.011	0.087						
	0.0002	0.0004			0.0027	0.0075	0.029	0.82	0.00014	0.003	0.017	0.12						

EPA200.8	**EPA200.8**	**EPA200.7**	**EPA200.7**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	
0.00001	**0.00001**	**0.00200**	**0.00200**	**0.00003**	**0.00003**	**0.0025**	**0.0025**	
3	**3**	**3**	**3**	**3**	**3**	**3**	**3**	
5	**5**	**5**	**5**	**5**	**5**	**4**	**4**	
mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	
Silver dissolved	**Silver Total**	**Strontium Dissolved ICAP**	**Strontium ICAP**	**Vanadium Dissolved**	**Vanadium Total**	**Zinc, Dissolved**	**Zinc, Total**	**Notes**
								end time 0300 on 4/25/17
								Start time 1240 on 04/24/17, end time 1140 on 04/25/17
								Start time 1240 on 04/24/17, end time 1140 on 04/25/17
								end time 2200 on 04/25/17
								end time 0100 on 04/26/17
								end time 11:00 on 04/26/17
						0.084	0.11	end time 7:00 on 5/30/17
						0.12	0.16	Start time 13:30 on 5/29/17, end time 12:30 on 5/30/17.
						0.2	0.33	Start time 13:30 on 5/29/17, end time 12:30 on 5/30/17.
								Not Sampled
						0.094	0.14	end time 21:00 on 5/31/17
						0.047	0.14	end time is 2:40 on 5/31/17
								end time 7:30 on 6/27/17
								Start time 11:30 on 6/26/17, end time 10:30 on 6/27/17
								Start time 11:30 on 6/26/17, end time 10:30 on 6/27/17
								Grab sample collected
								end time 15:00 on 6/28/17
								end time 22:00 on 6/28/17
						0.032	0.048	end time 08:30 on 7/18/17
						0.038	0.072	Start time 13:35 on 7/17/17, end time 12:35 on 7/18/17
						0.17	0.34	Start time 13:35 on 7/17/17, end time 12:35 on 7/18/17
						0.049	0.065	Grab sample collected
						0.039	0.051	end time 18:45 on 7/19/17
						0.021	0.059	end time 2:00 on 7/19/17
								end time 0715 on 8/15/17
								Start time 1450 on 8/14/17, end time 1350 on 8/15/17
								Start time 1450 on 8/14/17, end time 1350 on 8/15/17
								Grab sample collected
								Grab sample collected

EPA200.8	EPA200.8	EPA200.7	EPA200.7	EPA200.8	EPA200.8	EPA200.8	EPA200.8	
0.00001	0.00001	0.00200	0.00200	0.00003	0.00003	0.0025	0.0025	
3	3	3	3	3	3	3	3	
5	5	5	5	5	5	4	4	
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Silver dissolved	**Silver Total**	**Strontium Dissolved ICAP**	**Strontium ICAP**	**Vanadium Dissolved**	**Vanadium Total**	**Zinc, Dissolved**	**Zinc, Total**	**Notes**
								end time 0730 on 8/16/17
								end time 0400 on 9/19/17
								Start time 1315 on 9/18/17, end time 1215 on 9/19/17
								Start time 1315 on 9/18/17, end time 1215 on 9/19/17
								end time 2200 on 9/19/17
								end time 0055 on 9/20/17
								end time 1040 on 9/20/17
						0.088	0.079	end time 3:00 on 10/24/17.
						0.11	0.14	Start time 13:40 on 10/23/17, end time 12:40 on 10/24/17
						0.44	0.43	Start time 13:40 on 10/23/17, end time 12:40 on 10/24/17
						0.11	0.11	end time 0:10 on 10/25/17
						0.056	0.082	end time 3:30 on 10/25/17
						0.052	0.11	end time 12:30 on 10/25/17

Event Autosamplers (with TH metals)

Method				SM2550B	SM4500H+I	SM2510B	SM2130B	SM4500NH3H	SM4500NO3I	SM4500NO3I	SM4500PE	SM4500PE	SM4500NH3H	EPA 300.0	SM4500NorgB	Calc
DL				1.0	1.0	10	1.0	0.01	0.01	0.02	0.0025	0.0025	0.05	0.02	0.01	0.10
Max Sig figs				3	3	3	3	3	3	3	3	3	3	3	3	3
Max decimals				1	1	0	1	2	2	2	4	4	2	2	2	2
Reporting Units				°C	s.u.	µS/cm	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sample Date	Sample Time	Sample Type	Location ID	Temp	pH	Conductivity, Specific	Turbidity	Nitrogen, Ammonia (Salicylate)	Nitrogen, Nitrate+Nitrite	Nitrogen, Total Nitrogen	Phosphorus, Dissolved (DRP)	Phosphorus, Total	Nitrogen, Ammonia	Nitrogen, Nitrate+Nitrite	Nitrogen, Total Kjeldahl	Nitrogen, Total Nitrogen
04/06/17	5:45	CE	CC AS T2	11.9	7.6	747	6.5	< 0.01	0.31	0.46	< 0.0025	0.0097				
04/06/17	6:30	CE	CC AS T11	10.5	7.8	654	5.9	< 0.01	0.31	0.53	< 0.0025	0.0125				
07/26/17	20:20	CE	CC AS 50	21.9	7.3	328	784	0.03	0.38	1.7	0.023	0.373				
07/27/17	0:50	CE	CC AS 49	18.9	7.2	162	549	< 0.01	0.13	0.7	0.0107	0.433				
07/27/17	14:52	CE	CC AS T11	22.5	7.3	191	605	0.02	0.22	1.34	0.0121	0.289				
07/28/17	19:48	CE	CC AS 49	19.3	7.7	170	514	< 0.01	0.15	1.15	0.0107	0.056				
07/29/17	1:16	CE	CC AS T2	27.3	7.6	170	48	< 0.01	0.13	0.42	0.0063	0.0544				
11/07/17	9:00	CE	CC AS T4	10.2	7.6	294	26.4	< 0.01	0.16	0.45	0.0048	0.051				

SM4500PE	SM4500PE	SM5310B	SM2540D	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.7	EPA200.7
0.01	0.01	0.5	1	0.00015	0.00015	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00050	0.00050	0.00025	0.00025	0.01	0.01
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	2	1	0	5	5	5	5	5	5	5	5	5	5	5	5	3	3
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Phosphorous, Dissolved (SRP)	Phosphorous, Total	Carbon, Total Organic	Solids, Total Suspended	Arsenic, Dissolved	Arsenic, Total	Barium, Dissolved	Barium, Total	Beryllium, Dissolved	Beryllium, Total	Cadmium, Dissolved	Cadmium, Total	Chromium, Dissolved	Chromium, Total	Copper, Dissolved	Copper, Total	Iron, Dissolved	Iron, Total
		1.8	<1	0.00056	0.00061	0.054	0.063	<0.000054	<0.000054	0.00043	0.00053	0.00017	0.00049	0.0038	0.0091	0.015	0.37
		2.3	<1	0.00054	0.00079	0.044	0.05	<0.000054	<0.000054	0.00038	0.00041	0.00027	0.00053	0.0031	0.0053	0.014	0.25
		4.4	909							0.00052	0.0075			0.0048	0.16	0.12	70
		2.3	980							0.00043	0.003			0.0026	0.28	0.11	78
		4	736							0.000055	0.004			0.0042	0.41	0.095	80
		3.3	980							<0.000012	0.0012			0.0016	0.13	0.094	79
		2.3	53							0.000066	0.00092			0.0047	0.067	0.037	4.3
		2.2	61	0.0011	0.0033	0.052	0.073	ND	0.00011	0.000032	0.00086	0.00011	0.0016	0.002	0.021	0.04	2.8

EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.7	EPA200.7	EPA200.8	EPA200.8	EPA200.8	EPA200.8
0.00020	0.00020	0.00025	0.00025	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050							0.0025	0.0025
3	3	3	3	3	3	3	3	3	3							3	3
5	5	5	5	5	5	5	5	5	5							4	4
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Lead, Dissolved	**Lead, Total**	**Manganese, Dissolved**	**Manganese, Total**	**Molybdenum, Dissolved**	**Molybdenum, Total**	**Nickel, Dissolved**	**Nickel, Total**	**Selenium, Dissolved**	**Selenium, Total**	**Silver, Dissolved**	**Silver, Total**	**Strontium, Dissolved**	**Strontium, Total**	**Vanadium, Dissolved**	**Vanadium, Total**	**Zinc, Dissolved**	**Zinc, Total**
0.000068	0.001	0.1	0.14	0.0022	0.0025	0.0021	0.0021	0.0005	0.00048	<0.000014	0.000042	0.28	0.27	<0.000034	0.00038	0.097	0.14
0.000053	0.0008	0.0094	0.041	0.0022	0.0023	0.0019	0.0017	0.00044	<0.00015	<0.000014	0.000048	0.28	0.28	0.000042	0.00051	0.079	0.1
0.0012	0.32	0.055	2.9													0.086	1.6
0.002	1.8	0.15	1.3													0.038	0.72
0.0011	0.99	0.0015	2.1													0.017	1.1
0.00034	0.1	0.002	2													0.0038	0.48
0.00012	0.018	0.001	0.48													0.027	0.24
0.0006	0.022	0.0024	0.24	0.003	0.0031	0.0023	0.0062	0.00045	0.00027	<0.000014	<0.000014	0.28	0.3	0.00052	0.003	0.02	0.16

SM9221D				
1				
3				
0				
cfu/100mL				
E. coli,	**Notes**	**Conclusion**	**Field Notes**	**Lab Notes**
NT	First Flush. Botttles 1-12. Start time 0645 on 04/05/17, end time 0545 on 04/06/17.		FHL between T2 and T11 not incorporated into	
NT	First Flush. Botttles 1-12. Start time 0730 on 04/05/17, end time 0630 on 04/06/17.		FHL between T2 and T11 not incorporated into	
NT	Bottles 1-9. Start time 20:20 on 7/26/17, end time at 22:20 on 7/26/17. Retrieved on 7/27/17			
NT	Bottles 1-5. Start time 0:50on 7/27/17, end time at 1:50 on 7/27/17. Retrieved on 7/27/17.			
NT	Bottles 1-24. Start time 14:52 on 7/27/17, end time 20:37 on 7/27/17. Retrieved on 7/31/17 past 48 hour holding time.			
NT	Bottles 1-5. Start time 19:48 on 7/28/17, end time is 20:48 on 7/28/17. Retrieved on 7/31/17 which exceed the 48 hr hold time.			
NT	Bottles 1-6. Start time 1:16 on 7/29/17, end time was 2:31 on 7/29/17. Retrieved on 7/31/17			
NT	Bottles 1-24. Start time 10:00 on 11/6/17, end time 09:00 11/7/17.			

Clear Creek Event Autosamplers - Metals (Golden)

Method				EPA200.7	EPA200.7	EPA200.7	EPA200.7	EPA200.7	EPA200.7	EPA200.7	EPA200.7	EPA200.7	EPA200.7	EPA200.7	EPA200.7	EPA200.7
DL				variable	variable	variable	variable	variable	variable	0.004	0.004	0.01	0.01	0.001	0.001	0.030
Reporting Units				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sample Date	Sample Time	Sample Type	Location ID	Cadmium, Dissolved	Cadmium, Total	Chromium, Dissolved	Chromium, Total	Copper, Dissolved	Copper, Total	Iron, Dissolved	Iron, Total	Lead, Dissolved	Lead, Total	Manganese, Dissolved	Manganese, Total	Zinc, Dissolved
7/27/2017		CE	CC 59 Event	<0.001	0.01	NT	NT	0.049	8.254	8.653	128.2	0.009	2.019	0.455	5.132	0.208
7/29/2017		CE	CC 59 Event	<0.001	<0.001	NT	NT	0.002	0.011	0.059	5.11	<0.001	0.01	0.001	1.62	0.004
8/8/2017		CE	CC 59 Event	<0.001	<0.001	NT	NT	0.004	0.105	0.039	16.93	<0.001	0.345	0.123	0.568	0.033

EPA200.7	SM5310B	Contractor	Contractor	Contractor	Contractor	Contractor					
0.030	0.5										
mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L					
Zinc, Total	Carbon, Total Organic	Nitrogen - Ammonia (Auto. Phenate)	Nitrogen - TKN Kjeldahl	NO2/NO3 as N. 353.2	Phosphorus - Total, Auto Asc. Acid Red.	Solids - Total Suspended, 105	Notes	Conclusion	Field Notes	Lab Notes	Turbidity - Nephelometric
2.086	3.43	<0.05	3.1	0.17	1.9	1840					
0.041	3.55	<0.05	2.5	0.13	0.67	860					
0.433	2.36	0.2	0.4	0.15	0.31	213					

Standley Lake																			
Method				electrode	SM2510B	electrode	SM4500OG	SM4500H+	SM2550B	SM2130B	Secchi Disk	SM4500NH3H	SM4500NO3I	M4500NO3	FlowCAM	SM10200H	SM5910B	SM7110B	SM7110B
DL				1.0	10	1	1.0	1.0	1.0	1.0	0.1	0.01	0.01	0.02	1	1.0	0.001	variable	variable
Max Sig figs				3	3	3	3	3	3	3	3	3	3	3	4	3	3	2	2
Max decimals				1	0	0	1	1	1	1	2	2	2	2	0	1	3	1	1
Reporting Units				µg/L	µS/cm	mv	mg/L	s.u.	°C	NTU	m	mg/L	mg/L	mg/L	ct/mL	µg/L	10 cm^{-1}	pCi/L	pCi/L
Sample Date	Sample Time	Sample Type	Location ID	Chlorophyll a, Field	Conductivity, Specific	ORP Oxidation Reduction Potential	Oxygen, Dissolved	pH	Temp	Turbidity	Secchi Depth,	Nitrogen, Ammonia (Salicylate)	Nitrogen, Nitrate+Nitrite	Nitrogen, Total Nitrogen	Algae	Chlorophyll a, Lab (Methanol)	UV 254	Gross Alpha	Gross Alpha, Uncertainty
02/14/17		G	SL 10-00	< 1	379	362	11.5	8	2.9	1.6	5.2								
02/14/17	11:30	C	SL 10-PZ									0.06	0.03	0.19	573	2.5	0.304		
02/14/17	12:00	G	SL 10-70	1.5	394	354	10.7	7.8	3	2.3		0.07	0.07	0.32			0.3		
03/08/17		G	SL 10-00	< 1	387	376	10.7	7.8	3.3	2.2	3							0.9	1.5
03/08/17		C	SL 10-PZ									0.03	0.03	0.3	532	2.5	0.274	1.9	1.8
03/08/17		G	SL 10-70	7.2	388	88	10.5	7.7	3.1	5.5		0.03	0.03	0.23			0.274	0	1.5
03/21/17		G	SL 10-00	< 1	371	189	10.2	8.1	8.2	1	4.8								
03/21/17		C	SL 10-PZ									0.04	0.02	0.22	290	4.1	NT		
03/21/17		G	SL 10-70	3.8	370	187	9.8	8.1	6.5	4.5		0.03	0.02	0.25			NT		
04/10/17		G	SL 10-00	1.2	383	234	9.7	8.1	9.1	3.3	1.6								
04/10/17		C	SL 10-PZ									0.03	0.02	0.25	388	6	0.297		
04/10/17		G	SL 10-70	7.2	383	221	9.5	8.1	8.6	7.9		0.03	0.01	0.21			0.29		
04/24/17		G	SL 10-00	< 1	386	294	9.3	8.4	12.7	1.8	2.4								
04/24/17		C	SL 10-PZ									0.02	< 0.01	0.16	278	7	0.3		
04/24/17		G	SL 10-70	1.9	385	287	6.7	7.6	9.9	8.2		0.19	0.01	0.31			0.291		
05/08/17		G	SL 10-00	1.1	387	304	9.2	8.3	13.9	1.9	3.2								
05/08/17		C	SL 10-PZ									< 0.01	< 0.01	0.18	403	5.4	0.299		
05/08/17		G	SL 10-70	6	388	308	7.5	7.7	10.2	5.8		0.04	< 0.01	0.21			0.29		
05/22/17		G	SL 10-00	LE	LE	LE	LE	LE	LE	LE	3.1								
05/22/17		C	SL 10-PZ									< 0.01	< 0.01	0.17	310	5.6	0.349		
05/22/17		G	SL 10-70	LE	LE	LE	LE	LE	LE	LE		0.04	0.02	0.2			0.349		
06/05/17		G	SL 10-00	2.3	355	203	8.7	8.3	19.5	1.1	4.4							0.9	1.6
06/05/17		C	SL 10-PZ									0.01	< 0.01	0.24	365	3.3	0.426	1.4	0.6
06/05/17		G	SL 10-70	< 1	371	224	4.2	7.2	10.7	5.8		0.13	0.04	0.37			0.333	3.1	2.2
06/19/17		G	SL 10-00	< 1	344	198	7.6	8.4	21.9	1.8	3.9								
06/19/17		C	SL 10-PZ									0.01	< 0.01	0.25	217	4.1	0.455		
06/19/17		G	SL 10-70	< 1	380	254	2.5	7	11.2	5.8		0.19	0.11	0.5			0.324		
07/10/17		G	SL 10-00	< 1	321	255	7.4	8.3	23	< 1	5.8								
07/10/17		C	SL 10-PZ									0.02	< 0.01	0.19	152	2.4	0.452		
07/10/17		G	SL 10-70	< 1	379	264	2.7	7	11.8	6.6		0.03	0.23	0.42			0.337		
07/24/17		G	SL 10-00	< 1	306	303	7.5	8.3	23.5	1.1	4.6								
07/24/17		C	SL 10-PZ									0.01	< 0.01	0.15	235	2.3	0.42		
07/24/17		G	SL 10-70	< 1	375	323	< 1	6.9	12.3	7.1		0.07	0.17	0.42			0.341		
07/24/17		G	69-00																
08/08/17		G	SL 10-00	1.3	269	302	7.2	8.2	21.4	< 1	5								
08/08/17		C	SL 10-PZ									0.03	< 0.01	0.16	398	2.9	0.394		
08/08/17		G	SL 10-70	< 1	379	130	< 1	7	12.4	3.7		0.14	0.1	0.37			0.363		
08/21/17		G	SL 10-00	< 1	274	310	7.4	8.1	22.1	< 1	7								
08/21/17		C	SL 10-PZ									0.02	0.03	0.2	157	1.5	0.392		
08/21/17		G	SL 10-70	< 1	376	26	< 1	6.9	12.7	4.2		0.11	0.09	0.32			0.378		
09/11/17		G	SL 10-00	1.6	290	223	7.2	8.1	21.3	< 1	5.4								
09/11/17		C	SL 10-PZ									0.03	< 0.01	0.23	185	1.7	0.373		
09/11/17		G	SL 10-70	< 1	378	-92.5	< 1	7.1	12.7	3		0.08	< 0.01	0.27			0.393		
09/26/17		G	SL 10-00	1.2	289	390	6.7	7.6	17.7	1.6	4.7							2.2	2.1
09/26/17		C	SL 10-PZ									0.03	< 0.01	0.22	125	1.9	0.364	1.9	0.8
09/26/17		G	SL 10-70	< 1	376	-94.1	< 1	6.9	12.8	3.6		0.52	< 0.01	0.7			0.556	3.1	2.7
10/10/17		G	SL 10-00	2.3	296	302	7.3	7.7	14.2	1.5	3.3								
10/10/17		C	SL 10-PZ									0.04	0.01	0.22	205	4.3	0.367		
10/10/17		G	SL 10-70	1.7	336	34.6	3.4	7.2	13.4	3.7		0.06	0.01	0.24			0.379		

Standley Lake																			
Method				**electrode**	**SM2510B**	**electrode**	**SM4500OG**	**SM4500H+I**	**SM2550B**	**SM2130B**	**Secchi Disk**	**SM4500NH3H**	**SM4500NO3I**	**M4500NO3**	**FlowCAM**	**SM10200H**	**SM5910B**	**SM7110B**	**SM7110B**
DL				**1.0**	**10**	**1**	**1.0**	**1.0**	**1.0**	**1.0**	**0.1**	**0.01**	**0.01**	**0.02**	**1**	**1.0**	**0.001**	**variable**	**variable**
Max Sig figs				**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**4**	**3**	**3**	**2**	**2**
Max decimals				**1**	**0**	**0**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**0**	**1**	**3**	**1**	**1**
Reporting Units				**µg/L**	**µS/cm**	**mv**	**mg/L**	**s.u.**	**°C**	**NTU**	**m**	**mg/L**	**mg/L**	**mg/L**	**ct/mL**	**µg/L**	**10 cm^{-1}**	**pCi/L**	**pCi/L**
Sample Date	**Sample Time**	**Sample Type**	**Location ID**	**Chlorophyll a, Field**	**Conductivity, Specific**	**ORP Oxidation Reduction Potential**	**Oxygen, Dissolved**	**pH**	**Temp**	**Turbidity**	**Secchi Depth,**	**Nitrogen, Ammonia (Salicylate)**	**Nitrogen, Nitrate+Nitrite**	**Nitrogen, Total Nitrogen**	**Algae**	**Chlorophyll a, Lab (Methanol)**	**UV 254**	**Gross Alpha**	**Gross Alpha, Uncertainty**
10/23/17		G	SL 10-00	3.4	295	263	8.1	7.7	12.4	2.5	3.2								
10/23/17		C	SL 10-PZ									0.02	< 0.01	0.23	112	4.5	0.363		
10/23/17		G	SL 10-70	4	295	264	7.8	7.6	12.3	3.3		0.02	< 0.01	0.25			0.356		
11/14/17		G	SL 10-00	2.1	301	344	8.8	7.9	9.5	1.2	3.6								
11/14/17		C	SL 10-PZ									0.04	0.02	0.24	152	4.1	0.356		
11/14/17		G	SL 10-70	1.4	314	342	8.1	7.7	8.8	5.8		0.07	0.04	0.26			0.338		
11/28/17		G	SL 10-00	2.2	306	230	9	7.7	8	2.6	3.1								
11/28/17		C	SL 10-PZ									0.04	0.03	0.28	108	2.7	0.356		
11/28/17		G	SL 10-70	3.5	306	229	8.8	7.7	7.9	2.9		0.04	0.03	0.3			0.342		
12/12/17		G	SL 10-00	1.6	311	341	9.5	7.9	6.1	1.1	4.3							2.5	2
12/12/17		C	SL 10-PZ									0.03	0.04	0.24	145	3.3	0.337	< 1.5	1.5
12/12/17		G	SL 10-70	2.7	317	342	9.4	7.8	5.6	1.8		0.03	0.05	0.25			0.33	2.5	2

SM7110B	**SM7110B**	**SM4500PE**	**SM4500PE**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA524.2**	**EPA524.2**	**EPA524.2**	**EPA524.2**	**EPA200.8**	**EPA200.8**	**SM5310B**	**EPA200.8**	**EPA200.8**	**SM9221D**	**EPA200.8**
variable	**variable**	**0.0025**	**0.0025**	**0.00015**	**0.00015**	**0.00010**	**0.00010**	**0.00015**	**0.00015**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.00010**	**0.00010**	**0.5**	**0.00050**	**0.00050**	**1**	**0.00025**
2	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
1	**1**	**4**	**4**	**5**	**5**	**5**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**5**	**1**	**5**	**5**	**0**	**5**
pCi/L	**pCi/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**cfu/100mL**	**mg/L**
Gross Beta	**Gross Beta, Uncertainty**	**Phosphorus, Dissolved (DRP)**	**Phosphorus, Total**	**Arsenic, Dissolved**	**Arsenic, Total**	**Barium, Dissolved**	**Barium, Total**	**Beryllium, Dissolved**	**Beryllium, Total**	**BTEX, Benzene**	**BTEX, Ethylbenzene**	**BTEX, Toluene**	**BTEX, Xylenes**	**Cadmium, Dissolved**	**Cadmium, Total**	**Carbon, Total Organic**	**Chromium, Dissolved**	**Chromium, Total**	**E. coli,**	**Copper, Dissolved**
																			< 1	
		< 0.0025	0.0074													2				
		< 0.0025	0.0092													1.9			1	
0	2.3																		< 1	
0	2.1	< 0.0025	0.012	0.00041	0.00015	0.05	0.055	<0.000054	<0.000054					0.000022	0.000054	2	<0.000088	<0.000088		0.0012
0.4	2.1	< 0.0025	0.0091	0.0004	0.00047	0.05	0.051	<0.000054	<0.000054					0.000015	0.00004	1.9	<0.000088	<0.000088	3	0.001
		< 0.0025	0.0094																	
		< 0.0025	0.0107																	
																			< 1	
		< 0.0025	0.01													2.1				
		< 0.0025	0.0097													1.9			< 1	
		< 0.0025	0.0142																	
		< 0.0025	0.0173																	
																			< 1	
		< 0.0025	0.0102													2.1				
		< 0.0025	0.0135													1.9			< 1	
		< 0.0025	0.0136																	
		< 0.0025	0.0114																	
2.8	2.1																		< 1	
1	2.1	< 0.0025	0.0125	0.00046	0.0004	0.049	0.051	<0.000054	<0.000054					0.000018	0.000034	2.6	<0.000088	<0.000088		0.002
0.1	2.2	< 0.0025	0.0082	0.0004	0.00031	0.05	0.057	<0.000054	<0.000054					<0.000012	0.000019	2.1	<0.000088	<0.000088	< 1	0.00084
		< 0.0025	0.0102																	
		< 0.0025	0.0235																	
																			< 1	
		< 0.0025	0.0092													2.6				
		0.0048	0.0151													2.1			1	
		< 0.0025	0.0076																	
		0.0029	0.0165																	
										<0.0005	<0.0005	<0.0005	<0.0005							
																			< 1	
		0.004	0.0072													2.3				
		0.0103	0.0168													2			13	
		< 0.0025	0.0078																	
		0.0086	0.0222																	
																			< 1	
		0.0027	0.0069	0.00062	0.00069	0.044	0.042	<0.000054	<0.000054					0.000014	<0.000012	2.3	<0.000088	<0.000088		0.0013
		0.0178	0.0302	0.00065	0.00094	0.046	0.045	<0.000054	<0.000054					<0.000012	<0.000012	2.2	<0.000088	<0.000088	11	0.001
0.1	2.2																			
3	2.4	0.0026	0.0081																	
3	2.6	0.185	0.228																	
																			6	
		0.0039	0.0142													2.3				
		0.0135	0.0268													2.1			37	

SM7110B	**SM7110B**	**SM4500PE**	**SM4500PE**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA524.2**	**EPA524.2**	**EPA524.2**	**EPA524.2**	**EPA200.8**	**EPA200.8**	**SM5310B**	**EPA200.8**	**EPA200.8**	**SM9221D**	**EPA200.8**
variable	**variable**	**0.0025**	**0.0025**	**0.00015**	**0.00015**	**0.00010**	**0.00010**	**0.00015**	**0.00015**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.00010**	**0.00010**	**0.5**	**0.00050**	**0.00050**	**1**	**0.00025**
2	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
1	**1**	**4**	**4**	**5**	**5**	**5**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**5**	**1**	**5**	**5**	**0**	**5**
pCi/L	**pCi/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**cfu/100mL**	**mg/L**
Gross Beta	**Gross Beta, Uncertainty**	**Phosphorus, Dissolved (DRP)**	**Phosphorus, Total**	**Arsenic, Dissolved**	**Arsenic, Total**	**Barium, Dissolved**	**Barium, Total**	**Beryllium, Dissolved**	**Beryllium, Total**	**BTEX, Benzene**	**BTEX, Ethylbenzene**	**BTEX, Toluene**	**BTEX, Xylenes**	**Cadmium, Dissolved**	**Cadmium, Total**	**Carbon, Total Organic**	**Chromium, Dissolved**	**Chromium, Total**	**E. coli,**	**Copper, Dissolved**
		0.0028	0.0148	0.00047	0.00062	0.043	0.046	<0.000054	<0.000054					0.00002	0.000028		<0.000088	0.0003		0.00094
		0.0028	0.0111	0.00048	0.00077	0.044	0.047	<0.000054	<0.000054					0.000013	<0.000012		<0.000088	0.00034		0.00085
		< 0.0025	0.0119													2.1				
		0.0035	0.017													1.8				
																			20	
		< 0.0025	0.0107																	
		< 0.0025	0.0107																22	
< 2.3	2.4																		6	
2.2	2.3	0.0034	0.0074	0.00037	0.00044	0.048	0.046	<0.000054	<0.000054					<0.000012	0.000012	1.9	<0.000088	<0.000088		0.00085
< 2.3	2.4	< 0.0025	0.0105	0.00038	0.00038	0.049	0.047	<0.000054	<0.000054					<0.000012	0.000031	1.9	<0.000088	<0.000088	70	0.00087

EPA200.8	EPA130.2	EPA200.7	EPA200.7	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA245.1	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8	EPA200.8
0.00025	5	0.01	0.01	0.00020	0.00020	0.00025	0.00025	0.0002	0.00050	0.00050	0.005	0.005	0.00050	0.00050	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5	0	3	3	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5
mg/L	g/L as CaC(	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Copper, Total	**Hardness, Total**	**Iron, Dissolved**	**Iron, Total**	**Lead, Dissolved**	**Lead, Total**	**Manganese, Dissolved**	**Manganese, Total**	**Mercury, Total**	**Molybdenum, Dissolved**	**Molybdenum, Total**	**Nickel, Dissolved**	**Nickel, Total**	**Selenium, Dissolved**	**Selenium, Total**	**Silver, Dissolved**	**Silver, Total**	**Strontium, Dissolved**	**Strontium, Total**	**Vanadium, Dissolved**	**Vanadium, Total**
[redacted]																					
0.002	160	0.0039	0.11	< 0.000038	0.00054	0.0045	0.034	<0.000042	0.0026	0.0028	0.0018	0.00097	S 0.00046	<0.00015	S 0.000022	<0.000014	0.21	0.23	0.0002	0.0003
0.0014	160	0.0052	0.066	0.000039	0.00048	0.0014	0.033	<0.000042	0.0026	0.0026	0.0018	0.0015	0.00043	0.00034	0.000019	0.00003	0.21	0.24	0.00021	0.00024
[redacted]																					
	[redacted]																				
[redacted]																					
	[redacted]																				
	[redacted]																				
0.0036	NT	0.0085	0.052	< 0.000038	0.00014	0.00074	0.0059	<0.000042	0.0026	0.0026	0.0017	0.00066	0.00044	0.00057	<0.000014	<0.000014	0.21	0.21	0.0003	0.00054
0.0011	NT	<0.0000026	0.042	< 0.000038	0.00011	0.00055	0.042	<0.000042	0.0024	0.0025	0.0018	0.00084	0.00038	0.00061	<0.000014	<0.000014	0.23	0.25	0.0002	0.00051
	NT																				
	NT																				
	NT																				
	NT																				
	NT																				
	NT																				
	[redacted]																				
	NT																				
	NT																				
	NT																				
	NT																				
0.0015	NT	0.0036	0.064	< 0.000038	0.00028	0.00049	0.0085	<0.000042	0.0026	0.0024	0.0021	0.00053	0.00055	<0.00015	<0.000014	<0.000014	0.18	0.18	0.00061	0.00061
0.0011	NT	0.013	0.2	< 0.000038	0.00038	0.24	0.27	<0.000042	0.0028	0.0026	0.0023	0.00066	0.00047	<0.00015	<0.000014	<0.000014	0.19	0.19	0.0005	0.00056
	NT																				
	NT																				
	NT																				
	NT																				

EPA200.8	**EPA130.2**	**EPA200.7**	**EPA200.7**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA245.1**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**	**EPA200.8**
0.00025	**5**	**0.01**	**0.01**	**0.00020**	**0.00020**	**0.00025**	**0.00025**	**0.0002**	**0.00050**	**0.00050**	**0.005**	**0.005**	**0.00050**	**0.00050**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**
3	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
5	**0**	**3**	**3**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
mg/L	**g/L as CaC(**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Copper, Total	**Hardness, Total**	**Iron, Dissolved**	**Iron, Total**	**Lead, Dissolved**	**Lead, Total**	**Manganese, Dissolved**	**Manganese, Total**	**Mercury, Total**	**Molybdenum, Dissolved**	**Molybdenum, Total**	**Nickel, Dissolved**	**Nickel, Total**	**Selenium, Dissolved**	**Selenium, Total**	**Silver, Dissolved**	**Silver, Total**	**Strontium, Dissolved**	**Strontium, Total**	**Vanadium, Dissolved**	**Vanadium, Total**
0.0014	108	0.0085	0.12	0.00004	0.00041	0.067	0.083	<0.000042	0.0025	0.0026	0.0016	0.00086	0.00038	0.00044	<0.000014	0.000062	0.2	0.2	0.00041	0.00063
0.0014	50	0.0091	0.14	0.000042	0.00042	0.066	0.084	<0.000042	0.0025	0.0028	0.0016	0.00082	0.00041	0.00055	<0.000014	0.000019	0.19	0.19	0.00042	0.00064
0.0014	NT	0.0052	0.088	< 0.000038	0.00032	0.0095	0.019	<0.000042	0.0025	0.0025	0.0016	0.00092	0.00038	<0.00015	0.000016	<0.000014	0.19	0.2	0.00038	0.00044
0.0013	NT	0.0071	0.13	< 0.000038	0.00047	0.012	0.026	<0.000042	0.0026	0.0025	0.0016	0.00094	0.00034	<0.00015	<0.000014	<0.000014	0.2	0.21	0.00034	0.00054

SM2540D	**EPA200.8**	**EPA200.8**	**EPA200.7**				
1	**0.0025**	**0.0025**	**0.050**				
3	**3**	**3**	**3**				
0	**4**	**4**	**2**				
mg/L	**mg/L**	**mg/L**	**mg/L**				
Solids, Total Suspended	**Zinc, Dissolved**	**Zinc, Total**	**Silicon, Dissolved**	**Notes**	**Conclusion**	**Field Notes**	**Lab Notes**
4			0.66				
5			1.2				
<1	0.011	0.015	0.76				
2	0.0085	0.014	0.78				
			0.85				
			0.74				
7			0.45				
6			0.44				
			0.12				
			0.58				
2			ND				
4			0.19				
				We don't have 5/22/17 field data			
			0.3				
			0.57				
2	0.019	0.012	0.56				
3	0.0092	0.012	0.82				
			0.42				
			1.5				
5			0.65				
8			1.5				
			0.89				
			1.8				
				Switched to upper intake on 8/1/17.			
<1			0.98				
5			1.9				
			1.3				
			1.8				
2	0.0043	0.0047	1.2				
2	0.005	0.0066	1.5				
			1.4				
			3.1				
2			1.7				
<1			1.9				

SM2540D	**EPA200.8**	**EPA200.8**	**EPA200.7**				
1	**0.0025**	**0.0025**	**0.050**				
3	**3**	**3**	**3**				
0	**4**	**4**	**2**				
mg/L	**mg/L**	**mg/L**	**mg/L**				
Solids, Total Suspended	**Zinc, Dissolved**	**Zinc, Total**	**Silicon, Dissolved**	**Notes**	**Conclusion**	**Field Notes**	**Lab Notes**
	0.0051	0.0087	1.6				
	0.0042	0.0079	1.6				
<1			1.5				
8			2				
			1.4				
			1.4				
2	0.0062	0.0074	1.6				
4	0.0086	0.0099	1.8				