Cascade Reservoir

(HUC17050123)

2022 Monitoring Report

State of Idaho

Department of Environmental Quality

May 2023

Acknowledgments

Special thanks to contributors on this report: Cory Sandow, Ernest Bader, Kristina Lawcynell, Donald Snyder, Lance Holloway, Kiana Ziola, Emily Washburne, Jessie Sherburne, Brian Reese, Lenard Long, Vanessa Johnson, Grace Bowman, and Lucas Spelsberg. Thanks to the American Legion Post #60 for the use of their lodge in Cascade.

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DEQ, May 2023, PID 9003, CA code 42114. Costs associated with this publication are available from the State of Idaho Department of Environmental Quality in accordance with Idaho Code § 60-202.

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Abbreviations, Acronyms, and Symbols

µg	microgram
µS	micro-Siemens
cm	centimeter
CRA	Cascade Reservoir arms confluence monitoring site
CRD	Cascade Reservoir dam monitoring site
CRS	Cascade Reservoir Sugarloaf Island monitoring site
DEQ	Idaho Department of Environmental Quality
DO	dissolved oxygen
EPA	United States Environmental Protection Agency
HAB	harmful algal bloom
L	liter
mg	milligram
pH	potential of hydrogen
TP	total phosphorus
TMDL	total maximum daily load
TN	total nitrogen
VSWCD	Valley County Soil & Water Conservation District

Executive Summary

Idaho Department of Environmental Quality (DEQ) monitored water quality on Cascade Reservoir in 2022 to identify trends in progress toward meeting total maximum daily load (TMDL) goals. Targets are established for total phosphorus, dissolved oxygen, pH, and chlorophyll-a. Results indicate total phosphorus, pH, and chlorophyll-a targets are not being met. Monitoring included total nitrogen, turbidity, specific conductivity, and temperature. DEQ also plans to monitor Cascade Reservoir in 2023.

Beneficial uses, including recreation, aquatic habitat, and agricultural water supply, are impaired in part due to nuisance algae growth. Nuisance algae is a term used in Idaho's Water Quality Standards (IDAPA 58.01.02) which describes aquatic growth which "renders water harmful, detrimental, or injurious to public health…" or other beneficial uses. Cyanobacteria blooms occur often on Cascade Reservoir, posing health risk to people, animals, and wildlife. Implementation goals suggest that reducing external sources of total phosphorus by 37% for at least 5 years would improve water quality conditions. Water quality can be discussed in relationship to cyanobacteria favorable conditions, but more scientific analysis is needed. DEQ does not have a cyanobacteria monitoring program; however, DEQ and partner agencies respond to cyanobacteria harmful algal blooms to protect human health and the environment.

Partners, including the Valley County Soil & Water Conservation District, National Resource Conservation Service, Idaho Fish and Game, and Bureau of Reclamation continue to make significant strides in conservation implementation (ISWCC 2023). DEQ administers state and federal funds for agricultural, municipal, and recreational improvements to encourage nonpoint source pollution reduction.

1 Introduction

Cascade Reservoir has been identified as water quality limited due to not meeting water quality standards for dissolved oxygen, temperature, and pH. Elevated levels of phosphorus directly contribute to these violations. To improve water quality in Cascade Reservoir and its tributaries, the current contribution of phosphorus from external sources must be reduced by 37%, and this reduction must be maintained for at least 5 years. Although the 5-year review indicated that nutrient levels in the reservoir had decreased dramatically (DEQ 2018), recreational health advisories due to harmful algal blooms (HABs) have been issued for the reservoir each year from 2018 to 2021. HAB is a term used when abundant cyanobacteria have released toxic levels of cyanotoxins. This determination is based on Idaho's interagency plan to address HABs (DEQ 2017) and EPA's national recommendations. Two significant cyanobacteria blooms occurred in 2022, although harmful levels of cyanotoxins were not detected.

The Idaho Department of Environmental Quality (DEQ) conducts reviews of total maximum daily load (TMDL) activities for surface waters throughout Idaho. The Cascade Reservoir Implementation Plan states DEQ is responsible for evaluating trends in water quality data throughout the implementation process.

1.1 Purpose

The data collected during 2022 monitoring will be used to establish changes in Cascade Reservoir water quality. The sample results will be shared with other agencies as necessary to determine appropriate response activities. The data collected will be analyzed relative to Idaho's "Water Quality Standards" (IDAPA 58.01.02) basin wide and to TMDL targets.

1.2 Background

Cascade Reservoir, known locally as Lake Cascade, is a shallow water body, rich in nutrients and thus prone to eutrophication and nuisance algae growth. Cyanobacteria and nuisance algae growth have been documented as far back as 1975 (Clark and Wroten 1975, Zimmer 1983). In 1993 and 1994, dense mats of "blue-green algae", a common term for cyanobacteria, led to the deaths of 23 cattle and a substantial fish kill.

Cyanobacteria are naturally occurring microorganisms, capable of releasing cyanotoxins, including neurotoxins, hepatotoxins, and dermatoxins. Cyanobacteria is the modern, scientific term for common names including blue-green algae and toxic algae. Not all cyanobacteria blooms (prolific growth) necessarily contain harmful levels of cyanotoxins.

In 1996, the United States Environmental Protection Agency (EPA) accepted the Cascade Reservoir Phase I watershed management plan (DEQ 1996). Phase II was accepted in 1999 (DEQ 1998), an implementation plan followed in June 2000 (DEQ 2000), and Phase III was completed in February 2009 (DEQ 2009). Each phase of the watershed management plan serves as TMDLs

for different pollutants (Figure 1). A TMDL addendum for tributaries was added in 2011 (DEQ 2011) and a 5-year review of the TMDLs was completed in 2018 (DEQ 2018). These documents are found on DEQ's TMDL website for the *Payette River (North Fork) Subbasin*.

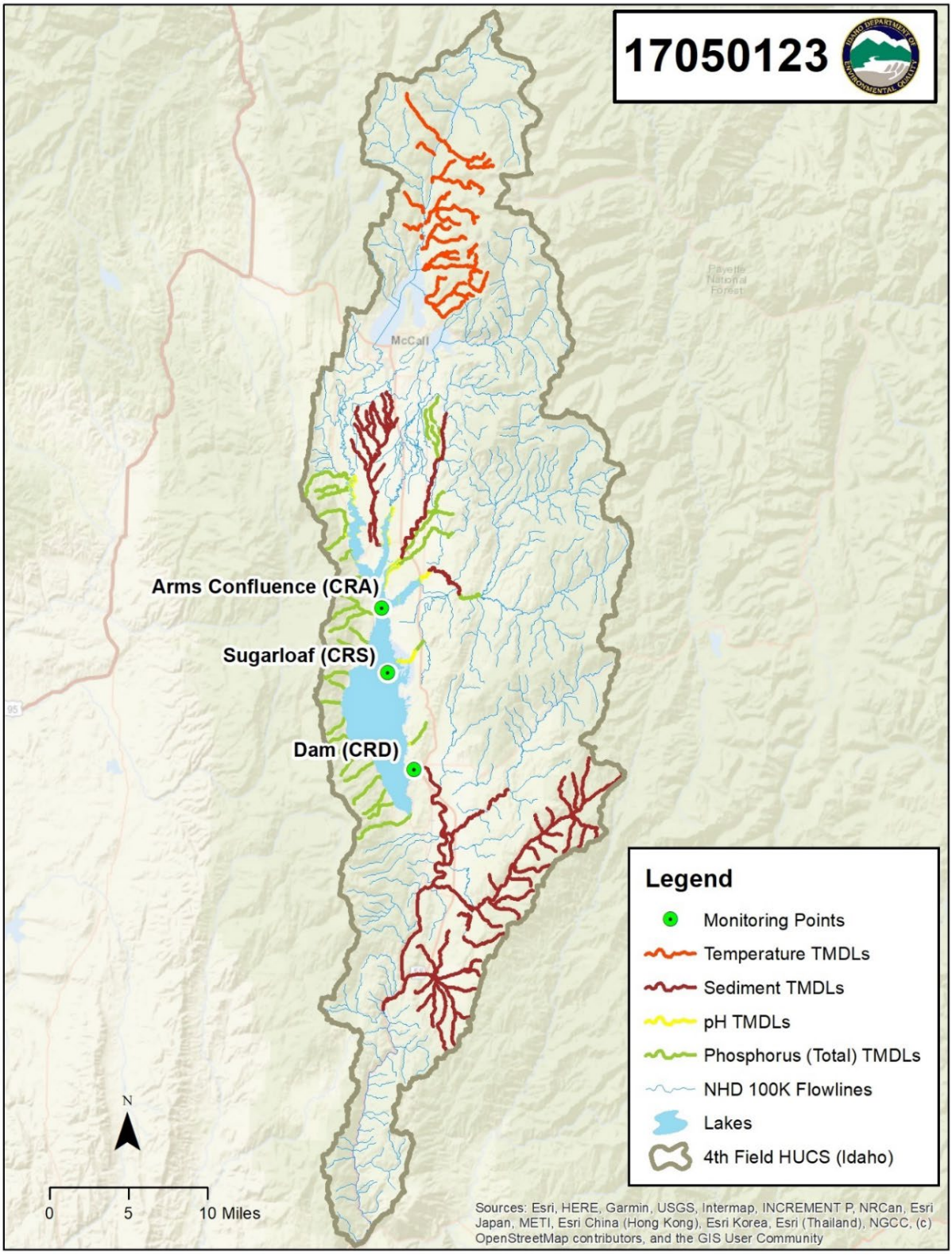

Figure 1. Map of the North Fork Payette River subbasin, including Cascade Reservoir and tributaries, monitoring points and TMDL assessment units.

1.3 Objectives

DEQ monitors water quality of Cascade Reservoir to assess progress toward meeting TMDL targets (Table 1).

Table 1. Cascade Reservoir TMDL targets.

Water Body	4a Assessment Unit	Pollutant	Target	Critical Period
Cascade Reservoir	ID17050123 SW 007L_0L	Phosphorus (total)	≤ 0.025 mg/L	May–September
		Dissolved oxygen[a]	≥ 6.0 mg/L[a]	Year-round
		pH	6.5 ≥ pH ≤ 9.0	Year-round
		Chlorophyll-a	≤ 10 µg/L	May–September

Notes: milligram (mg), liter (L), microgram (µg)
a. Dissolved oxygen criteria does not apply to the bottom 20% in reservoirs with less than 35-meter depth.

Reservoir monitoring occurred monthly in 2022 from June through October (Table 2). Monitoring also included maximum depth, water transparency (Secchi depth), specific conductivity, temperature, and total nitrogen (TN). The sampling was divided into two limnetic zones: epilimnion (euphotic, light-penetrating, surface zone) and hypolimnion (zone below light penetration). The depth of the euphotic zone is calculated from Secchi disk (visibility range) measurements on the day of sampling. The sampling structure is described in Table 2.

Table 2. Summary of Cascade Reservoir samples collected in 2022.

Sample Type	Parameters	Result type	Samples collected
Field parameters	Max depth, Secchi depth	Sample site characteristics	15 events: 3 locations, 5 dates CRA, CRS, CRD; June–October
Sonde measurements	Dissolved oxygen, dissolved oxygen %, pH, specific conductivity, temperature	Vertical water column profile	12 events: 3 locations, 4 dates CRA, CRS, CRD; June–September
Composite sample of euphotic zone	Total phosphorus, total nitrogen, chlorophyll-a	Euphotic zone concentration	15 events: 3 locations, 5 dates CRA, CRS, CRD; June–October
Grab sample 1 meter above lake bed	Total phosphorus, total nitrogen	Hypolimnion concentration	15 events: 3 locations, 5 dates CRA, CRS, CRD; June–October

Notes: Cascade Reservoir arms confluence (CRA), Sugarloaf Island (CRS), dam (CRD). No sonde measurements were collected in October due to equipment failure.

Table 3 and Figure 1 provide the locations where sampling occurred at the Cascade Reservoir's Sugarloaf Island, dam, and arms confluence. These sites were identified in the original TMDLs and have been used consistently to determine trends.

Table 3. Cascade Reservoir monitoring site locations.

Location	Latitude	Longitude
Sugarloaf Island (CRS)	44.610528	-116.091053
Dam (CRD)	44.522055	-116.054721
Arms confluence (CRA)	44.669296	-116.101201

A final review of the collected dataset was completed during the spring following field sampling. The results will be presented to Valley County Soil & Water Conservation District (VSWCD) and made available to the public upon completion.

2 TMDL Targets Evaluation

During 2022, Cascade Reservoir did not meet the water quality targets for TP, DO, or chlorophyll-a. The pH goal was met, except at the arms confluence in June. Reservoir water quality varies seasonally, typically failing the targets toward the end of summer.

DEQ will continue monitoring efforts during the 2023 season. The Bureau of Reclamation also conducts monthly monitoring during summer months according to the watershed management plans. These efforts provide the agencies with opportunities to collaborate.

2.1 Total Phosphorus

The total phosphorus (TP) concentration target is to be less than 0.025 milligrams per liter (mg/L) from May through September. In 2022, TP was measured monthly from June through October at all three monitoring locations, for a total of 15 sampling events (Figure 2 and Figure 3). Most TP concentrations were well above the target concentration. Generally, no obvious pattern of difference exists between the euphotic and hypolimnetic concentrations (Figure 4).

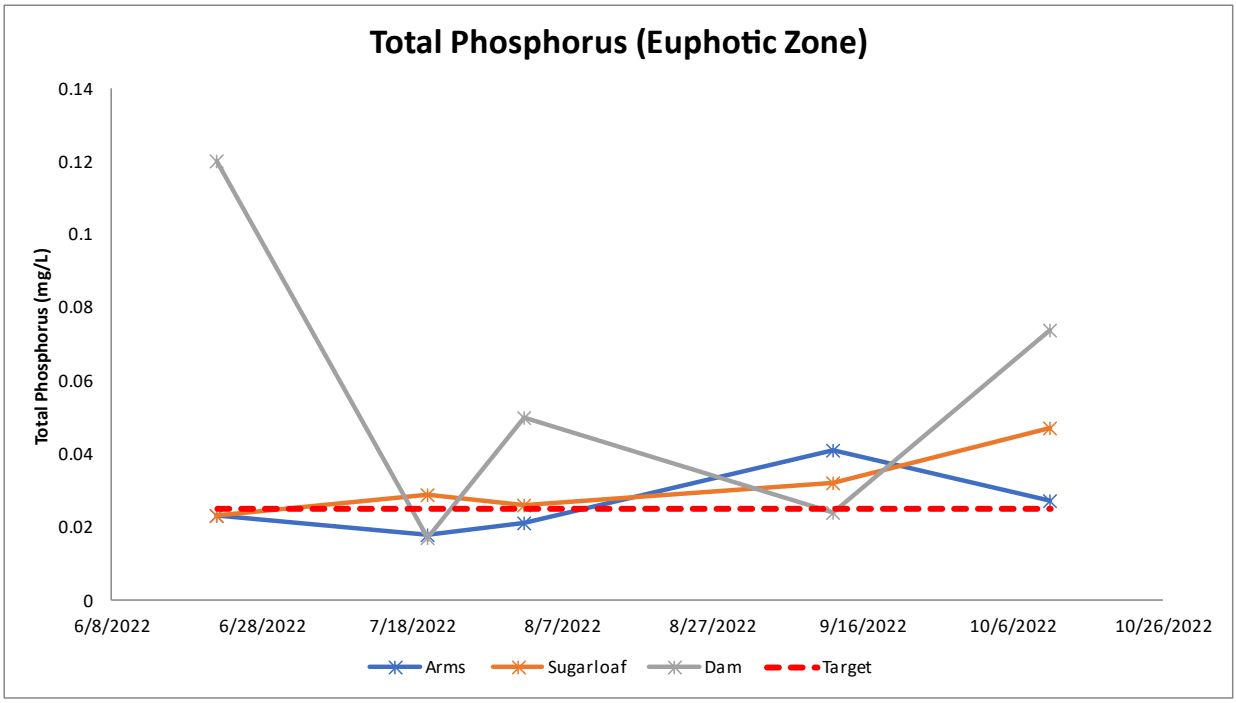

Figure 2. Euphotic zone total phosphorus concentrations.

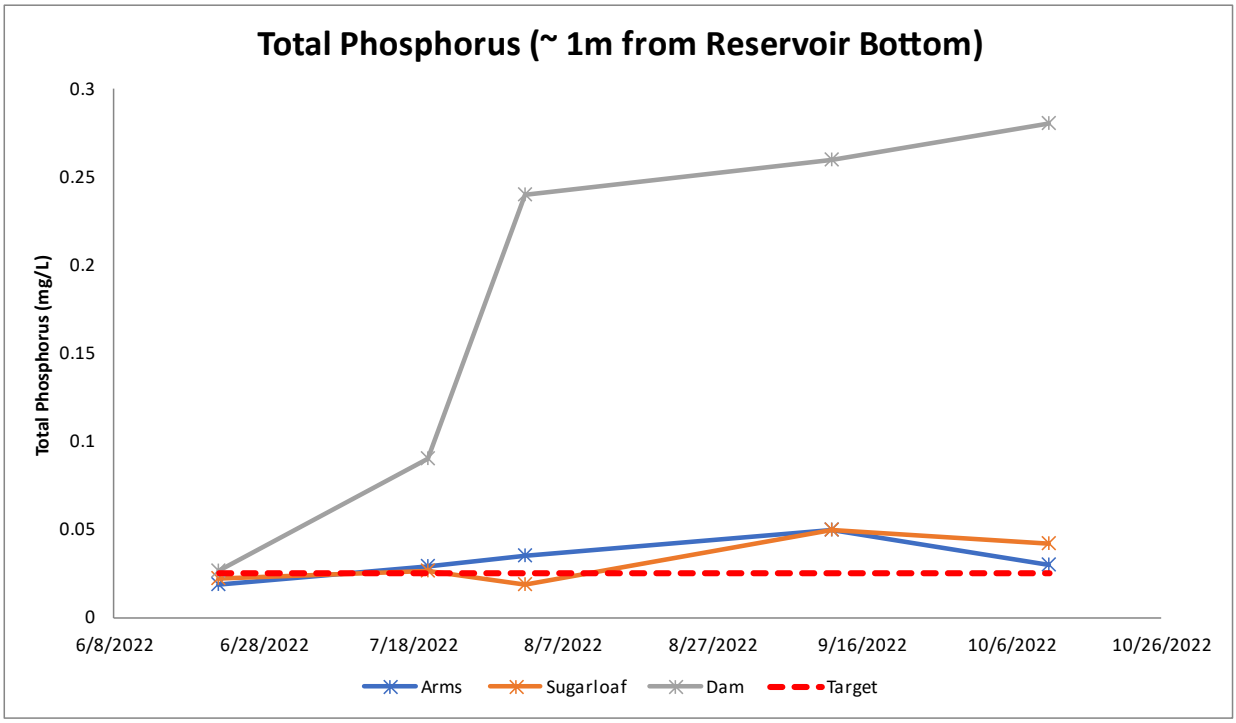

Figure 3. Hypolimnion total phosphorus concentrations.

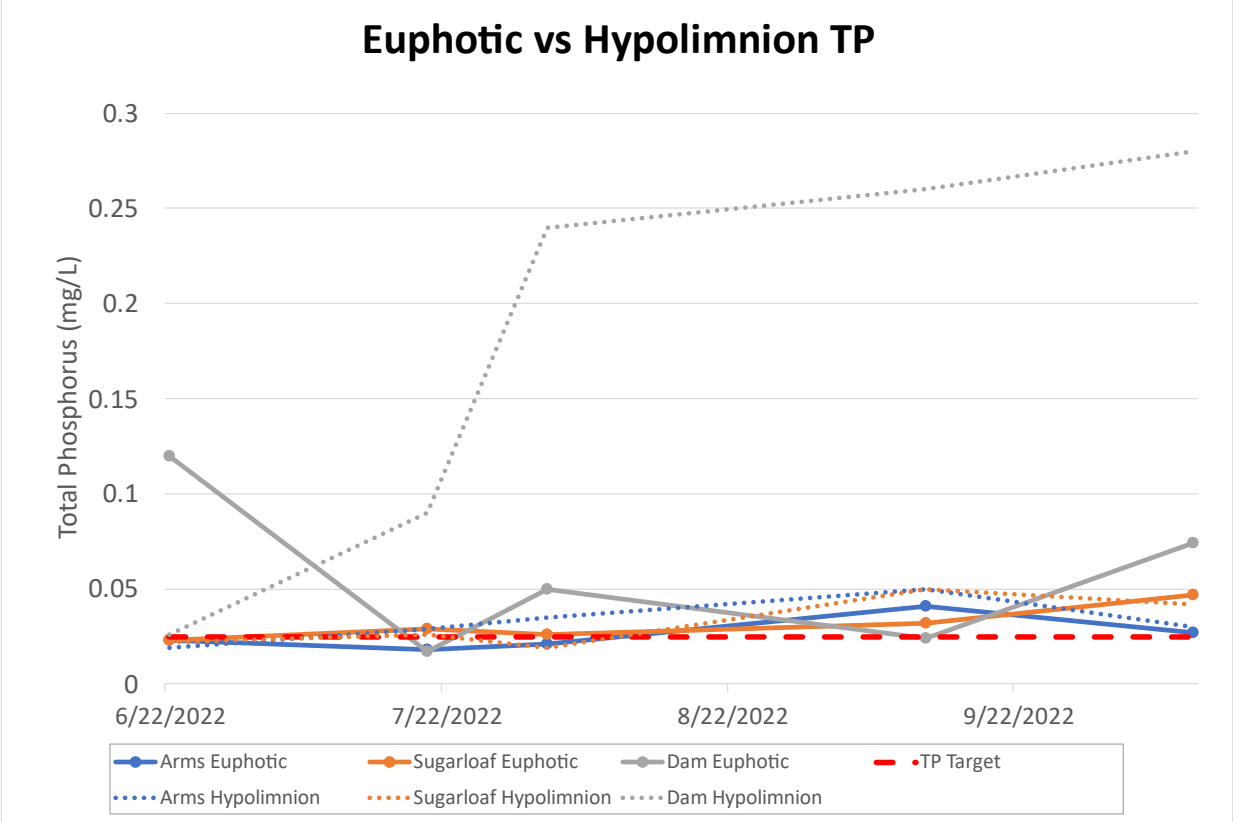

Figure 4. Comparison of euphotic and hypolimnion total phosphorus concentrations.

The dam location experienced drastically higher hypolimnion TP concentrations during the latter half of the summer, coinciding with a cyanobacteria bloom. In contrast, this site had a high TP in the euphotic zone during the June cyanobacteria bloom. The zone (epilimnion versus hypolimnion) of elevated TP was not the same for both blooms.

The overall average TP concentration was 0.060 mg/L, well above the target. The euphotic zone average was 0.038 mg/L, and the hypolimnion zone average was 0.081 mg/L. High TP concentrations at the dam in late summer had a large influence on these high averages.

2.2 Dissolved Oxygen

The dissolved oxygen (DO) concentration target should be above 6.0 mg/L in reservoirs year-round. The bottom 20% of depth in reservoirs that are less than a 35-meters deep are excluded from this criterion (excluded data are indicated by black 'X' markers in Figure 5 through Figure 7). In 2022, DO was measured monthly from June through September at all three monitoring locations, for a total of 12 sampling events. DO was measured in a vertical profile at each location. DO concentration profiles for each location over the summer are presented in Figure 5, Figure 6, and Figure 7.

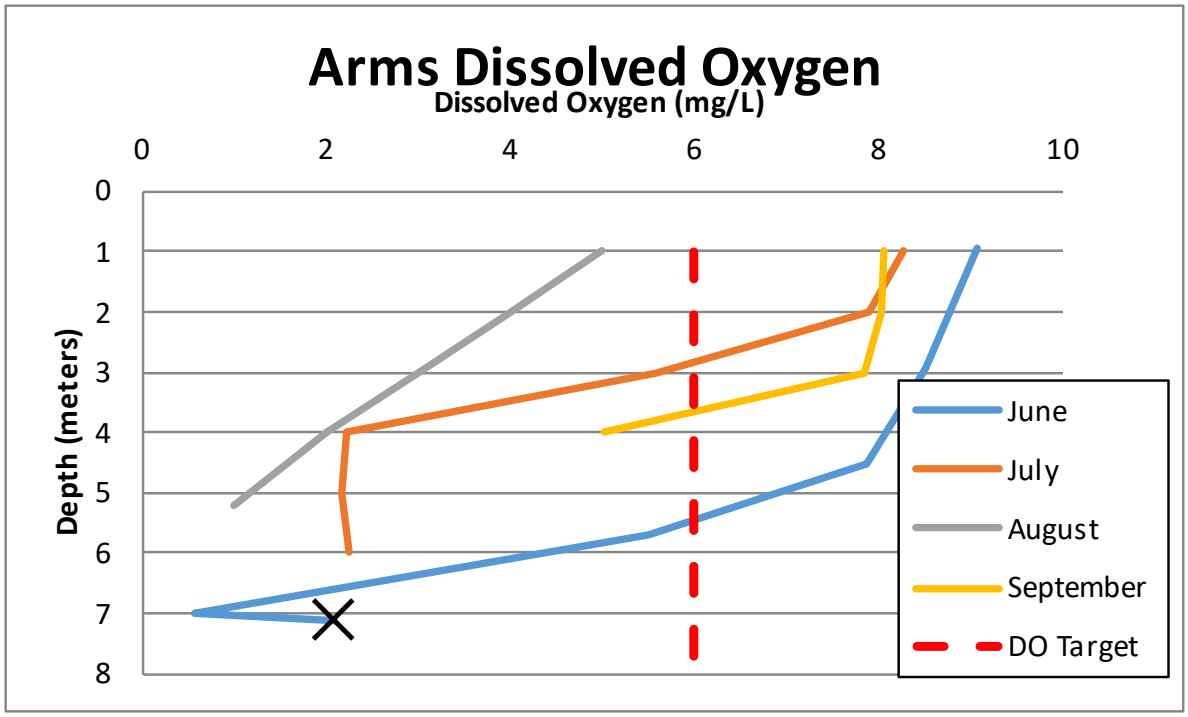

Figure 5. Monthly dissolved oxygen profiles at the arms confluence (depth excluded data points are indicated with black 'X').

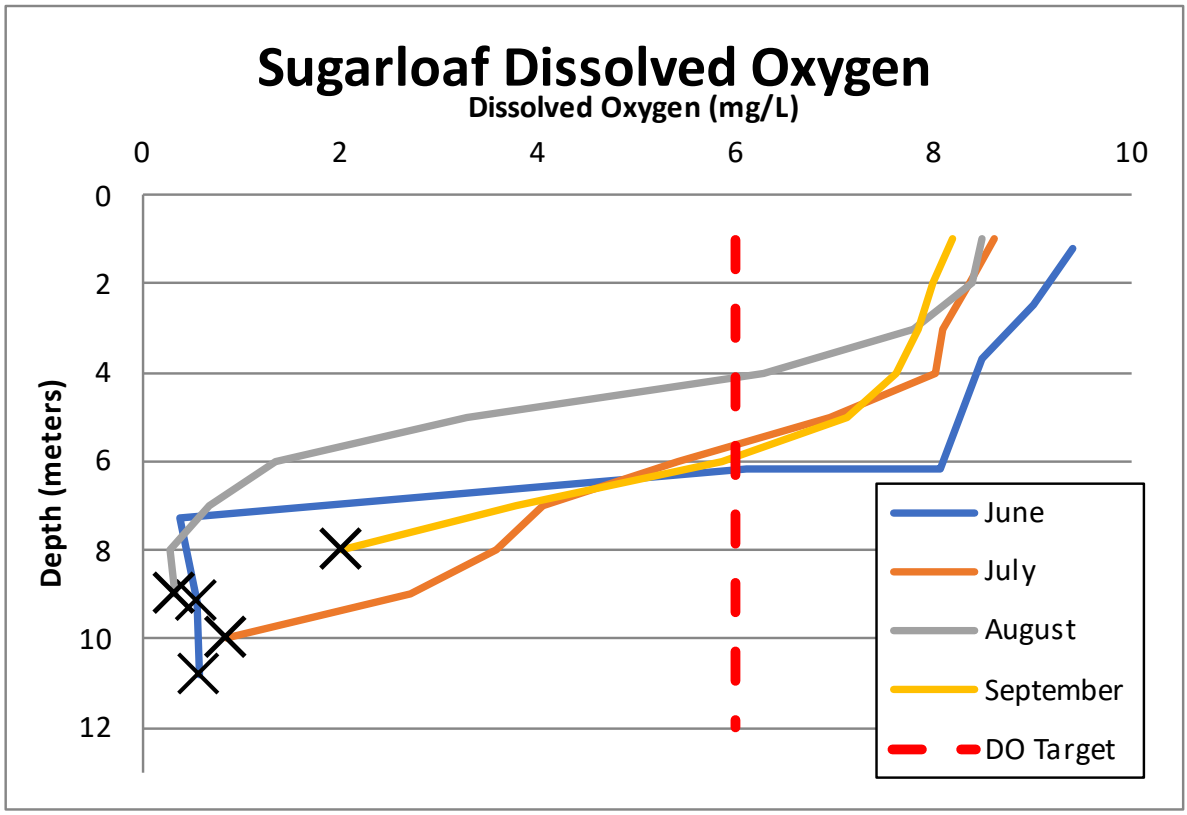

Figure 6. Monthly dissolved oxygen profiles at Sugarloaf Island (depth excluded data points are indicated with black 'X' markers).

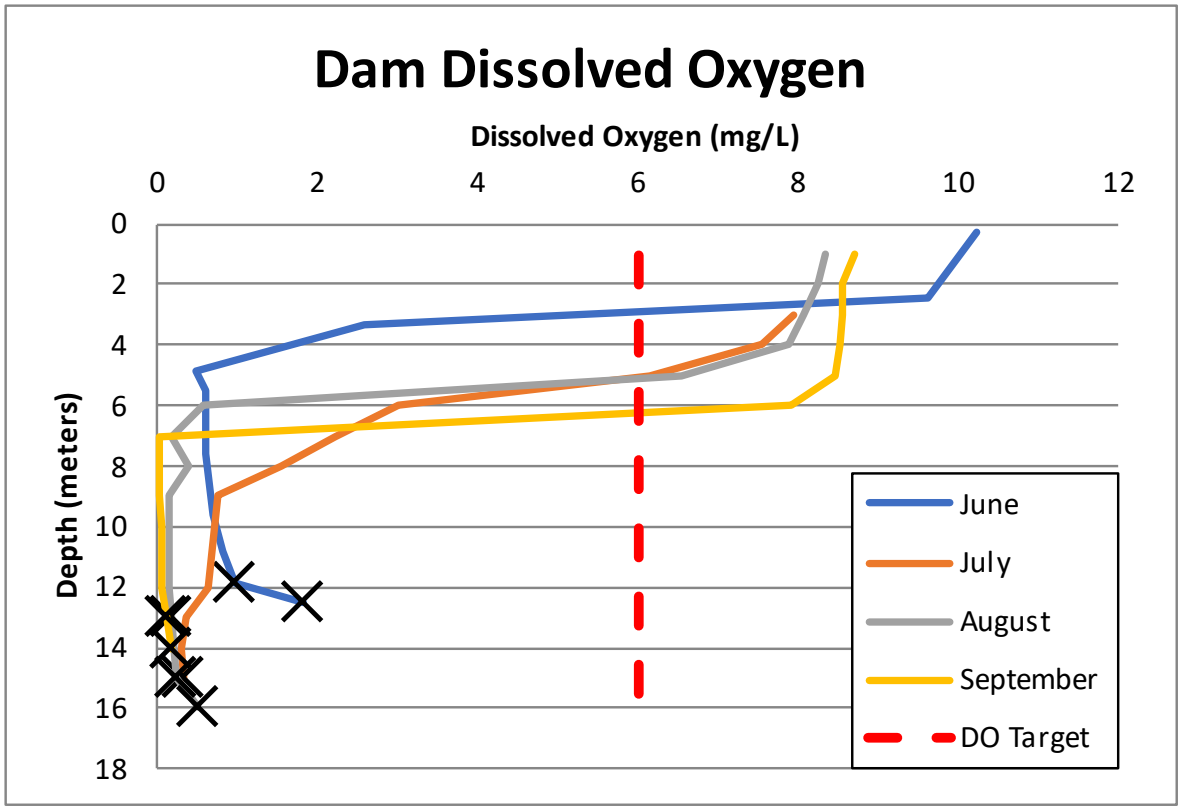

Figure 7. Monthly dissolved oxygen profiles at the dam (depth excluded data points are indicated with black 'X' markers).

Generally, in the top 3 to 6 meters of the water column, DO was sufficiently above the target. Below this, DO failed to meet the target. Average DO concentrations at the arms confluence and Sugarloaf Island sites met the target of 6.0 mg/L from June through September. The dam site did not meet the target. Excluding the lower 20% of depth, the average DO concentration at the arms confluence was 6.2 mg/L, at Sugarloaf Island was 6.1 mg/L, and at the dam was 3.4 mg/L.

2.3 pH

Cascade Reservoir pH should be between 6.5 and 9.0 year-round to meet the TMDL target. In 2022, pH was measured monthly from June through September at all three sites, for a total of 12 sampling events. Vertical pH profiles for each site are shown in Figure 8, Figure 9, and Figure 10. The average of each profile is shown in Table 4.

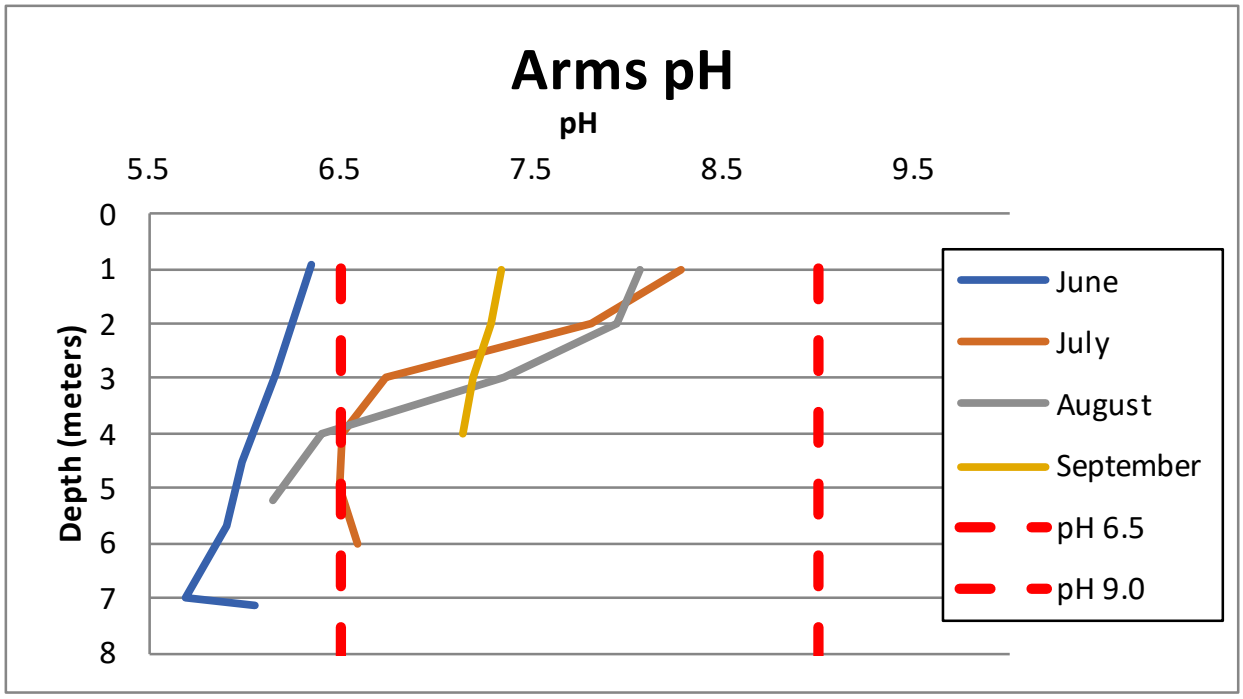

Figure 8. Monthly pH profiles at the arms confluence.

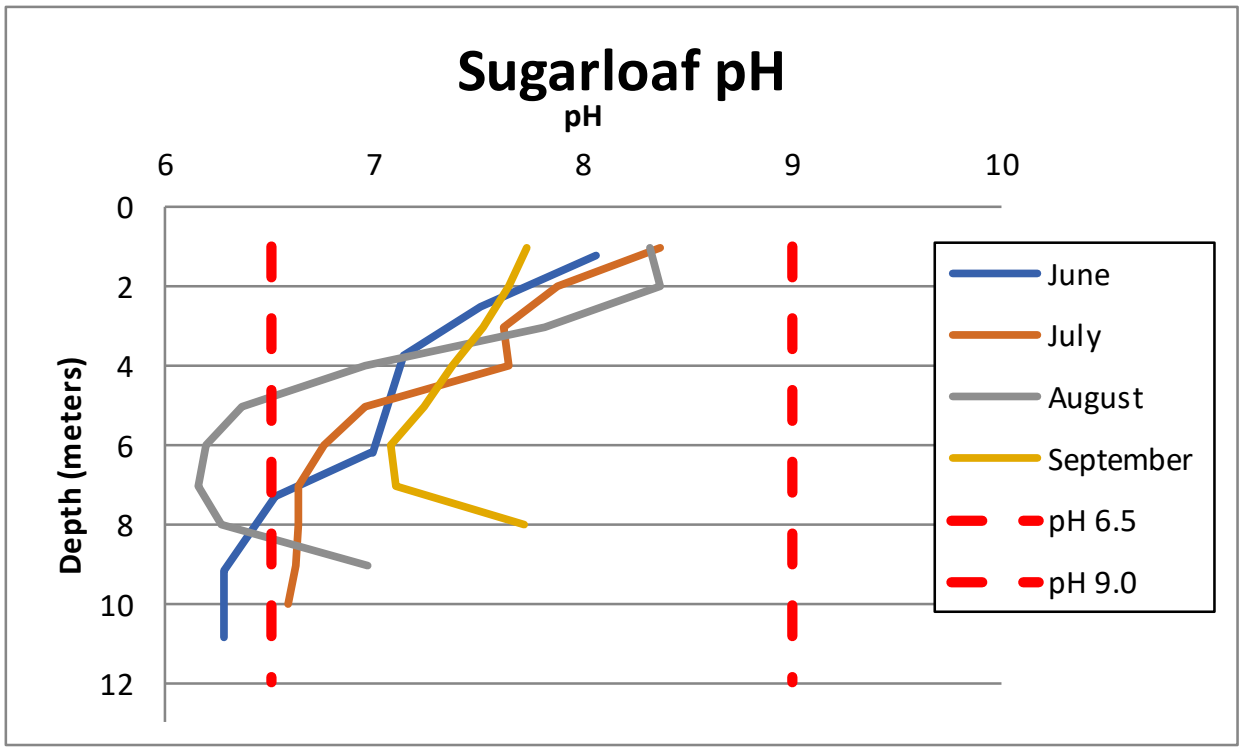

Figure 9. Monthly pH profiles at Sugarloaf Island.

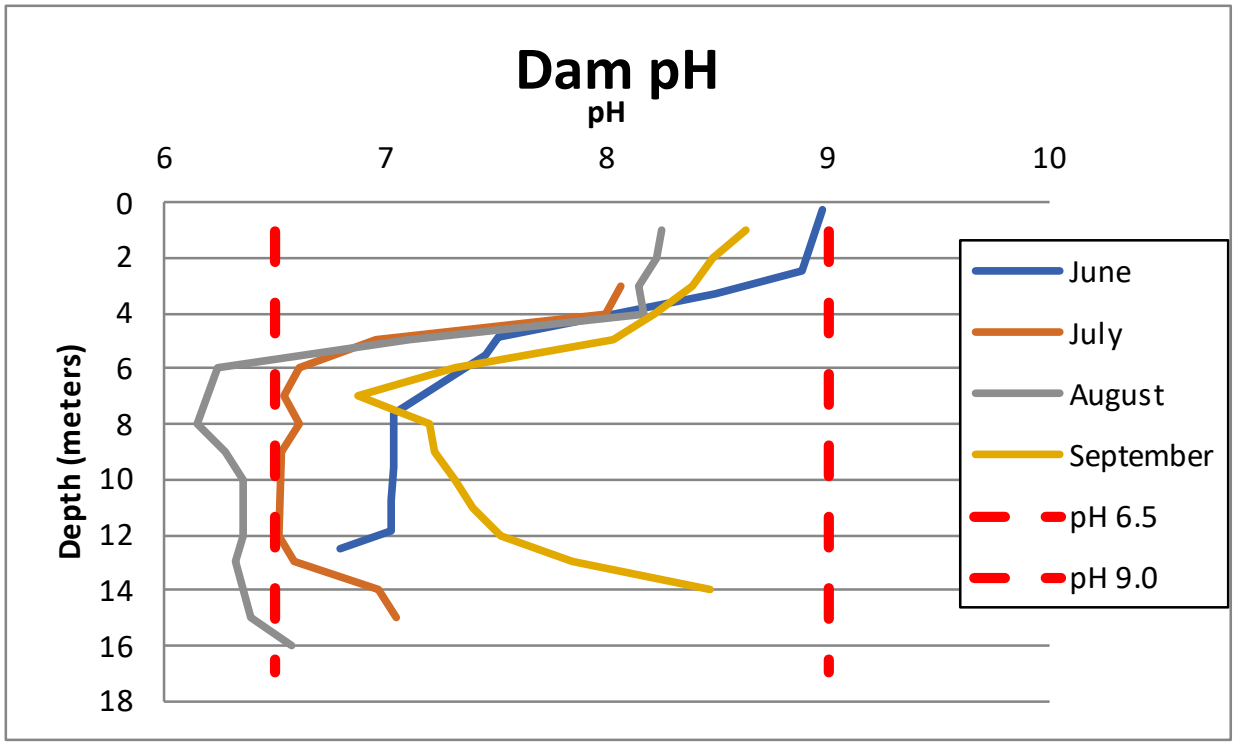

Figure 10. Monthly pH profiles at the dam.

Table 4. Average of pH profiles at each monitoring site.

	Arms Confluence	Sugarloaf Island	Dam
June	6.03	6.97	7.62
July	7.07	7.17	6.95
August	7.19	7.04	6.84
September	7.25	7.42	7.78
Season	6.83	7.15	7.27

The arms confluence site did not meet the minimum pH target in June. This measurement was collected on June 22, which occurred during the onset of the June cyanobacteria bloom. Normally, cyanobacteria blooms are accompanied by high pH. This bloom was present mostly in the southern areas of the reservoir, whereas the arms confluence is in the north. Generally, at all sites throughout the season pH dropped low in a zone a few meters from the bottom of the reservoir but rose again at the lake bottom. At the dam site, a large pH difference occurred between surface and midlevel, at a depth around 5 to 7 meters.

The pH target was met at all three sites for every month during 2022, except for the arms confluence in June. Season averages at each site also met the goal (Table 4).

2.4 Chlorophyll-a

Chlorophyll-a concentrations should be below 10 µg/L from May through September. Chlorophyll-a was collected as a composited sample of three equally spaced depths from the euphotic zone at each site, monthly from June through October, for a total of 15 samples.

Chlorophyll-a degrades to pheophytin. Both constituents were analyzed and summed together for a corrected chlorophyll-a result. Corrected chlorophyll-a concentrations for all locations are shown in Figure 11. Results below the minimum reporting limit were omitted.

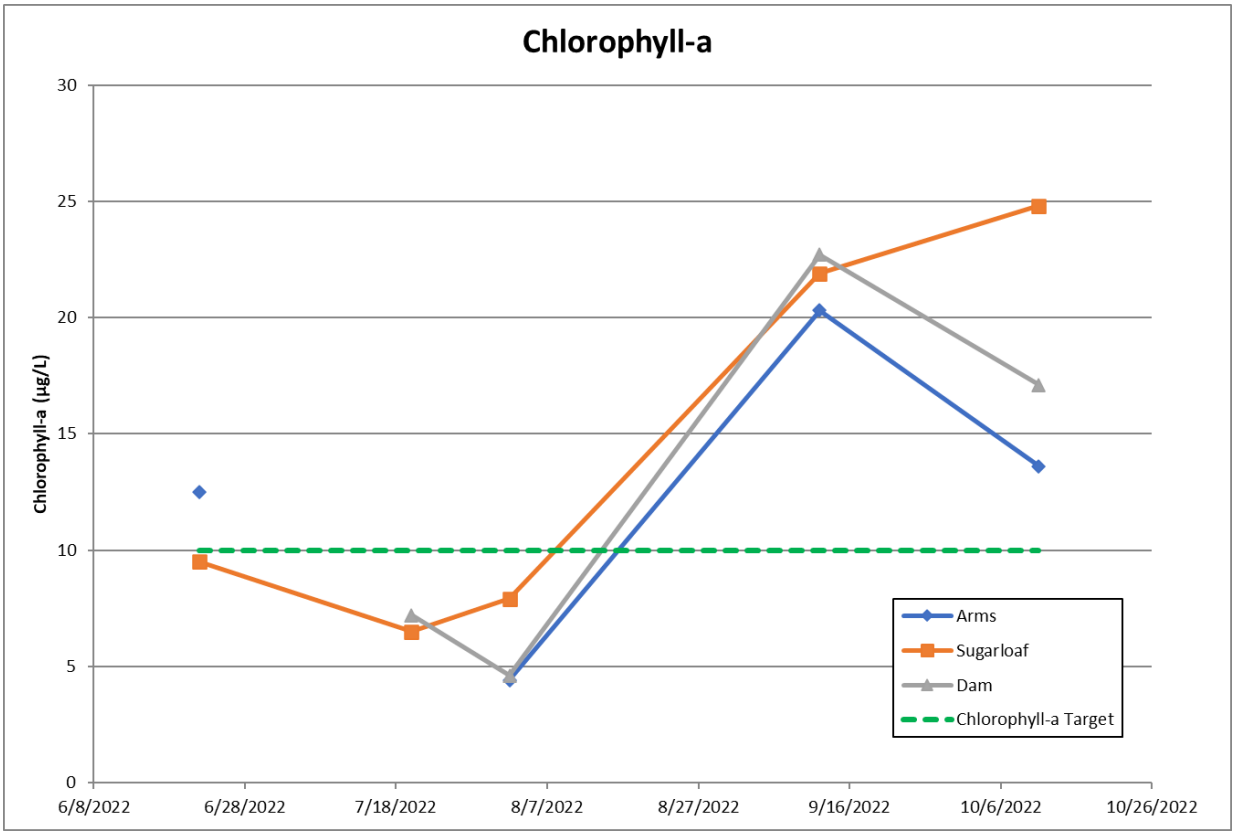

Figure 11. Corrected chlorophyll-a concentrations.

Chlorophyll-a concentrations exceeded the 10 mg/L target in September and October at all sites, and the arms confluence site exceeded the target in June.

3 Long Term Trends

This section discusses 2022 Cascade Reservoir water quality in relation to target attainment progress over time.

3.1 Total Phosphorus

After Watershed Management Plan Phase I was completed in 1996 TP initially declined but never met the water quality target. TP stayed consistent for several years, but since 2019 concentrations have been increasing. Splitting the hypolimnion and euphotic zones in 2021 and 2022 revealed much higher TP concentrations at the bottom of the reservoir (Figure 12).

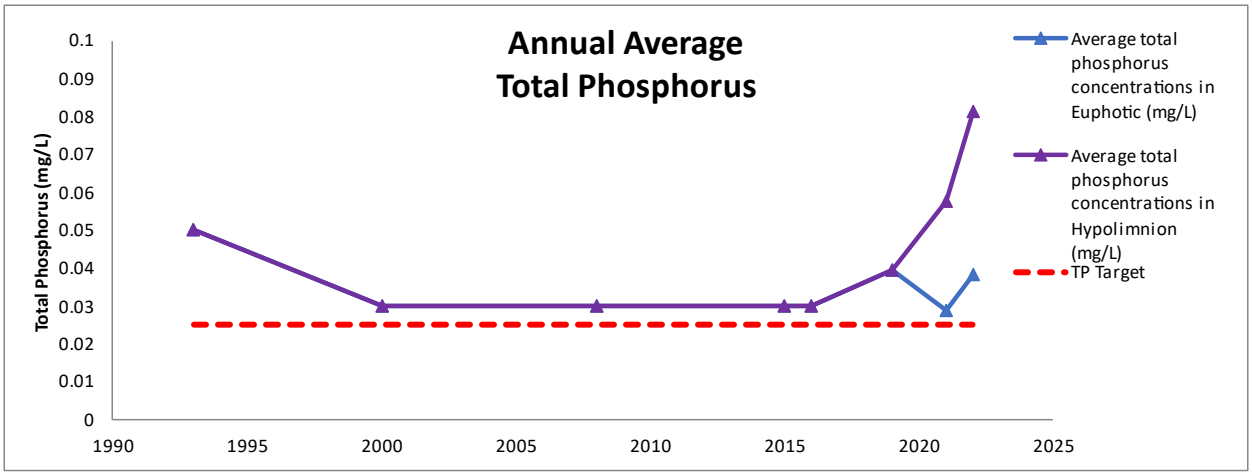

Figure 12. Annual average total phosphorus concentrations from 1993 to 2022.

Before 2021, TP was averaged throughout the entire water column, resulting in only one average TP value for these years. In 2021 and 2022, TP monitoring changed to separate euphotic zone and hypolimnion characteristics. High concentrations at the dam site in late summer drove up hypolimnion TP concentrations in both years.

3.2 Chlorophyll-a

Cascade Reservoir exceeded the chlorophyll-a target in 2022 (Figure 13). Since the Watershed Management Plan Phase I was completed in 1996, chlorophyll-a improved for several years. The target was met in 2015, 2016, and 2019. The watershed management plans expect that controlling TP for 5 years would result in improvements in chlorophyll-a. The increase in chlorophyll-a coincides with the increase seen in TP.

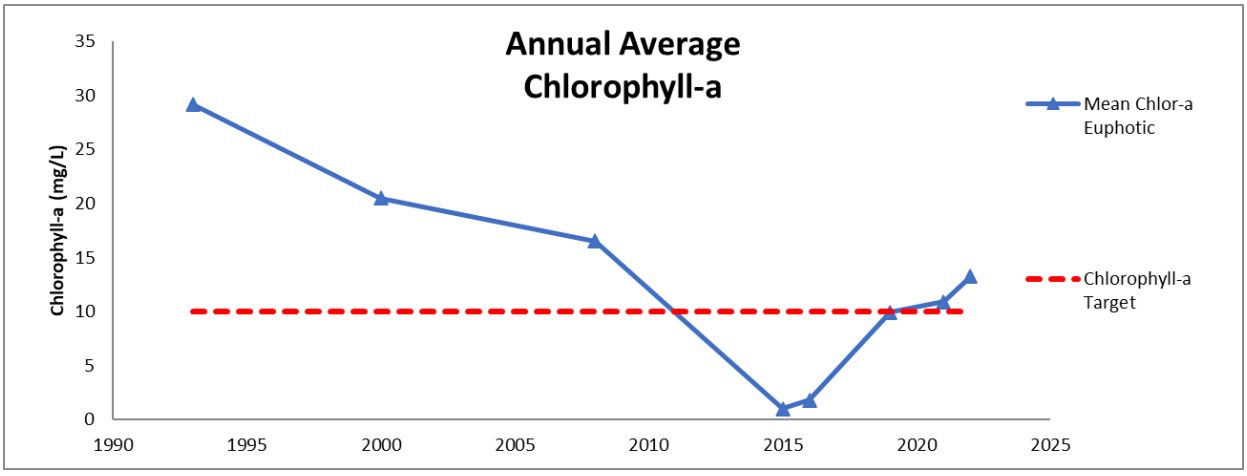

Figure 13. Annual average chlorophyll-a concentrations from 1996 to 2022.

3.3 Dissolved Oxygen

Overall, average DO concentration fell below the target in 2022. Calculating annual averages from available recent data, Cascade Reservoir failed this criterion for the first time since 2015 (Figure 14). DO was particularly low in the hypolimnion at Sugarloaf Island and the dam. The dam was anoxic at depth for much of the summer (Figure 7). DO influences pH and corresponds with lower pH observed at the dam (Figure 10). DO also influences nutrient availability and corresponds with greater TP concentrations at the dam (Figure 3 and Figure 4).

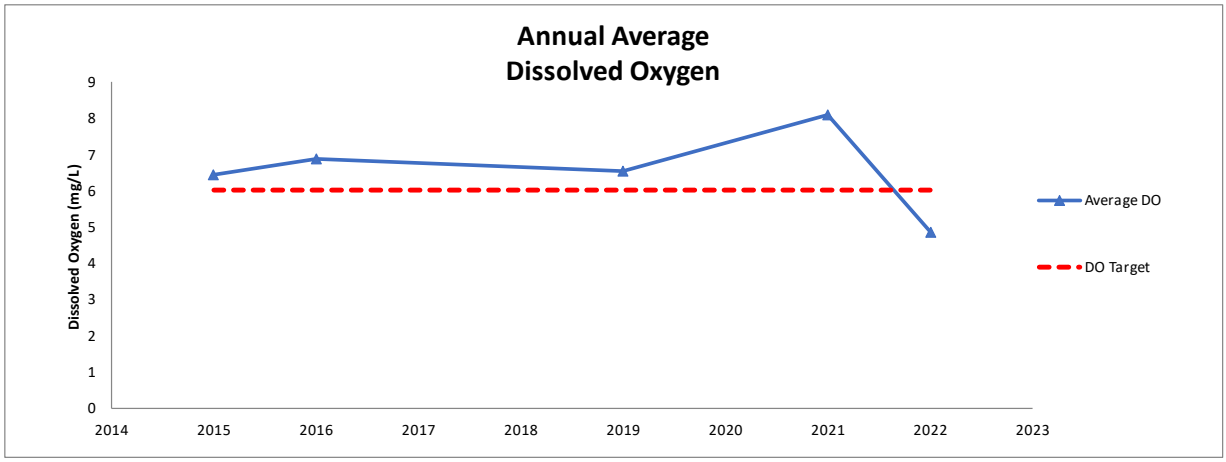

Figure 14. Average dissolved oxygen concentrations from 2015 to 2022.

3.4 pH

Cascade Reservoir met pH targets during 2022 (Table 4). Recent available data shows this goal has been met consistently since 2015 (Figure 15).

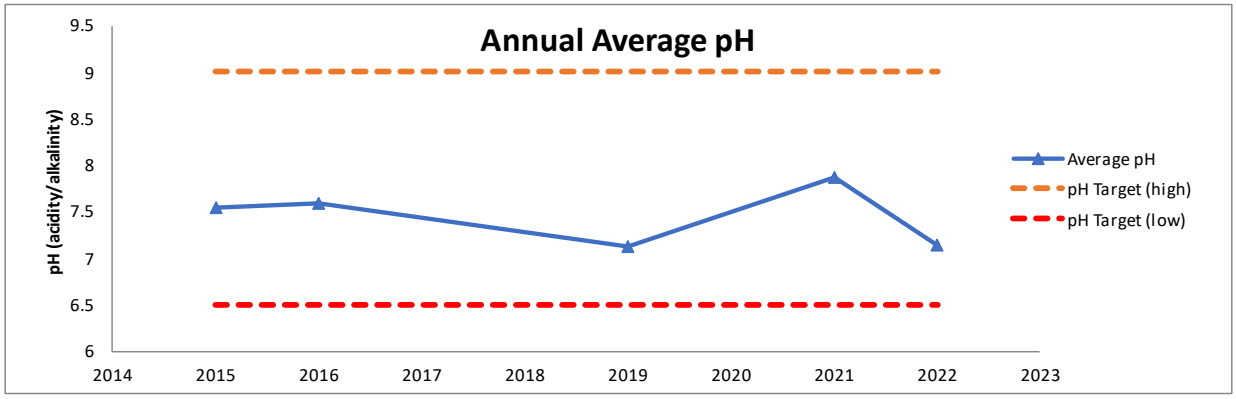

Figure 15. Annual average pH concentrations from 2015 to 2022.

3.5 Improvement Projects Implemented

VSWCD made major strides in implementing nonpoint source improvement projects around the lake. Many local groups and schools participated in willow plantings and fencing projects. VSWCD was awarded a WaterSMART grant from the Bureau of Reclamation to plan a North

Fork Payette River watershed coalition to identify and prioritize restoration projects and find more funding sources. Additionally, the National Resource Conservation Service designated the North Fork Payette River watershed as a source water protection high priority area (ISWCC 2023). This designation opens more funding and cost-sharing opportunities to encourage practices that advance conservation and benefit agricultural businesses.

4 Cyanobacteria and Water Quality Patterns

This section discusses 2022 water quality patterns associated with chlorophyll-a and the presence of cyanobacteria on Cascade Reservoir. Chlorophyll-a is used as a measurement of phytoplankton in the water column, including algae and cyanobacteria. Limnetic physical dynamics and seasonal trends influence nutrient and temperature mixing. Interpretations of 2022 monitoring results should be analyzed within the context of stratifications observed during the season.

4.1 Temperature and Thermal Stratification

Water in lakes and reservoirs mixes vertically through the water column. Some lakes may become stratified as sunlight warms the surface layer and a thermal barrier between the epilimnion (surface) and hypolimnion prevents mixing. This stratification creates water quality zones with distinct temperature, pH, and DO characteristics in each that influence constituents such as nutrient solubility or trophic productivity (phytoplankton, cyanobacteria, chlorophyll-a).

Cascade Reservoir is rather shallow and may not always become stratified. Thermal gradients for each site are presented in Figure 16, Figure 17, and Figure 18.

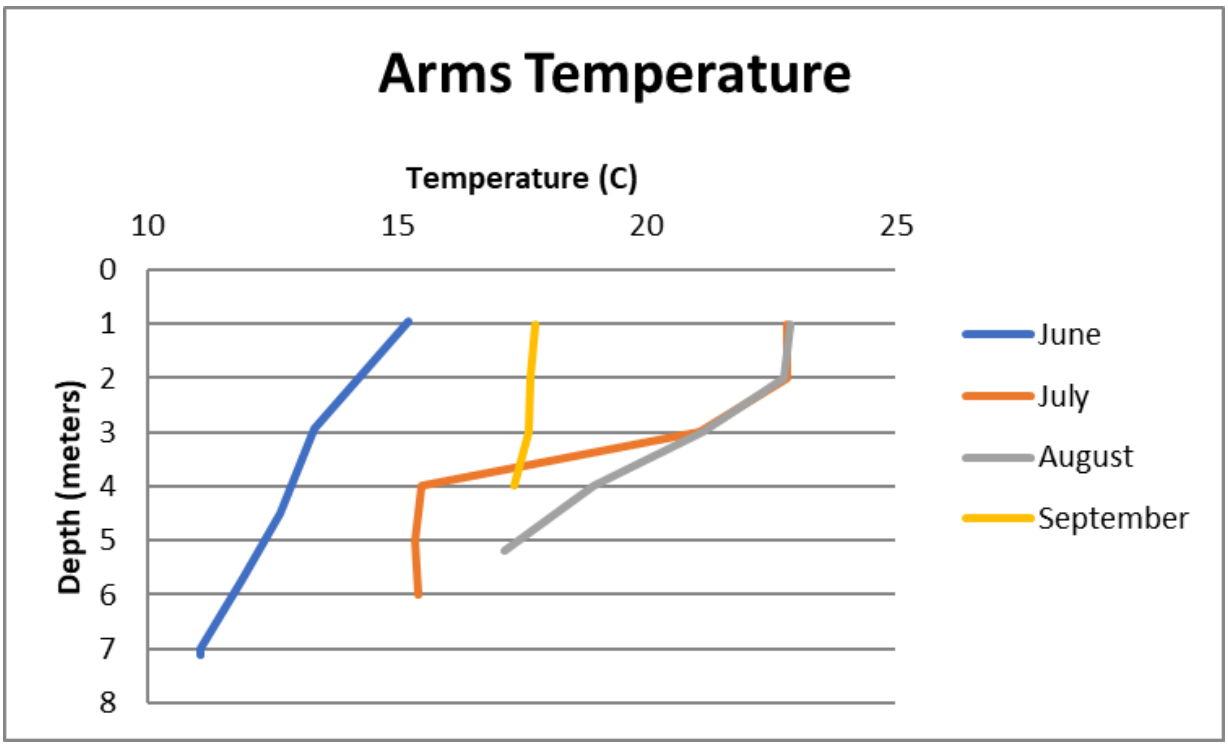

Figure 16. Monthly temperature profiles at the arms confluence.

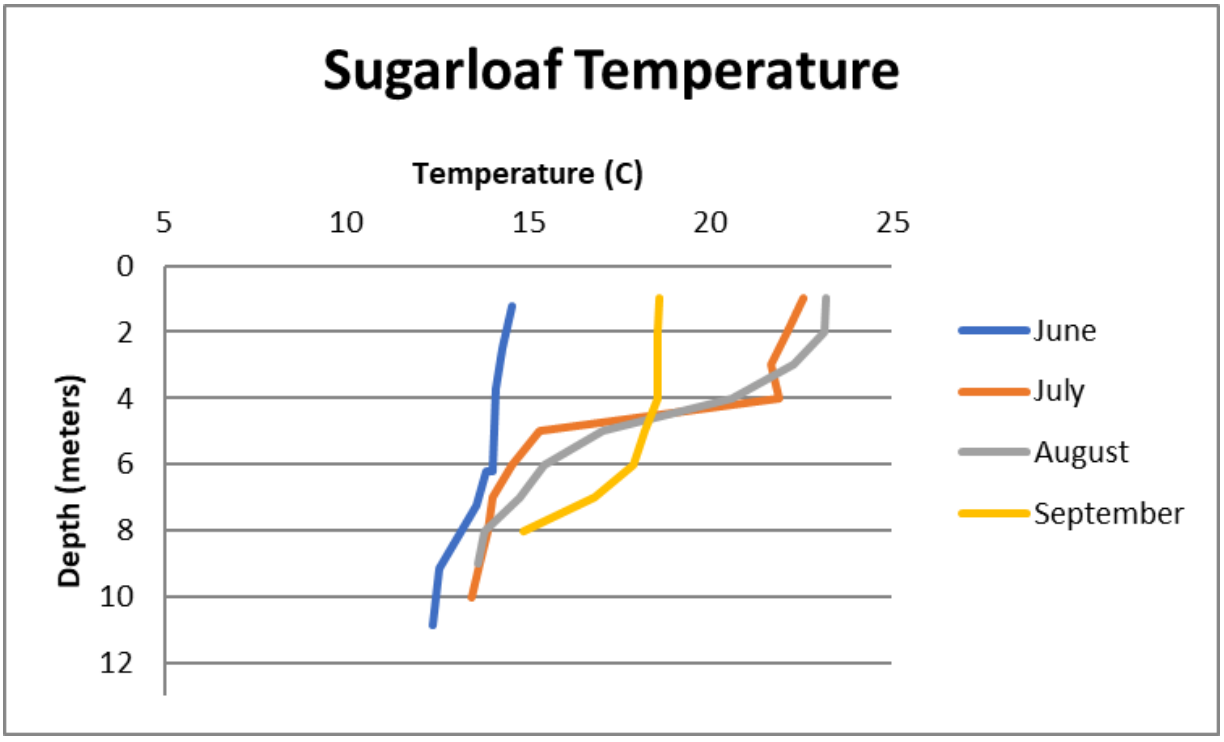

Figure 17. Monthly temperature profiles at Sugarloaf Island.

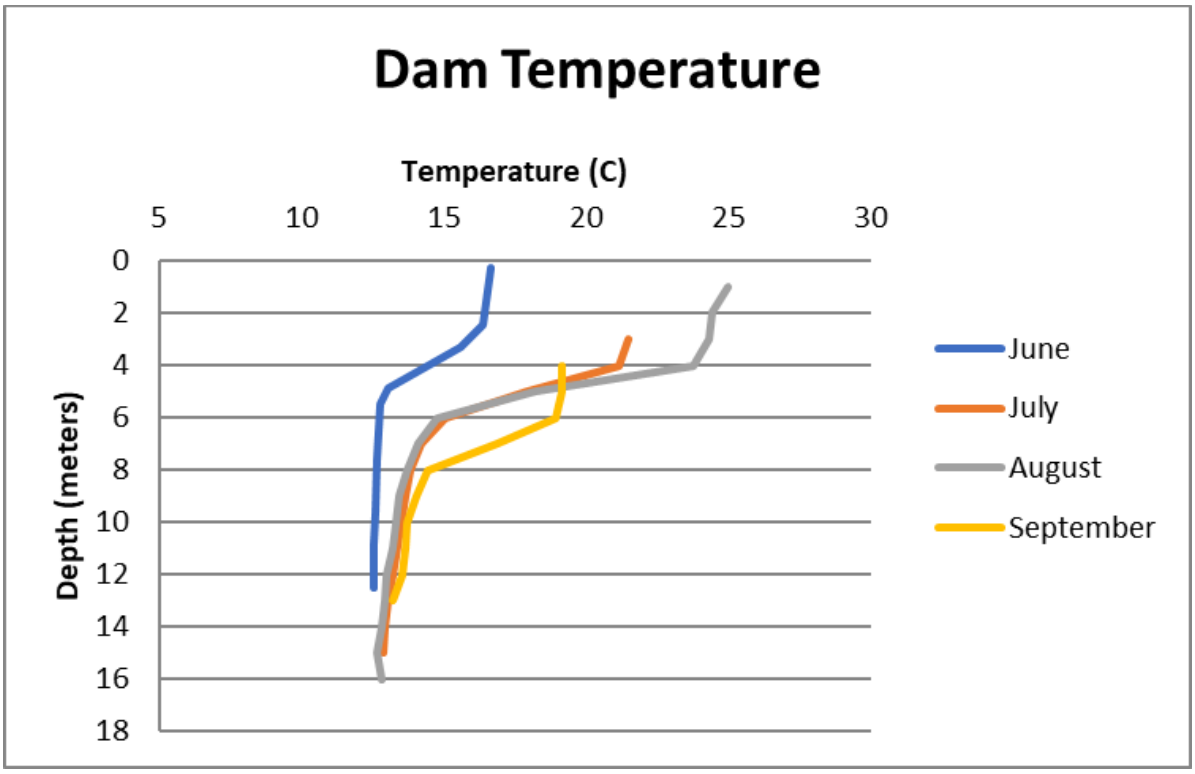

Figure 18. Monthly temperatures profiles at the dam site.

The arms confluence site developed a defined stratification only in July. The temperature difference correlated vertically with a drop in pH and DO, indicative of a mixing barrier. This shallow site experiences flow from incoming tributary streams. Sunlight penetrates the entire column, and aquatic vegetation was observed on the reservoir floor during sampling.

The Sugarloaf Island site became stratified in July and August, waning by September. The surface temperature lowered as mixing increased.

The dam site was stratified throughout the season. The thermocline (i.e., zone of greatest temperature difference) moved downward from about 4 meters to about 7 meters. This site has unique hydrologic conditions. The dam was built where the North Fork Payette River once cut through a narrow passage. This site is in the deepest of all and is located in the former river channel depression.

4.2 Total Nitrogen

Cascade Reservoir does not have a total nitrogen (TN) TMDL target. Nutrient issues are primarily focused on phosphorus availability and controls. Eutrophication and trophic productivity relate to nutrients, including both phosphorus and nitrogen, thus 2022 monitoring included TN sampling. Most results came back below the laboratory minimum reporting limit (0.010 micrograms per liter [µg/L]). The reportable detected TN results are shown in Figure 19. Results below the minimum reporting limit were omitted.

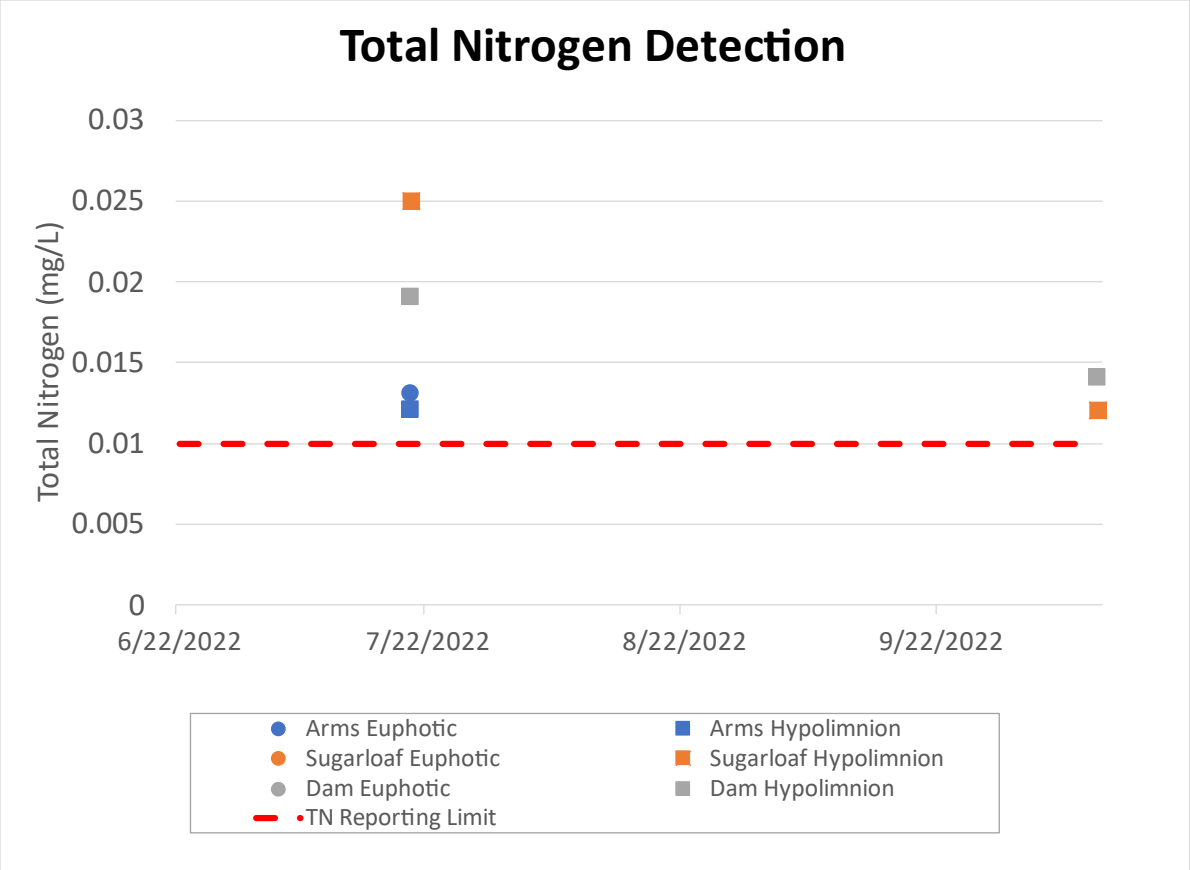

Figure 19. Total nitrogen detections.

Cyanobacteria are capable of fixing nitrogen from the atmosphere for their nutrient needs. Cascade Reservoir is considered phosphorus limited (DEQ 1991).

> Phosphorus generally controls algal productivity in large lakes or reservoirs that have significant inputs of non-point source nutrients (Thormann and Mueller 1987 as cited in DEQ 1991). Conversely, nitrogen limitation is more commonly associated with a waterbody that receives large amounts of discharge from point sources (Welch 1980 as cited in DEQ 1991).

TN analysis included inorganic forms of nitrogen, nitrate, nitrite, and ammonia. In 2023, TN analysis will likely include organic total Kjeldahl nitrogen (organic species of nitrogen).

4.3 Chlorophyll-a and Total Phosphorus

Cascade Reservoir beneficial uses—fishing, swimming, boating, and agricultural water supply—are impaired due to excessive algal growth. Cascade Reservoir water quality is impaired because it is not meeting standards for DO, temperature, and pH. Elevated phosphorus contributes directly to these issues. Chlorophyll-a was monitored as a measurement of trophic productivity. Chlorophyll-a measurements include all photosynthetic phytoplankton, including algae and cyanobacteria.

Cyanobacteria flourish when TP and chlorophyll-a are higher. Figure 20 and Figure 21 depict trends in chlorophyll-a in relationship to TP at each monitoring site. Chlorophyll-a concentrations appear somewhat correlated with euphotic TP but not hypolimnetic TP.

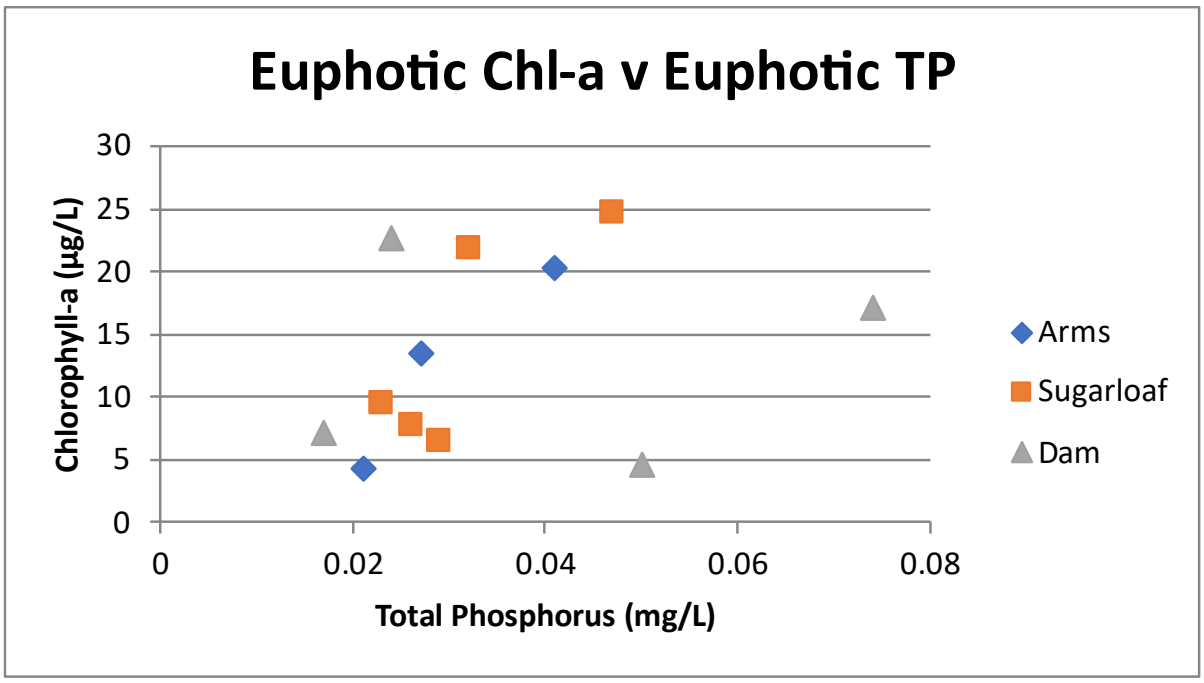

Figure 20. Chlorophyll-a concentrations correlated with surface level total phosphorus.

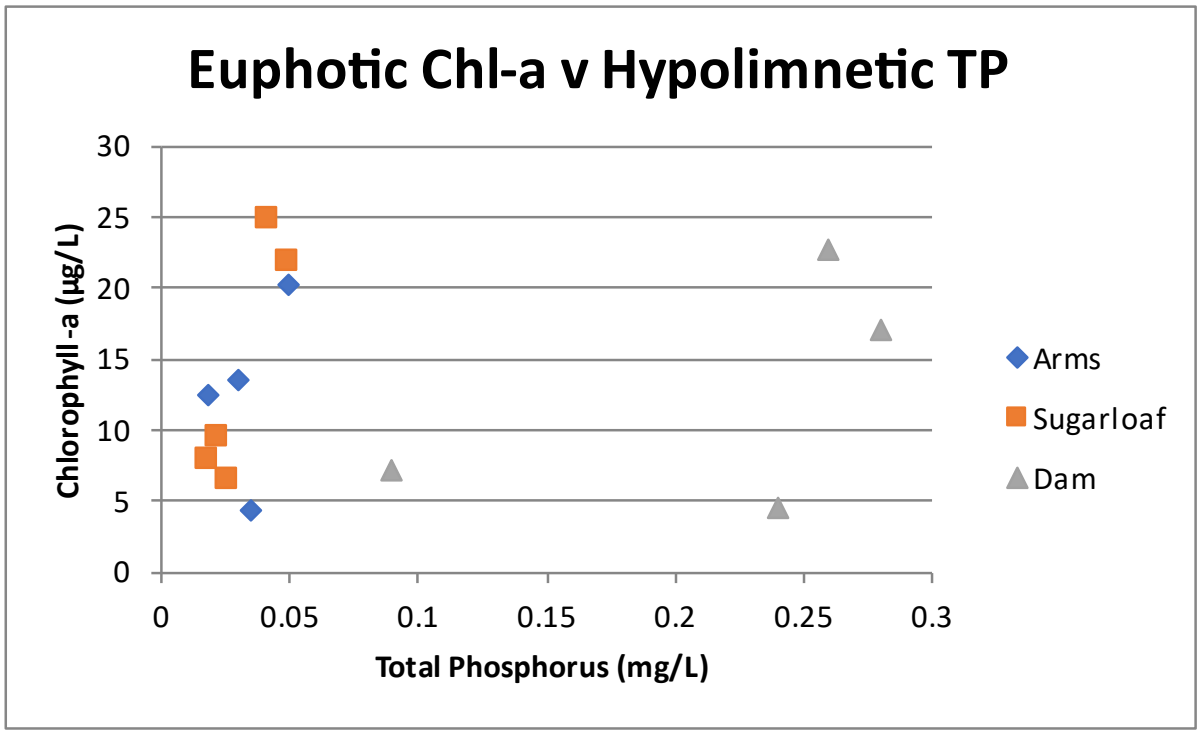

Figure 21. Chlorophyll-a concentrations correlated with reservoir bottom total phosphorus.

4.4 Turbidity

Turbidity is also associated with higher trophic productivity (i.e., more eutrophic conditions) as photosynthesis increases and more phytoplankton are present in the water column. Secchi disk measurements are based on visibility and indicate the depth that light can penetrate. Lower Secchi depths indicate an increase of turbidity or dissolved and suspended material obstructing light. Visibility depth is shorter when water is cloudier. Figure 22, Figure 23, and Figure 24 correlate Secchi depth readings with chlorophyll-a concentrations and total site depth. Reservoir water levels draw down in late summer, corresponding to an increase in turbidity and chlorophyll-a.

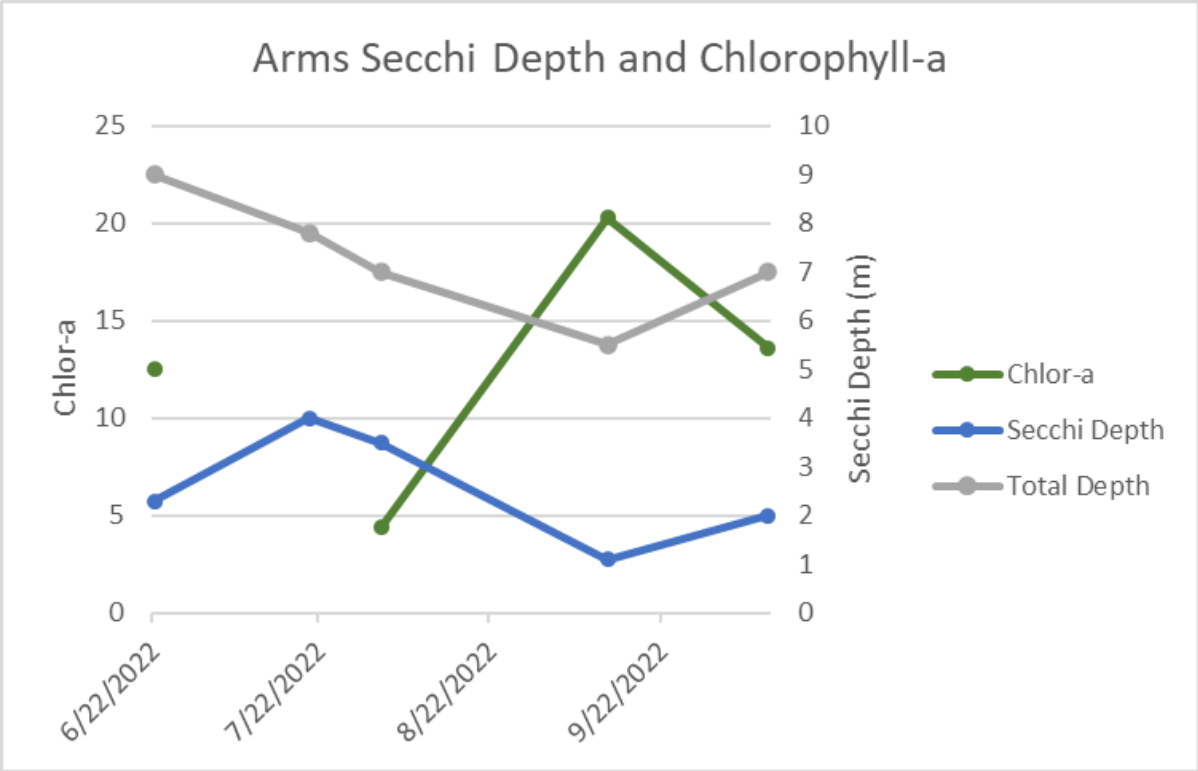

Figure 22. Arms confluence site chlorophyll-a concentrations correlated with Secchi depth and total site depth.

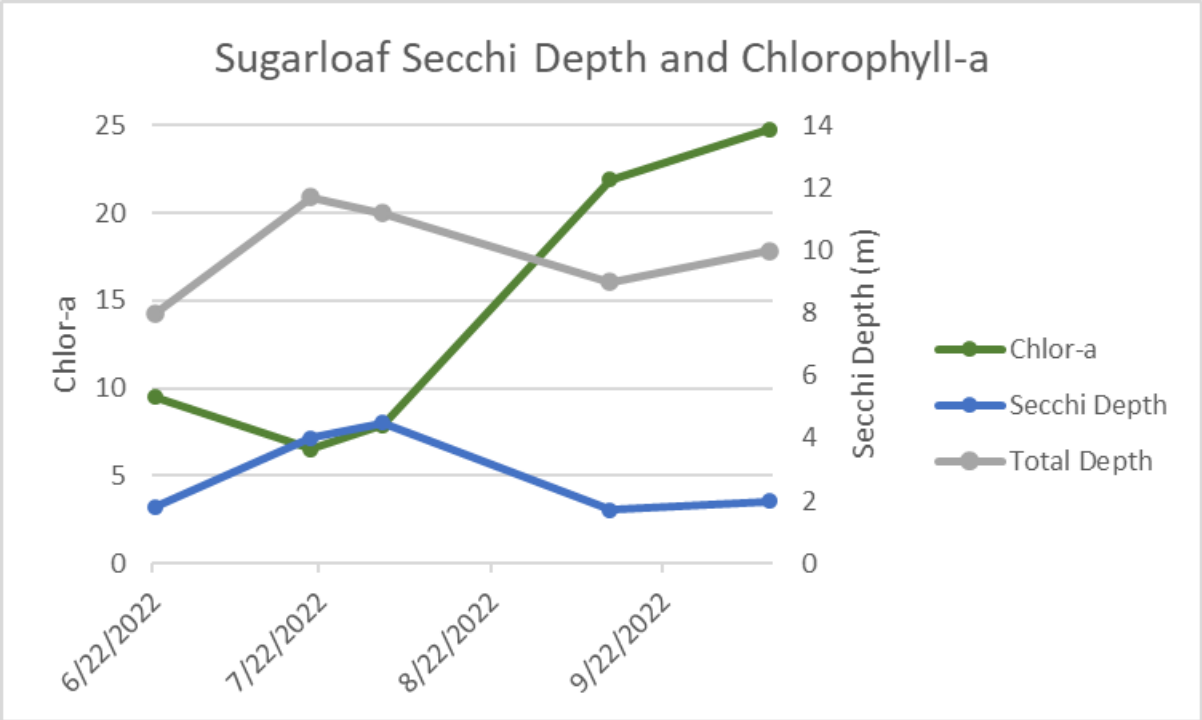

Figure 23. Sugarloaf Island site chlorophyll-a concentrations correlated with Secchi depth and total site depth.

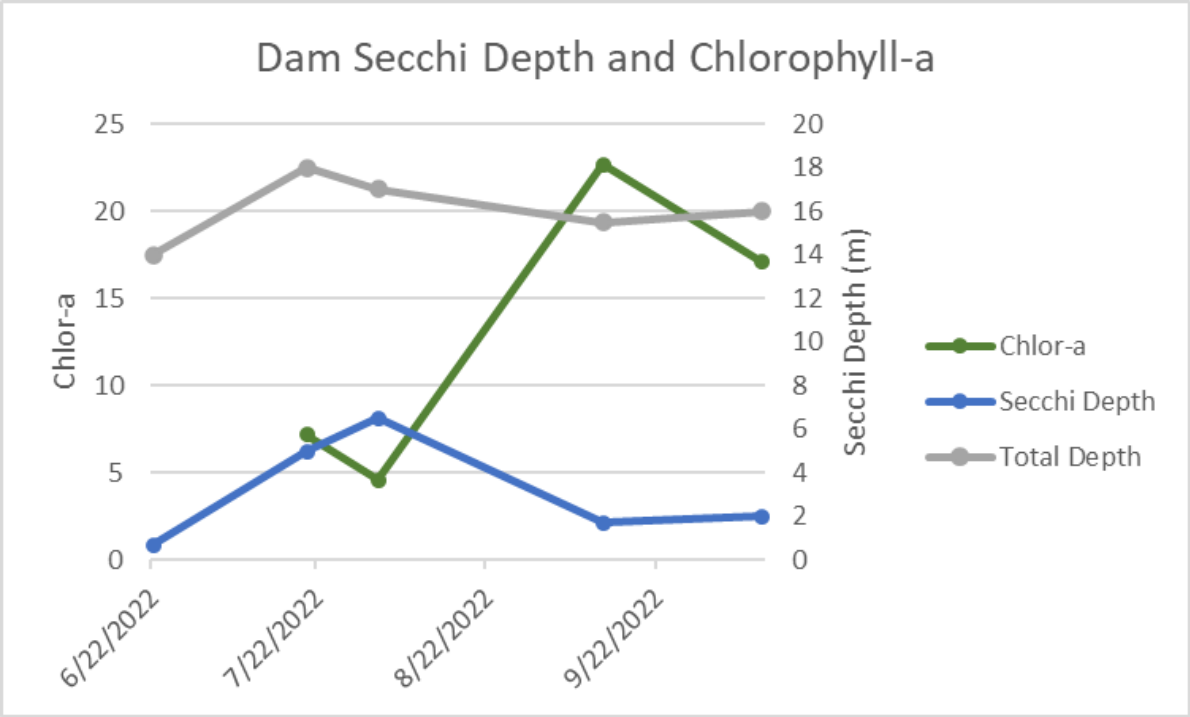

Figure 24. Dam site chlorophyll-a concentrations correlated with Secchi depth and total site depth.

5 2022 Major Events - Cyanobacteria Blooms and Four Corners Fire

In June 2022, an unseasonable and substantial cyanobacteria bloom occurred in the reservoir. Initial detection came from Friends of Lake Cascade, reporting photographic and microscopic observations to DEQ on June 19 (FOLC 2022). Samples that DEQ took from Boulder Creek, Sugarloaf Island, and Blue Heron campground on June 22 indicated little to no cyanotoxins or cyanotoxin-producing genes present in the bloom. Although the June bloom was not toxic enough to warrant a health advisory, the presence of the unsightly, odorous, widespread bloom grabbed the attention of the community and environmental agencies. Before the July 4 weekend, DEQ and the Idaho Department of Health and Welfare issued a news release to warn recreators of the presence of a cyanobacteria bloom and inform the public that harmful levels of cyanotoxins were not found. The bloom appeared to last 2 or 3 weeks and dispersed by early July. DEQ hosted an interagency open house, attended by many state and federal agencies and local partners, for the community of Cascade to discuss their cyanobacteria concerns.

Later in the summer, the Four Corners fire burned the slopes west of the reservoir. Fire suppression efforts scooped water from the reservoir. During this time, ash and debris were observed accumulating on the shores. Smoke obscured satellite imagery for cyanobacteria monitoring.

By late August, Friends of Lake Cascade provided photos of green, streaky water and microscopy, suggesting the onset of a second cyanobacteria bloom (FOLC 2022). DEQ samples from August 30 and September 26 did not detect harmful levels of cyanotoxins. Visual observations during this period and into October indicated cyanobacteria were flourishing. Despite the low cyanotoxin concentrations, an animal illness was observed. The Idaho Department of Health and Welfare issued a warning press release on October 5, explaining the circumstances and urging caution when recreating on Cascade Reservoir or the downstream North Fork Payette River.

DEQ monitors Cascade Reservoir to assess water quality trends and TMDL targets as discussed in the Cascade watershed management plans. While Idaho does not have a cyanobacteria monitoring program, DEQ and partner agencies respond to reported or discovered cyanobacteria harmful algal blooms to assess health risk and inform the public of toxic conditions. The impairments and water quality issues related to nuisance algal growth and algae were identified as the reasons for writing the original TMDL (DEQ 1996). Cyanobacteria bloom events and HABs can be discussed relative to these water quality trends. Further study of cyanobacteria is needed to make any assertive conclusions or specific recommendations. Further improvement toward attaining the TMDL goals will reduce algae and cyanobacteria growth.

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Glossary

Cyanobacteria	Microorganism; bacteria capable of photosynthesis and sometimes nitrogen fixation; capable of producing cyanotoxins. Also called blue-green algae.
Cyanobacteria bloom	A proliferation of cyanobacteria in which cyanotoxin concentration is unknown or below guidance threshold values. When the bloom has been tested and cyanotoxin concentrations exceed the threshold, the bloom becomes toxic (see HAB).
Cyanotoxins	Toxic compounds that can be harmful to humans, animals, and wildlife. Produced by cyanobacteria.
Euphotic	Also called epilimnion; the upper layer of a water body with sufficient light for photosynthesis.
Eutrophic	Water body that is rich in nutrients, promoting growth of aquatic plants and phytoplankton.
HAB	Harmful algal bloom; toxic cyanobacteria bloom. Cause for issuance of a recreational health advisory.
Health advisory	Official notice by Idaho Department of Health and Welfare or local public health districts to inform the public of where there is risk or a threat to public health.
Hypolimnion	Lower layer of a stratified lake.
pH	Potential of hydrogen; measure of acidity or alkalinity.
Secchi disk	Opaque (black and white) disk used to gauge transparency of water.
Stratification	Tendency of lakes to form separate and distinct thermal layers during warm weather.
TMDL	Total maximum daily load is an EPA-required plan to restore impaired waters to meet water quality standards.
Turbidity	Optical characteristic of water, a measurement of light penetration or obscuring by particles dissolved or suspended in the water.