



Technical Memorandum

To: Lake Elsinore and Canyon Lake TMDL Task Force

From: Steve Wolosoff, CDM Smith

Date: January 5, 2021

Subject: Implementation of Alum Additional Program in Canyon Lake

Background

Alum addition, an in-lake nutrient control BMP, has been implemented in Canyon Lake since 2013. When added to water, alum forms an aluminum hydroxide floc, which then binds with phosphorus in the water column and settles to the lake bottom. Once on the lake bottom, any remaining binding capacity is used to sequester a portion of phosphorus in porewater. The portion of phosphorus bound with aluminum on the lake bottom is inert and insoluble. It is no longer available for cycling back to the water column by processes of desorption and diffusive flux. The LECL Task Force, with partial support from a Proposition 84 Grant, implemented a pilot project to demonstrate the efficacy of alum addition for reducing bioavailable phosphorus as an algal control strategy in Canyon Lake. Following satisfactory completion of California Environmental Quality Act (CEQA) requirements, carefully controlled doses of alum have been applied via surface spreading twice per year in Canyon Lake since September 2013.

Water quality has improved dramatically since the alum program began. TP levels have steadily decreased at all monitoring sites since the first alum treatment and these sites now meet the final TMDL causal target for TP (see Section 3.1.2 of the 2020 Compliance Assessment). On average, conditions throughout Canyon Lake have been historically nitrogen-limited. However, since 2015 as a result of alum application, Canyon Lake has shifted to a phosphorus-limited condition, an important goal for this water quality management approach. Specifically, pre- and post-alum application program N:P ratios are as follows:

- Pre alum addition - Long-term (2011-2013) average TN:TP ratio of 4.6 and 6.5 in Main Lake and East Bay respectively.
- Post alum addition - Long-term (2014 – 2020) average TN:TP ratio of 24.8 and 24.7 in Main Lake and East Bay, respectively.

Routine water quality monitoring is performed at four lake stations before and after each alum application. Two of the sampling sites are located in the Main Lake (CL07 and CL08) and two are located in the East Bay (CL09 and CL10). Figure 1 shows the decline in average TP concentrations in the Main Lake and East Bay following each alum application. The greatest reductions shown come following wet seasons with above average rainfall when TP in the water column is elevated prior to the alum additions.

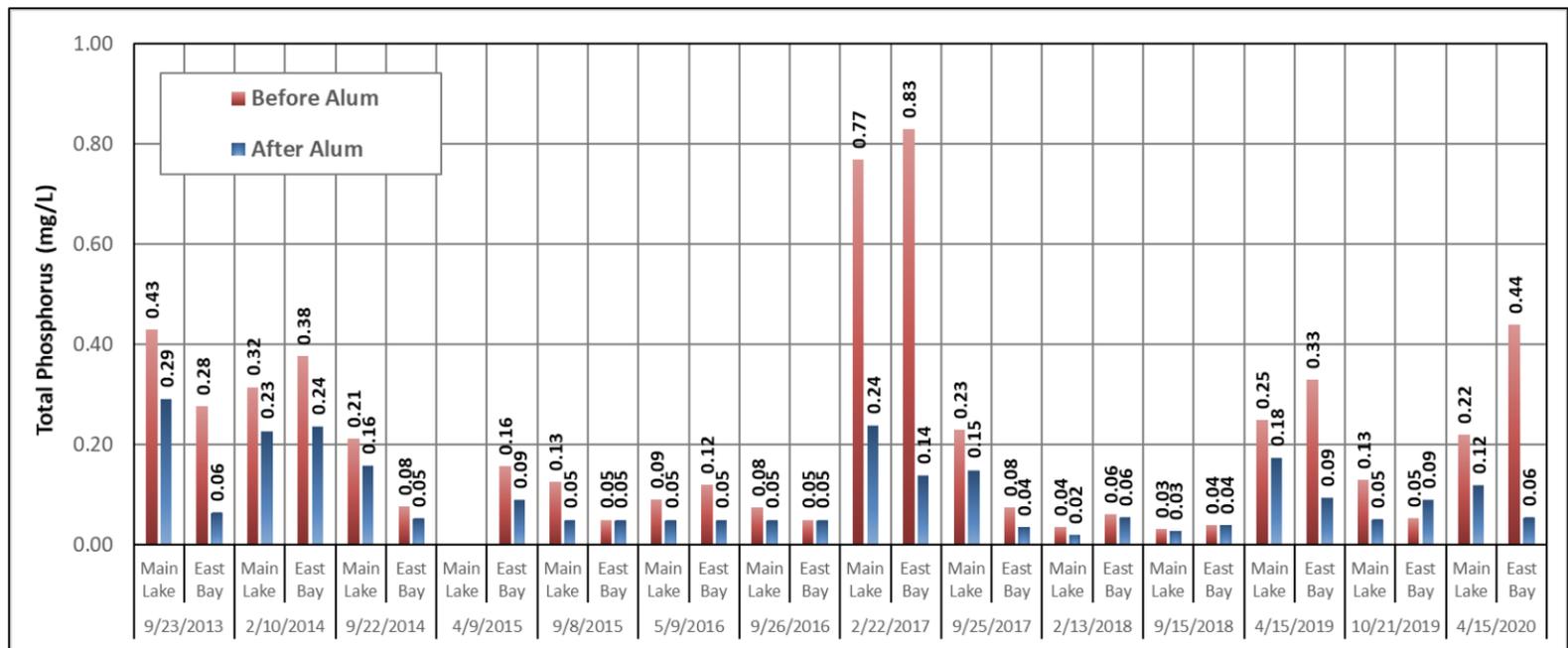


Figure 1. Depth-Integrated Total Phosphorus Concentrations in Canyon Lake Before and After Alum Applications

Guidance for Upcoming Annual Alum Additions

The alum addition program is designed to offset all excess TP load (increment of measured lake inflow load above TMDL allocations from watershed) from the San Jacinto River watershed to Canyon Lake. The LECL TMDL Task Force decided to implement the alum addition program collectively, which allowed for the use of mass emission monitoring at the lake inflows to demonstrate that excess loading over 2011-2020 has been effectively offset by in-lake TP reductions achieved with alum additions (see Table 3-1 of the 2020 Compliance Assessment). The alum dose and application frequency prescribed in the CNRP and AgNMP were determined from applications of the Task Force's DYRESM-CAEDYM model, which projected chlorophyll-a concentrations below response targets (Anderson, 2012)¹. Accordingly, the alum addition program was strategically designed to involve two additions per year with distinct functions, as follows:

¹ Anderson, 2012. Predicted Water Quality in Canyon Lake with In-Lake Alum Treatment and Watershed BMPs, Technical Memorandum submitted September 18, 2012.

- **Spring alum addition** – The objective of the spring alum addition is to apply alum soon after the end of the wet season to strip recent influxes of bioavailable phosphorus from the water column prior to seasonal algal growth in early spring (typically occurring in February - April). The timing of future spring alum additions should be decided based on distinct conditions in early spring of each year. This is important to avoid an addition that is too early, having an increased risk for a late season storm to bring new watershed TP load to the lake after the alum is applied (ex. February 28, 2014 storm that followed alum application on Canyon Lake). Long-range weather forecasts should be consulted to help assess the likelihood of a late season storm. Conversely, an addition that occurs too late may not be effective in preventing the seasonal bloom when warmer temperatures and sunny days can cause earlier spring blooms, especially during extended droughts. A few other factors should also be considered; 1) addition of alum during an active bloom can cause a floating floc scum for a temporary period of time as a result of supersaturation dissolved oxygen at the water surface, 2) alum must be applied prior to Memorial Day weekend, 3) algal blooms are less likely to occur when the water is highly turbid, a condition that can persist following wetter years and allow for some delay in the spring application, and 4) the alum application contractor requires lead time to schedule material delivery and mobilize crews.
- **Fall alum addition** – The objective of the fall alum addition is to remove TP released from the lake bottom sediment over the course of the dry season that is generally held within the hypolimnion prior to the period of vertical thermal destratification (typically occurring in October - November), thereby preventing an influx of bioavailable phosphorus into the photic zone and the associated seasonal algal bloom. The fall application can occur anytime after Labor Day weekend and generally should fall between September 15 – October 15. Years with cooler temperatures in September may begin thermal destratification earlier, thus alum additions should be scheduled as early as possible. Conversely, an alum addition later in the fall may be more effective because of better floc formation associated with lower pH levels relative to summer conditions.

Certain water quality conditions limit the effectiveness of TP removal with alum additions in Canyon Lake when implemented as prescribed in the CNRP and AgNMP, including 1) applications when water column average TP is less than 0.1 mg/L in the pre-event sample and 2) applications within East Bay in the fall season. Since 2013, less than five percent of the total water column TP removal comes from alum applications under such conditions. Thus, a simple method was developed to support the LECL TMDL Task Force on decisions about whether to conduct each seasonal alum application in the future (Figure 2). By following this approach, the stakeholders will focus implementation actions to maximize cost effectiveness without impacting the ability to meet long-term TMDL load reduction requirements based on 10-year average excess loading to Canyon Lake.

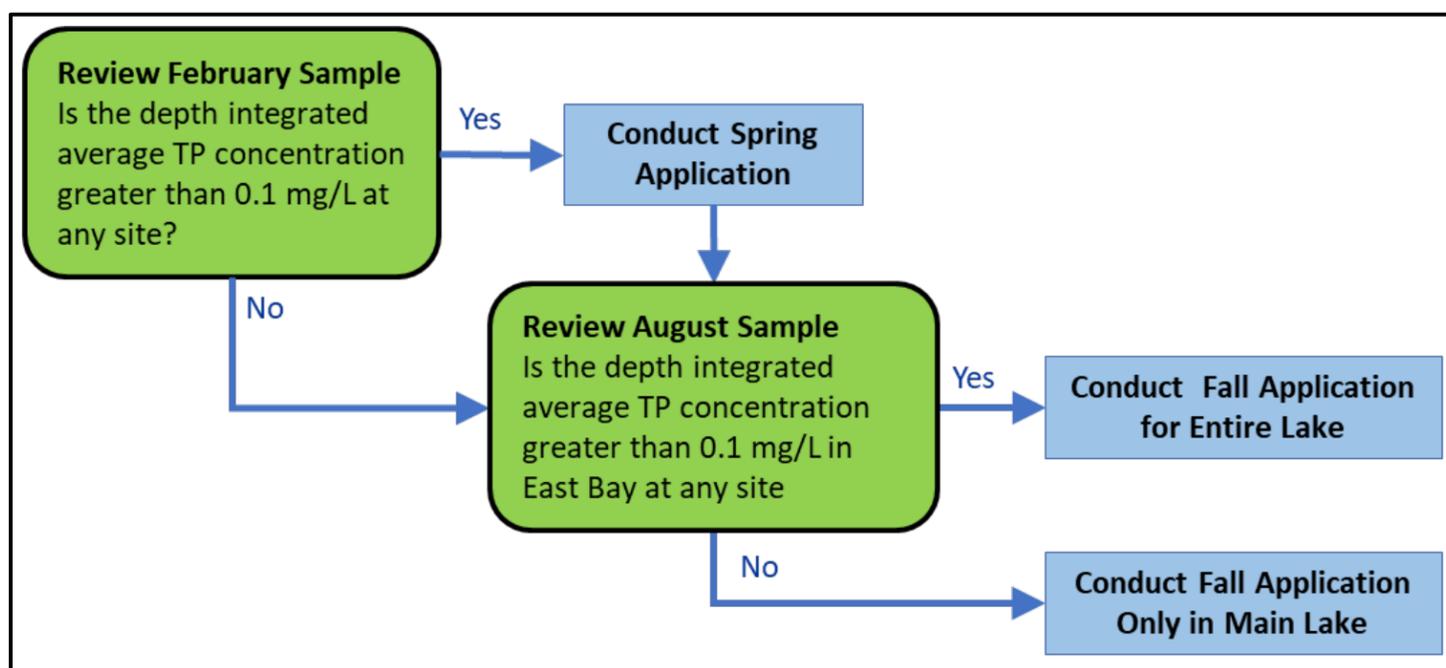


Figure 2. Decision Tree to Support Future Alum Addition Program Implementation in Canyon Lake