Ferric Chloride Water Treatment Facility
2019 Annual Report

NPDES/SDS Permit No: MN0067377

Mailed to:
Submittals Center
Minnesota Pollution Control Agency
520 Lafayette Road North
Saint Paul, MN 55155

January 2020

PRIOR LAKE
SPRING LAKE
WATERSHED DISTRICT

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Background

Spring Lake is a recreational lake located in central Scott County, Minnesota. The lake is listed on the State Impaired Waters List as impaired for aquatic recreation due to excess nutrients. Monitoring completed by the Prior Lake-Spring Lake Watershed District (PLSLWD) in the 1990's identified phosphorus as the nutrient most contributing to water quality impairment and algae blooms. That study also noted that a significant portion of the phosphorus entering Spring Lake was in the form of dissolved phosphorus (soluble reactive phosphorus, or SRP) thus making it readily available for algal uptake. Spring Lake flows directly into Upper Prior Lake, which is also listed as impaired due to excess nutrients.

The treatment system involves the injection of 32.5% liquid $FeCl_3$ solution into a stormwater pond, or desiltation basin. The iron within the $FeCl_3$ binds with the dissolved phosphorus in the water and creates colloidal particles (floc) which settle at the bottom of the basin. The treated water then flows downstream into Spring Lake.

Figure 1. Ferric Chloride Shed and Weir

In 1998, the PLSLWD constructed the ferric chloride ($FeCl_3$) treatment system to precipitate SRP out of stormwater from County Ditch 13, the main inflow to Spring Lake. The system was constructed as part of a Minnesota Pollution Control Agency (MPCA) Clean Water Partnership Implementation Project. The treatment system began operating under a permit from the Department of Natural Resources. In 2004, the treatment system permit was renewed as a National Pollutant Discharge Elimination System permit administered by the MPCA. The District applied to the MPCA for a renewed permit in 2009. That permit was approved in 2012. However, the system did not operate in 2011 or 2012 because it no longer met the requirements of the permit. During this time, the District was working toward a design that would meet requirements of the new MPCA permit. The old system injected $FeCl_3$ directly into the channel immediately downstream of the Ferric Chloride weir on the south side of Highway 13 where it would mix until reaching the desiltation pond.

In July 2013, the treatment facility began operating again after it was retrofitted to meet new MPCA permit requirements. The new design transfers $FeCl_3$ underground for 900 feet from the treatment building through a double walled pipe to a culvert north of Highway 13 that flows directly into the desiltation basin. The new design addresses the previous concerns of the MPCA by avoiding direct discharge into a water of the state, and instead, goes directly into a stormwater pond.

Figure 2. Bypass Weir

The retrofit project was designed by consultants Bolton and Menk, Inc. and installed by S.M. Hentges & Sons, Inc. The new design allowed for more water to be treated as compared to the old system. With the old system, high flows could resuspend phosphorus-iron flocculants within the basin and flush the flocculent downstream and into Spring Lake. The new system was designed to overtop a bypass weir (and flow around the desiltation basin) before the flows reached a point of resuspension in the pond. This allows for the maximum amount of phosphorus to be treated without resuspending the material in the desiltation basin. Staff reviewed the project design and confirmed it was operating as designed.

Figure 3. Aerial Map of Ferric Chloride Treatment System

Operations and Maintenance

Access is needed to the Desilt pond outlet and injection site. A grass path to the outlet of the Desilt pond was regularly mowed by the homeowner, Gary Stevens. When the water level of the outlet was low enough, he voluntarily drove his lawnmower across the outlet and mowed a path from the outlet of the Desilt pond to the injection site at the berm. When water conditions were too high, staff weed whipped a path to the injection site.

Figure 4. Weed Whipped Path from Desilt Pond Outlet to Injection Site

The Scott County Highway Department cleared brush and mowed the edges of the driveway to the Ferric Chloride shed. Mowing and clearing is necessary for the Ferric Chloride delivery truck to have a clear path to the shed and to reduce encroachment on the driveway.

City of Prior Lake staff (Public Works Water Department) helps PLSLWD staff maintain the pump, hoses, and injection site every year. Each spring, City staff inspects the pump and hoses, replaces old and worn parts, re-installs the injector, starts the pump, and ensures proper pumping. In fall, the City staff winterizes the facility by purging the ferric line to prevent freezing and removes, cleans, and stores the injector in a City facility over-winter.

Other routine maintenance by PLSLWD staff included cleaning the staff gauge, removing debris from the Ferric Chloride and bypass weir, installing snowmobile signs, downloading and calibrating the ultrasonic distance sensor, inspecting the facility 3 times per week, taking flow measurements and weekly samples, and cleaning in and around the shed.

Prior to September 11, 2018 the pump was manually programmed to dose between a half and four gallons per hour of ferric chloride depending on the stream level, or anticipated stream level. The problem with this method was that if it rained unexpectedly on Friday night, staff couldn't adjust the dosing until Monday, missing an opportunity to increase the dosing and possibly not remove as much phosphorus. In contrast, staff may have anticipated a rain event over the weekend and increased the dose, but less rain fell than was predicted, wasting the ferric chloride by dosing over the recommended amount. On September 11, the pump was programmed to dose ferric chloride automatically, based on a relationship with stream height. The maximum dose rate of treatment is 4 gallons per hour at 0.50 feet of depth over the ferric chloride weir. Over 0.50 feet of depth, the pump will continue dosing at 4 gallons per hour based on maximum flow calculations of the desilt pond diversion culvert.

Operations and Maintenance items that were done in 2019, in addition to the above-mentioned routine items:

- A tree that fell across path to desilt pond was cut down and removed by PLSLWD staff and interns
- Scott County removed a tree that was stuck on the weir and mowed/trimmed the driveway to the ferric shed

- Interior of ferric shed was cleaned, and light bulbs changed
- Pump head failed and was replaced
- A new Ferric Chloride manufacturer company (Hydrite) was chosen due to spill in 2018 and poor overall communications
- 2 electrofishing events at the Geis Wetland along with a small number of carp removed
- A district tour included a stop at the Ferric Chloride Treatment System
- A YouTube video was created by the Spring Lake Association highlighting the Ferric Chloride Treatment System https://www.youtube.com/watch?v=Nr7kr-CE8vQ&feature=youtu.be
- A new eye-wash station was installed in the shed
- A new driveway design was analyzed to be less intrusive on the Geis's lawn which may be constructed in 2020
- A "pit tag station" was installed above and below weir to monitor if the carp are getting into the Geis wetland
- The design for the new weir has been completed and will be installed in 2020
- DO measurements were taken in winter to check capacity for fish to survive in the wetland for carp/fish study
- The drawdown gate was opened and closed a couple times to accommodate construction of the Highway 13 culvert. During times the drawdown gate was open, the pump was placed on manual mode and operated at high dosing rates to account for influx or water moving through the system not registered on the ultrasonic

Figure 5. Ferric Chloride Delivery Truck

Ferric Usage

The tank contained 1,385 gallons at the beginning of the season and 1,955 gallons were left in the tank at the end of the season. Two shipments of Ferric Chloride occurred in 2019 - 3,450 gallons on April 26 and 3000 gallons on August 15. A total of 5,880 gallons of Ferric Chloride treated the stream before it reached Spring Lake as shown in Table 1.

Table 1. Ferric Usage (usage wasn't tracked prior to 2014)

Year	Starting Ferric (gal)	Delivered Ferric (gal)	Ending Ferric (gal)	Total Ferric Used (gal)
2019	1385	6450	1955	5880
2018	3700	3500	1350	5850
2017	1970	8800	3500	7270
2016	2680	6000	1950	6730
2015	2925	3000	1445	4480
2014	N/A	10200	2925	>7275

Future Maintenance

Carp have been observed in the wetland adjacent to the Ferric Chloride shed (Highway 13 Wetland) and the water has become noticeably more turbid in the past few years (visually and in the data). The turbid water could be a sign of carp infestation which could have been caused by missing tines in the fish barrier on the weir. In 2018, WSB Consulting estimated 1,452±615 carp are living in the pond, equating to a biomass of 198±61 pounds per acre. Because the current fish barrier is missing tines and inoperable, an engineer at WSB Consulting designed a new concept for the fish barrier. This will be constructed in 2020.

The Ferric Chloride weir is also showing signs of age. Repair is anticipated to take place at the same time as the fish barrier is constructed and will address the cracks, loose boards, and unstable railings.

The ferric chloride tank is now 21 years old and needs to be replaced. Staff will research options for removing and replacing the tank. A considerable complication regarding the facility is that the shed was not designed for the tank to be removed, so the shed will need to be at least partially dismantled. The tank is anticipated to be replaced in 2021 when funds are available.

The driveway to the shed continues to be an issue when ferric is delivered. Staff has begun to discuss design options that could reduce the damage done to the Geis's lawn and provide easier access for the delivery driver. Modifications could take place in 2021, or when funds become available.

Figure 6. Ferric Chloride Weir and Fish Barrier

Desilt Pond

The desilt pond needs to be cleaned out (dredged) when the pond starts filling up with sediment. The last time the pond was dredged was 2012 and that was dredged down to 902 feet in mean sea level. As storage volume is reduced, the detention time for settling and pollutant removal efficiency is reduced. Once the pond bottom nears 908', the pond should be dredged again.

In 2019, staff mapped the bathymetry of the pond using a kayak that has the BioBase unit attached to it. The pond was found to be about 7-8 feet deep (bottom elevation of 903.5") in the middle and as a result, is likely several years away from needing to be dredged. The bathymetry map is shown below.

Some historic pond dredging and survey information is summarized here:

1978: Desilt pond constructed with a bottom elevation of 902.5', and an outlet elevation of 910.3'
1998: Desilt pond bottom surveyed at 907.8'
1999: Pond was dredged to an elevation of 902.5'
2005: Pond bottom surveyed at 904.5'
2010: Pond bottom surveyed at 906.5'
2012: Pond was dredged to 902.0' (as-built survey available)
2016: Pond mapped by Platypus and estimated to be 903.5' using BioBase software
2019: Pond mapped twice with new BioBase kayak setup. It was mapped in July and October (before and after Highway 13 culvert replacement) to see if the desilt pond would fill in with sediment after construction. BioBase shows it is still about the same as 2016 – 903.5'.

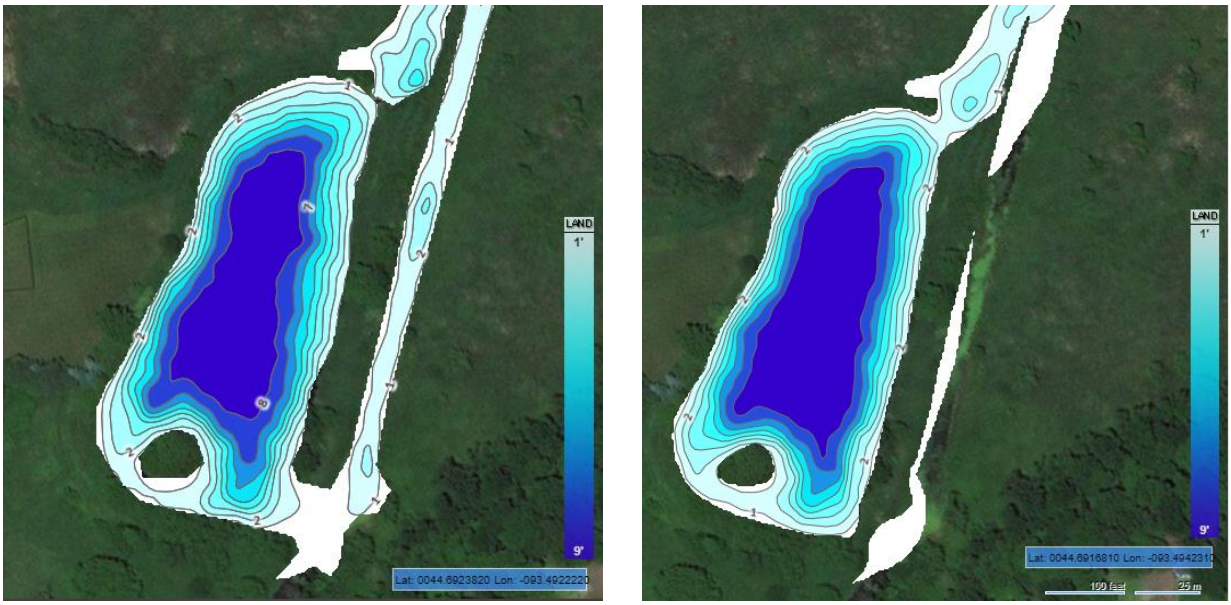

Figure7. - Bathymetry map of Desilt Pond on 7/26/19 (left) before Highway 13 culvert construction started. Bottom of pond was 903.5'. Bathymetry map of Desilt Pond on 10/24/19 (right) after Highway 13 culvert was replaced and the bottom still mapped out at about 903.5'.

Results

Table 2 shows that during 2019 operations, the system treated approximately 1,981 million gallons (MG) of ditch water. The system reduced the average concentration of Total Phosphorus (TP) by 19% and removed a calculated 466 pounds of total phosphorus. As seen in Table 3, the concentration of dissolved phosphorus (also referred to as SRP or Soluble Reactive Phosphorus) was reduced by an average of 43% and approximately 594 pounds of SRP were removed from the system. The breakdown of monthly average nutrient concentrations and loads are listed in Table 4.

Table 22. Summary of Phosphorus removals since 2011

Year	Lbs P Removed	Lbs SRP Removed	% TP Reduction	% SRP Reduction	MG of Water Treated	Notes
2011	N/A	N/A	14% treated; 1% no treatment	54% treated, 5% no treatment	N/A	30 days total treatment
2012	N/A	N/A	12% (no treatment)	7% (no treatment)	N/A	No Treatment this year
2013	449	323	47% (while treating)	56% (while treating)	635	Treated 2 months
2014	550	752	43%	72%	959	Treated 4/1- 10/31
2015	402	103	48%	51%	348	Treated 4/1- 10/31
2016	578	323	36%	64%	1327	Treated 3/11-11/10
2017	534	240	35%	58%	938	Treated 3/5 – 11/30
2018	465	616	31%	58%	1614	Treated 4/1-11/20
2019	466	594	19%	43%	1981	Treated 4/1-11/12

Table 3. – Phosphorus Concentrations and Percent Removal (Negative values indicate a reduction)

	Before Treatment (SW001) Monthly Mean		After Treatment (SD002) Monthly Mean		% Change after Treatment	
Month	Total Phosphorous (mg/l)	SRP (mg/l)	Total Phosphorous (mg/l)	SRP (mg/l)	Total Phosphorous (mg/l)	SRP (mg/l)
April	0.181	0.069	0.17	0.062	-5%	-10%
May	0.129	0.057	0.118	0.022	-9%	-61%
June	0.207	0.08	0.143	0.028	-31%	-65%
July	0.268	0.138	0.236	0.081	-12%	-41%
August	0.298	0.123	0.220	0.073	-26%	-41%
September	0.21	0.105	0.15	0.06	-27%	-39%
October	0.129	0.08	0.113	0.046	-12%	-43%
November	0.069	0.035	0.049	0.019	-29%	-46%
AVERAGE	**0.186**	**0.086**	**0.151**	**0.049**	**-19%**	**-43%**

Table 3. Monthly and Annual Load Reductions

		SW-001	SD-002
April	Average SRP (mg/L)	0.069	0.062
	Average TP (mg/L)	0.181	0.17
	Treated Water (MG)		358.0
	SRP Load Reduction (pounds)		20.9
	TP Load Reduction (pounds)		26.9
May	Average SRP (mg/L)	0.057	0.022
	Average TP (mg/L)	0.129	0.118
	Treated Water (MG)		419.0
	SRP Load Reduction (pounds)		122.3
	TP Load Reduction (pounds)		38.4
June	Average SRP (mg/L)	0.08	0.028
	Average TP (mg/L)	0.207	0.143
	Treated Water (MG)		152.0
	SRP Load Reduction (pounds)		65.9
	TP Load Reduction (pounds)		81.1
July	Average SRP (mg/L)	0.138	0.081
	Average TP (mg/L)	0.268	0.236
	Treated Water (MG)		340.0
	SRP Load Reduction (pounds)		161.6
	TP Load Reduction (pounds)		90.7
August	Average SRP (mg/L)	0.123	0.073
	Average TP (mg/L)	0.298	0.220
	Treated Water (MG)		106.0
	SRP Load Reduction (pounds)		44.2
	TP Load Reduction (pounds)		69.0
September	Average SRP (mg/L)	0.105	0.06
	Average TP (mg/L)	0.21	0.15
	Treated Water (MG)		227.0
	SRP Load Reduction (pounds)		77.6
	TP Load Reduction (pounds)		107.9
October	Average SRP (mg/L)	0.08	0.046
	Average TP (mg/L)	0.129	0.113
	Treated Water (MG)		340.0
	SRP Load Reduction (pounds)		96.4
	TP Load Reduction (pounds)		45.4
November	Average SRP (mg/L)	0.035	0.019
	Average TP (mg/L)	0.069	0.049
	Treated Water (MG)		39.0
	SRP Load Reduction (pounds)		5.2
	TP Load Reduction (pounds)		6.5
Total	Total Treated Water (MG)		1981
	Total SRP Load Reduction (pounds)		594
	Total TP Load Reduction (pounds)		466

Graphs

The following graphs display the monthly mean of samples analyzed in 2019, before treatment at site SW-001 (FC_CD2) and after treatment, at SD-002 (FC_CD3). These are required to be reported by the permit. Treatment began on April 1 and treated continuously until November 12. During that time, water quality sampling and monitoring was conducted once per week.

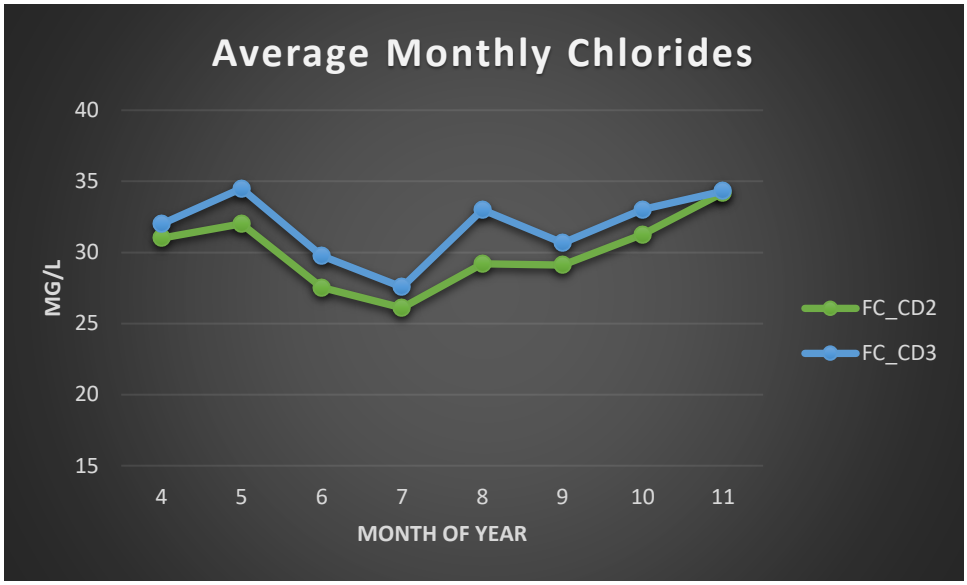

Figure 6 Chloride from de-icing salt, water softening, dust suppressant, fertilizer, and manure gets into lakes and streams. The state water quality standard for chlorides is 230 mg/l, which these sites are well below.

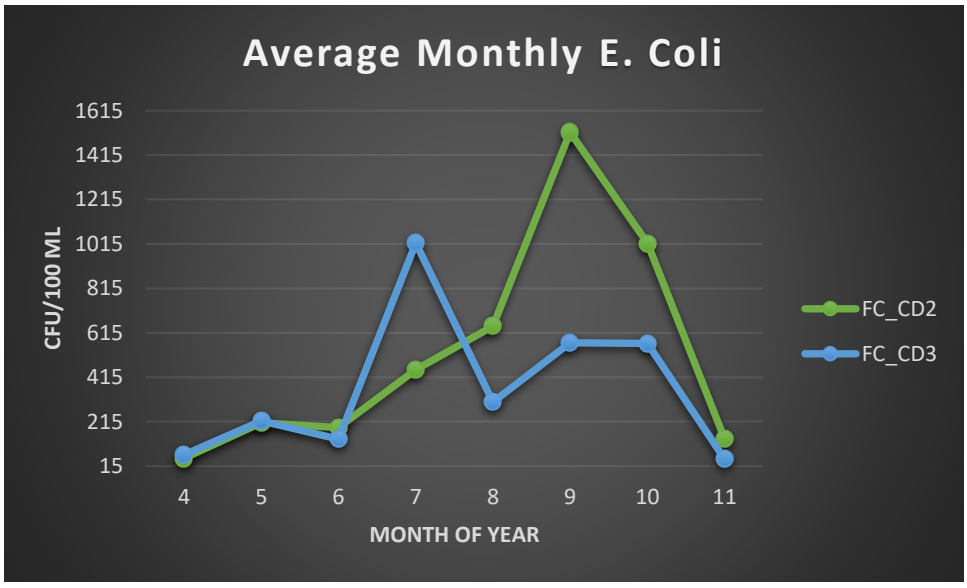

Figure 7 Bacteria in Minnesota lakes and streams mainly come from sources such as failing septic systems, wastewater treatment plant releases, livestock, and urban stormwater. A monthly geometric mean greater than 126 colony-forming units per 100 milliliters of water, between April and October, suggests that the stream is not meeting the standard.

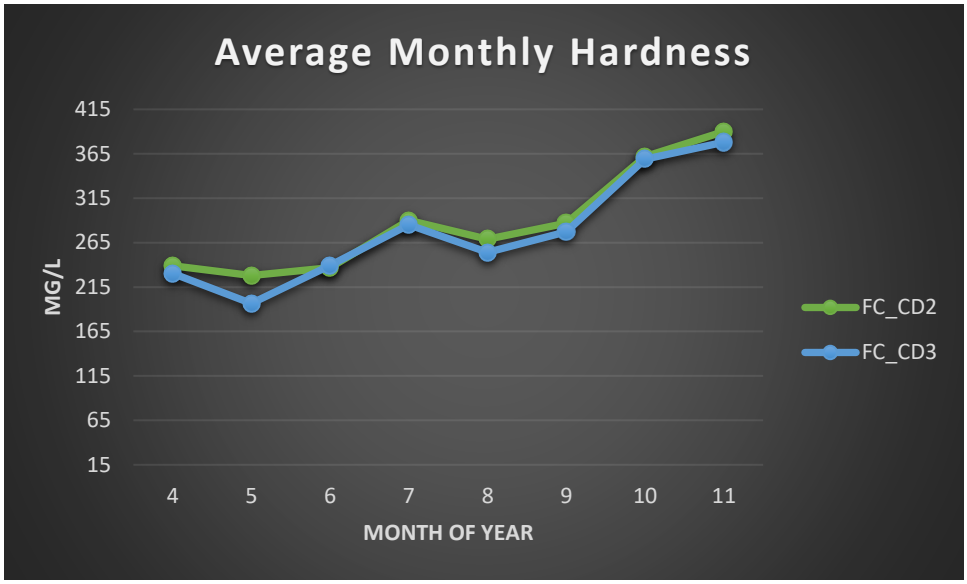

Figure 8 Hardness does not have a standard itself but is used in calculations to analyze the water quality of other standards. Waters with a total hardness in the range of 0 to 60 mg/L are termed soft; from 60 to 120 mg/L moderately hard; from 120 to 180 mg/L hard; and above 180 mg/L very hard.

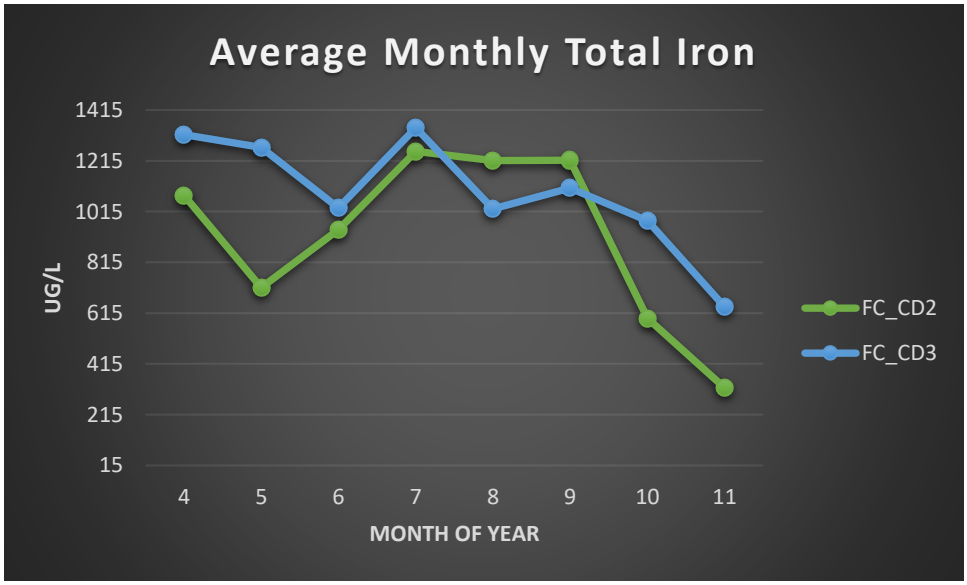

Figure 9 Average Monthly Total Iron

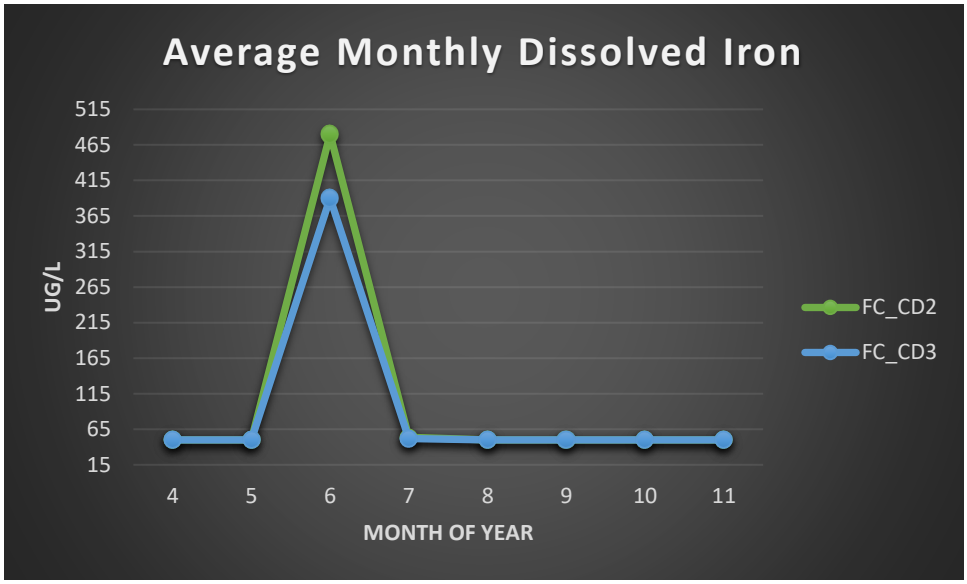

Figure 10 Average Monthly Dissolved Iron. The minimum detectable value was 0.5 ug/l.

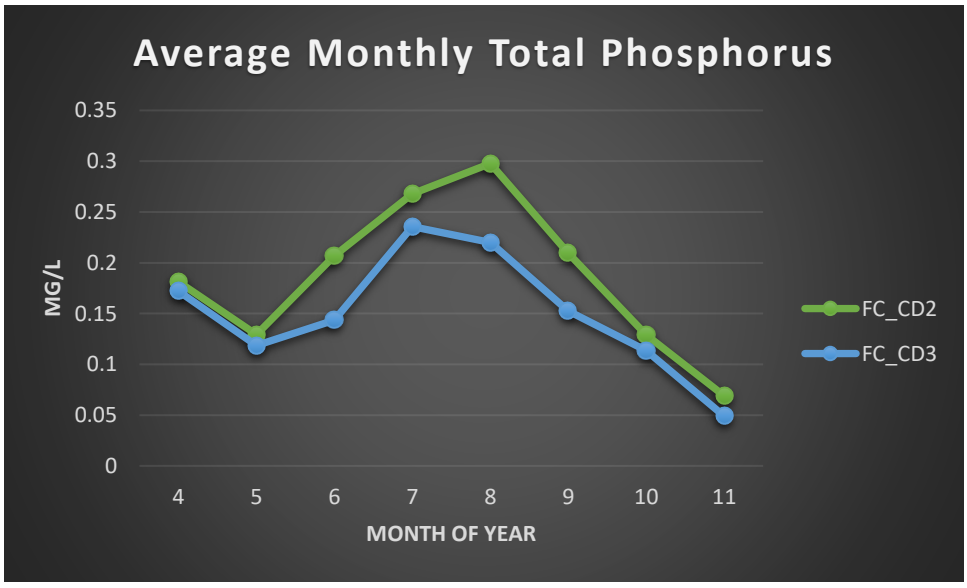

Figure 11 EPA recommends less than 0.1 mg/l.

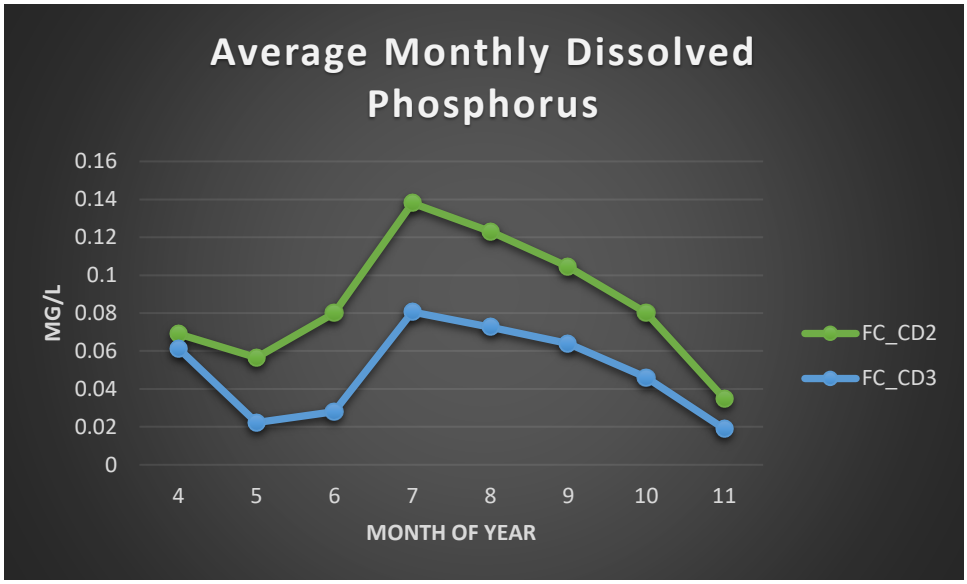

Figure 12 Average Monthly Dissolved Phosphorus.

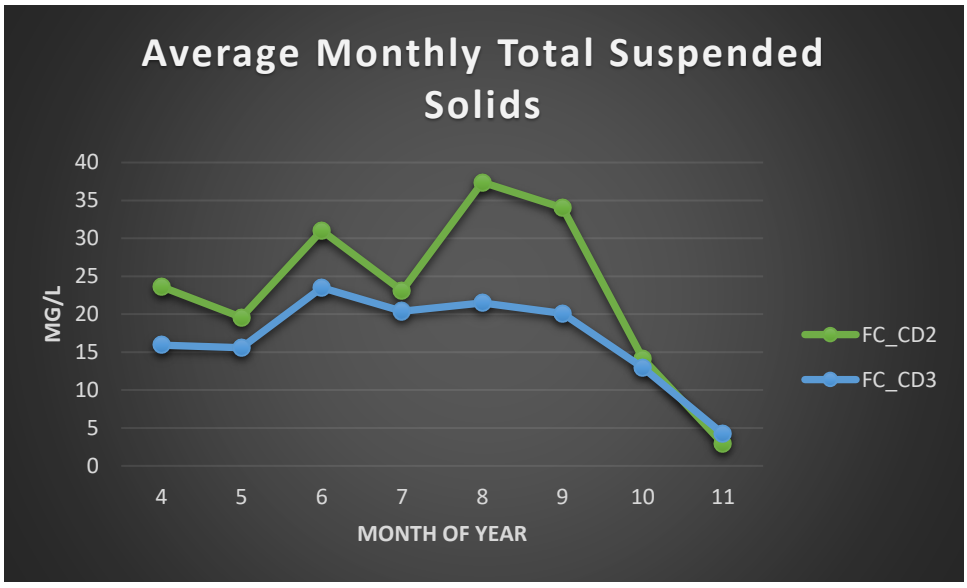

Figure 13 TSS standard for Southern River Nutrient Region is 65 mg/l.

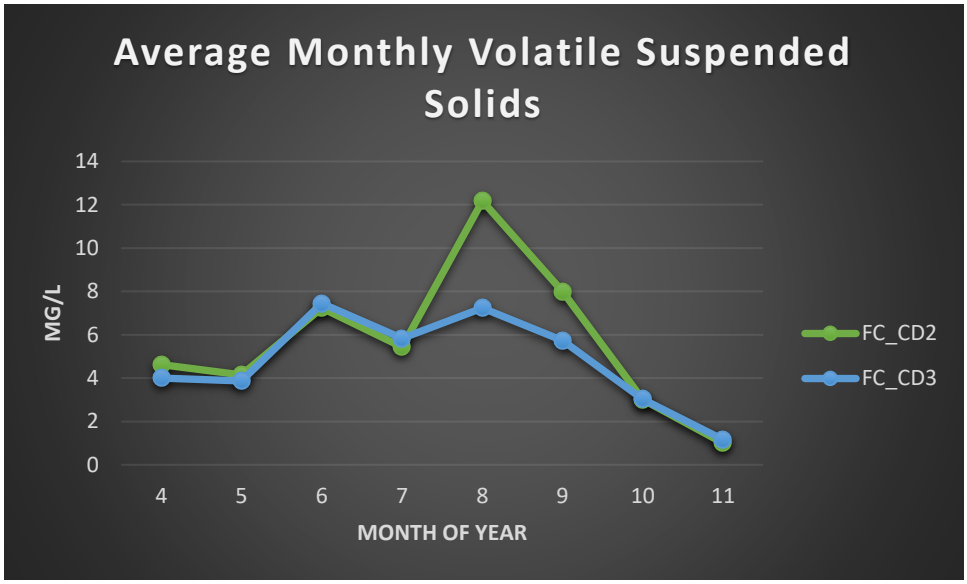

Figure 14 Average Monthly Volatile Suspended Solids

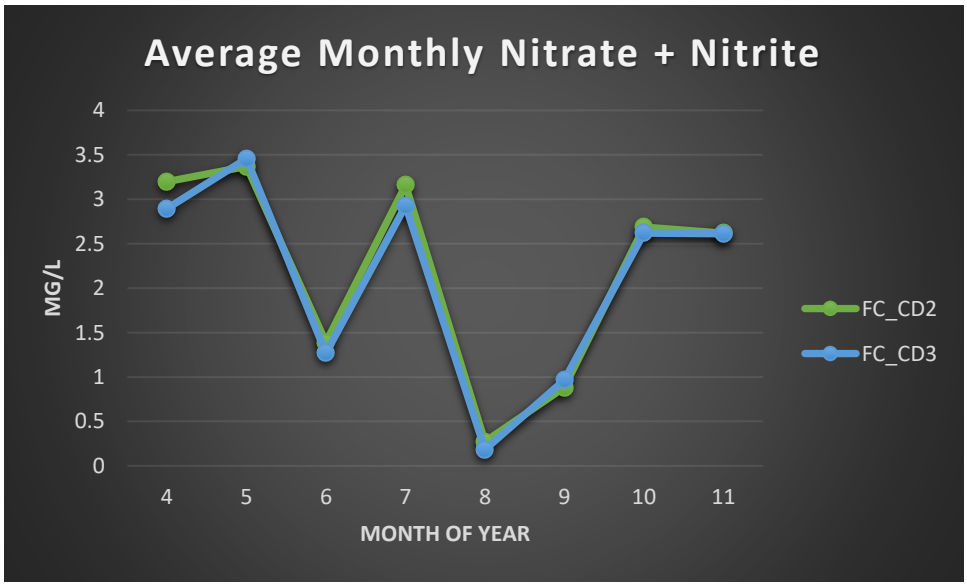

Figure 15 Average Monthly Nitrate + Nitrite

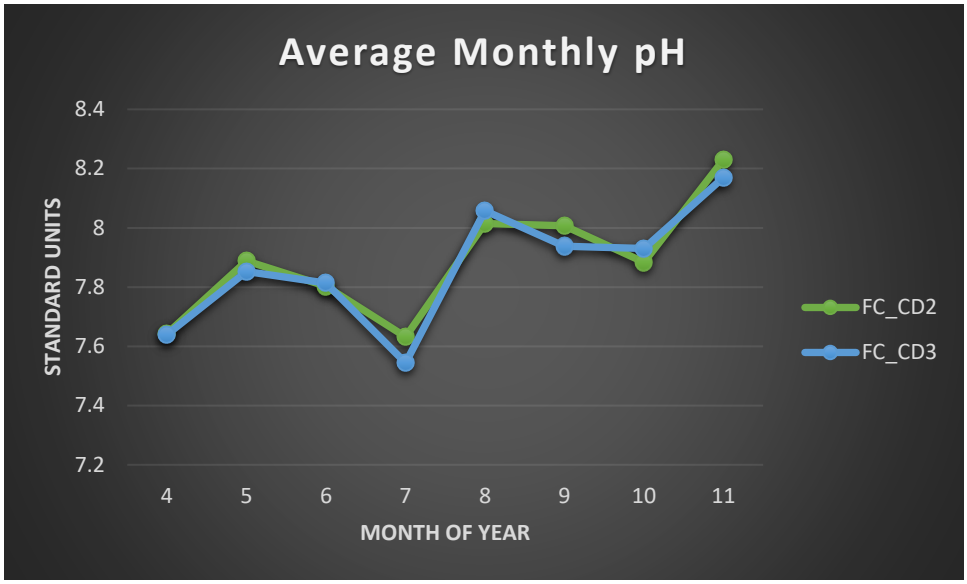

Figure 16 The pH water quality standard is a minimum of 6.5 and max of 8.5.