FRIENDS OF
CORTE MADERA CREEK
WATERSHED

2017 and 2018 Water Quality Report

Corte Madera Creek Watershed

Prepared by
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April 22, 2019

Thanks to the Marin County Fish & Wildlife Commission for funding the purchase of most of our loggers. Thanks also to Parker Pringle and Andrew Bartshire for installing the loggers and visiting them throughout the summer.

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1: Background

The purpose of the monitoring is to characterize the temperature regimes and document dissolved oxygen (DO) at various locations in creeks in the Corte Madera Creek watershed. We have installed loggers in Ross Creek each year beginning in 2008. In 2009 we added loggers in Bill Williams Creek and Phoenix Creek, tributaries to Phoenix Lake. In 2012, we added loggers in Corte Madera Creek, San Anselmo Creek, Fairfax Creek, and Sleepy Hollow Creek. Typically, the loggers are installed in March or April and removed when the site dries or when winter rains start. Since 2016 we have not had loggers in Phoenix Lake or its tributaries. We removed the loggers near the mouth of Ross Creek because Corte Madera Creek at the mouth of Ross Creek is infested with New Zealand mud snails; they are easily carried on boots and equipment and we did not want to spread the infestation into the upstream reaches of Ross Creek.

2: Water Temperature and Dissolved Oxygen in Salmonid Habitat

Temperature is one of the most important environmental influences on salmonid biology. Water temperature determines the metabolism of steelhead and salmon. Temperature influences the availability of food, as well as growth and feeding rates; metabolism; development of embryos and alevins; and timing of life history events such as upstream migration, spawning, freshwater rearing, and seaward migration. Elevated temperatures can cause stress and lethality. Temperatures at sub-lethal levels can effectively block migration, lead to reduced growth, stress fish, affect reproduction, inhibit smoltification, create disease problems, and alter competitive dominance. Further, the impact of elevated water temperature on salmonids is cumulative and positively correlated to duration and severity of exposure. The longer the salmonid is exposed to thermal stress, the less chance it has for long-term survival.
Table 1 and Table 2 provide the temperature requirements for different life stages of steelhead trout and when those life stages are likely to occur.

Table 1: Some habitat requirements for steelhead trout

Life Stage	**Optimal Water Temperatures**	**Dissolved Oxygen (mg/l)**
Immigration, Spawning, Incubation	7.8 - 11.2 °C	≥7 at ≤15°C ≥9 at >15°C
Fry Emergence	8.9 - 11.2 °C	
Rearing	12.8 – 15.6 °C	
Smoltification, Emigration	7.0 - 11.3 °C	

Source: A.A. Rich and Associates 2000

Table 2: Steelhead trout life stage periodicities in the Corte Madera Creek Watershed

Life Stage	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Adult Immigration												
Spawning												
Egg/Alevin Incubation												
Fry Emergence												
Fry/Juvenile Rearing												
Smoltification, Emigration												

Range of Periodicity
Peak Periodicity

Source: A.A. Rich and Associates 2000

3: Equipment

We use Onset Computer's HOBO Water Temp Pro v2 loggers (Figure 1[1]). They are downloaded in the field using a waterproof data shuttle (base station) to collect the data and launch the logger. In the office, we connect the shuttle to a computer and transfer the data. During each visit when loggers are installed, downloaded, or removed, we measure temperature and DO using a YSI Pro20 instrument.

4: Logger Installation

Figure 2 shows the locations of loggers in Ross Creek. Table 3 lists locations of loggers and Table 4 and Table 5 provide the dates they were deployed in 2017 and 2018, respectively. Figure 3 shows the logger locations further upstream in the watershed. Loggers FX01 and SA01 were moved in spring 2018 because the sites used in earlier years were inaccessible or too shallow for loggers; however, at the scale of the map in Figure 3, the locations are not obviously different.

[1] All figures follow the text.

Table 3: Logger locations, shown on Figure 2 and Figure 3

Location	Creek	Latitude Longitude	Years in Place	Notes
Near Vault	Ross	37.955889 -122.575074	2008-2018	Located on right bank near base of vault.
RC0.5	Ross	37.955862 -122.574989	2008-2018	Located on right bank a short distance downstream of vault
RC1.5	Ross	37.959370 -122.572398	2013-2018	On right bank under large root wad.
RC2	Ross	37.960875 -122.571561	2008-2018	Just upstream of first house along Ross Creek on right bank.
RC3	Ross	37.964685 -122.564746	2008-2018	End of Southwood, adjacent to Branson Field on left bank
FC10	Fairfax	37.996175 -122.599255	2012-2018	Downstream of 300 Olema Road, left bank
FC20	Fairfax	37.98758 -122.592675	2012-2017	Behind Fairfax Lumber, left bank
FC20	Fairfax	37.98729 -122.592206	2018	Just downstream of Merwin Avenue, left bank
SA10	San Anselmo	37.983665 -122.589934	2012-2017	Downstream of confluence with Deer Park Creek, right bank
SA10	San Anselmo	37.983738 -122.589832	2018	Downstream of Creek Bridge, left bank
SA 20 (Lansdale)	San Anselmo	37.982329 -122.576429	2012-2018	Downstream of fishway, left bank
SH10	Sleepy Hollow	38.008964 -122.583877	2012-2018	17 Katrina Lane, left bank
SH20 Firehouse	Sleepy Hollow	37.991839 -122.576247	2012-2018	Firehouse 20, left bank

Table 4: Deployment of loggers in 2017

Location	Logger ID	Installed	Removed	Notes
Near Vault	10094558	5/5/17 16:27	11/19/17 13:46	
RC0.5	20090355	5/5/17 17:12	11/19/17 13:43	
RC1.5	10094561	5/5/17 16:03	11/19/17 14:13	
RC2	20090357	5/5/17 15:20	11/19/17 13:30	
RC3	10094554	5/5/17 18:02	8/18/17	Missing
FX10	20090354	5/7/17 11:28	11/19/17 12:11	
FX20	20090356	5/27/17 14:05	11/19/17 12:21	
SA10	1292334	5/27/17 14:05	11/19/17 12:30	
SA20 (Lansdale)	20090353	5/7/17 11:10	11/19/17 11:58	
SH10	10094560	5/7/17 10:30	9/30/17 10:00	
SH20	10094559	5/7/17 10:55	9/30/17 10:50	

Table 5: Deployment of loggers in 2018

Location	Logger ID	Installed	Removed	Notes
Near Vault	20090356	3/30/18 16:14	10/19/18 14:45	
RC0.5	20090354	3/30/18 16:25	10/19/18 14:57	
RC1.5	20090355	3/30/18 16:49	10/19/18 15:11	
RC2	10094559	3/30/18 17:18	10/19/18 15:20	
RC3	10094557	3/30/18 17:55	6/29/18 15:32	
FX10	20312880	5/4/18 16:34	11/17/18 16:34	
FX20	20090357	5/4/18 16:15	11/17/18 16:15	
SA10	20312690	5/4/18 17:00	9/8/18	Missing during 9/8/18 visit
SA20	20090353	5/4/18 14:51	11/17/18 17:28	
SH10	20312891	5/4/18 17:02	11/17/18 17:02	
SH20	20312881	5/4/18 15:55	9/7/18 13:26	

The temperature loggers are designed for long-term deployment and are relatively robust. Each logger is attached to a stainless-steel cable with a shackle; the cable is fastened to a rock or tree root. We are careful to hide the cable and logger, but they are not completely invisible. These loggers are vulnerable to damage from rocks in the water or curious passers-by. To provide some protection, we place the loggers in protective plastic covers (boots). Unfortunately, areas where people have easy access to the creek have proved problematical. Three loggers have been stolen and some loggers have been removed from the water. It is easy to detect when a logger has been removed from the water, as it continues to record, and air temperatures are more extreme than water temperature.

We attempt to locate sites with relatively deep, moving water; the deepest pools are not selected, because we want to measure the temperature of water moving in the creek, not standing in pools. Unfortunately, it is inevitable that as water levels drop, some loggers are in stratified pools with little or no current.

5: Data Gathering and Analysis

Before each logger is downloaded, the YSI unit is used to measure and record temperature and DO. The YSI unit is accurate for DO only in moving water. Where the water is still, the sensor must be kept moving so that the oxygen immediately adjacent to the sensor is not depleted before the reading stabilizes. This works only moderately well later in the summer when water levels are low and some of the pools have stratified. Readings for both temperature and DO vary significantly within one pool when the water is mixed by the moving probe.

Loggers were set to record data points every 15 minutes. Loggers in creeks were downloaded periodically. During a download, each logger is connected to the data shuttle, which reads and then empties the logger memory.

Data gathering proceeded smoothly during 2017, but there were several problems in 2018. First, equipment failures included the malfunction of loggers at Lansdale (SA20) and at the Firehouse (SH20) when they were downloaded at installation. The data files from the initial download were unreadable and both the start time for logging and the logging intervals were changed at each download. In addition, Sandra Guldman failed to change the logging interval after calibration on two loggers installed in Ross Creek (RC1.5, RC2), so they recorded data every second and quickly filled the memory. The third problem was caused when Onset did not upgrade HOBOware for the iOS11 operating system. It was necessary to use an old computer to download the shuttle. In the process of changing software and moving data from one computer to another, all data from the Ross Creek loggers recorded between the download on 5/3/18 and the subsequent download on 6/29/18 were lost.

6: Water Temperature and Dissolved Oxygen

During 2017 and 2018, loggers were installed at five locations in Ross Creek. Time series of temperature and DO are in Figure 4 through Figure 12.

Two loggers were installed in Fairfax Creek, one (FC10) just downstream of 300 Olema Road; the second (FC20), behind Fairfax Lumber in 2017 and downstream of Merwin Avenue in 2018. The times series for 2017 and 2018 for those loggers and the YSI data are shown in Figure 13 through Figure 16. Two loggers were installed in San Anselmo Creek, one just near the confluence of Deer Park Creek and San Anselmo Creek (SA10) in 2017 and just downstream of the Creek Road Bridge in 2018 (stolen), and one just downstream of the Lansdale pool-and-drop structure (Lansdale, SA20). Time series for these loggers and YSI data are in Figure 17 through Figure 19. Two loggers were installed in Sleepy Hollow Creek, one behind 17 Katrina Lane (SH10) and one behind the fire station on Butterfield Road (SH20). Time series for these loggers are in Figure 20 through Figure 23.

7: Discussion

Ross Creek: Ross Creek is perennial within Natalie Coffin Greene Park, where no water is diverted from the creek. In residential areas below RC2, the creek typically dries early in the summer (see plots for RC3). Although we have no proof that groundwater pumping is the cause of this early drying, most parcels downstream of the park have wells and we suspect that pumping for irrigation of large gardens is lowering the groundwater and causing the creek to dry very early in the summer. Unless smolts move into the mainstem before lower Ross Creek is dry, they are not able to leave the creek.

The two upstream loggers (Figure 4 and Figure 5 [Near Vault] and Figure 6 and Figure 7 [RC0.5]) show the effect on Ross Creek of water flowing over the spillway at Phoenix Lake. Warm water flowing over the spillway in late spring, further warmed by the sun shining on the spillway, dominates flow in the upstream portion of Ross Creek; both temperature and DO are high. After the lake level drops and water stops flowing over the spillway, the water temperature and DO drop dramatically; at that point, Ross Creek flow is dominated by leakage from the low-level release valve and groundwater. This suggests that when water in upper Ross Creek becomes too warm for salmonids, releasing water from the low-level release valve until spillway flow ceases has the potential to benefit salmonids in Ross Creek, particularly if the water is aerated near the low-level release valve. The added flow might also encourage smolts to move downstream before lower Ross Creek dries.

Upper Ross Creek in Natalie Coffin Greene Park has great potential for improvement as salmonid habitat. The removal of two barriers to passage (Taylor 2006), enhancement of riparian vegetation, and addition of structure are recommended.

The next two downstream loggers (Figure 8 and Figure 9 [RC1.5] and Figure 10 and Figure 11 [RC2]) show strong diurnal variations in temperature, with typically high daytime and lower nighttime temperatures. This reach of the creek has some deep pools and structures that provide summer rearing habitat for salmonids. DO is relatively high.

Logger RC3 is located in the developed section of Ross Creek. There is abundant riparian vegetation and the water temperature is suitable for steelhead. However, most parcels have wells. There is no information about the amount of pumping, but it is reasonable to assume that significant water is withdrawn from the groundwater directly connected to Ross creek baseline flow for irrigation in this reach. Throughout the developed reach, which extends from Natalie Coffin Greene Park to its confluence with Corte Madera Creek, Ross Creek dries early in the year. The plot of temperatures in Figure 12 show that this occurred on 7/15/17, when the recorded temperatures began to reflect air temperature. IN most years, the creek at this location dries by mid-May.

Fairfax Creek: At both logger locations (FX10 [Figure 13 and Figure 14} and FX20 [Figure 15 and Figure 16]), temperatures tended to be high for salmonids. Fairfax Creek has a culvert at its mouth that is a total barrier to salmonid passage. The barrier also causes major flooding in downtown Fairfax; treating both problems was identified in the Capital Improvement Program for the Ross Valley Watershed Program. Because the culvert is on Town of Fairfax property, treating the undersized culvert will depend on the Town of Fairfax initiating major efforts to obtain funding. There is a second dam, just downstream of 300 Olema Road. If both barriers to salmonid passage could be treated, then it would be prudent to work on adding riparian vegetation and structure to improve salmonid habitat.

San Anselmo Creek: San Anselmo Creek is the longest named creek in the watershed, reaching from its confluence with Ross Creek upstream into the Cascade Canyon Open Space Preserve. Some sections, especially through downtown San Anselmo and the older neighborhoods with small lots, have considerable concrete rubble, hardened banks, and limited creek capacity. Although there is perennial flow in these areas, they are characterized by a lack of summer rearing habitat and the near absence of high-flow refugia. A section of high-quality spawning gravels upstream of its confluence with Fairfax Creek dries in the summer. AA Rich and Associates assessed habitat and measured temperature during 1999. The report (AAR 2000) states:

> For steelhead trout, thermal conditions in San Anselmo Creek: (1) were stressful to incubation and fry emergence, beginning in May; (2) depending upon the habitat type and location, there were a number of times when juvenile rearing conditions were stressful; and, (3) with regard to smolt emigration, thermally stressful conditions began in May. For rainbow trout, thermal conditions were generally acceptable, provided the fish could find thermal refuge areas during the hot summer months.

Logger SA10 (Figure 16), located upstream of the confluence with Fairfax Creek, typically records fairly warm temperatures, but nighttime cooling provided some respite and the DO levels were adequate. At Lansdale (Figure 17 and Figure 18) there are significant groundwater inputs, demonstrated during construction of the pool-and-drop structure during summer 2012, when water poured into the excavated work area and a major dewatering effort was needed to complete construction.

Salmonid habitat in San Anselmo Creek would benefit from more structure and riparian vegetation.

Sleepy Hollow Creek: Loggers in Sleepy Hollow Creek (SH10 [Figure 20 and Figure 21]) and SH20 at the Firehouse [Figure 22 and Figure 23]) show temperatures similar to those in Fairfax Creek. AAR also measured temperature in Sleepy Hollow Creek in 1999. The report (AAR 2000) states:

> Thermal conditions in Sleepy Hollow Creek were generally satisfactory for all life stages of both steelhead and rainbow trout, with the exception of the lowest reaches near Sir Francis Drake High School. There were many areas that had dried up throughout this drainage.

The observations for the last few years suggest that conditions have deteriorated in this watershed since 1999. In 2017-2018, temperatures were similar to those observed in 2013 – 2016: above 15°C beginning in July and extending into September. This was a very dry period with low flow, which likely contributed to the higher temperatures.

8: References

AAR 2000
A.A. Rich & Associates. 2000. *Fishery Resources Conditions of the Corte Madera Creek Watershed, Marin County, California*. Prepared for Friends of Corte Madera Creek Watershed by A.A. Rich and Associates, San Anselmo, California. November 10, 2000.

Taylor 2006
Ross Taylor and Associates. 2006. *Corte Madera Creek Stream Crossing Inventory and Fish Passage Evaluation.* Prepared for Friends of Corte Madera Creek Watershed, with funding from the National Fish and Wildlife Foundation. 54 p and appendices.

Figure 1: Diagram of logger, shuttle, and computer used in data collection and transfer

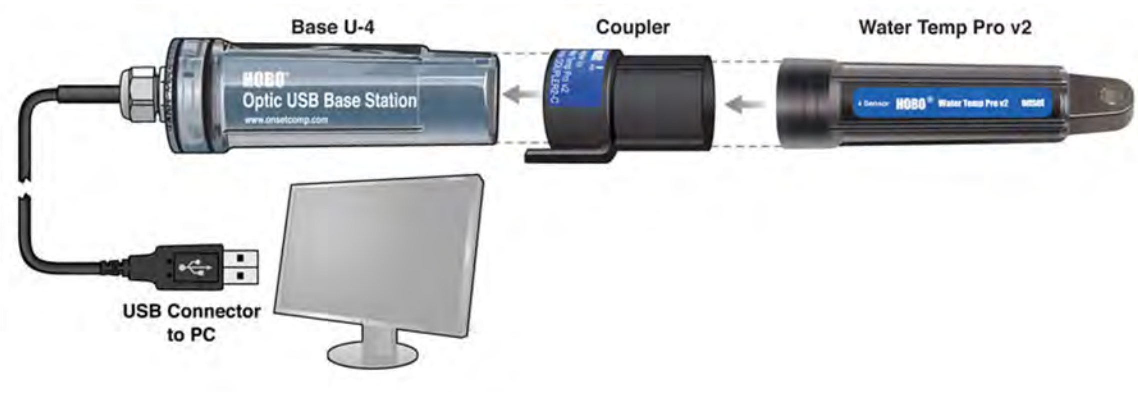

Figure 2: Temperature logger locations in Ross Creek

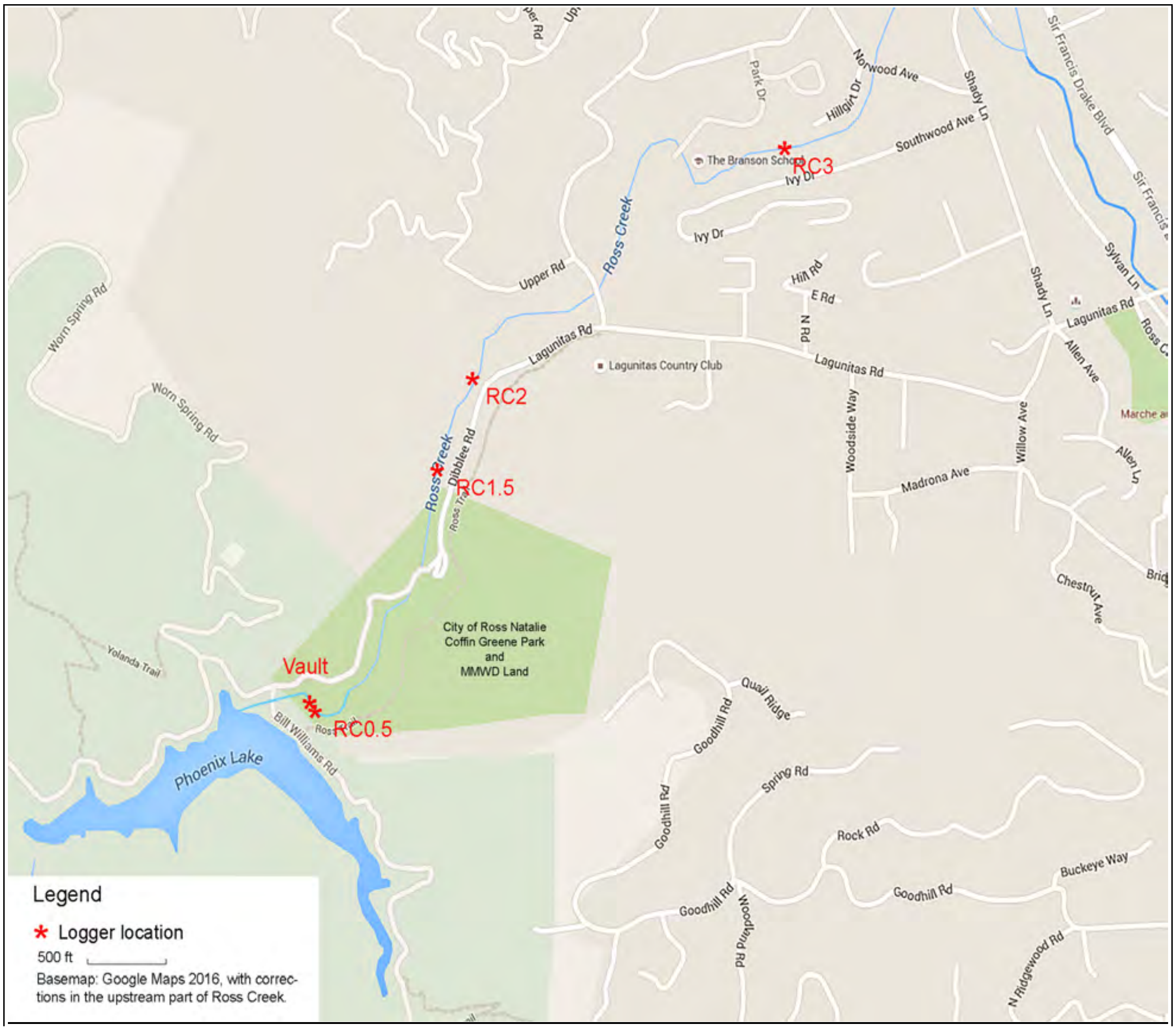

Figure 3: Temperature logger locations in San Anselmo, Fairfax, and Sleepy Hollow creeks

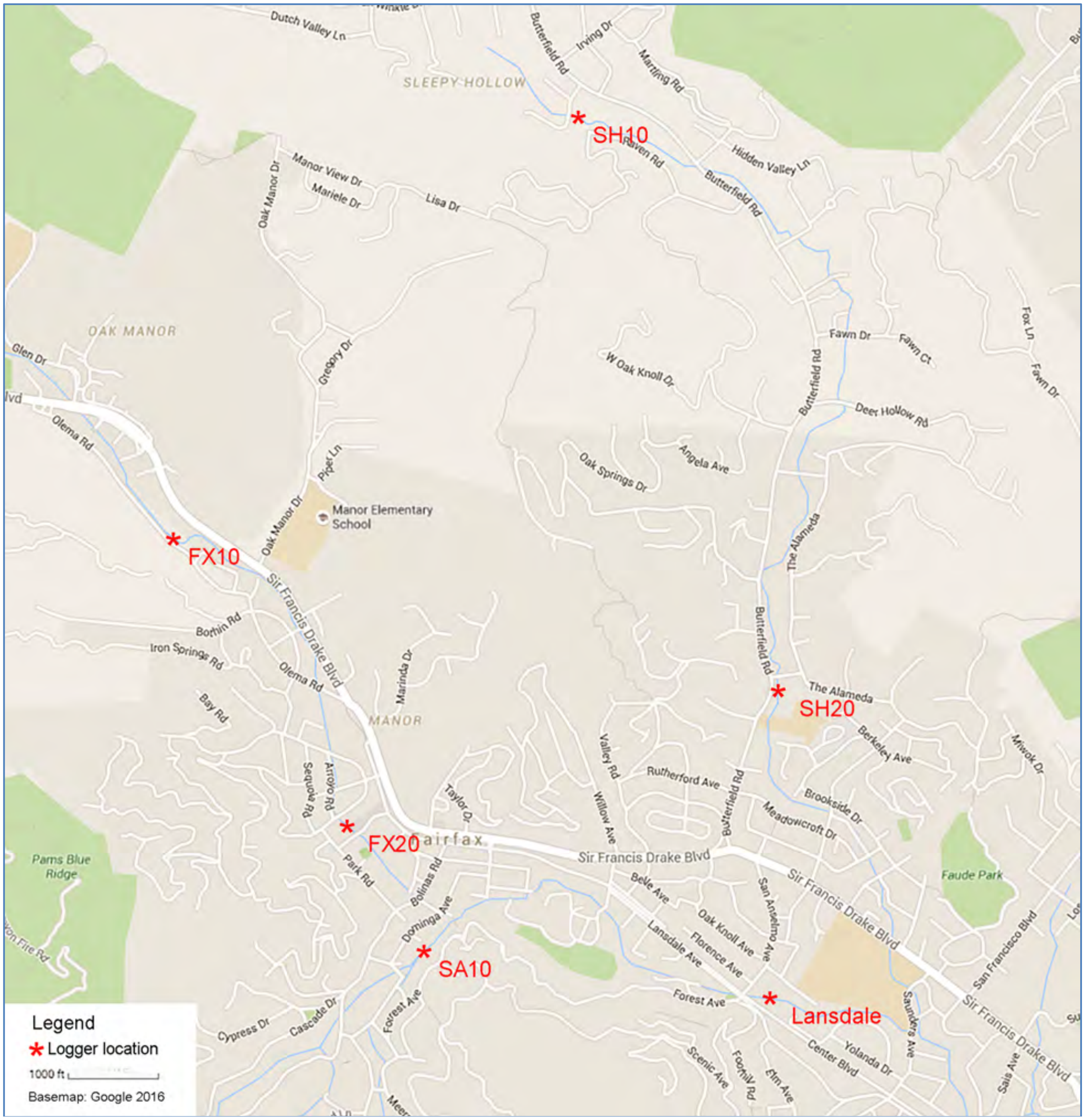

Figure 4: Temperature and DO in Ross Creek near Vault in 2017

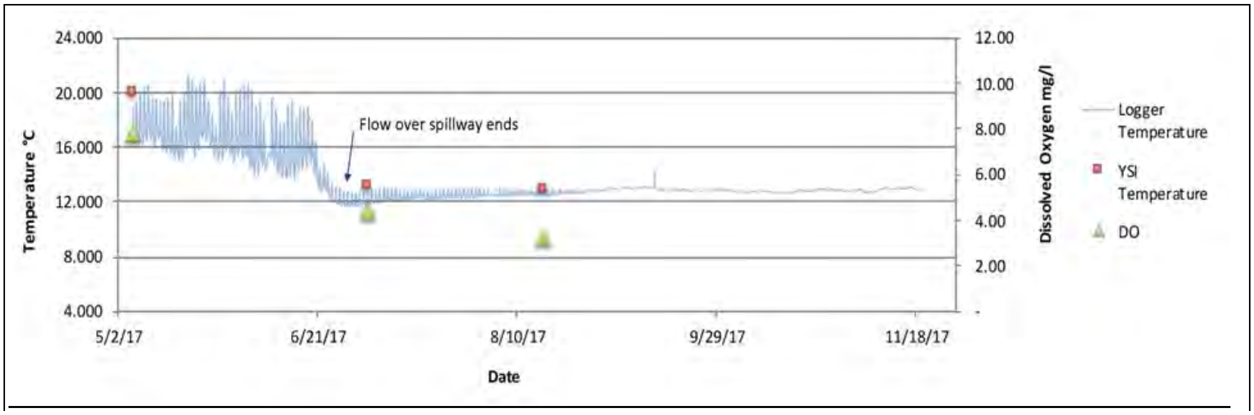

Figure 5: Temperature and DO in Ross Creek near Vault in 2018

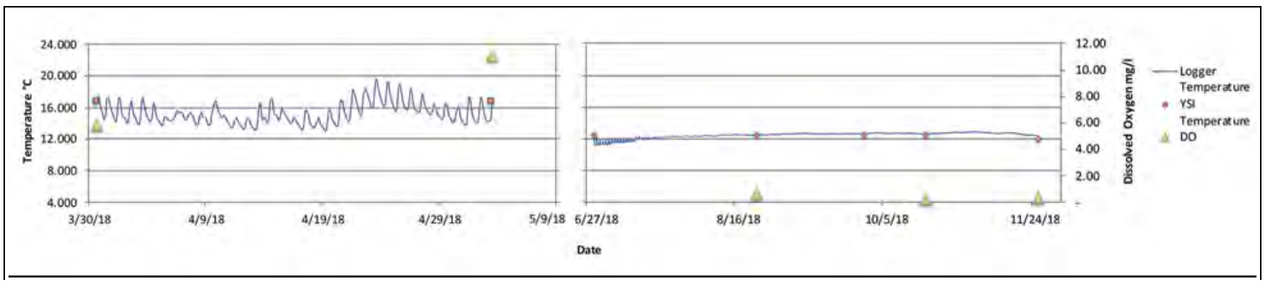

Figure 6: Temperature and DO in Ross Creek at Logger RC0.5 in 2017

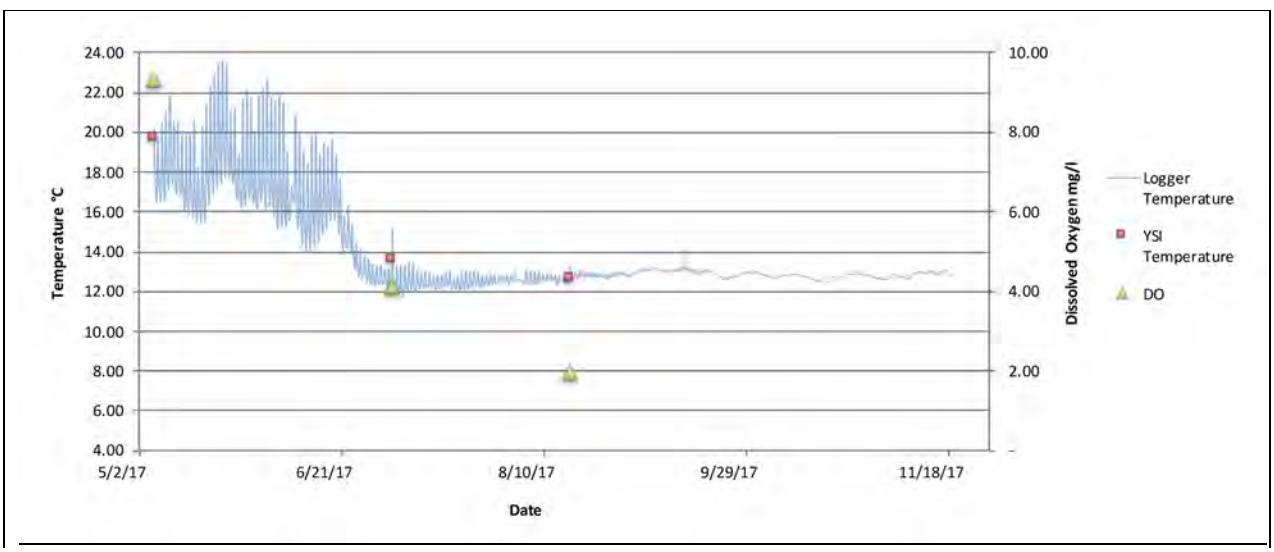

Figure 7: Temperature and DO in Ross Creek at RC0.5 in 2018

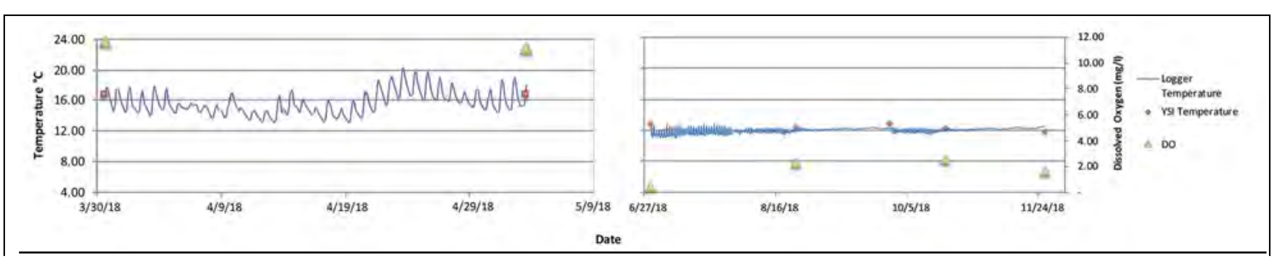

Figure 8: Temperature and DO in Ross Creek at Logger RC1.5 in 2017

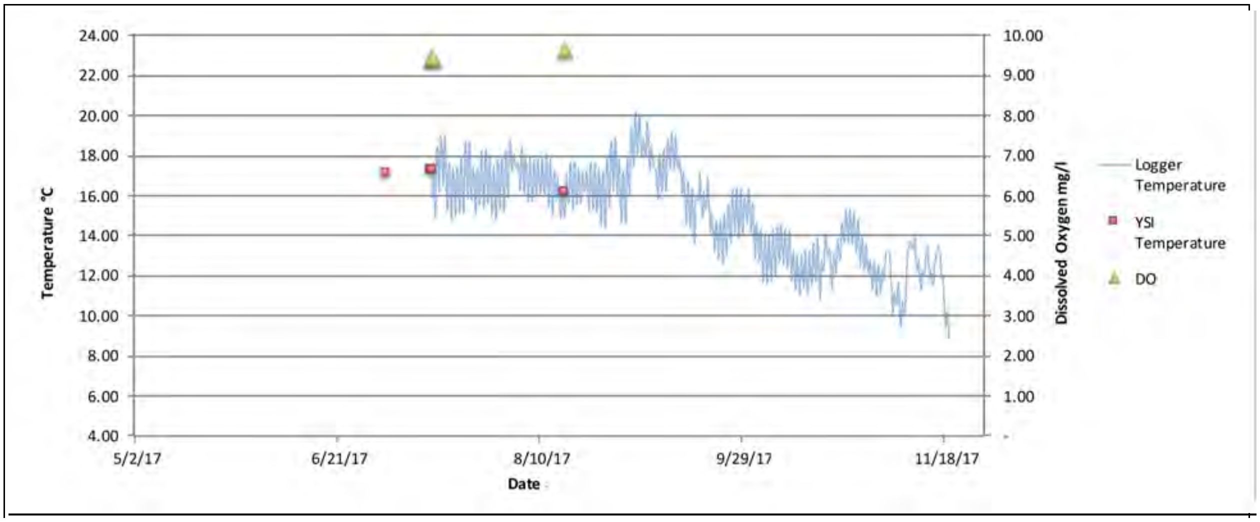

Figure 9: Temperature and DO in Ross Creek at Logger RC1.5 in 2018

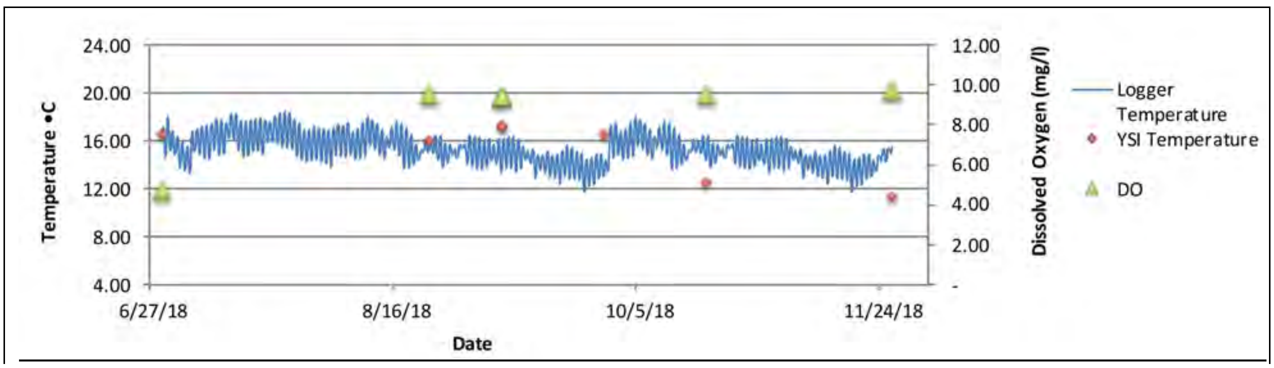

Figure 10: Temperature and DO in Ross Creek at Logger RC2 in 2017

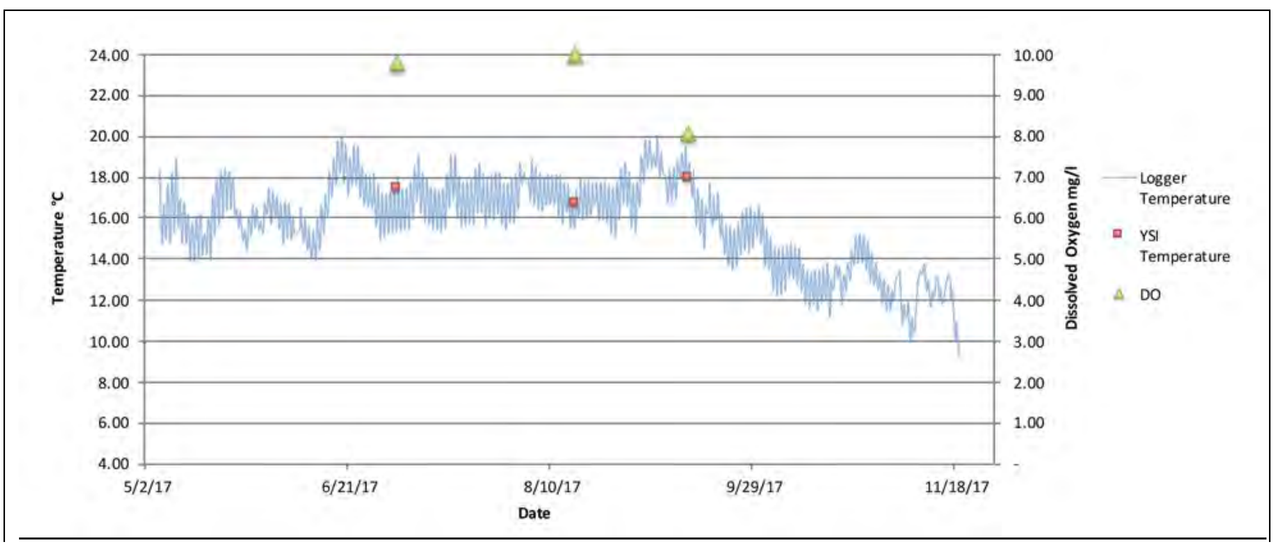

Figure 11: Temperature and DO in Ross Creek at RC2 in 2018

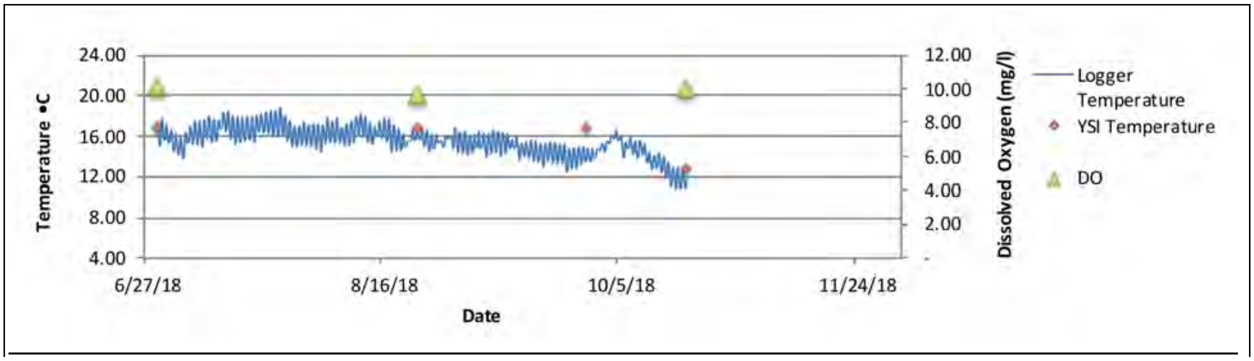

Figure 12: Temperature and DO in Ross Creek at Logger RC3 in 2017

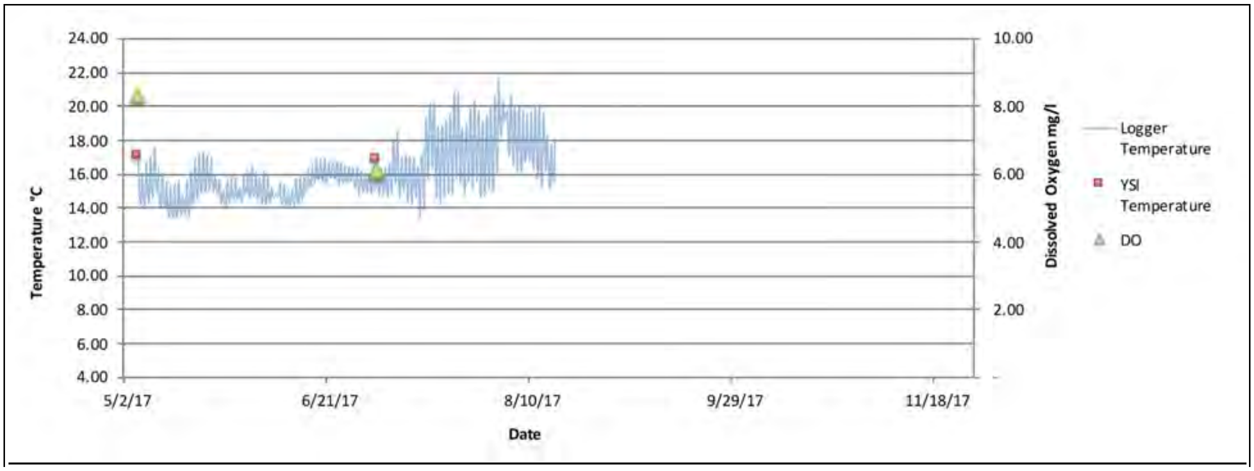

Figure 13: Temperature and DO in Ross Creek at Logger RC3 in 2018

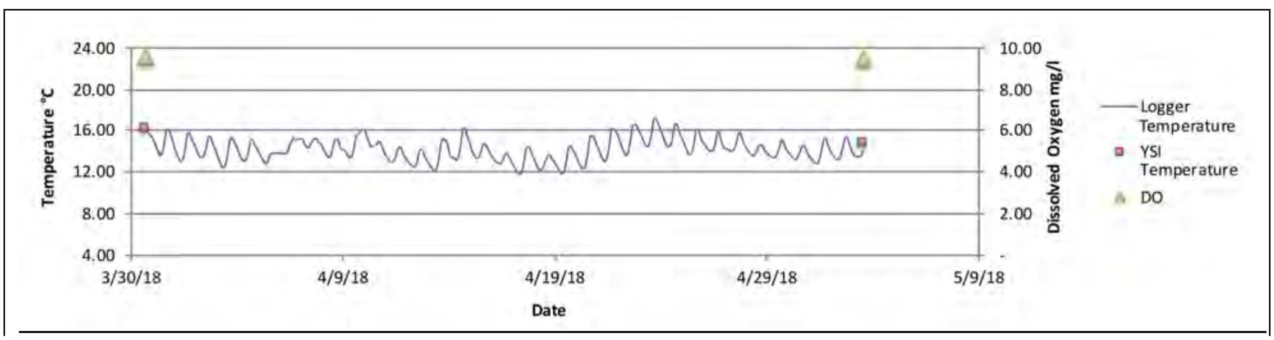

Figure 14: Temperature and DO in Fairfax Creek downstream of 300 Olema Road in 2017

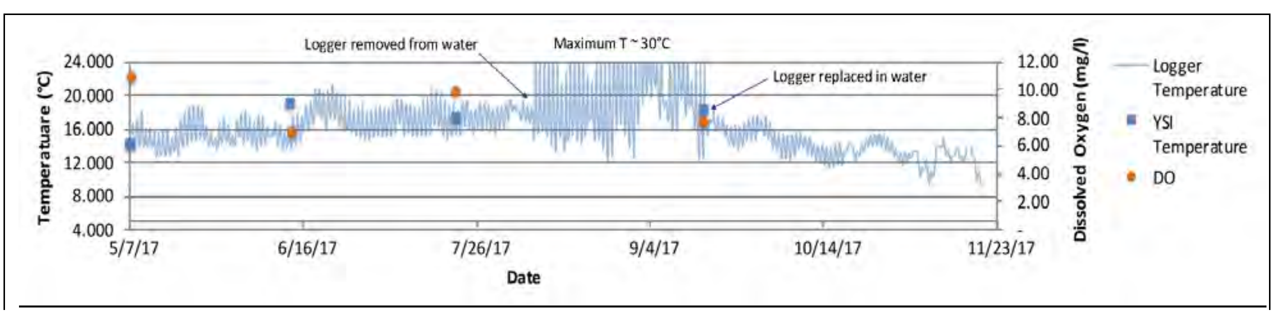

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Figure 15: Temperature and DO in Fairfax Creek downstream of 300 Olema Road in 2018

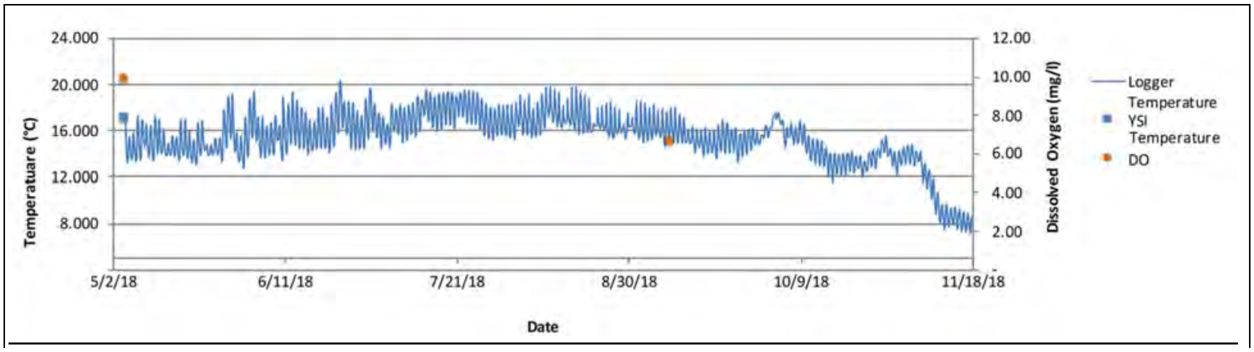

Figure 16: Temperature and DO in Fairfax Creek at Logger FX20 behind Fairfax Lumber in 2017

Figure 17: Temperature and DO in Fairfax Creek at Logger FX20 near Merwin Avenue in 2018

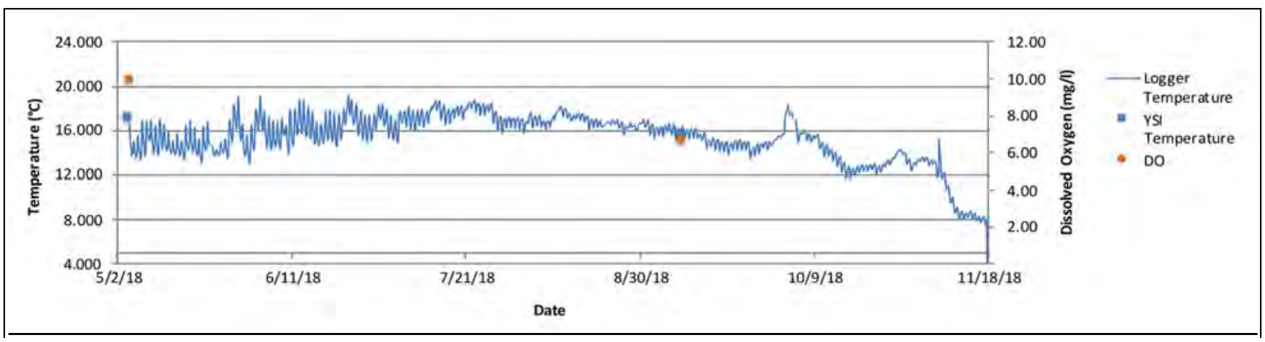

Figure 18: Temperature and DO in San Anselmo Creek near Deer Park Creek in 2017

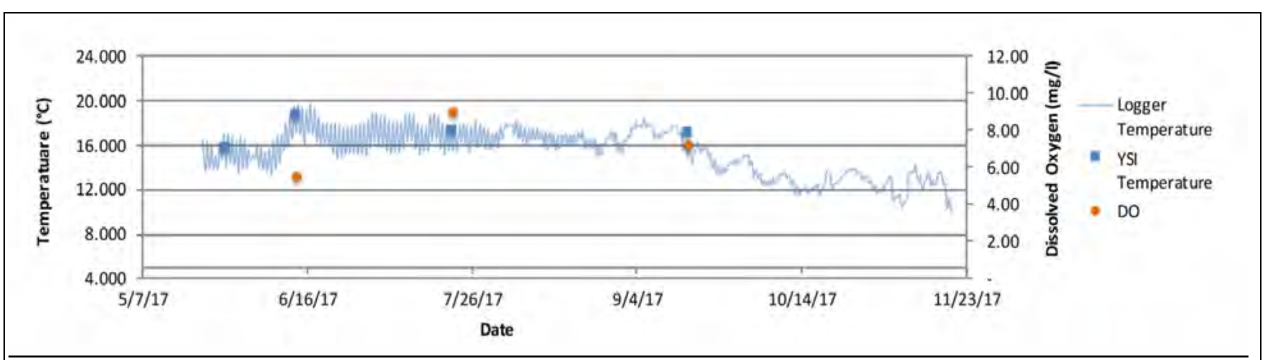

Figure 19: Temperature and DO in San Anselmo Creek near Lansdale in 2017

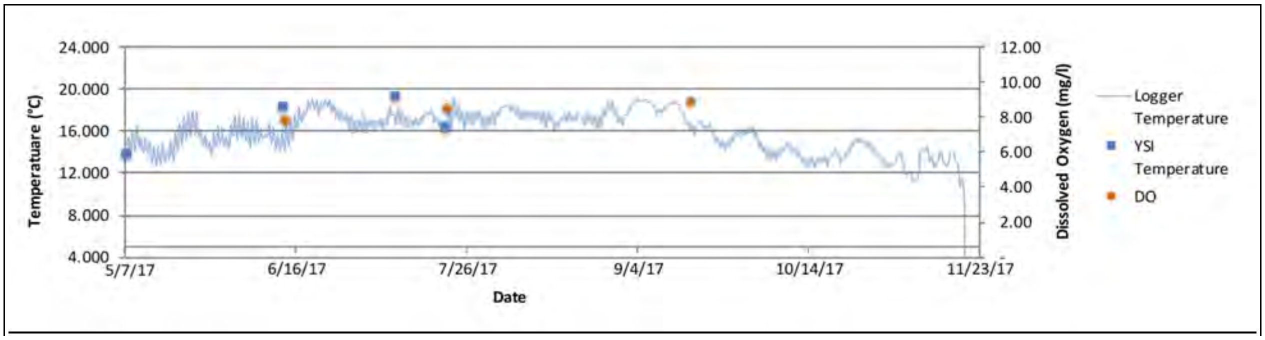

Figure 20: Temperature and DO in San Anselmo Creek near Lansdale in 2018

Figure 21: Temperature and DO in Sleepy Hollow Creek at 17 Katrina Lane in 2017

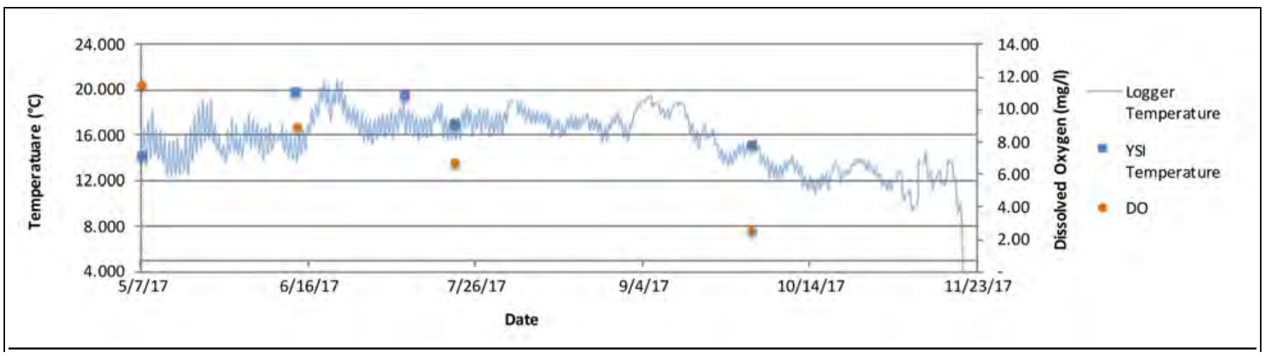

Figure 22: Temperature and DO in Sleepy Hollow Creek at Katrina Lane in 2018

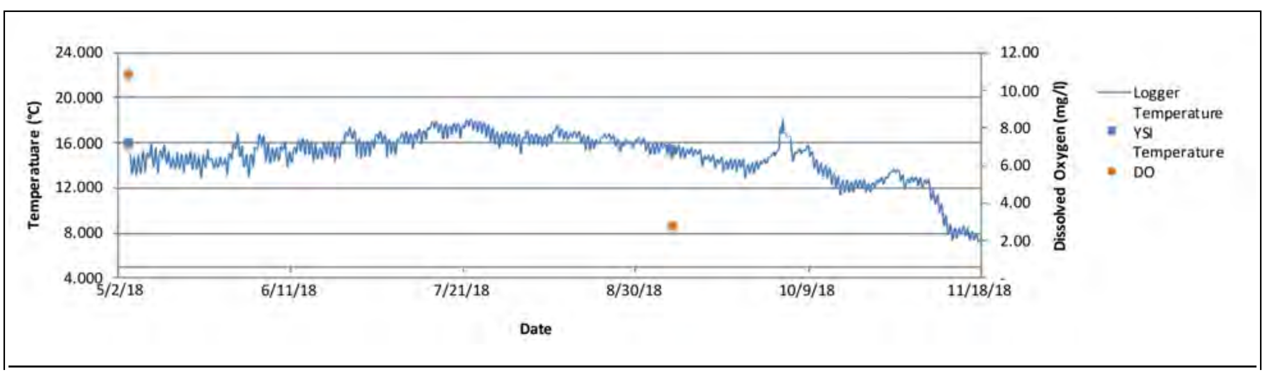

Figure 23: Temperature and DO in Sleepy Hollow Creek at Fire Station in 2017

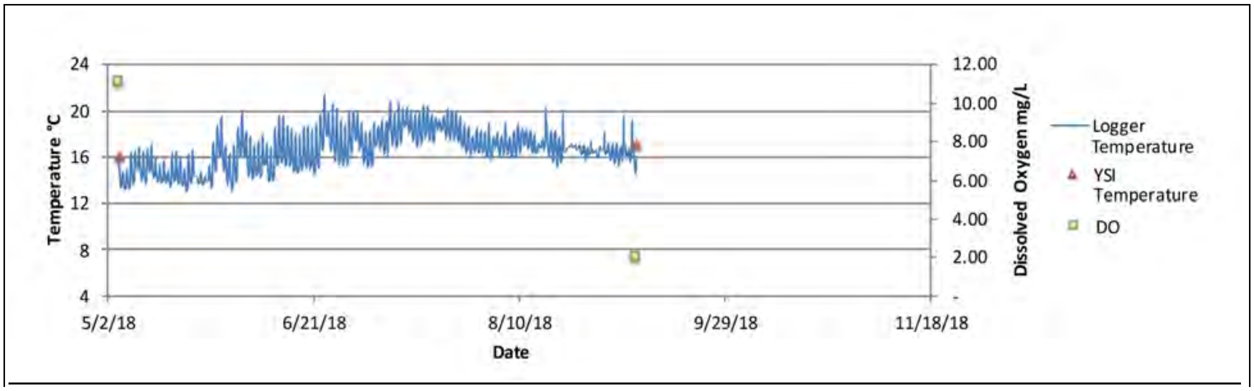

Figure 24: Temperature and DO in Sleepy Hollow Creek at Fire House in 2018