Russian River Water Quality Summary for the 2019 Temporary Urgency Change

Sonoma County Water Agency

March 2020

Contents

1.0 Introduction

On 24 April 2019, the Sonoma County Water Agency (Sonoma Water) filed Temporary Urgency Change Petitions (TUCPs) with the State Water Resources Control Board (SWRCB) to temporarily reduce minimum instream flows in the Russian River to meet the terms and conditions of the Russian River Biological Opinion (NMFS 2008).

In summary, the SWRCB approved the following temporary changes to the Decision 1610 (D1610) instream flow requirements from 1 May 2019 until 15 October 2019 to the following:

(1) Minimum instream flow in the upper Russian River (from its confluence of the East and West Forks of the Russian River to its confluence with Dry Creek) shall remain at or above 125 cubic feet per second (cfs).

(2) Minimum instream flow requirements in the lower Russian River (from its confluence with Dry Creek to the Pacific Ocean) shall remain at or above 70 cfs.

For purposes of compliance with this term, the minimum instream flow requirements for the upper river shall be based on a five-day running average of average daily stream flow measurements, provided that instantaneous flows shall be no less than 110 cfs. For the lower river, the minimum instream flow requirements shall be based on instantaneous flow measurements and shall be no less than 70 cfs. Approval of the request to temporarily reduce minimum instream flows to benefit the fishery would also maintain storage levels in Lake Mendocino for a longer period of time so that water would be available in the fall for fisheries purposes. The SWRCB issued the Order (Order) approving Sonoma Water's TUCP on 20 June 2019.

2.0 2019 Russian River Flow Summary

In early January 2019, following a dry December in 2018, water storage in Lake Mendocino was similar to storage levels experienced in 2015 during the drought. However, storage quickly increased through a series of storms in January and February, and by April storage levels were similar to levels observed in 2011 prior to the onset of drought, and in 2016 and 2017 following the end of the drought (Figure 2-1). Storage in Lake Mendocino peaked in early June at over 94,800 acre-feet and remained above 80,000 acre-feet through mid-September. In addition, 2019 storage remained above conditions experienced during the drought (2013 - 2015) for the remaining calendar year. However, late-season storms seen in prior years in November and December did not materialize, and storage only slightly increased through the month of December. Storage declined from 80,000 acre-feet in mid-September to just over 65,000 acre-feet by mid-December before increasing to just under 70,000 acre-feet by 31 December (Figure 2-1).

The 2019 average daily flows at the Talmage, Hopland, Cloverdale, Jimtown, Digger Bend, and Hacienda USGS gaging stations are shown in Figure 2-2.

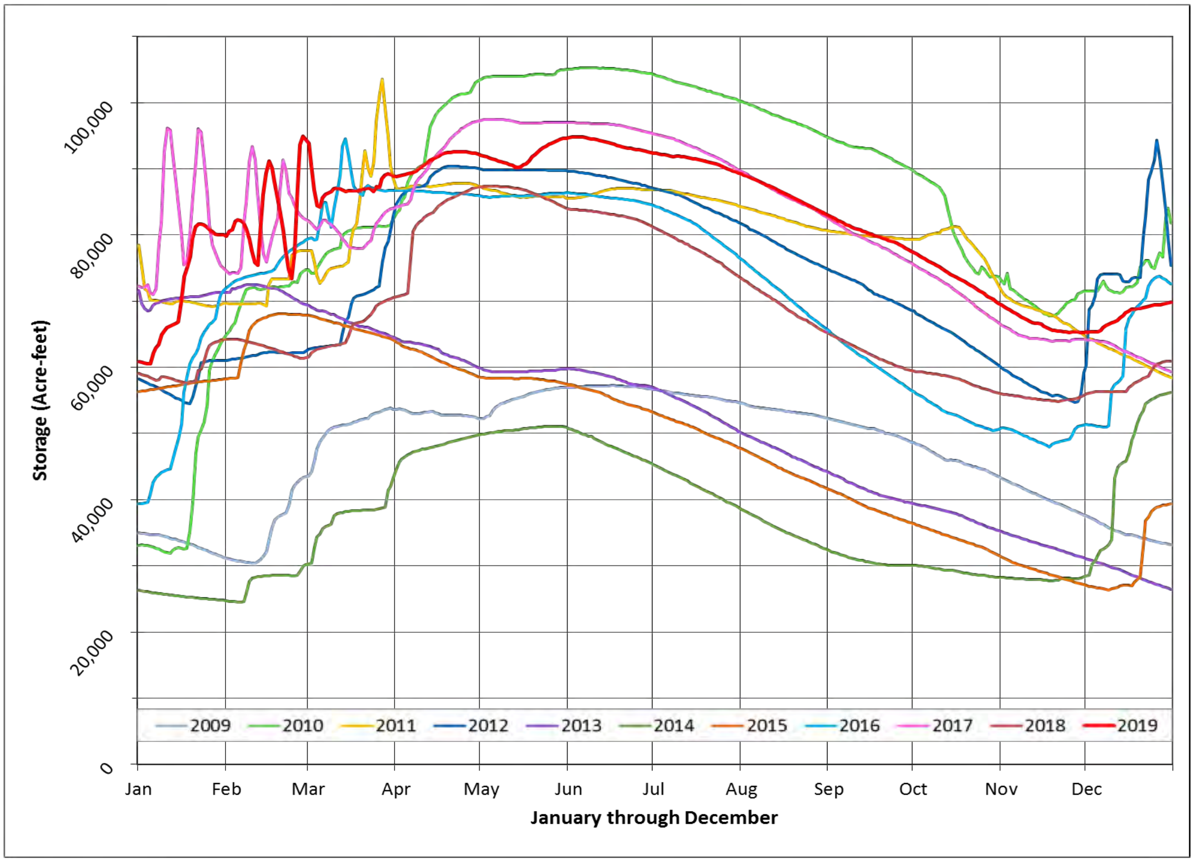


Figure 2-1. Lake Mendocino water storage levels, in acre-feet, from 2009 through 2019.

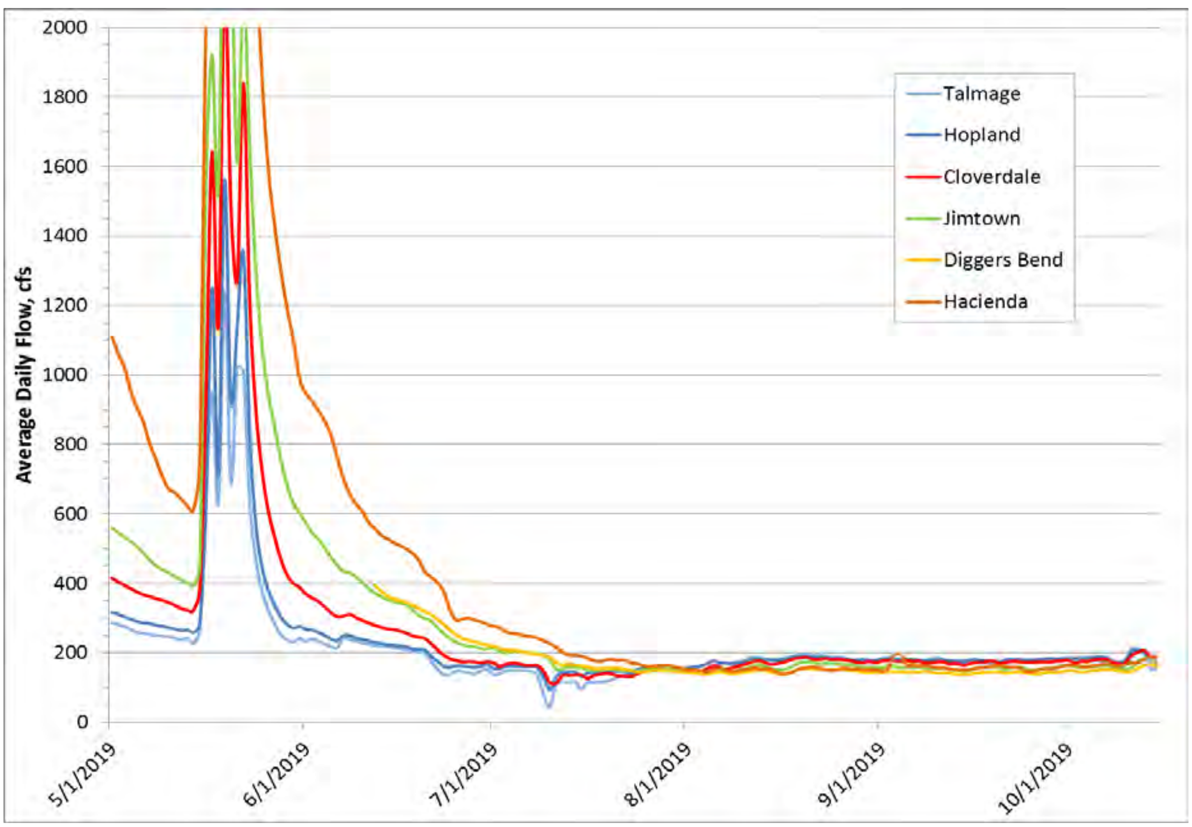


Figure 2-2. 2019 average daily flows in the Russian River as measured at U.S. Geological Survey (USGS) gages in cubic feet per second (cfs). Flow rates are preliminary and subject to final revision by USGS.

The changes in upper Russian River minimum instream flow requirements authorized by the Order allowed flows to decline below D1610 minimum instream flows of 185 cfs during late June at the Talmage, Hopland and Cloverdale gages, and in mid-July at the Jimtown and Diggers Bend gages (Figure 2-3). However, upper Russian River flows did not decline below the TUC minimum flows of 125 cfs or the instantaneous minimum flow of 110 cfs authorized by the Order with the exception of a few days in early July, when Lake Mendocino reservoir releases were temporarily decreased to facilitate the recovery of a body near the outlet structure at the bottom of the reservoir (Figure 2-3).

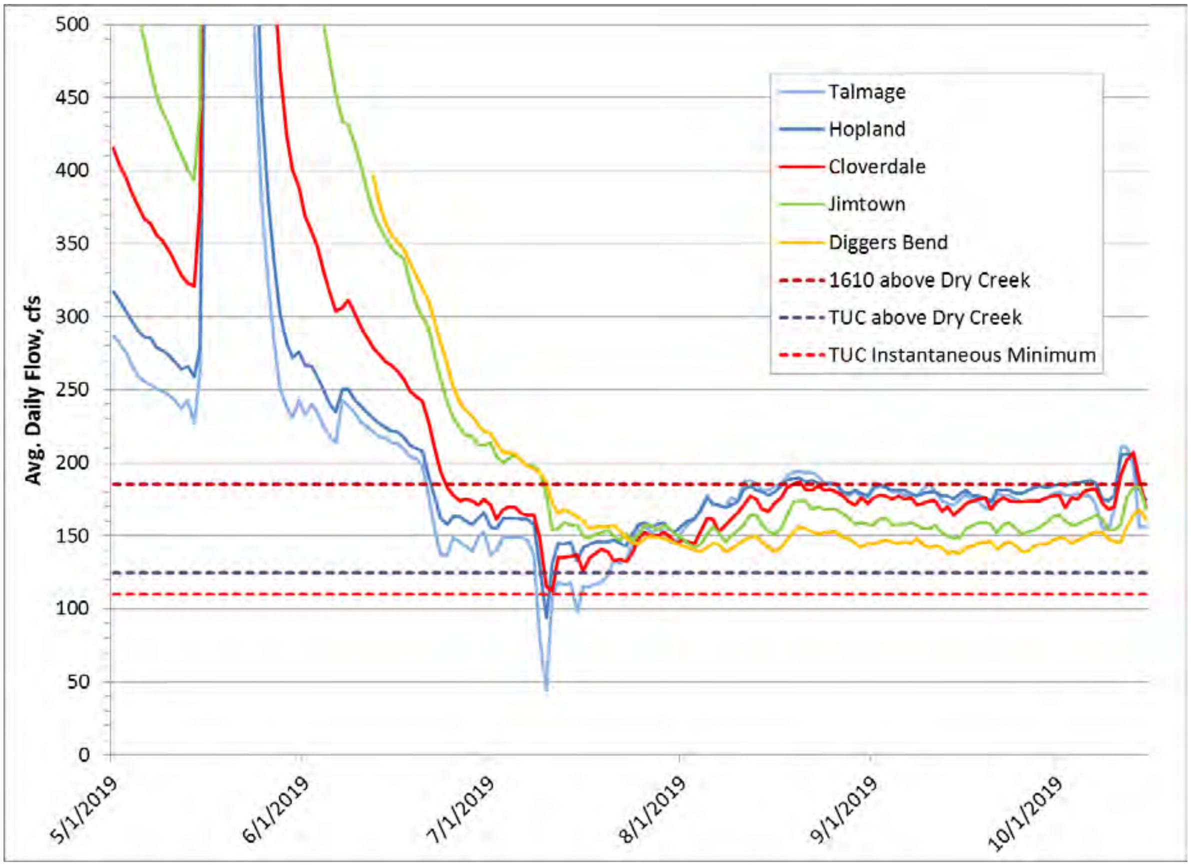


Figure 2-3. 2019 average daily flows in the Upper Russian River as measured at USGS gages above the Dry Creek confluence in cubic feet per second. Flow rates are preliminary and subject to final revision by USGS.

While the Order was in effect, lower Russian River flows at Hacienda (downstream of the confluence with Dry Creek) did not drop below the D1610 minimum flows of 125 cfs or the TUC and instantaneous minimum flow of 70 cfs authorized by the Order (Figure 2-4).

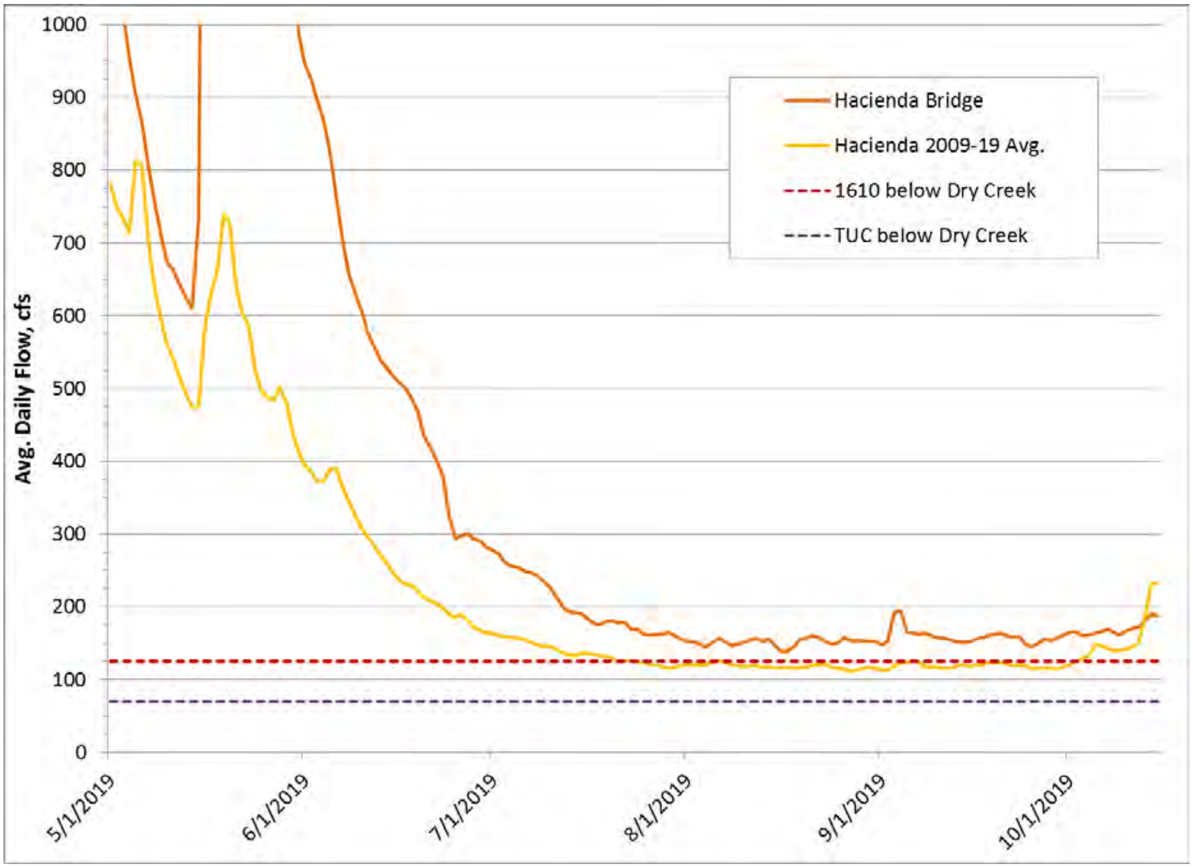


Figure 2-4. 2019 average daily flows in the Lower Russian River as measured at USGS gages below the Dry Creek confluence in cubic feet per second. Flow rates are preliminary and subject to final revision by USGS.

3.0 Water Quality Monitoring

Water quality data was collected to monitor TUC flows for potential effects to recreation and available aquatic habitat for salmonids. The data was used to supplement existing data to provide a more complete basis for analyzing spatial and temporal water quality trends due to Biological Opinion-stipulated changes in river flow and estuary management.

3.1 Mainstem Russian River Water Quality Monitoring

The North Coast Regional Water Quality Control Board (NCRWQCB), Sonoma County Department of Health Services (DHS), Sonoma Water, and Sonoma County Department of Parks and Recreation (Regional Parks) formed a workgroup to coordinate a monitoring approach for assessing cyanobacteria in the Russian River during the summer of 2016. Sonoma Water staff continue to consult and coordinate with NCRWQCB staff regarding monitoring activities related to the workgroup. As a result of ongoing consultation, Sonoma Water has made modifications to their existing Water Quality Monitoring Plan for the Russian River Estuary Management Project to include freshwater monitoring for the purpose of assisting in the evaluation of cyanobacteria harmful algal bloom (cyanoHAB) conditions and the risk of co-factors contributing to biostimulatory conditions and nuisance blooms (e.g., flow, temperature, nutrient, etc.).

In 2019, the Sonoma County DHS conducted weekly bacteriological sampling at ten (10) beaches with recreational activities involving the greatest body contact on the Russian River between Cloverdale and

Patterson Point. DHS did not conduct cyanotoxin sampling in 2019. Sonoma Water conducted mainstem sampling for nutrients at five (5) sites, and algae and cyanobacteria at four (4) sites, along the Russian River between Hopland and Patterson Point to support NCRWQCB analysis and evaluation of water quality data relating to biostimulatory conditions and cyanotoxins. In addition, Sonoma Water continued to conduct long-term water quality monitoring and weekly grab sampling for nutrients, bacteria, and algae in the middle and upper reaches of the Russian River Estuary and the upper extent of inundation and backwatering during lagoon formation, between Patty's Rock in Jenner and Vacation Beach, including in two tributaries.

The California Department of Public Health (CDPH) developed the "Draft Guidance for Fresh Water Beaches," which describes bacteria levels that, if exceeded, may require posted warning signs in order to protect public health (CDPH 2011). The CDPH draft guideline for single sample maximum concentrations is: 10,000 most probable numbers (MPN) per 100 milliliters (mL) for Total Coliform; 235 MPN per 100 mL for *E. coli*; and 61 MPN per 100 mL for *Enterococcus*. In 2012, the United States Environmental Protection Agency (EPA) issued Clean Water Act (CWA) §304(a) Recreational Water Quality Criteria (RWQC) for States (EPA 2012). The RWQC recommends using two criteria for assessing water quality relating to fecal indicator bacteria: the geometric mean (GM) of the dataset, and changing the single sample maximum (SSM) to a Statistical Threshold Value (STV) representing the 75th percentile of an acceptable water-quality distribution. However, the EPA recommends using STV values as SSM values for potential recreational beach posting and those values are provided in this report for comparative purposes. Exceedances of the STV values are highlighted in Table 3-1. It must be emphasized that these are draft guidelines and criteria, not adopted standards, and are therefore both subject to change (if it is determined that the guidelines and/or criteria are not accurate indicators) and are not currently enforceable.

Cyanobacteria are present in most freshwater and marine environments. When conditions are favorable, including abundant light, elevated water temperature, elevated levels of nutrients, and lack of water turbulence and velocity, cyanobacteria can quickly multiply into a bloom. Not every bloom is toxic; however, cyanoHABs are a concern as some species of cyanobacteria produce toxins that have the potential to impact drinking water, recreation, and fish and wildlife. Cyanotoxins were detected in the Russian River in 2015, 2016, 2017, and 2018, which led to Sonoma County DHS posting warning signs.

Currently, there are no federal or state standards for cyanotoxins in drinking water and recreational waters, however the EPA has issued draft guidance and continue to work toward identifying appropriate standards. Agencies participating in the California Water Quality Monitoring Council's (CWQMC) California Cyanobacteria and Harmful Algal Bloom (CCHAB) Network, including the SWRCB, California Office of Environmental Health Hazard Assessment (OEHHA), and CDPH, have developed and are further refining suggested guidelines for addressing health concerns for cyanotoxins in recreation waters (CWQMC 2017). The CDPH, county health departments, and water body managers are encouraged to use this guidance for posting of water bodies when cyanoHABs pose a health threat. Three primary trigger levels have been developed for posting and closing beaches for Total Microcystins, Anatoxin-a, and Cylindrospermopsin. Caution signs are recommended when Total Microcystins exceed 0.8 micrograms per liter (µg/L), any detection is made of Anatoxin-a, and when Cylindrospermopsin exceeds 1 µg/L. Warning signs (Tier I) are recommended when Total Microcystins exceed 6 µg/L, Anatoxin-a exceeds 20 µg/L, and cylindrospermopsin exceeds 4 µg/L. Danger signs (Tier II) are recommended when Total Microcystins exceed 20 µg/L, Anatoxin-a exceeds 90 µg/L, and cylindrospermopsin exceeds 17 µg/L. Secondary triggers have also been developed for the posting of caution signs when cell densities of toxin producers exceed 4,000 cells/mL or if there are site specific indicators of cyanobacteria including blooms, scums, and mats.

3.1.1 Sonoma County DHS Seasonal Mainstem Bacterial Sampling (Beach Sampling)

The Sonoma County DHS conducts seasonal bacteriological sampling to monitor levels of pathogens at ten (10) Russian River beaches with recreational activities involving the greatest body contact. Results are used by the Sonoma County DHS to determine whether or not bacteria levels fall within State guidelines. The 2019 Sonoma County DHS seasonal beach sampling locations consisted of: Cloverdale River Park; Del Rio Woods Beach; Camp Rose Beach; Healdsburg Veterans Memorial Beach; Steelhead Beach; Forestville Access Beach; Sunset Beach; Johnson's Beach; Monte Rio Beach; and Patterson Point. Bacteriological samples were collected weekly beginning 28 May and continued until 3 September. The samples were analyzed using the Colilert quantitray MPN method for Total Coliform and *E. coli*. Results from the sampling program were reported by the Sonoma County DHS at their website and on the Sonoma County DHS Beach Sampling Hotline. The 2019 seasonal results are shown in Table 3-1 and in Figures 3-1 and 3-2.

Table 3-1. Sonoma County DHS 2019 Seasonal Mainstem Bacteria Sampling Results (Sonoma County DHS, 2019a).

Date Sampled	Cloverdale River Park		Del Rio Woods Beach		Camp Rose Beach		Healdsburg Veterans		Steelhead Beach		Forestville Access Beach		Sunset Beach		Johnson's Beach		Monte Rio Beach		Patterson Point	
	TC	EC	TC	EC	TC	EC	TC	EC	TC	EC	TC	EC	TC	EC	TC	EC	TC	EC	TC	EC
28-May	2,143	86	1,723	31	1,565	20	1,274	52	2,178	63	1,720	41	1,515	41	3,076	691*	1,234	74	1,789	20
29-May															1,500	41				
3-Jun	1,515	62	1,850	41	1,372	61	1,455	75	3,448	41	4,106	41	3,448	31	1,850	41	1,126	52	1,515	31
10-Jun	1,860	74	1,723	10	Lab Accident***		1,259	<10	2,014	20	1,467	10	1,483	41	933	10	1,106	63	416	10
11-Jun					1,576	10														
17-Jun	4,611	20	1,014	10	880	<10	1,187	20	1,169	30	1,607	30	1,234	10	703	20	1,071	63	862	<10
24-Jun	2,382	75	1,467	31	1,539	52	855	31	1,246	20	1,333	10	1,515	20	1,145	31	2,481	31	1,467	10
1-Jul	3,076	10	1,616	31	2,282	20	1,860	20	2,142	10	1,918	10	2,061	<10	2,359	75	2,098	110	1,401	10
8-Jul	2,247	31	3,076	<10	2,098	20	1,236	31	2,400	20	1,860	10	2,382	31	1,274	20	1,259	10	1,017	20
15-Jul	4,106	31	2,247	<10	2,909	<10	865	<10	2,247	10	1,722	20	1,789	31	1,500	41	5,475	<10	2,733	<10
22-Jul	4,106	20	2,247	<10	2,282	<10	882	<10	1,106	<10	1,624	<10	1,935	<10	2,098	52	9,804	<10	4,352	31
29-Jul	2,987	20	2,282	<10	4,106	10	4,611	<10	1,071	10	1,789	41	1,414	10	5,475	31	>24,196*	243*	5,172	110
30-Jul																	24163*	63		
31-Jul																	19,863	131		
5-Aug	3,873	41	3,076	<10	2,014	20	8,164	<10	1,529	20	3,448	10	2,613	10	2,603	31	6,488	211	4,611	10
12-Aug	3,255	41	1,529	10	2,755	<10	1,076	10	1,450	10	2,143	20	1,376	10	1,529	<10	1,529	10	1,467	<10
19-Aug	4,106	74	3,654	<10	3,255	10	1,918	<10	1,565	<10	2,495	<10	1,565	<10	1,624	85	1,658	<10	1,670	<10
26-Aug	3,654	31	2,851	<10	3,076	10	1,639	10	1,236	<10	2,755	10	1,396	<10	2,014	<10	1,153	<10	880	<10
3-Sep	2,613	75	1,723	31	1,860	20	1,467	20	1,553	10	2,481	<10	1,178	<10	1,396	<10	884	<10	904	<10

* Resample conducted for confirmatory test.

** Beach closed.

*** Resample conducted for lab accident.

GREEN indicates the beach is open - bacterial level results are within State guidelines.

YELLOW indicates the beach is open, but swimming is not advised - bacterial level results exceed State guidelines.

RED indicates the beach is closed - bacterial level results exceed State guidelines and are associated with a known or suspected human sewage release.

Recommended California Department of Public Health (CDPH) Draft Guidance and Environmental Protection Agency (EPA) Recreational Water Quality Criteria - Statistical Threshold Values (STV):

(Beach posting is recommended when indicator organisms exceed the STV) - Indicated by red text

Total Coliforms (STV): 10,000 per 100ml

E. coli (STV): 235 per 100 ml

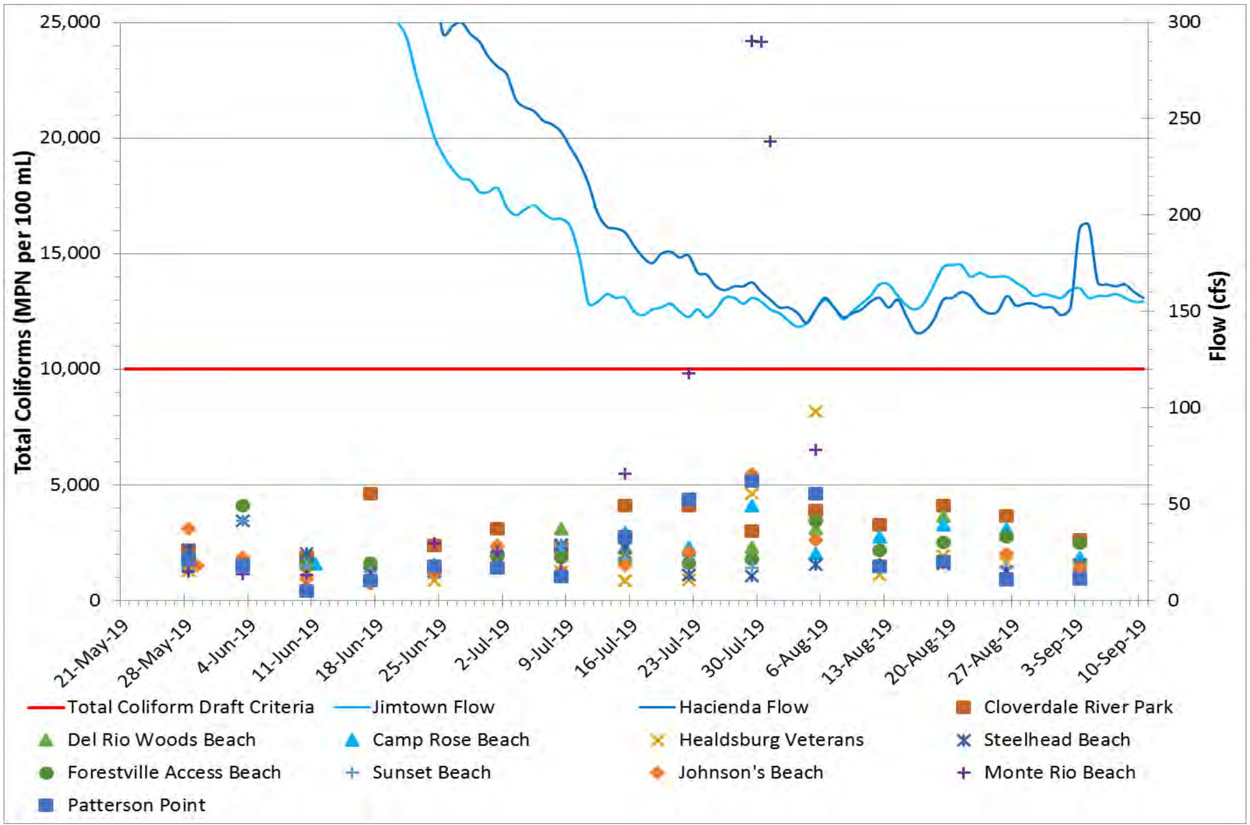


Figure 3-1. Sonoma County DHS 2019 Seasonal Mainstem Russian River Bacteria Sample Results for Total Coliform. Flow rates are preliminary and subject to final revision by USGS.

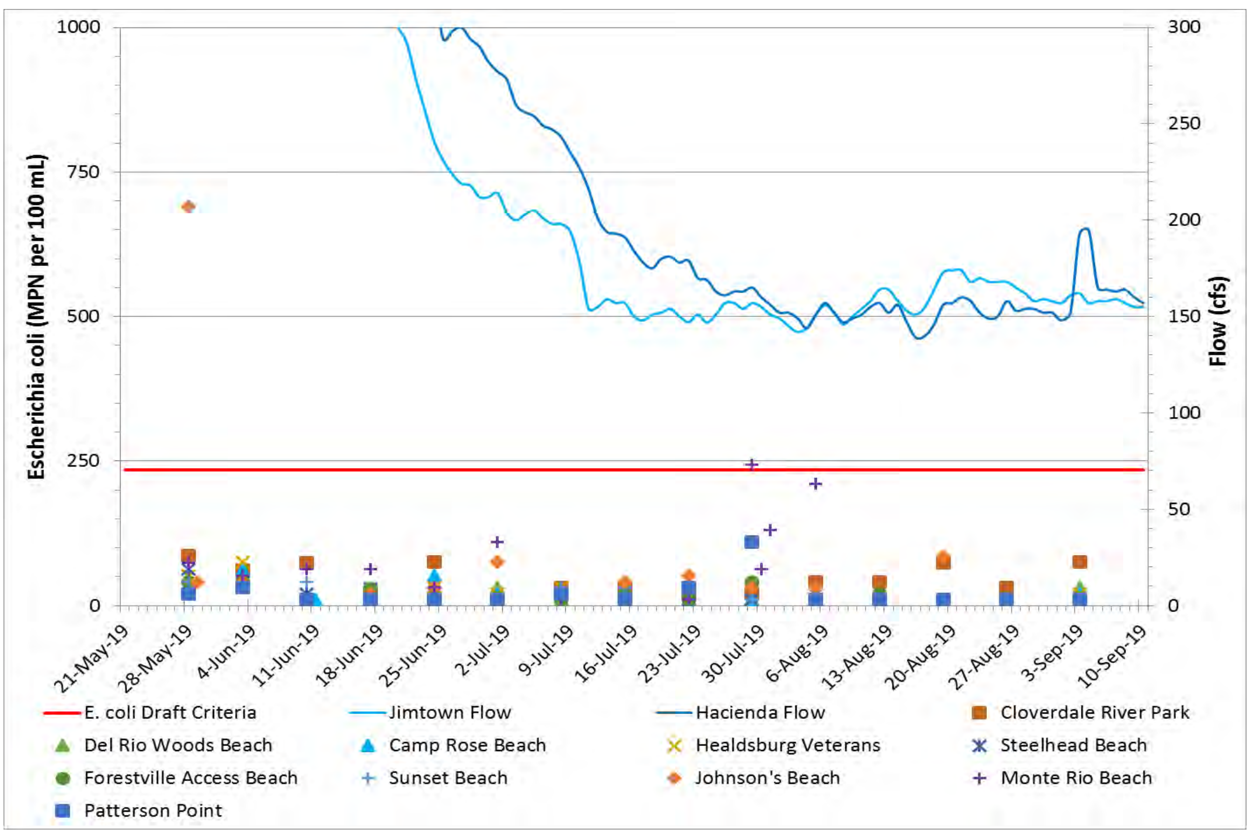


Figure 3-2. Sonoma County DHS 2019 Seasonal Mainstem Russian River Bacteria Sample Results for *E. coli*. Flow rates are preliminary and subject to final revision by USGS.

3.1.2 Sonoma County DHS Seasonal Mainstem Cyanotoxin Sampling (Beach Sampling)

In 2019, the Sonoma County DHS did not conduct seasonal cyanotoxin sampling.

3.1.3 Sonoma Water Seasonal Mainstem Russian River Ambient Algae and Nutrient Grab Sampling

In 2019, ambient algae and cyanobacterial monitoring and sampling was conducted from 14 May through 15 October at four (4) stations including: the Hopland USGS gaging station north of Hopland, the Jimtown USGS gaging station in Alexander Valley, Syar Vineyards downstream of the confluence with Dry Creek, and Patterson Point in Villa Grande to support NCRWQCB and Sonoma County DHS cyanotoxin monitoring and assessment of the potential for cyanoHABs in the Russian River (Figure 3-3). This effort is also being conducted to identify algal and cyanobacterial genera and species in the Russian River, as well as to estimate algal cover, density, and seasonal growth patterns. In addition, Sonoma Water staff conducted algae monitoring and sampling at two (2) additional sites for a separate monitoring program including: the USGS Calpella station located on the East Fork of the Russian River above Lake Mendocino, and the mainstem below Pieta Creek. Table 3-2 and Figure 3-4 provide a list and relative abundance of algal species observed in the mainstem Russian River during the 2019 monitoring season at the four TUC stations and the two additional stations. Relative abundance is represented as the number of sample slides a given species was observed on out of a total of 753 sample slides.

Sonoma Water staff conducted biweekly nutrient grab sampling monitoring at five (5) stations in the mainstem Russian River including: the Hopland USGS gaging station, Cloverdale River Park in Cloverdale, the Jimtown USGS gaging station, Syar, and Patterson Point. Grab sampling involves the collection of water from the water column for laboratory analysis. The grab sample sites are shown in Figure 3-3, and results are summarized in Tables 3-3 through 3-5 and Figures 3-5 through 3-10.

All grab samples were analyzed for nutrients, *chlorophyll a*, total dissolved solids, and turbidity. Grab samples were submitted to Alpha Analytical Labs in Ukiah for analysis. Grab sample data was collected during Sonoma Water's ambient algae and cyanobacteria monitoring and sample collection effort.

Ambient algae, cyanobacteria, estuary response, and associated grab sampling data for 2019 is currently being compiled and will be discussed in greater detail in the Russian River Biological Opinion 2019-2020 annual report, which will be posted to Sonoma Water's website when available: http://www.scwa.ca.gov/bo-annual-report/.

Highlighted values indicate those values exceeding EPA recommended criteria for "Nutrients, *Chlorophyll a*, and Turbidity in Rivers and Streams in Aggregate Ecoregion III" (EPA 2000). However, it must be emphasized that the EPA criteria are not adopted standards and are therefore both subject to change (if it is determined that the guidelines or criteria are not accurate indicators) and are not currently enforceable.

Figure 3-3. Sonoma Water 2019 Seasonal Mainstem Russian River Ambient Algae and Nutrient Grab Sampling Stations.

Table 3-2. Genera observed during algae monitoring, June - October 2019.

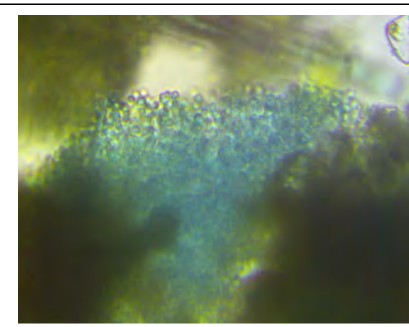
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Known Toxins (4)	Photograph
Cyanophyta	*Anabaena**	168 (22.3%)	Alkilibiontic (1)	Microcystins, Anatoxin-a, Saxitoxins, BMAA	
Cyanophyta	*Aphanizomenon*	11 (1.5%)	Nitrogen fixer Blooms in eutrophic water	Cylindrospermopsin, Anatoxin-a, Saxitoxins	
Cyanophyta	*Aphanocapsa/Aphanothece*	45 (6.0%)	Open water in bogs (2)	Microcystins	

Table 3-2 cont.

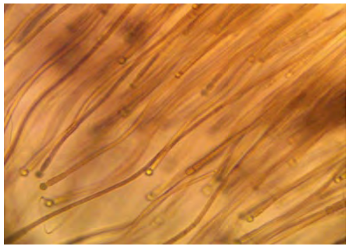
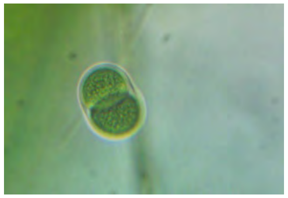
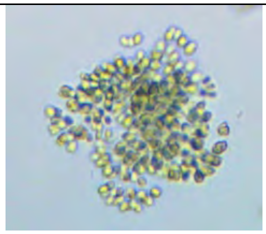
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Known Toxins (4)	Photograph
Cyanophyta	*Calothrix*	16 (2.1%)	Lower river/estuarine habitats Clean fresh water and marine littoral zones	Lipopolysaccharide	
Cyanophyta	*Chroococcus*	14 (1.9%)			
Cyanophyta	*Coelosphaerium*	2 (0.3%)		Lipopolysaccharide	
Cyanophyta	*Cylindrospermum*	66 (8.8%)	Soft, acid lakes (2) Nitrogen fixer	Anatoxin-*a*	

Table 3-2 cont.

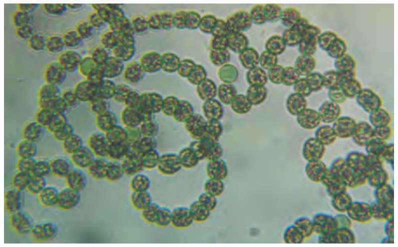
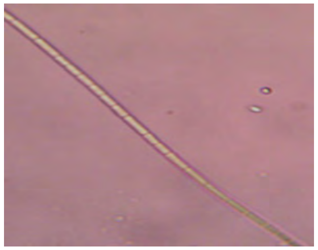
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Known Toxins (4)	Photograph
Cyanophyta	*Dolichospermum*	83 (11.0%)	N-fixer	Microcystins, Cylindrospermopsins, Anatoxins, Saxitoxins, Lipopolysaccharide	
Cyanophyta	*Geitlerinema*	377 (50.1%)	Soft, clean freshwater biotopes(2) Inhabits periphyton of oligotrophic to mesotrophic waters(2)	Not know to produce toxins	
Cyanophyta	*Gloeotrichia*	8 (1.1%)	N-fixer Planktonic/periphytic	Lipopolysaccharides, Microcystins	
Cyanophyta	*Hapalosiphon*	8 (1.1%)		Microcystins	

Table 3-2 cont.

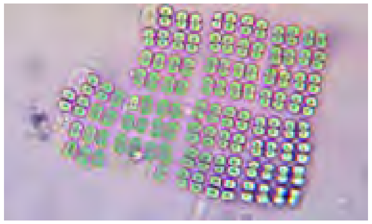
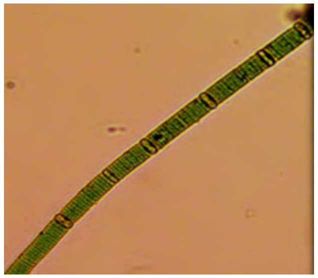
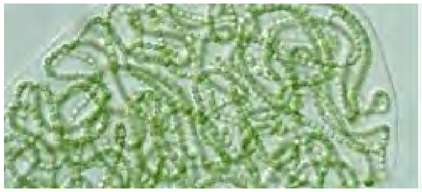
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Known Toxins (4)	Photograph
Cyanophyta	*Merismopedia*	28 (3.7%)	Found in eutrophic and mesotrophic water Fresh water or marine	Lipopolysaccharide	
Cyanophyta	*Nodularia*	37 (4.9%)	N-fixer	Nodularin	
Cyanophyta	*Nostoc*	69 (9.2%)	Nitrogen fixer Low N concentrations-2High N:P ratio-2	Microcystins, Nodularin, BMAA	
Cyanophyta	*Oscillatoria*	122 (16.2%)	Organic pollution (2)	Microcystins, Anatoxin-a, Aplysiatoxins	

Table 3-2 cont.

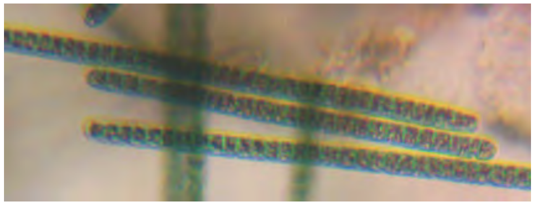
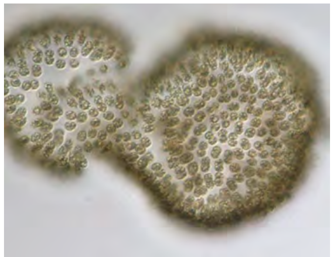
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Known Toxins (4)	Photograph
Cyanophyta	*Phormidium* *Lyngbya*	333 (44.2%)	Low temp., low light (2)	Lyngbyatoxin-a, Aplysiatoxins, Saxitoxins, Anatoxins (Phormidium)	
Cyanophyta	*Planktothrix*	44 (5.8%)	Nitrogen fixer Low/high temp., low light (2)	Microcystins, Saxitoxins	
Cyanophyta	*Pseudanabaena*	17 (2.3%)			
Cyanophyta	*Woronichinia*	10 (1.3%)			

Table 3-2 cont.

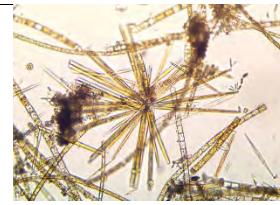
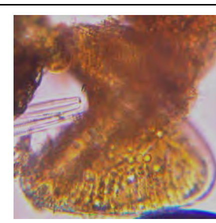
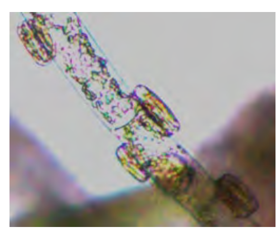
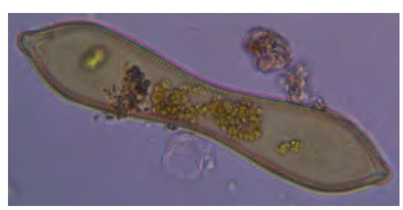
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Bacillariophyta	*Amphora*	287 (38.1%)		
Bacillariophyta	*Asterionella*	38 (5.0%)		
Bacillariophyta	*Aulacoseira*	93 (12.4%)		
Bacillariophyta	*Bacillaria*	88 (11.7%)	Brackish (1) Low DO (1) Eutrophic (1)	
Bacillariophyta	*Campylodiscus*	44 (5.8%)	Epipelic habitats in lentic ecosystems	
Bacillariophyta	*Cocconeis*	402 (53.4%)	Alkiliphilous (1) Fresh-brackish (1) Moderate-high DO (1) Eutrophic (1)	
Bacillariophyta	*Cymatopleura*	121 (16.1%)	Epipelic habitats in lakes, rivers and wetlands	

Table 3-2 cont.

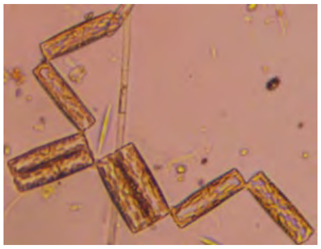
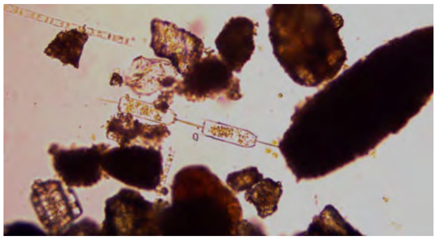
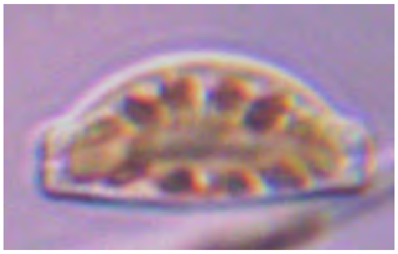
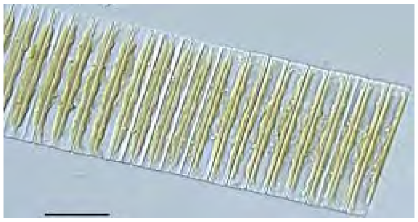
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Bacillariophyta	*Cymbella*	209 (27.8%)	Alkiliphilous (1) Fresh (1) Oligotrophic (1) High DO (1)	
Bacillariophyta	*Diatoma/ Tabellaria*	456 (60.6%)	Alkiliphilous (1) Fresh-brackish(1) High to moderate DO (1) Meso-eutrophic (1)	
Bacillariophyta	*Ditylum*	1 (0.1%)		
Bacillariophyta	*Encyonema*	398 (52.9%)	Alkiliphilous (1) Fresh (1) Oligotrophic (1) High DO (1)	
Bacillariophyta	*Fragilaria*	273 (36.3%)	Alkiliphilous (1) Fresh (1) High to moderate DO (1) Eurytrophic (1)	

Table 3-2 cont.

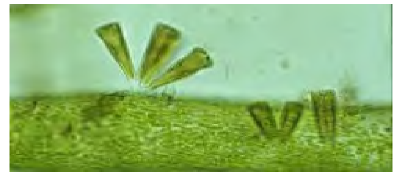
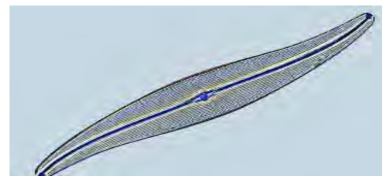
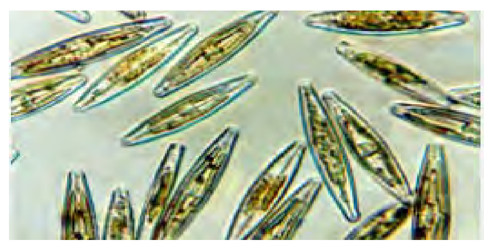
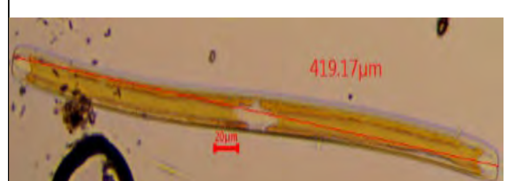
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Bacillariophyta	*Gomphonema*	338 (44.9%)	Alkiliphilous (1) Fresh (1) Organic pollution (2)	
Bacillariophyta	*Gyrosigma*	308 (40.9%)	Alkiliphilous (1)	
Bacillariophyta	*Melosira*	580 (77.0%)	Alkiliphilous (1) Fresh (1) Moderate DO (1) Eutrophic (1)	
Bacillariophyta	*Navicula*	629 (83.5%)	Alkiliphilous (1) Fresh – brackish (1) Organic pollution (smaller species) (2) Soft substrate (2)	
Bacillariophyta	*Nitzschia*	528 (70.1%)	Moderate DO (1) Eutrophic (1) Organic pollution (smaller species (2) Soft Substrate (2)	

Table 3-2 cont.

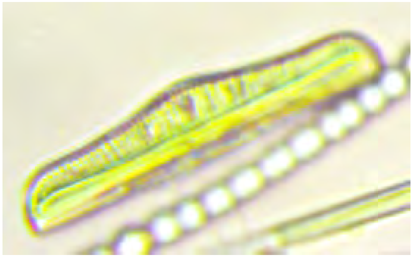
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Bacillariophyta	*Pinnularia*	144 (19.1%)	Soft substrate (2)	
Bacillariophyta	*Rhoicosphenia*	208 (27.6%)		
Bacillariophyta	*Rhopalodia*	134 (17.8%)	Alkilibiontic (1) Fresh (1) Moderate DO (1) Eutrophic (1) Nitrogen fixer	
Bacillariophyta	*Stephanodiscus*	9 (1.2%)		
Bacillariophyta	*Surirella*	123 (16.3%)	Alkiliphilous (1) Fresh (1) Moderate DO (1) Eutrophic (1)	
Bacillariophyta	*Synedra*	437 (58.0%)	Fresh (1) Organic pollution (1 & 2)	

Table 3-2 cont.

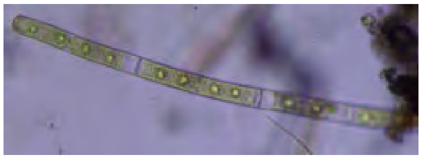
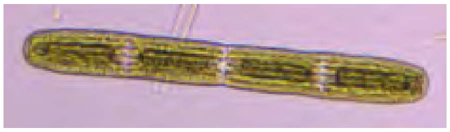
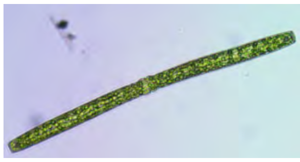
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Charophyta	*Closterium* sp.	364 (48.3%)	Oligotrophic (2) Low pH bogs (2)	
Charophyta	*Cosmarium*	62 (8.2%)	Oligotrophic (2) Low pH bogs (2)	
Charophyta	*Mougeotia*	192 (25.5%)	High and Low pH (2) Low nutrients (2)	
Charophyta	*Mougeotiopsis*	8 (1.1%)	Freshwater benthic	
Charophyta	*Penium*	1 (0.1%)	Oligotrophic (2) Low pH bogs (2)	
Charophyta	*Pleurotaenium*	3 (0.4%)	Oligotrophic (2) Low pH bogs (2)	

Table 3-2 cont.

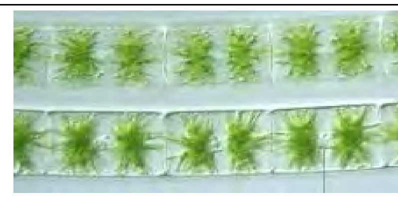
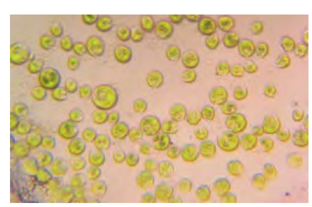
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Charophyta	*Spirogyra*	238 (31.6%)	Standing and running waters (2) Low pH bogs (2)	
Charophyta	*Staurastrum*	1 (0.1%)	Found in wetlands and acidic freshwater lakes/ponds	
Charophyta	*Zygnema*	15 (2.0%)	Shallow freshwater benthos	
Chlorophyta	*Actinastrum*	1 (0.1%)		
Chlorophyta	*Ankistrodesmus*	10 (1.3%)	Organic pollution (2)	
Chlorophyta	*Chlamydomonas*	70 (9.3%)		

Table 3-2 cont.

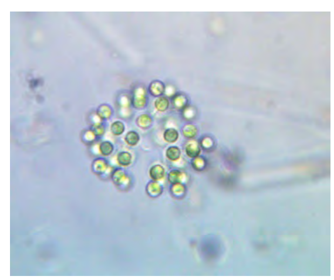
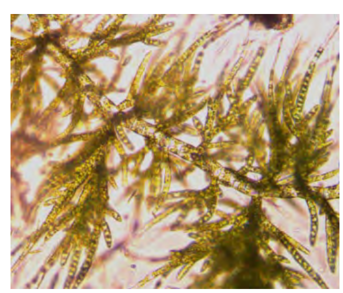
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Chlorophyta	*Cladophora* sp. (few species)	329 (43.7%)	Eutrophic to Hypertrophic (2)	
Chlorophyta	*Closteriopsis*	1 (0.1%)	Nutrient rich ponds or lakes Abundant in sewage ponds	
Chlorophyta	*Coelastrum*	20 (2.7%)	Planktonic, abundant in eutrophic conditions(2) Freshwater habitats from arctic to tropical	N 
Chlorophyta	*Dictyosphaerium*	3 (0.4%)		
Chlorophyta	*Draparnaldia*	8 (1.1%)	Clean freshwater sites in fast or slow moving water	

Table 3-2 cont.

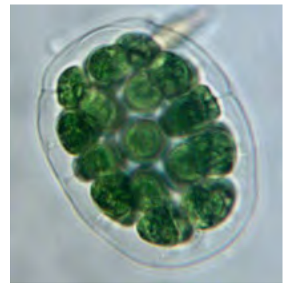
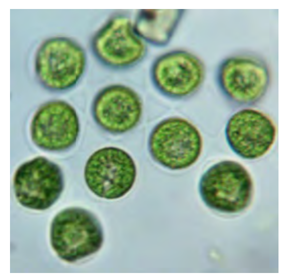
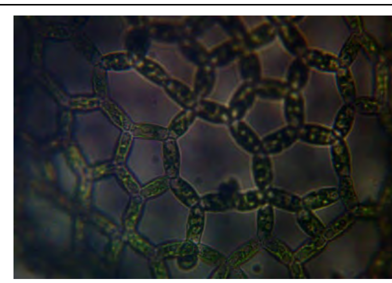
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Chlorophyta	*Eudorina*	9 **(1.2%)**	Nutrient rich ponds. Sewage ponds	
Chlorophyta	*Gonatozygon*	1 (0.1%)	Sphagnum-dominated bogs and acidic oligotrophic lakes	
Chlorophyta	*Gonium*	1 (0.1%)	Found in freshwater plankton, rocks and soil	
Chlorophyta	*Hydrodictyon*	15 (2.0%)	Hard water-high Ca concentration (2)	
Chlorophyta	*Microspora*	11 (1.5%)	Cool water (3) Low pH (3)	

Table 3-2 cont.

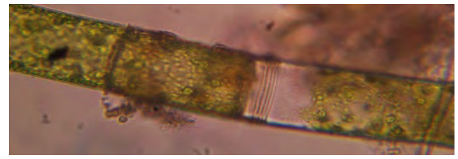
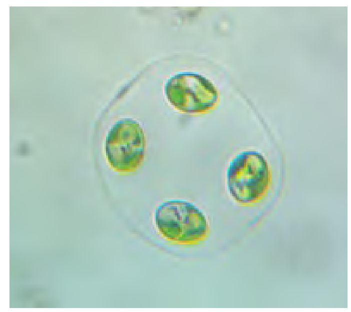
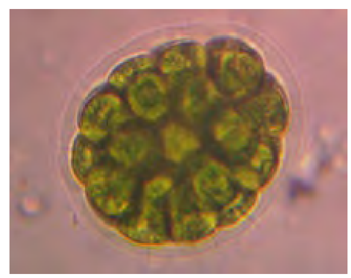
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Chlorophyta	*Oedogonium*	190 (25.2%)	Standing water (2)	
Chlorophyta	*Oocystis*	13 (1.7%)	Nutrient rich lakes and ponds Abundant in sewage ponds	
Chlorophyta	*Pandorina*	27 (3.6%)	Nutrient rich ponds including sewage ponds	
Chlorophyta	*Pediastrum* sp.	99 (13.1%)	Standing water (2) Eutrophic to Hypertrophic (1 & 2)	
Chlorophyta	*Scenedesmus* sp.	217 (28.8%)	Standing and running waters (2) Eutrophic to Hypertrophic (2) Organic pollution (2)	

Table 3-2 cont.

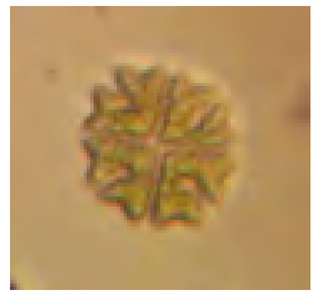
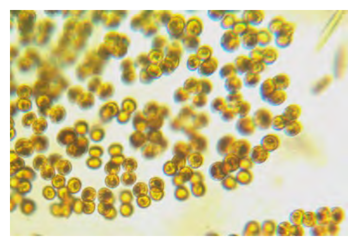
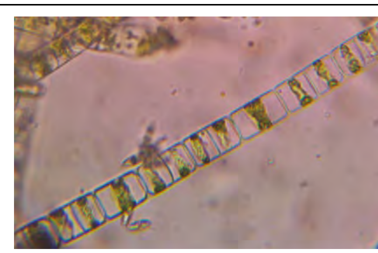
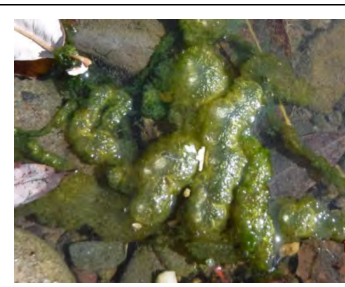
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Chlorophyta	*Selenastrum* sp.	33 (4.4%)	Standing waters-wetlands (2)	
Chlorophyta	Stauridium	20 (2.7%)		
Chlorophyta	*Stigeoclonium* sp.	228 (30.3%)	Organic pollution (2)	
Chlorophyta	*Tetraspora*	4 (0.5%)		
Chlorophyta	*Ulothrix* sp.	56 (7.4%)	Damp soil or stagnant water (3)	
Chlorophyta	*Ulva*	26 (3.5%)		

Table 3-2 cont.

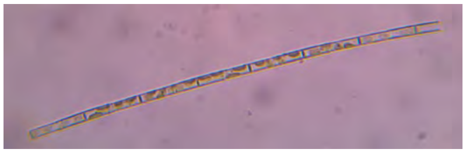
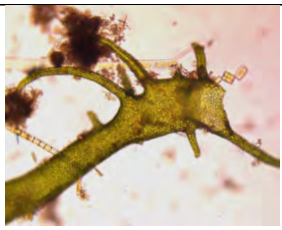
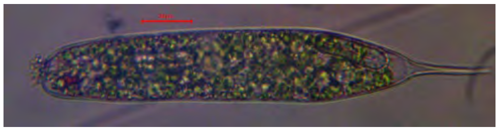
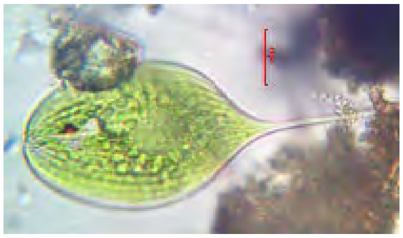
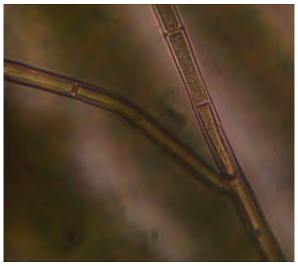
Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Xanthophyta	*Tribonema*	151 (20.1%)	Humic water (2)	
Xanthophyta	*Vaucheria*	37 (4.9%)	Brackish water (2)	
Dinoflagellata (taxonomy of *Ceratium* varies among sources)	*Ceratium*	13 (1.7%)	Hard water – high Ca concentrations (2) High P concentrations in deeper water (2)	
Euglenozoa	*Euglena*	36 (4.8%)	Eutrophic small water bodies Very high nutrients, i.e. sewage (2)	
Euglenozoa	*Lepocinclis*	5 (0.7%)	Eutrophic small water bodies Very high nutrients, i.e. sewage (2)	
Euglenozoa	Phacus	5 (0.7%)	Eutrophic small water bodies Very high nutrients, i.e. sewage (2)	

Table 3-2 cont.

Algae Division	Genus/Genera	No. Slides Genera Present (out of 753)	Bioindicator Type(s)	Photograph
Ochraphyta	*Dinobryon*	20 (2.7%)	Slightly acidic to strongly acidic water (2) Oligotrophic (2)	
Ochraphyta	*Mallomonas*	41 (5.4%)	Fresh water plankton in slow moving water. Can impart a foul taste and odor	
Ochraphyta	*Synura*	20 (2.7%)	Found in fresh water plankton in slow moving water Can impart a foul taste and odor	
Rhodophyta	*Audouinella*	147 (19.5%)	Polluted (3)	

1. Asarian, J.E. et al. 2014. *Spatial and Temporal Variation of Periphyton Assemblages in the Klamath River 2004-2012*. Prepared by Kier Associates, Portland State University, and Aquatic Ecosystem Sciences LLC. for the Klamath Basin Tribal Water Quality Work Group. 50p. + appendices.
2. Bellinger, E.G. and Sigee, D.C. 2015. *Freshwater Algae: Identification, Enumeration, and Use as Bioindicators*. 2nd edition. John Wiley and Sons, Ltd., Hoboken, New Jersey.
3. Wehr, J.D., Sheath, R.G., Kociolek, J.P. 2015. *Freshwater Algae of North America: Ecology and Classification*. 2nd edition. Elsevier, San Diego, CA.
4. www.cees.iupui.edu/research/algal-toxicology/cyanotoxins. January 23, 2017. "Cyanotoxin Fact Page." Center for Earth and Environmental Science, Indiana University-Purdue University, Indianapolis, IN.

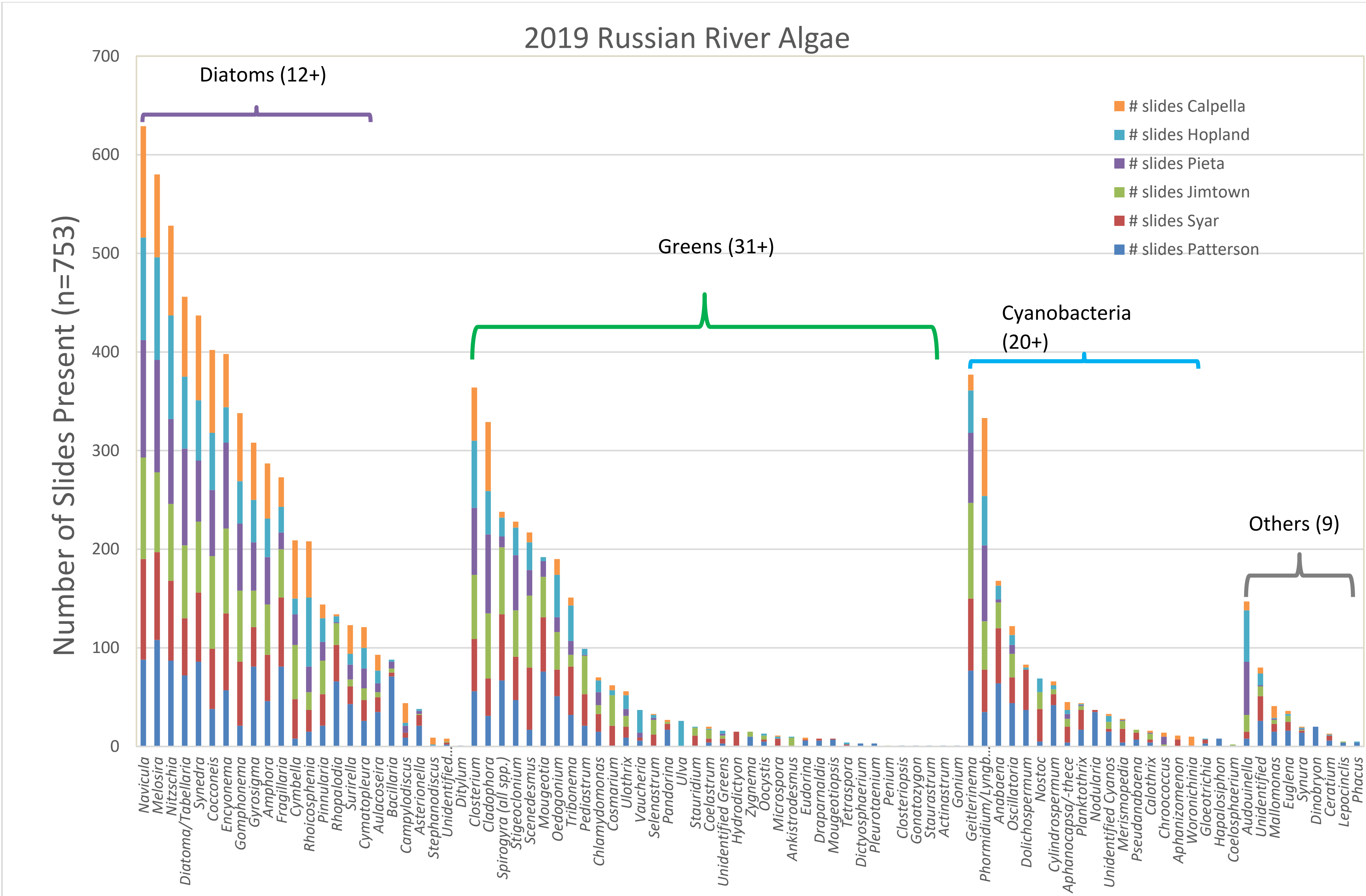


Figure 3-4. 2019 Russian River Algae Observed at Hopland, Jimtown, Syar, and Patterson Point Ambient Algae Sampling Stations.

The Hopland, Jimtown, and Patterson Point stations all had exceedances of the EPA criteria for Total Nitrogen during the ambient algae monitoring effort (Tables 3-3 through 3-5). Hopland had eight exceedances, and Jimtown and Patterson Point each had two exceedances that occurred during the first half of the season with flows ranging from 93.6 cfs to 3060 cfs at the Hopland, Jimtown and Hacienda USGS gages. By contrast, the Cloverdale and Syar stations did not have any exceedances of the EPA criteria (Tables 3-3 and 3-4). It should be noted that sampling did not begin at Cloverdale until 24 July.

Table 3-3. Sonoma Water 2019 Seasonal Mainstem Russian River Grab Sampling Results at Hopland and Cloverdale.

Hopland	Time	Temperature	pH	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Dissolved Solids	Turbidity***	Chlorophyll-a	USGS 11462500 RR near Hopland****
MDL*				0.200	0.10	0.00010	0.030	0.030	0.10		0.020	4.2	0.020	0.000050	Flow Rate*****
Date		°C		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)
5/15/2019	11:40	12.7	7.9	0.21	ND	ND	0.46	ND	0.21	**0.67**	**0.052**	120	**12**	ND	279
5/29/2019	10:40	15.6	7.8	0.21	ND	ND	0.39	ND	0.21	**0.60**	**0.042**	120	**9.3**	ND	282
6/12/2019	12:20	15.3	7.7	ND	ND	ND	0.31	ND	ND	**0.41**	**0.048**	110	**12**	0.0010	230
6/26/2019	11:40	15.3	7.6	ND	ND	ND	0.28	ND	ND	**0.42**	**0.039**	98	**10**	0.0016	163
7/10/2019	12:10	17.4	7.7	ND	ND	ND	0.50	ND	ND	**0.64**	**0.040**	120	**8.4**	0.0010	93.6
7/24/2019	13:30	15.9	7.7	0.61	ND	ND	0.27	ND	0.61	**0.88**	**0.045**	100	**14**	0.0015	152
8/7/2019	12:30	15.0	7.9	ND	ND	ND	0.22	ND	ND	**0.40**	**0.037**	99	**9.6**	0.0017	171
8/21/2019	12:20	14.6	7.9	ND	ND	ND	0.18	ND	0.23	**0.41**	**0.051**	110	**13**	ND	187
9/4/2019	11:30	14.3	8.0	ND	ND	ND	0.11	ND	ND	0.20	**0.079**	120	**11**	0.0010	181
9/18/2019	11:20	14.7	7.9	ND	ND	ND	0.088	ND	ND	0.26	**0.10**	120	**22**	**0.0061**	177
10/2/2019	11:10	13.2	7.7	0.21	ND	ND	0.098	ND	0.21	0.31	**0.12**	120	**29**	ND	184
10/16/2019	11:50	13.8	7.8	ND	ND	ND	0.11	ND	ND	0.28	**0.14**	110	**28**	**0.0023**	184

Cloverdale River Park	Time	Temperature	pH	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Dissolved Solids	Turbidity***	Chlorophyll-a	USGS 11463000 RR near Cloverdale***
MDL*				0.200	0.10	0.00010	0.030	0.030	0.10		0.020	4.2	0.020	0.000050	Flow Rate*****
Date		°C		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)
7/24/2019	11:20	21.0	8.0	ND	ND	ND	0.16	ND	ND	0.26	**0.026**	140	**5.1**	0.0015	139
8/7/2019	10:20	19.3	8.0	ND	ND	ND	0.14	ND	ND	0.28	**0.027**	120	**6.2**	**0.0020**	153
8/21/2019	10:20	18.1	8.0	ND	ND	ND	0.12	ND	ND	0.26	**0.035**	120	**7.6**	0.0016	182
9/4/2019	9:40	17.8	8.1	ND	ND	ND	0.082	ND	ND	0.22		120	**6.4**	**0.0025**	175
9/18/2019	9:50	16.8	7.9	ND	ND	ND	0.084	ND	ND	0.17	**0.069**	130	**12**	**0.0030**	175
10/2/2019	9:40	13.4	8.0	ND	ND	ND	0.088	ND	ND	0.19	**0.062**	140	**13**	**0.0032**	169
10/16/2019	10:00	13.2	8.1	ND	ND	ND	0.12	ND	ND	0.21	**0.079**	120	**15**	**0.0023**	176

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

*** Turbidity results after 6/16 were recorded using a YSI 6600 datasonde.

**** United States Geological Survey (USGS) Continuous-Record Gaging Station

***** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Chlorophyll *a*: 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Total Nitrogen: 0.38 mg/L

Turbidity: 2.34 FTU/NTU

Table 3-4. Sonoma Water 2019 Seasonal Mainstem Russian River Grab Sampling Results at Jimtown and Syar.

Jimtown	Time	Temperature	pH	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Dissolved Solids	Turbidity***	Chlorophyll-a	USGS 11463682 RR at Jimtown****
MDL*				0.200	0.10	0.00010	0.030	0.030	0.10		0.020	4.2	0.020	0.000050	Flow Rate*****
Date		°C		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)
5/15/2019	8:30	15.6	7.9	ND	ND	ND	0.48	ND	ND	**0.65**	**0.027**	170	**3.9**	ND	443
5/29/2019	9:00	16.8	7.7	ND	ND	ND	0.33	ND	ND	**0.40**	**0.037**	140	**6.6**	ND	681
6/12/2019	9:20	20.2	7.8	ND	ND	ND	0.14	ND	ND	0.21	0.018	180	**2.4**	**0.0026**	372
6/26/2019	9:00	19.7	7.7	ND	ND	ND	0.16	ND	ND	0.23	0.016	90	1.7	**0.0021**	224
7/10/2019	8:50	20.6	7.8	ND	ND	ND	0.15	ND	ND	0.29	0.017	150	1.4	0.0010	178
7/24/2019	10:40	21.4	7.6	ND	ND	ND	0.14	ND	ND	0.25	0.017	160	0.96	0.0012	147
8/7/2019	9:00	20.7	7.7	ND	ND	ND	0.084	ND	ND	0.22	0.014	150	1.7	0.0011	152
8/21/2019	9:00	20.2	7.8	ND	ND	ND	0.081	ND	ND	0.19	0.017	180	1.8	**0.0043**	174
9/4/2019	8:40	19.8	7.8	ND	ND	ND	0.066	ND	ND	0.21	**0.023**	140	**4.4**	**0.0054**	157
9/18/2019	8:40	19.0	7.7	ND	ND	ND	0.060	ND	ND	0.24	**0.032**	180	2.3	**0.017**	159
10/2/2019	8:20	14.8	7.6	ND	ND	ND	0.081	ND	ND	0.19	**0.031**	140	**3.6**	**0.0032**	160
10/16/2019	8:50	14.2	7.7	ND	ND	ND	0.094	ND	ND	0.094	**0.036**	140	**4.8**	**0.0040**	159

Syar	Time	Temperature	pH	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Dissolved Solids	Turbidity***	Chlorophyll-a	USGS 11465390 RR near Windsor***
MDL*				0.200	0.10	0.00010	0.030	0.030	0.10		0.020	4.2	0.020	0.000050	Flow Rate*****
Date		°C		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)
5/14/2019	12:10	17.0	8.0	ND	ND	ND	0.27	ND	ND	0.34	**0.081**	170	**3.4**	**0.0024**	682
5/21/2019	11:10	14.5	7.9	ND	ND	ND	0.11	ND	ND	0.28	**0.063**	130	**30**	0.0016	2520
5/28/2019	11:40	16.5	7.9	ND	ND	ND	0.21	ND	ND	0.28	**0.035**	140	**10**	0.0011	1270
6/4/2019	10:30	18.3	8.1	ND	ND	ND	0.16	ND	ND	0.30	**0.027**	130	**5.3**	0.0016	909
6/11/2019	11:10	20.2	7.9	ND	ND	ND	0.089	ND	ND	0.19	0.020	150	**3.4**	**0.0038**	608
6/18/2019	10:50	19.3	7.9	ND	ND	ND	0.10	ND	ND	0.14	**0.025**	140	**3.5**	**0.0032**	525
6/25/2019	11:50	20.9	7.9	ND	ND	ND	0.092	ND	ND	0.23	**0.028**	150	**3.8**	**0.0032**	341
7/2/2019	10:40	21.0	8.1	ND	ND	ND	0.085	ND	ND	0.19	0.020	150	2.0	0.0017	335
7/9/2019	12:40	21.6	8.1	ND	ND	ND	0.042	ND	ND	0.15	0.019	140	1.8	0.0010	308
7/16/2019	11:40	22.4	8.1	ND	ND	ND	0.069	ND	ND	0.17	0.019	170	**2.4**	**0.0059**	264
7/23/2019	11:30	21.2	8.2	ND	ND	ND	0.049	ND	ND	0.15	0.018	140	2.3	ND	250
7/30/2019	12:00	21.5	8.2	ND	ND	ND	0.056	ND	ND	0.13	0.020	140	2.2	0.0014	251
8/6/2019	12:00	21.3	8.2	ND	ND	ND	ND	ND	ND	0.13	**0.023**	98	**3.6**	ND	275
8/20/2019	11:30	20.2	8.2	ND	ND	ND	ND	ND	ND	0.085	**0.022**	110	**2.7**	**0.0026**	265
9/3/2019	11:50	22.0	8.3	ND	ND	ND	ND	ND	ND	0.21	**0.030**	140	**2.5**	**0.0028**	302
9/17/2019	11:10	18.5	8.0	ND	ND	ND	0.043	ND	ND	0.15	**0.022**	140	**3.0**	0.0016	243
10/1/2019	11:30	15.6	8.1	ND	ND	ND	0.057	ND	ND	0.13	0.020	130	**2.4**	ND	243
10/15/2019	11:30	14.0	8.2	ND	ND	ND	0.048	ND	ND	0.15	**0.022**	130	**2.7**	**0.0020**	256

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

*** Turbidity results after 6/16 were recorded using a YSI 6600 datasonde.

**** United States Geological Survey (USGS) Continuous-Record Gaging Station

***** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a*: 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

All five monitoring stations were observed to have exceedances of the EPA criteria for Total Phosphorous during the monitoring season (Tables 3-3 through 3-5). The station at Hopland was observed to have the highest concentrations of the stations, including a maximum value of 0.14 mg/L on 16 October, and exceeded the EPA criteria during the entire term of the Order under flows that ranged from 93.6 cfs to 282 cfs (Table 3-3 and Figure 3-5b). A maximum concentration of 0.079 mg/L also occurred on 16 October at the Cloverdale River Park station with a flow of 176 cfs (Table 3-3 and Figure 3-6b). The Jimtown station had two exceedances at the beginning of the season and four more at the end of the season; however, concentrations were significantly lower than those at Hopland and Cloverdale River Park (Table 3-4 and Figure 3-7b). Syar Vineyards had eleven exceedances during the season, including a maximum value of 0.081 mg/L, with flows ranging from 243 cfs to 2520 cfs (Table 3-5 and Figure 3-8b). Patterson Point exceeded the criteria throughout the season during open and closed conditions, including a maximum value of 0.13 mg/L, with flows ranging from 157 cfs to 3060 cfs (Table 3-5 and Figure 3-9b). While concentrations generally increased through the season at Hopland and Cloverdale River Park, they remained relatively level at Jimtown, Syar Vineyards, and Patterson Point, with the exception of samples collected during May storm events.

Table 3-5. Sonoma Water 2019 Seasonal Mainstem Russian River Grab Sampling Results at Patterson Point.

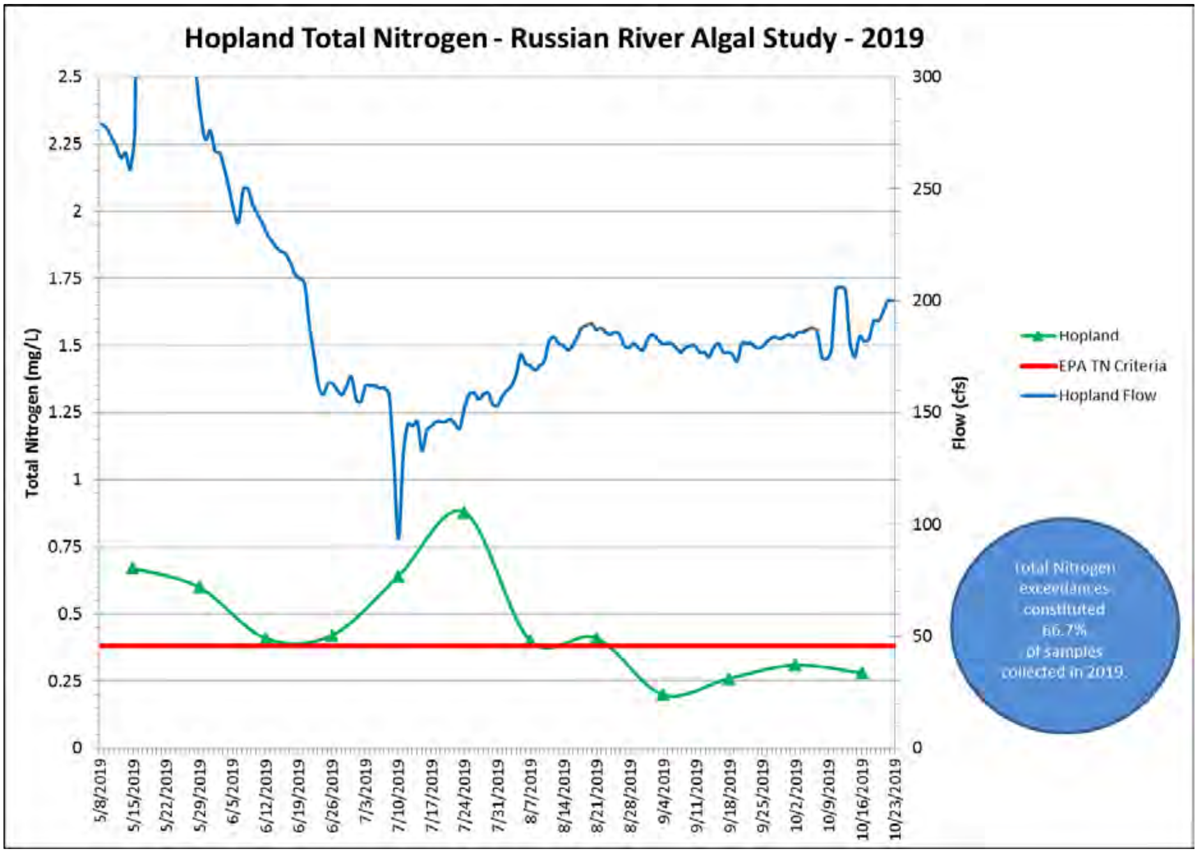
Patterson Point	Time	Temperature	pH	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Dissolved Solids	Turbidity***	Chlorophyll-a	USGS 11467000 RR near Guerneville (Hacienda)***
MDL*				0.200	0.10	0.00010	0.030	0.030	0.10		0.020	4.2	0.020	0.000050	Flow Rate*****
Date		°C		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)
5/14/2019	8:30	18.7	7.9	ND	ND	ND	0.20	ND	ND	**0.38**	**0.11**	170	**3.3**	**0.0031**	610
5/21/2019	9:20	14.6	7.8	0.26	ND	ND	0.12	ND	0.26	**0.38**	**0.13**	150	**50**	ND	3060
5/28/2019	8:50	17.0	7.7	ND	ND	ND	0.20	ND	ND	0.30	**0.063**	140	**13**	**0.0023**	1300
6/4/2019	8:40	18.5	7.9	ND	ND	ND	0.16	ND	ND	0.34	**0.059**	140	**7.1**	**0.0026**	867
6/11/2019	8:50	21.3	8.1	0.26	ND	ND	ND	ND	0.26	0.30	**0.035**	160	**3.3**	**0.0069**	576
6/18/2019	8:40	20.6	7.9	ND	ND	ND	0.050	ND	ND	0.19	**0.032**	130	**2.5**	**0.0021**	487
6/25/2019	8:50	22.7	8.1	ND	ND	ND	ND	ND	ND	0.18	**0.036**	160	**2.6**	**0.0037**	294
7/2/2019	8:30	22.8	8.0	ND	ND	ND	ND	ND	ND	0.21	**0.034**	150	2.2	**0.0074**	273
7/9/2019	9:30	22.5	8.1	ND	ND	ND	ND	ND	ND	0.20	**0.034**	150	1.6	**0.0022**	235
7/16/2019	8:40	24.5	7.8	ND	ND	ND	ND	ND	ND	0.10	**0.038**	170	**3.1**	**0.0062**	184
7/23/2019	8:40	22.8	7.9	ND	ND	ND	ND	ND	ND	0.15	**0.036**	190	**2.7**	**0.0052**	170
7/30/2019	9:20	24.2	7.8	ND	ND	ND	0.040	ND	ND	0.18	**0.043**	140	1.7	**0.0036**	160
8/6/2019	9:00	23.1	7.8	ND	ND	ND	ND	ND	ND	0.070	**0.037**	110	**2.4**	ND	157
8/20/2019	9:00	22.9	7.9	ND	ND	ND	ND	ND	ND	0.0047	**0.036**	140	2.0	0.0016	157
9/3/2019	9:20	22.8	7.8	ND	ND	ND	ND	ND	ND	0.070	**0.033**	130	**2.4**	0.0012	193
9/17/2019	8:30	21.1	7.9	ND	ND	ND	ND	ND	ND	0.10	**0.025**	140	1.6	ND	158
10/1/2019	8:40	17.2	7.8	ND	ND	ND	ND	ND	ND	0.070	0.020	130	1.3	0.0012	165
10/15/2019	9:00	14.5	7.8	ND	ND	ND	ND	ND	ND	0.070	0.020	110	2.0	ND	188

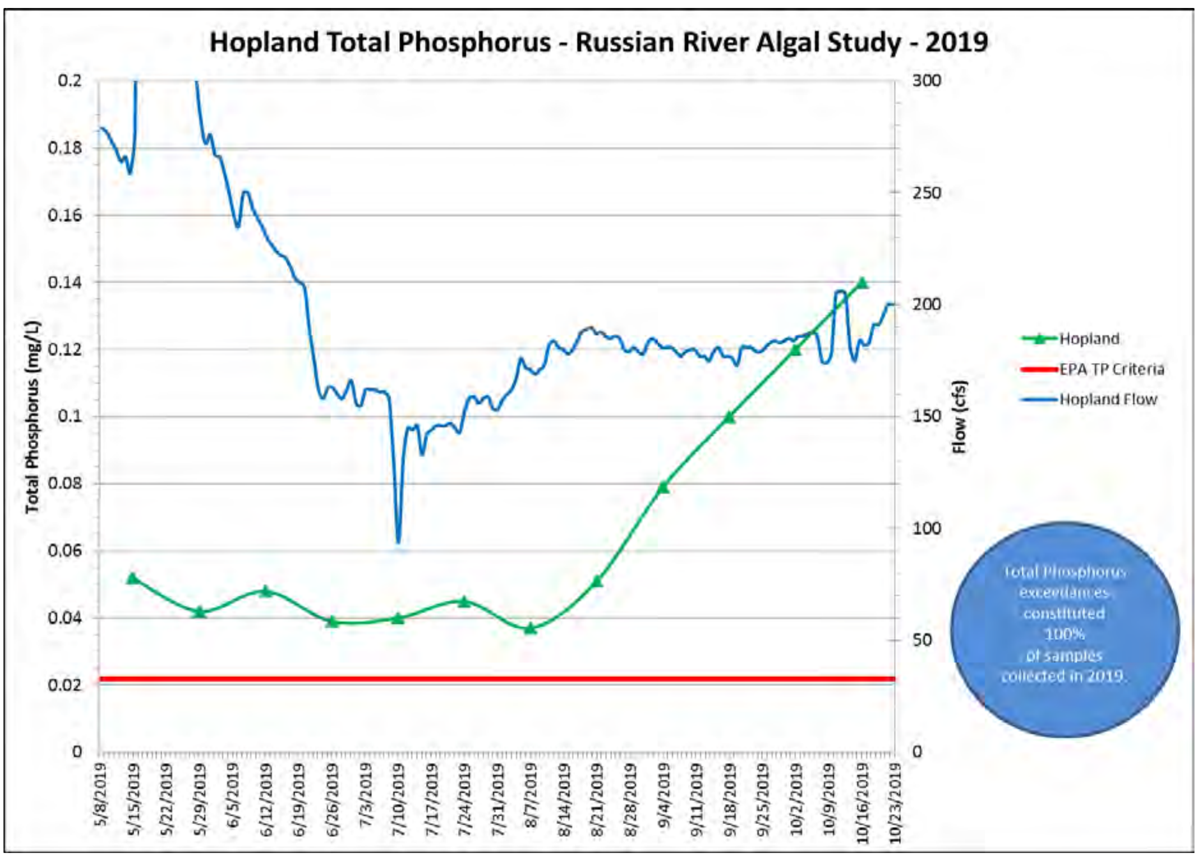
* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.
** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.
*** Turbidity results after 6/16 were recorded using a YSI 6600 datasonde.
**** United States Geological Survey (USGS) Continuous-Record Gaging Station
***** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a*: 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

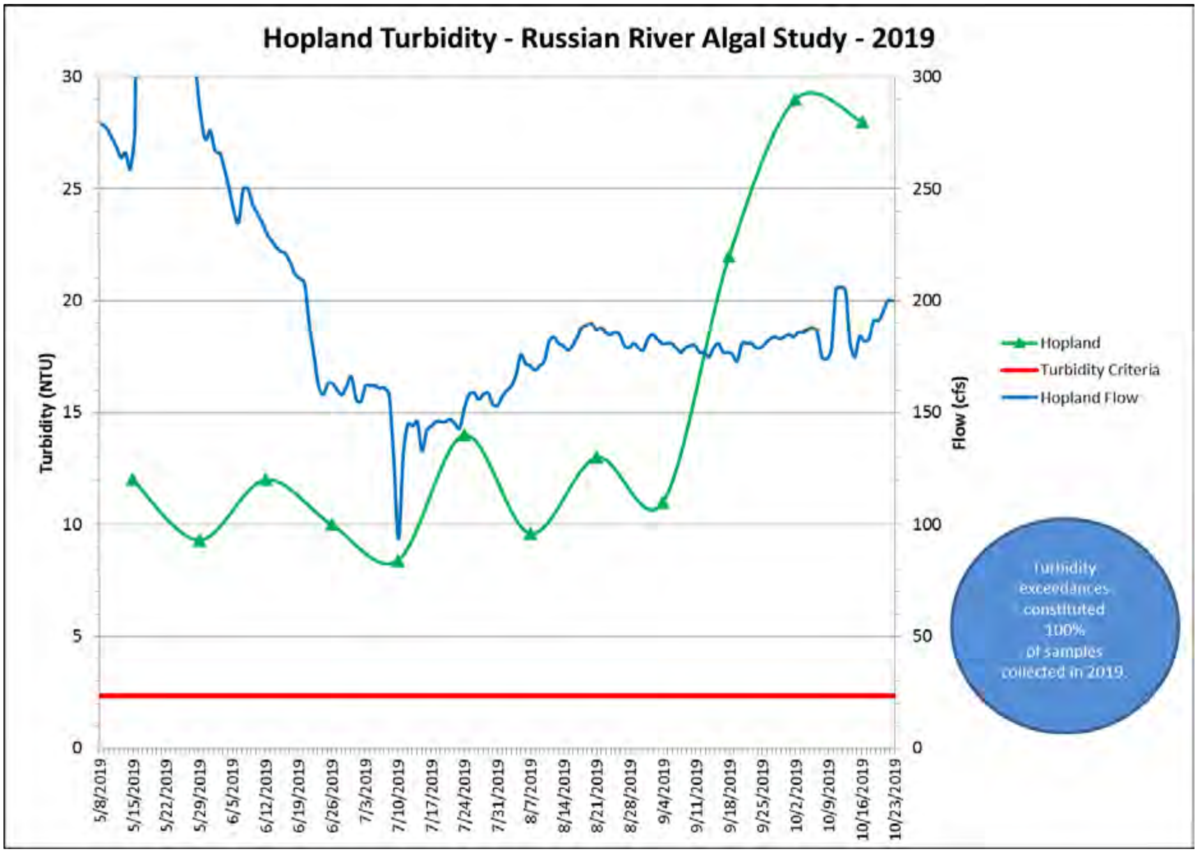
Turbidity levels exceeded the Turbidity EPA criteria during the entire monitoring season at the Hopland and Cloverdale River Park stations (Table 3-3). Values were observed to generally increase through the season at these stations, similar to the pattern observed for Total Phosphorus (Figures 3-5b, 3-6b, 3-5c, and 3-6c). The maximum values observed occurred at Hopland on 2 October with a value of 29 NTU, and at Cloverdale River Park on 16 October with a value of 15 NTU (Table 3-3). Turbidity values at Jimtown were observed to increase during the May storms before decreasing through mid-season and increasing again toward the end of the season (Table 3-4). Values exceeded the EPA criteria during the May storms and latter half of the season with a maximum value of 6.6 NTU that occurred on 29 May with a flow of 681 cfs (Table 3-4 and Figure 3-7c). 2019 represents the second season where increasing turbidity values appear to be associated with increasing Total Phosphorus values at Hopland and Cloverdale River Park, and possibly Jimtown (Figures 3-5c through 3-7c). Additional data will continue to be collected to potentially determine if there is a positive correlation. The Syar Vineyards station exceeded the EPA criteria a majority of the time with flows ranging from 243 to 2520 cfs (Table 3-4). A maximum value of 30 NTU was observed on 21 May at Syar Vineyards during the May storms with a flow of 2520 cfs (Table 3-4 and Figure 3-8c). The Patterson Point station exceeded the turbidity criteria eleven times, including during and following the May storm events, with a maximum value of 50 NTU observed on 21 May with a flow of 3060 cfs (Table 3-5). Patterson Point was observed to exceed the turbidity criteria during open and closed estuary conditions, but not during summer dam removal, with flows ranging from 157 to 3060 cfs (Table 3-5 and Figure 3-9c).

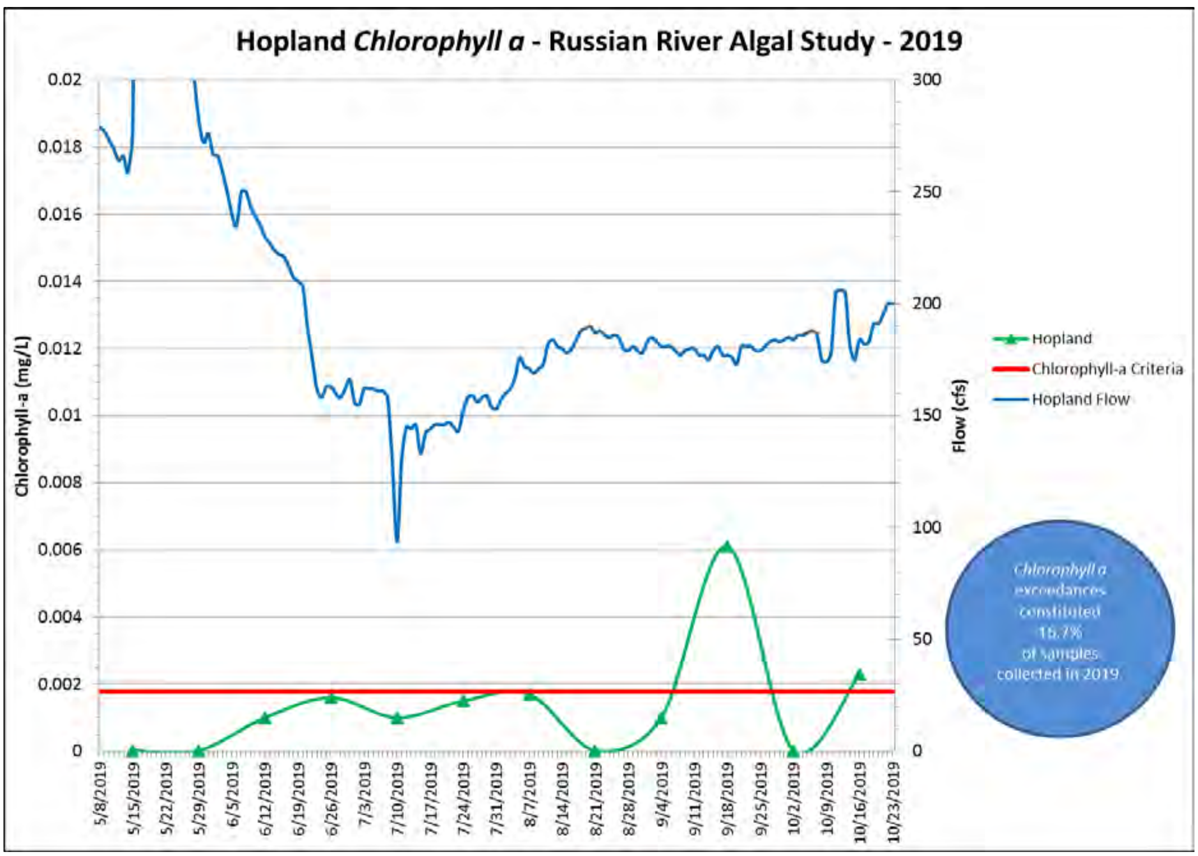
Chlorophyll a (used as an indicator for algae) results were observed to periodically exceed the EPA criteria at all five stations during the season, with flows that ranged from 153 cfs to 1300 cfs (Tables 3-3 through 3-5). Hopland had two exceedances, including a maximum value of 0.0061 mg/L that occurred on 18 September with a flow of 177 cfs (Table 3-3 and Figure 3-5d). Cloverdale River Park had five exceedances, including a maximum value of 0.0032 mg/L that occurred on 2 October with a flow of 169 cfs (Table 3-3 and Figure 3-6d). Jimtown had seven exceedances, including a maximum value of 0.017 mg/L that occurred on 18 September with a flow of 159 cfs (Table 3-4 and Figure 3-7d). Syar Vineyards had eight *chlorophyll a* exceedances, including a maximum value of 0.0059 mg/L that occurred on 16 July with a flow of 264 cfs (Table 3-4 and Figure 3-8d). Patterson Point had eleven *chlorophyll a* exceedances, including a maximum value of 0.0074 mg/L that occurred during open estuary conditions on 2 July with a flow of 273 cfs at Hacienda (Table 3-5 and Figure 3-9d).



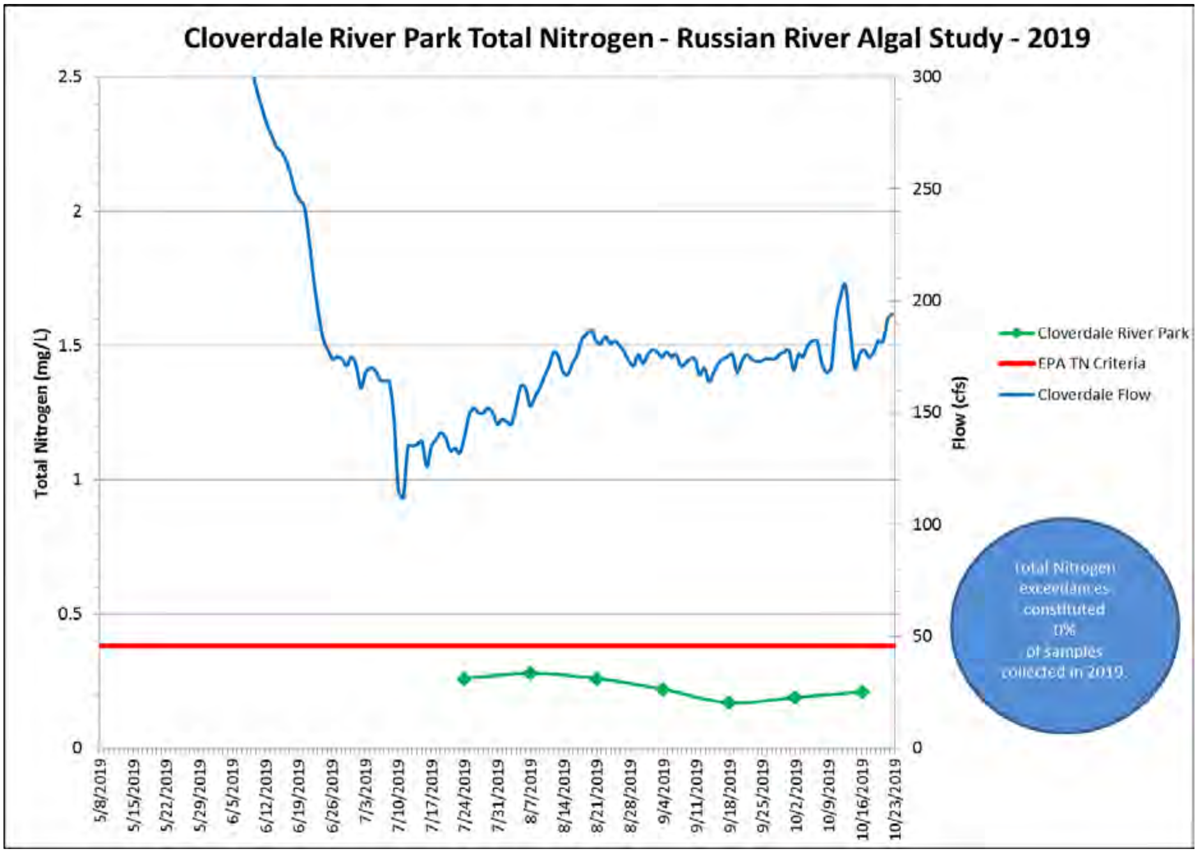


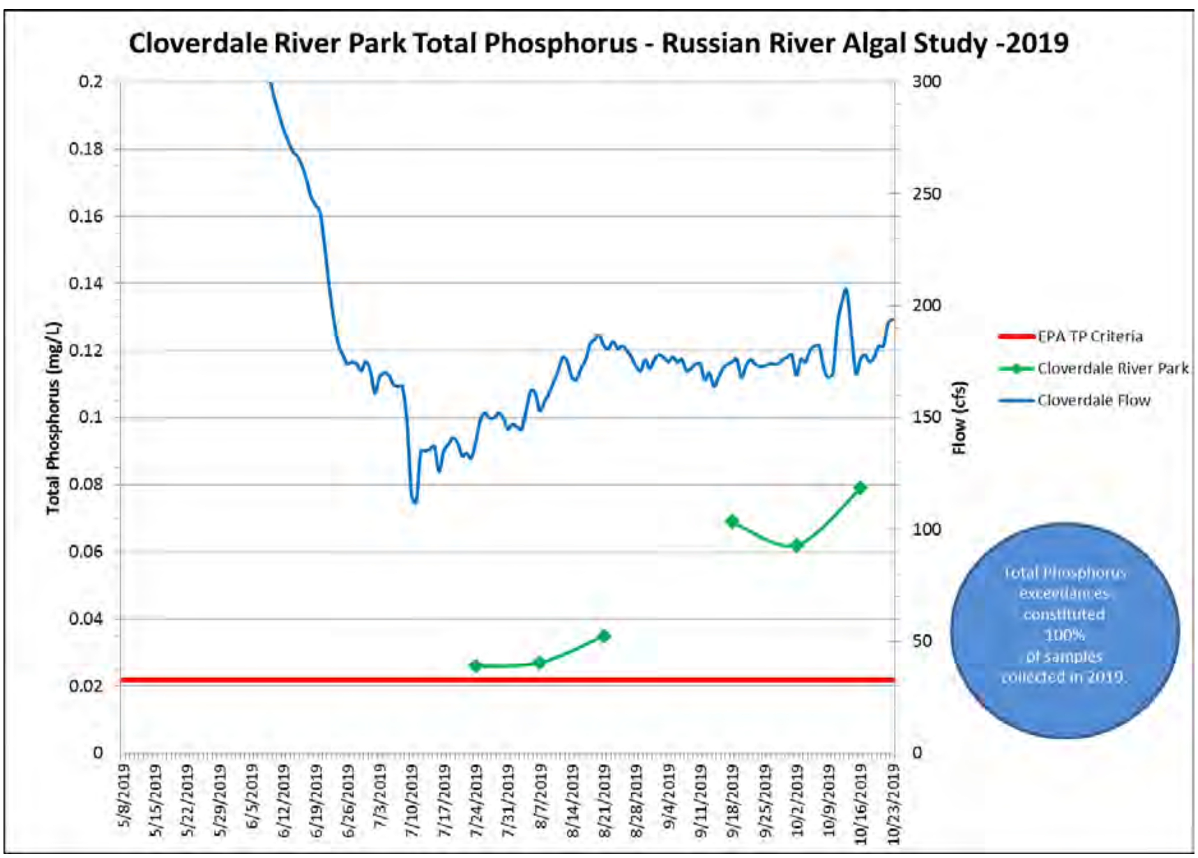
Figures 3-5 a and b. Sonoma Water Seasonal Mainstem Russian River Grab Sampling Total Nitrogen and Total Phosphorus Results from Hopland in 2019.



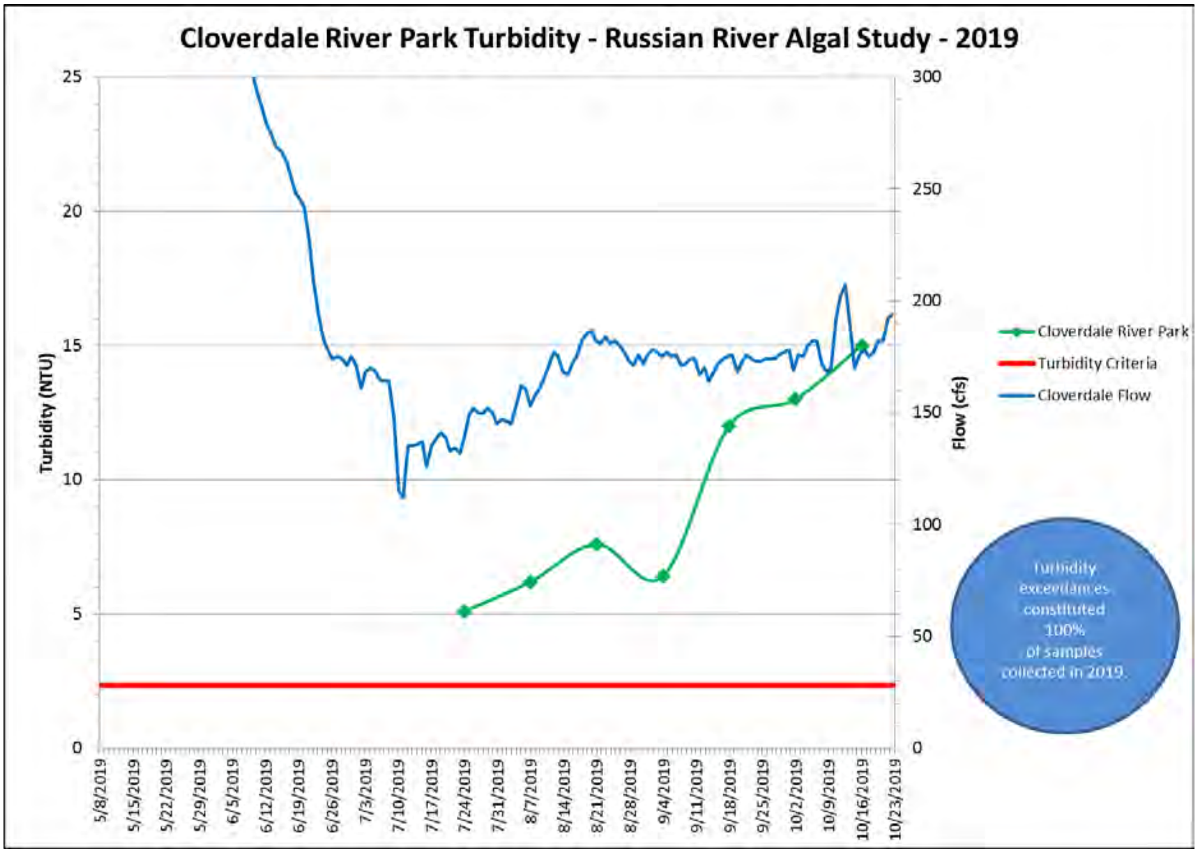


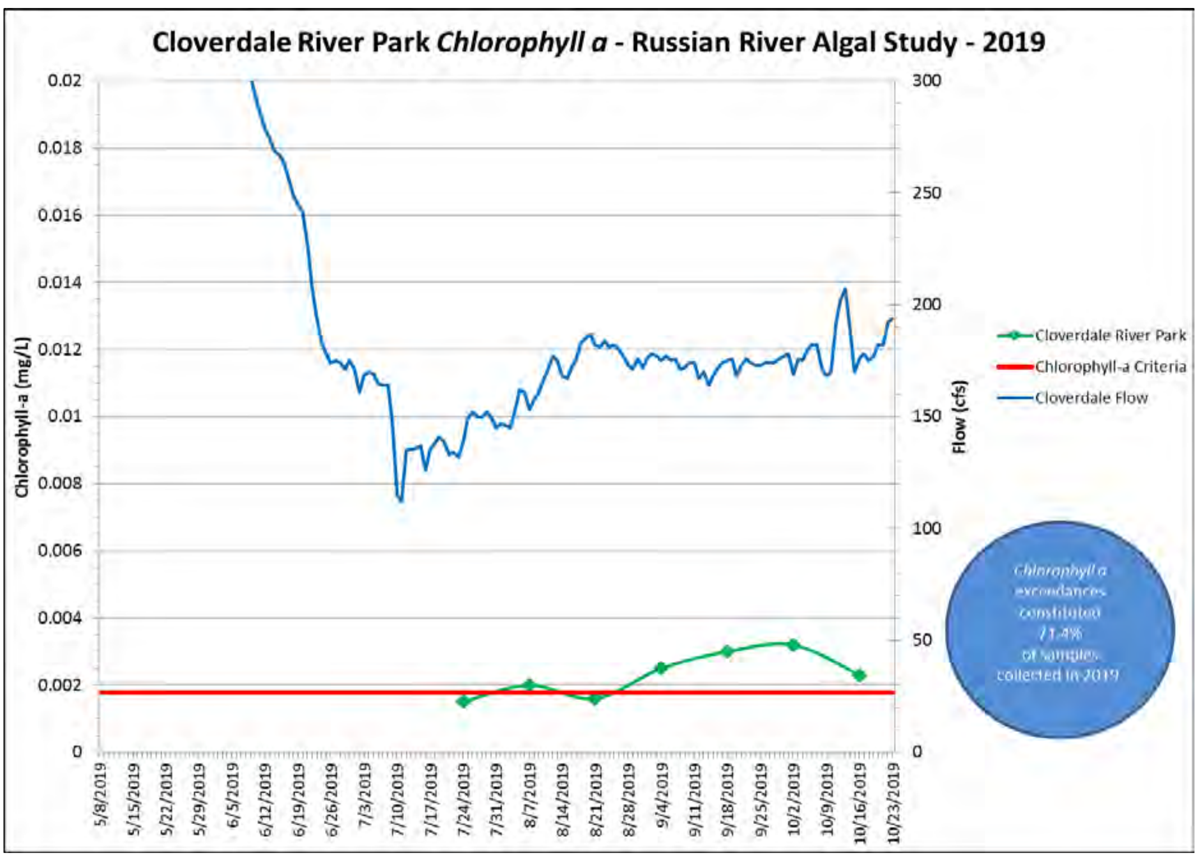
Figures 3-5 c and d. Sonoma Water Seasonal Mainstem Russian River Grab Sampling Turbidity and *Chlorophyll a* Results from Hopland in 2019.



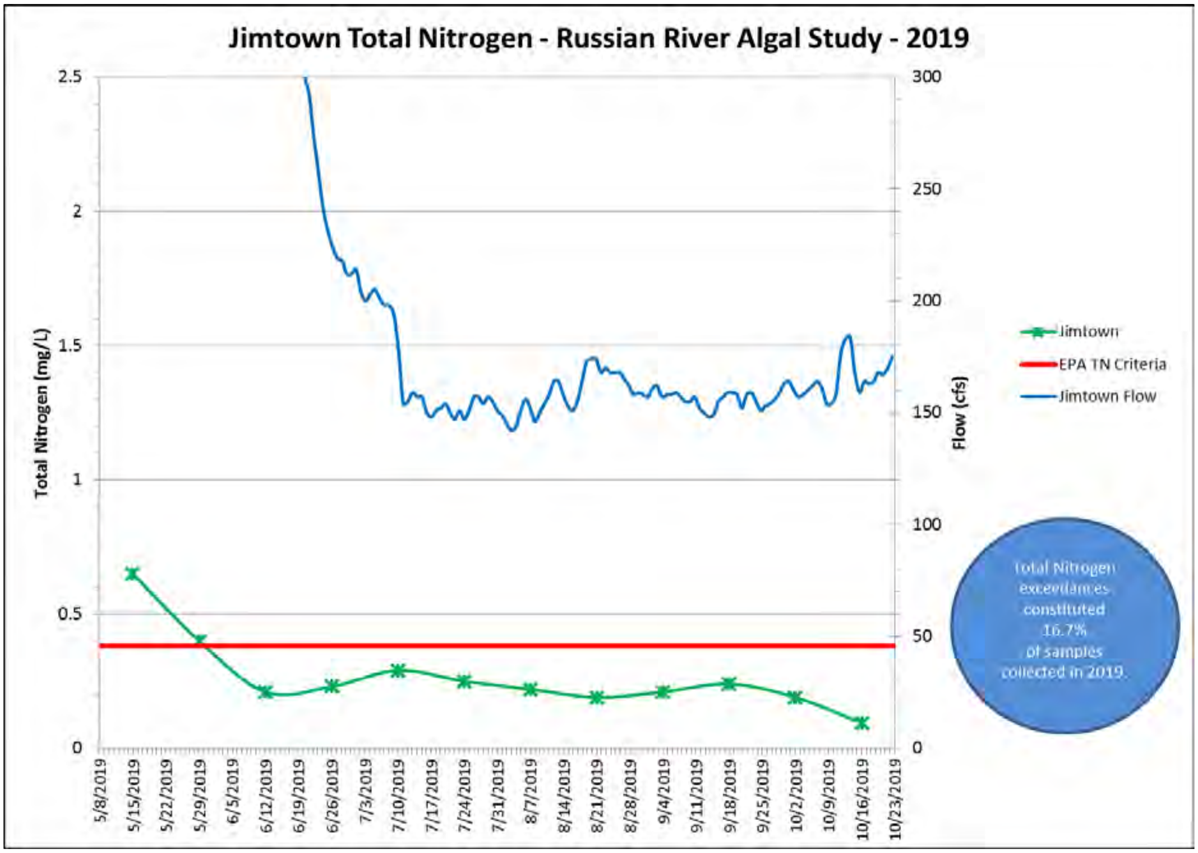


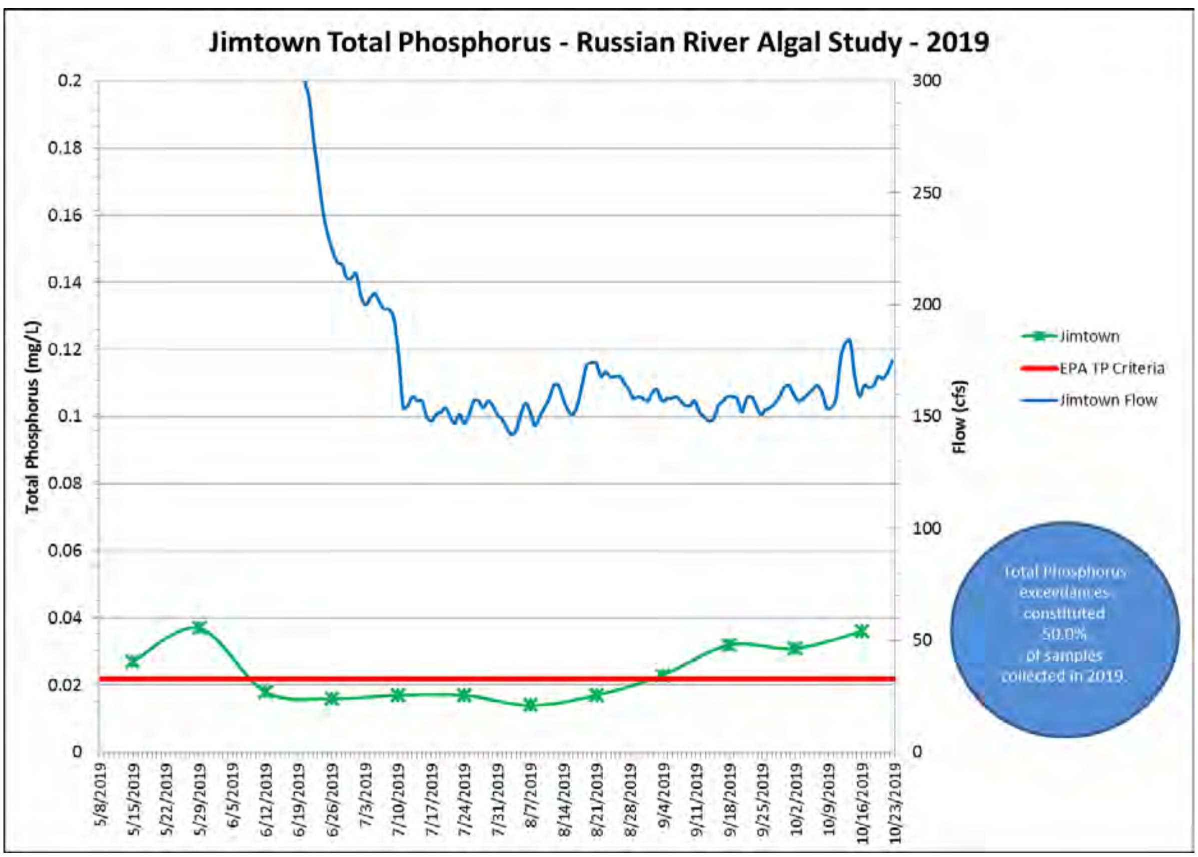
Figures 3-6 a and b. Sonoma Water Seasonal Mainstem Russian River Grab Sampling Total Nitrogen and Total Phosphorus Results from Cloverdale River Park in 2019.



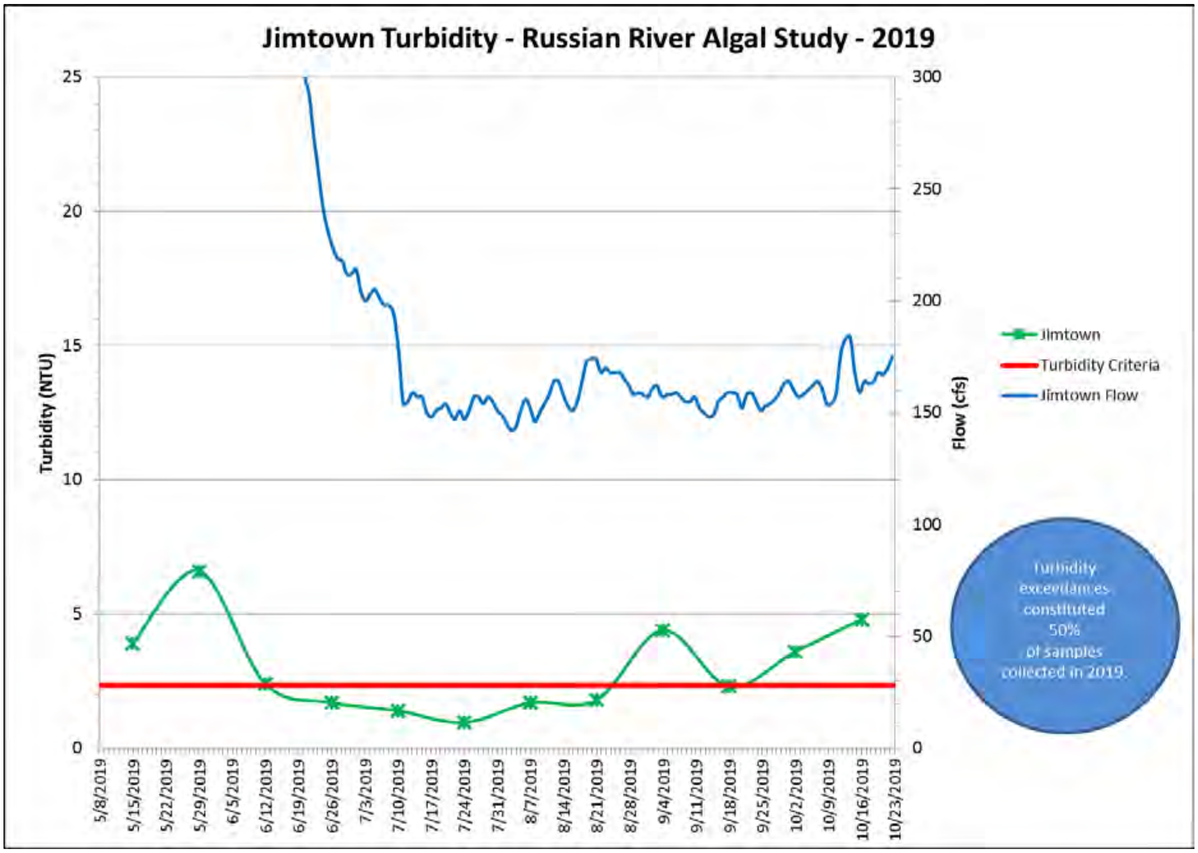


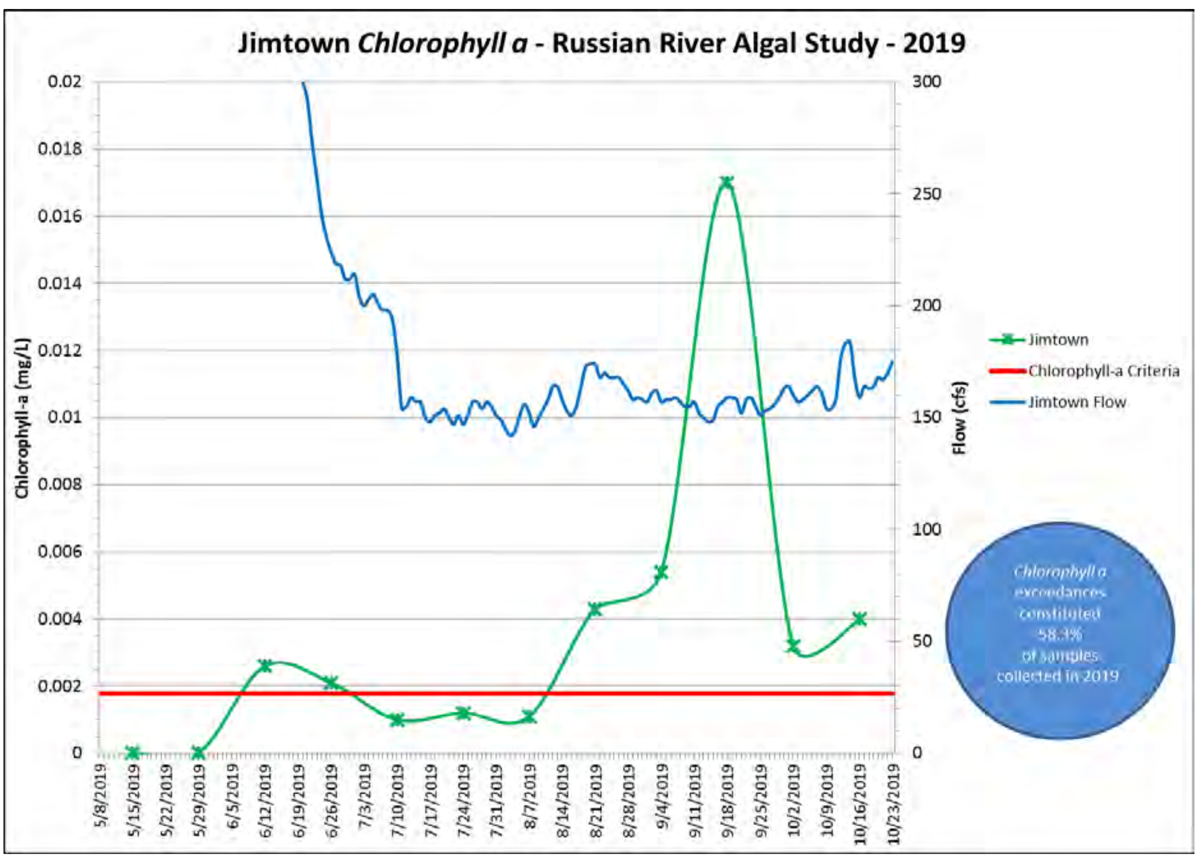
Figures 3-6 c and d. Sonoma Water Seasonal Mainstem Russian River Grab Sampling Turbidity and *Chlorophyll a* Results from Cloverdale River Park in 2019.



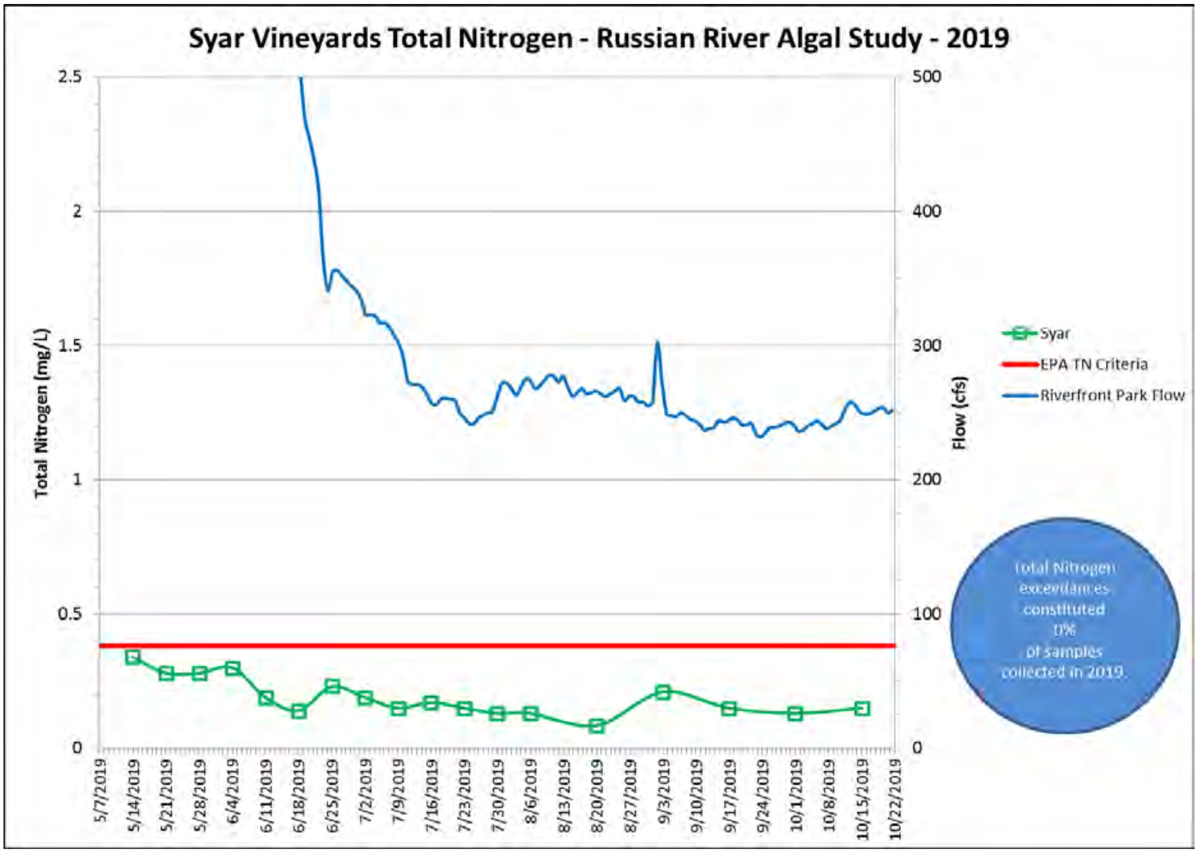


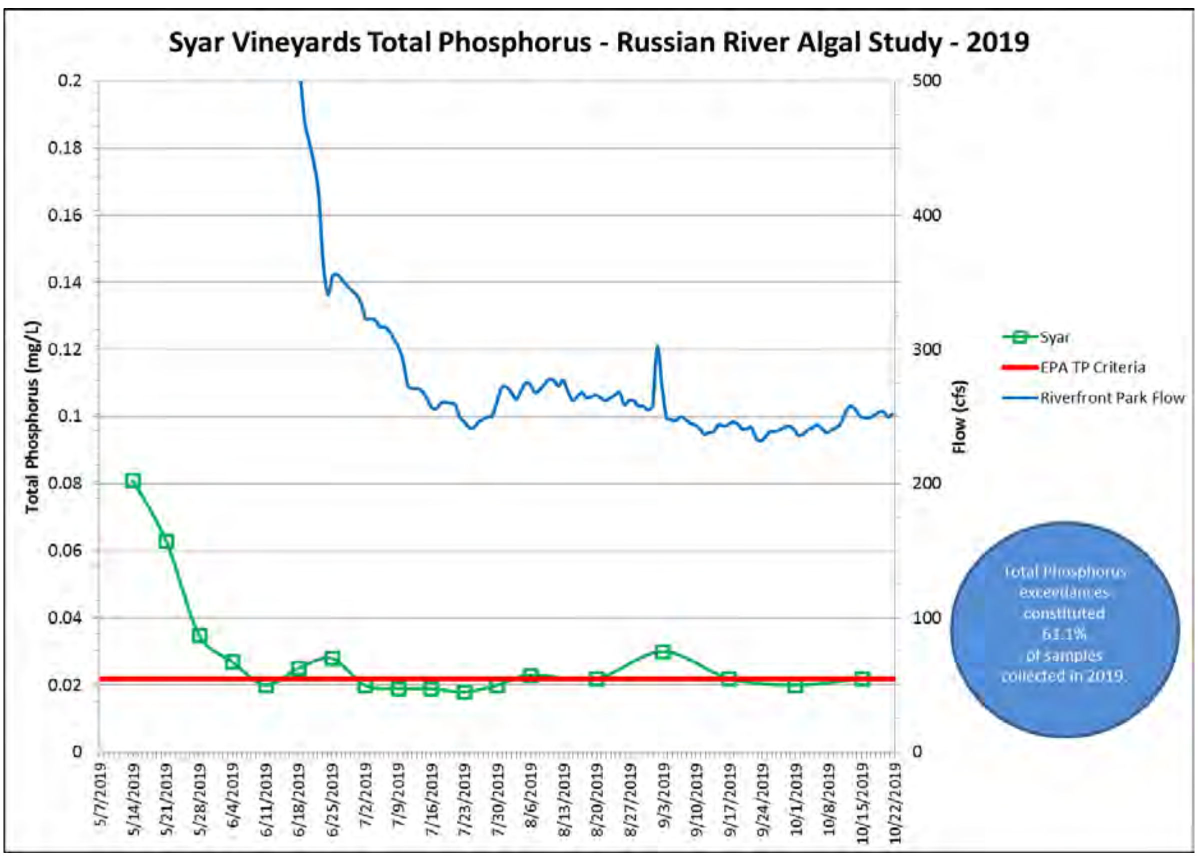
Figures 3-7 a and b. Sonoma Water Seasonal Mainstem Russian River Grab Sampling Total Nitrogen and Total Phosphorus Results from Jimtown in 2019.



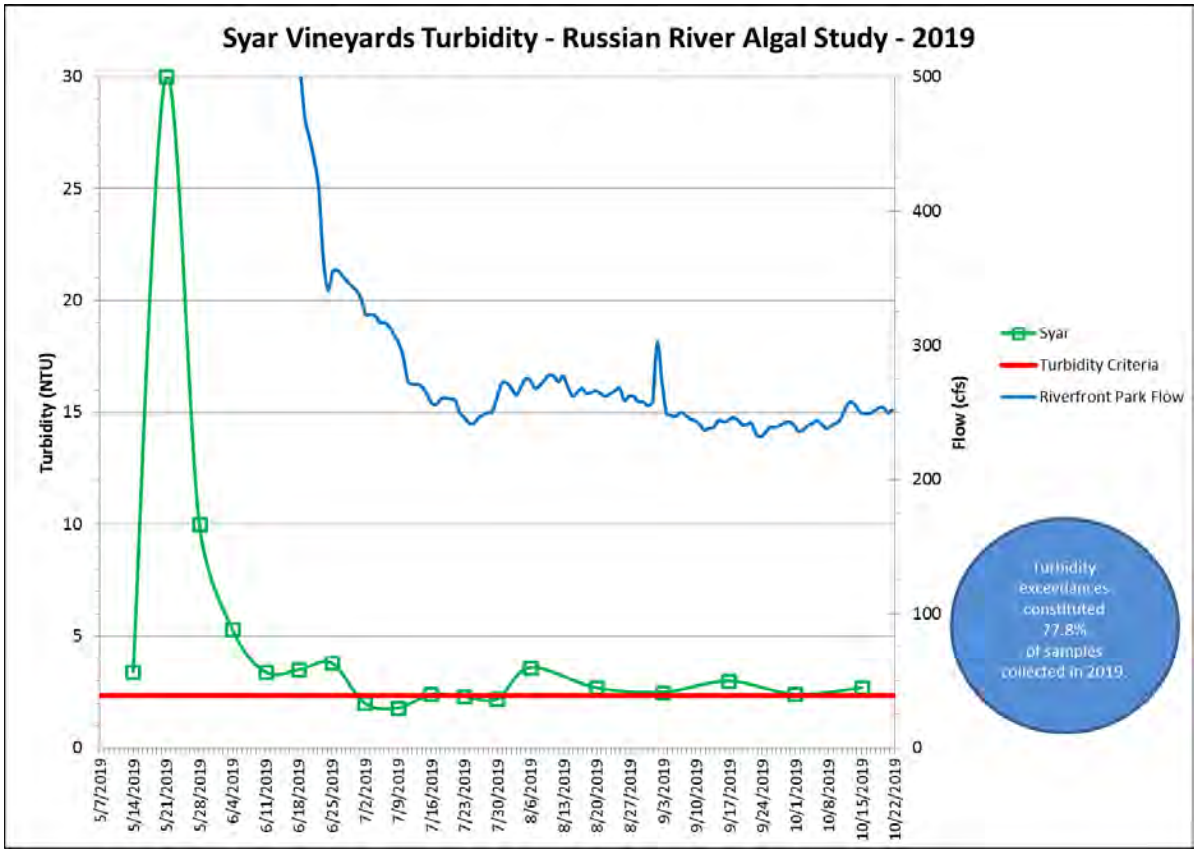


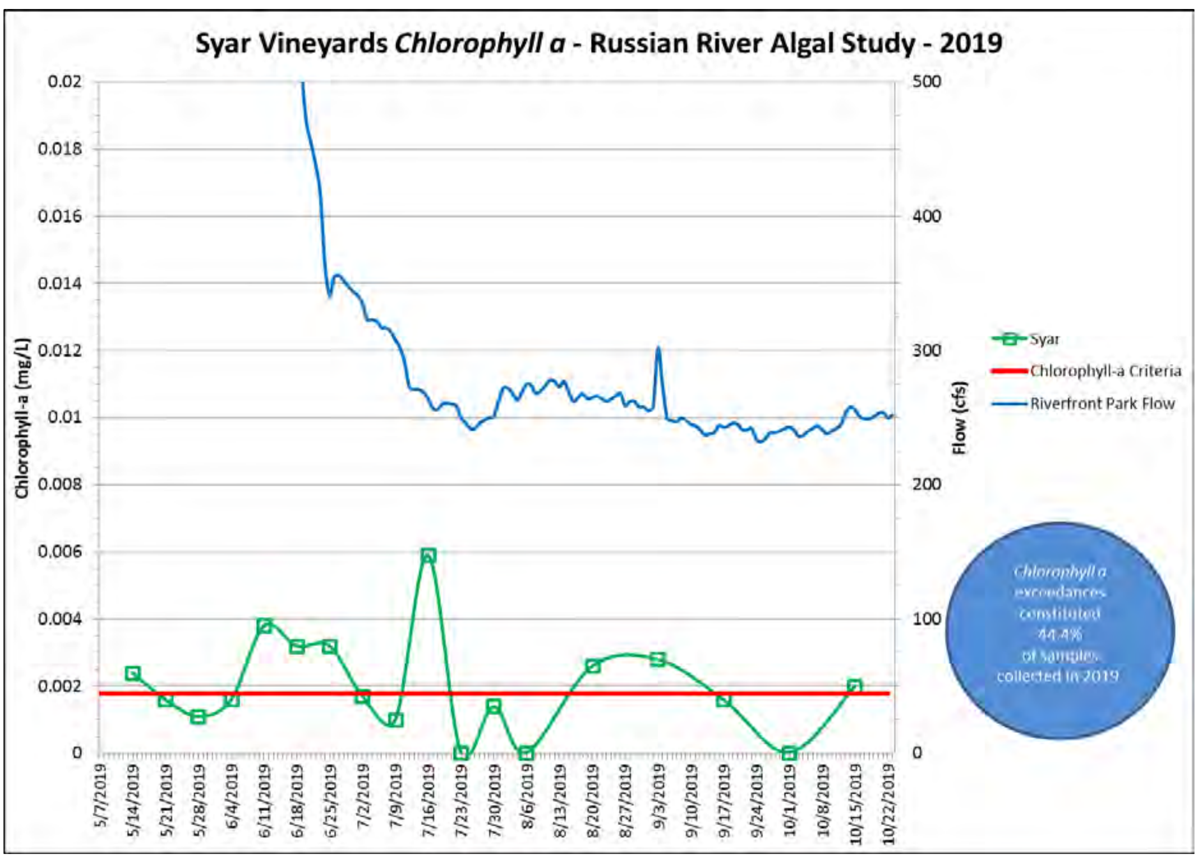
Figures 3-7 c and d. Sonoma Water Seasonal Mainstem Russian River Grab Sampling Turbidity and *Chlorophyll-a* Results from Jimtown in 2019.



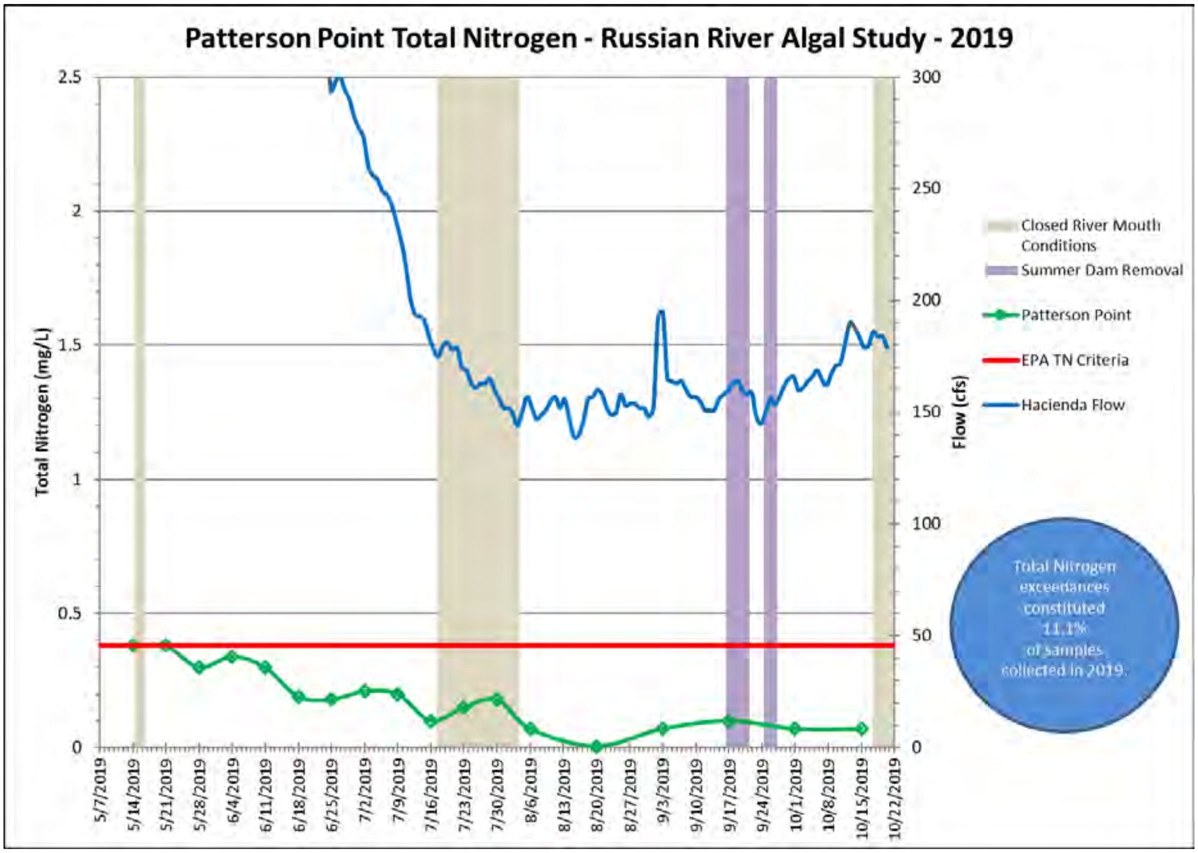


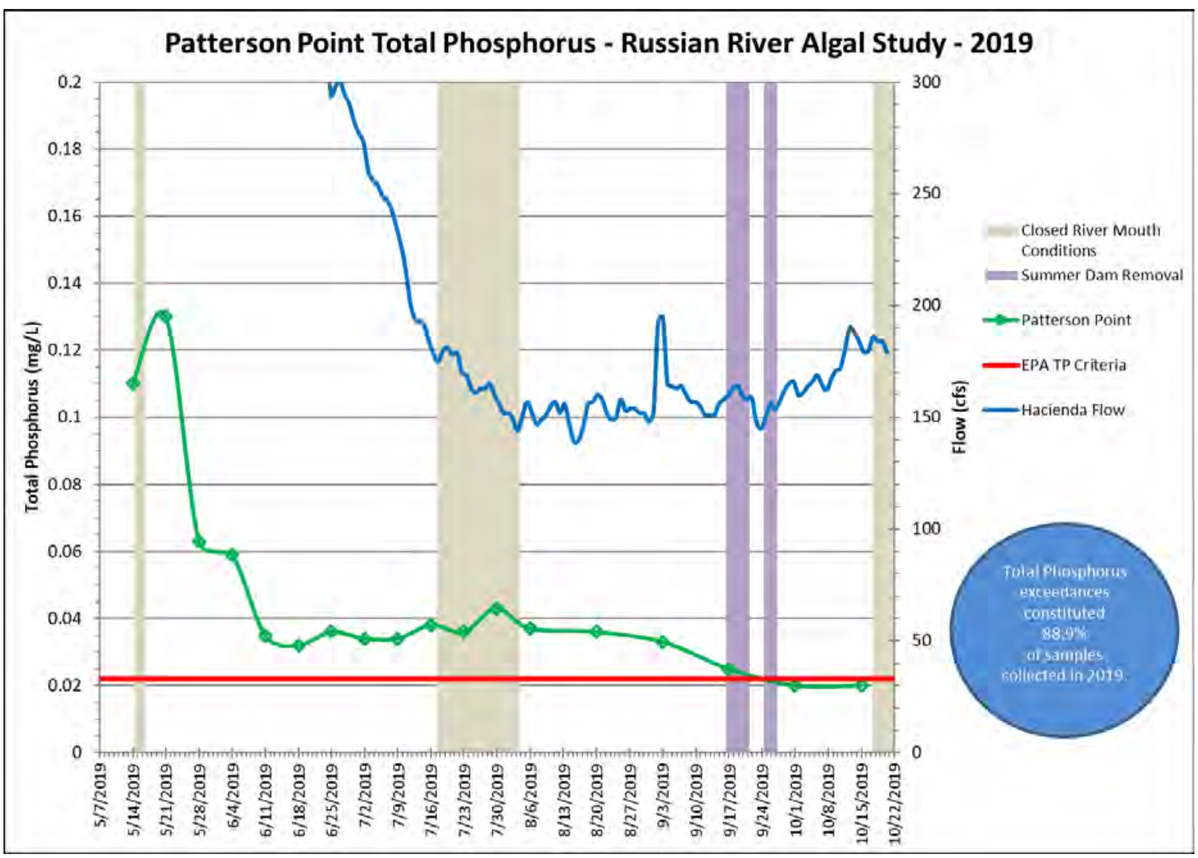
Figures 3-8 a and b. Sonoma Water Seasonal Mainstem Russian River Grab Sampling Total Nitrogen and Total Phosphorus Results from Syar Vineyards in 2019.



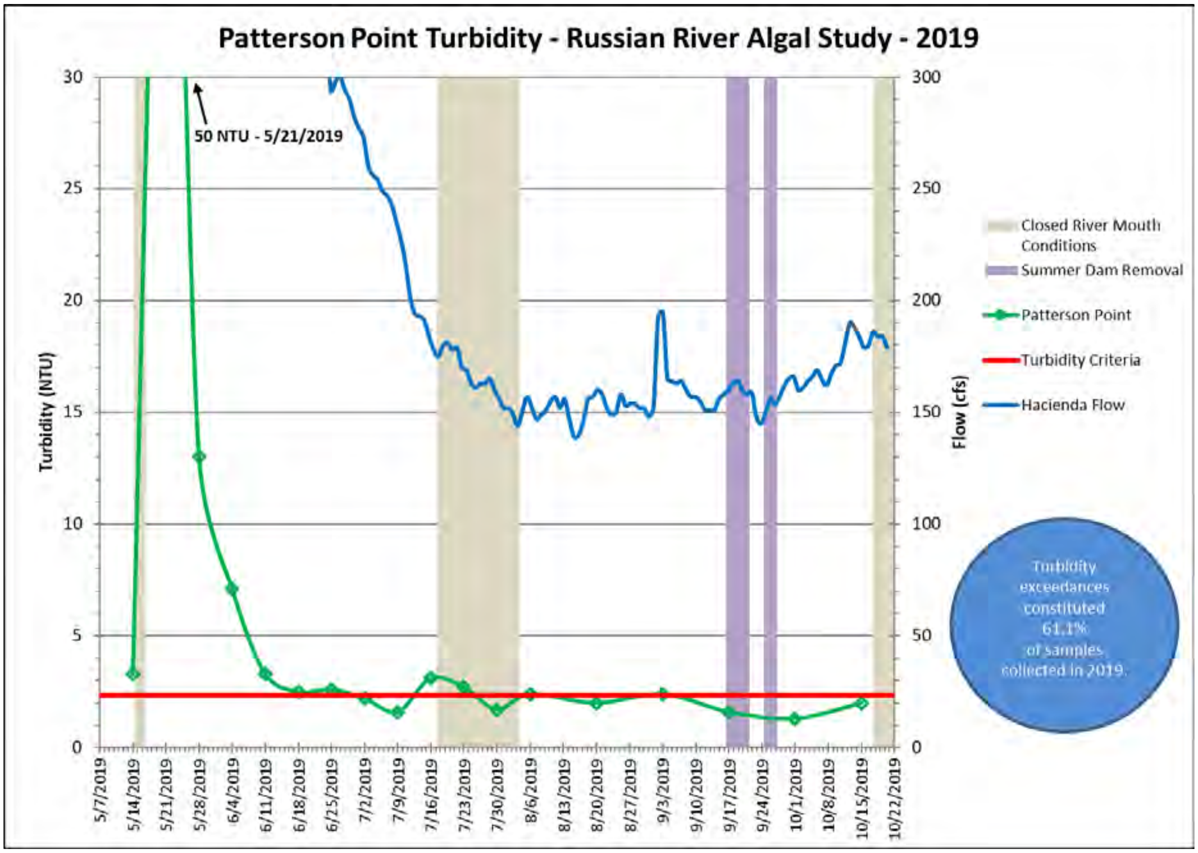


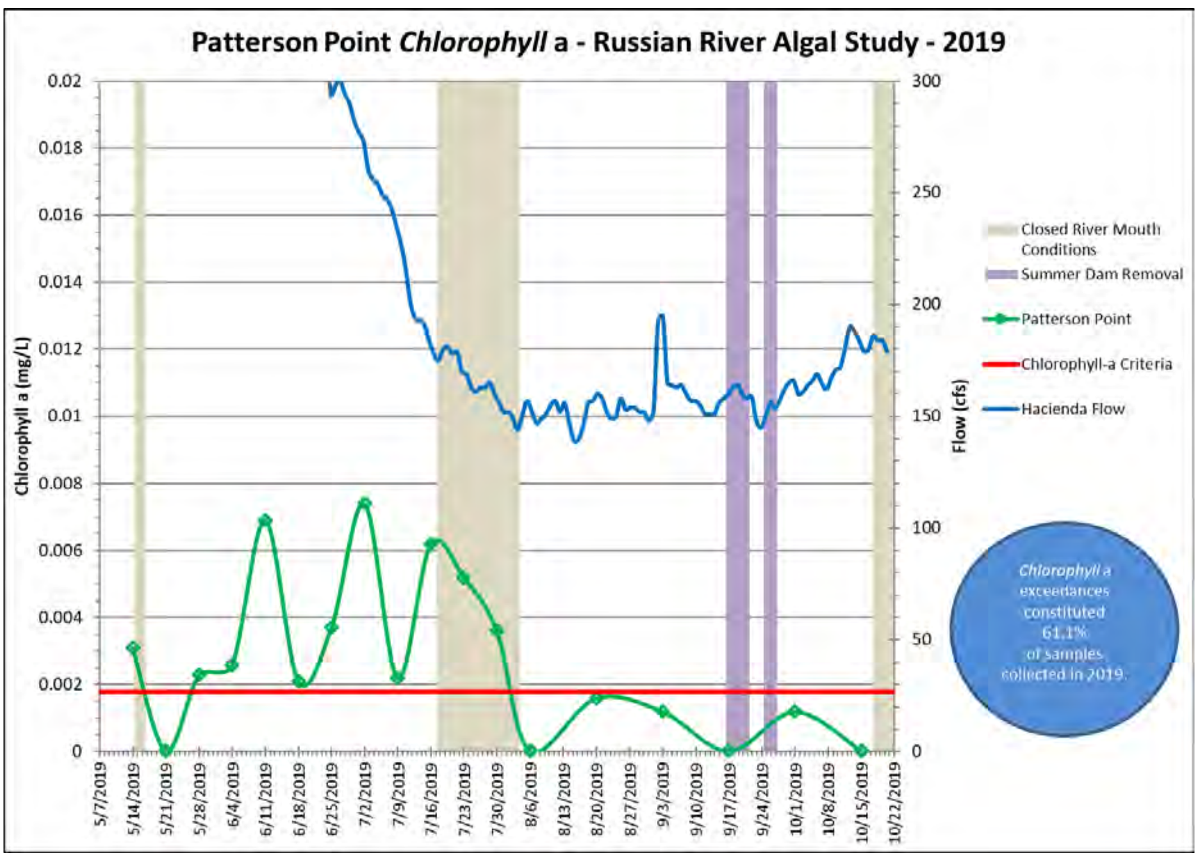
Figures 3-8 c and d. Sonoma Water Seasonal Mainstem Russian River Grab Sampling Turbidity and *Chlorophyll-a* Results from Syar Vineyards in 2019.





Figures 3-9 a and b. Sonoma Water Seasonal Mainstem Russian River Grab Sampling Total Nitrogen and Total Phosphorus Results from Patterson Point in 2019.





Figures 3-9 c and d. Sonoma Water Seasonal Mainstem Russian River Grab Sampling Turbidity and *Chlorophyll- a* Results from Patterson Point in 2019.

3.2 Sonoma Water Russian River Estuary Water Quality Monitoring

Flows in the lower Russian River at Hacienda (downstream of the confluence with Dry Creek) did not drop below the D1610 minimum flow of 125 cfs while the Order was in effect from 1 May through 15 October (Figure 2-4). Long-term water quality monitoring and weekly grab sampling was conducted in the middle and upper reaches of the Russian River Estuary and the upper extent of inundation and backwatering during lagoon formation, referred to as the maximum backwater area (MBA), between Patty's Rock at Jenner and Vacation Beach, including in two tributaries.

Saline water is denser than freshwater and a salinity "wedge" forms as freshwater outflow passes over the denser tidal inflow. During the lagoon management period (15 May to 15 October), the lower and middle reaches of the Estuary up to Sheephouse Creek are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater. The upper reach of the Estuary transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates upstream to Duncans Mills during low flow conditions and barrier beach closure.

Sonoma Water staff continued to collect long-term monitoring data to: establish baseline information on water quality in the Estuary and assess the availability of aquatic habitat in the Estuary; gain a better understanding of the longitudinal and vertical water quality profile during the ebb and flow of the tide; and track changes to the water quality profile that may occur during periods of low flow conditions, barrier beach closure, lagoon outlet channel implementation, and reopening. Long-term monitoring datasondes were deployed at seven stations in the Russian River estuary, including two tributary stations during the 2019 monitoring season (Figure 3-10). Sonoma Water submits an annual report to the National Marine Fisheries Service and California Department of Fish and Wildlife documenting the status updates of Sonoma Water's efforts in implementing the Biological Opinion. The water quality monitoring data for 2019 is currently being compiled and will be discussed in the Russian River Biological Opinion 2019-2020 annual report, which will be posted to Sonoma Water's website when available: http://www.scwa.ca.gov/bo-annual-report/.

Water Agency staff conducted weekly grab sampling from 14 May to 15 October at three stations in the lower mainstem Russian River, including: Vacation Beach, Monte Rio, and Patterson Point (Figure 3-10). All samples were analyzed for nutrients, *chlorophyll a*, standard bacterial indicators (Total Coliform, *E. coli*, and *Enterococcus*), total and dissolved organic carbon, total dissolved solids, and turbidity. Samples were collected during the monitoring season for diluted and undiluted analysis of Total Coliform and *E. coli* for comparative purposes and the results are included in Tables 3-6 through 3-8 and Figures 3-11 and 3-12. Samples collected for *Enterococcus* were undiluted only and results are included in Tables 3-6 through 3-8 and Figure 3-13. Sonoma Water submitted samples to the Sonoma County DHS Public Health Division Lab in Santa Rosa for bacteria analysis. Total Coliform and *E. coli* were analyzed using the Colilert method and *Enterococcus* was analyzed using the Enterolert method. Samples for all other constituents were submitted to Alpha Analytical Labs in Ukiah for analysis. Total Coliform and *E. coli* data presented in Figures 3-11 and 3-12 utilize undiluted sample results unless the reporting limit has been exceeded, at which point the diluted results are utilized.

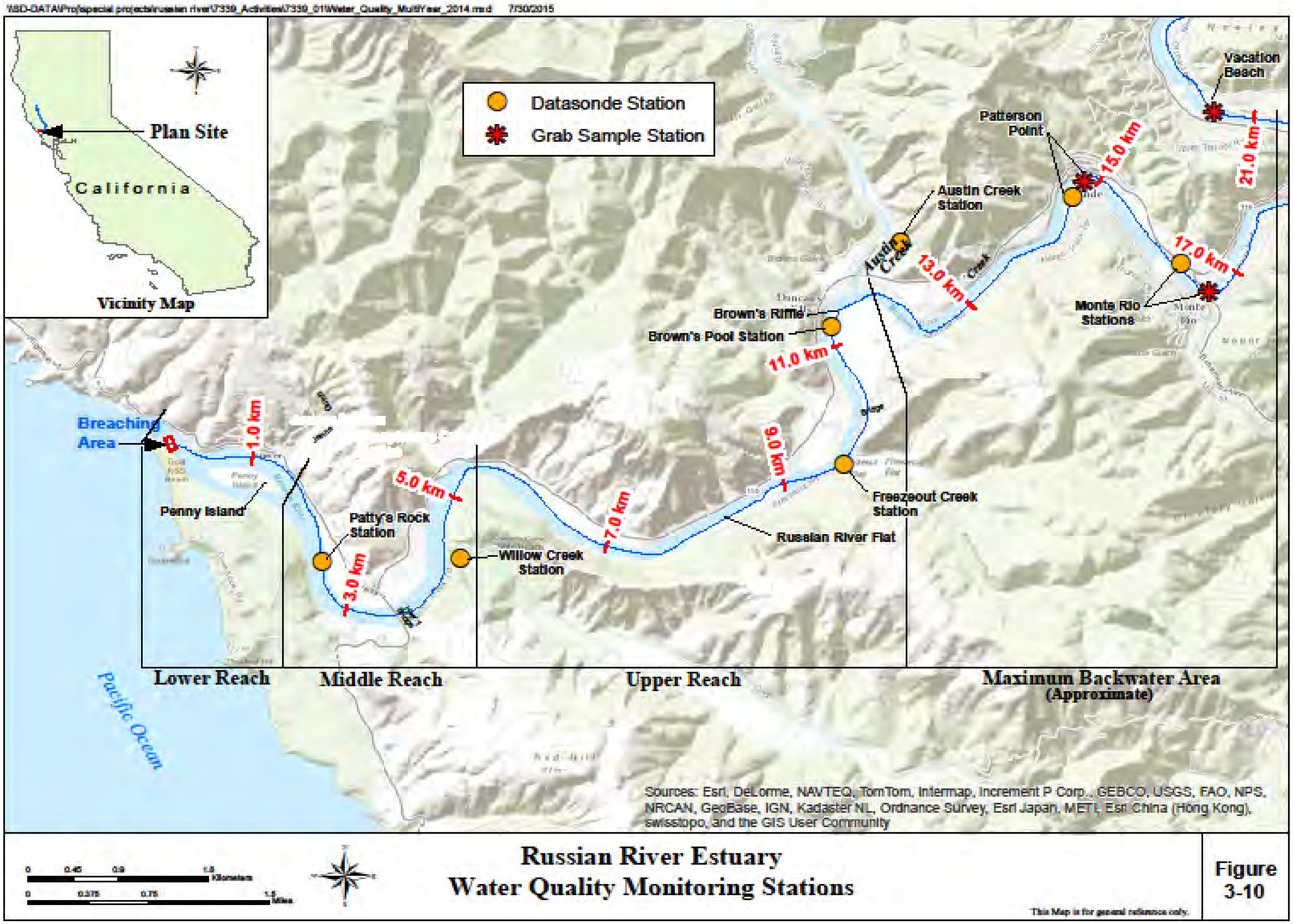


Figure 3-10. Sonoma Water 2019 Russian River Estuary water quality monitoring stations.

NCRWQCB staff has indicated, based on guidance from Sonoma County DHS, that *Enterococcus* is not currently being utilized as a fecal indicator bacteria in freshwater conditions due to uncertainty in the validity of the lab analysis to produce accurate results, as well as evidence that *Enterococcus* colonies can be persistent in the water column and therefore its presence at a given site may not always be associated with a fecal source. Sonoma Water staff will continue to collect *Enterococcus* samples and record and report the data, however, *Enterococcus* results will not be relied upon when coordinating with the NCRWQCB and Sonoma County DHS about potentially posting warning signs at freshwater beach sites or to discuss potential adaptive management actions including mechanical breaching of the barrier beach to address potential threats to public health.

Sampling for human-host *Bacteroides* bacteria was conducted at public freshwater beaches when other bacteria samples were collected. Samples were submitted to the DHS lab where they were filtered, frozen and archived for possible future analyses of human-host *Bacteroides* bacteria by staff at the NCRWQCB. Lab analysis of *Bacteroides* bacteria will be conducted only for those sample dates and locations when operational standards for *E. coli* bacteria are exceeded. The analysis of human-host *Bacteroides* bacteria will help determine if the source of the high level of *E. coli* bacteria is from human or other sources.

The grab sample sites are shown in Figure 3-10, and the results are summarized in Tables 3-6 through 3-11 and Figures 3-11 through 3-17. Highlighted values indicate those values exceeding California Department of Public Health Draft Guidance for Fresh Water Beaches for Indicator Bacteria (CDPH 2011), EPA Recreational Water Quality Criteria (EPA 2012), and EPA recommended criteria for Nutrients, *Chlorophyll a*, and Turbidity in Rivers and Streams in Aggregate Ecoregion III (EPA 2000). However, it must be emphasized that the draft CDPH guidelines and EPA criteria are not adopted standards, and are therefore both subject to change (if it is determined that the guidelines or criteria are not accurate indicators) and are not currently enforceable.

There were two exceedances of the recommended EPA Recreational Water Quality Criteria (RWQC) for Total Coliform at the Monte Rio station during open and closed estuary conditions with Hacienda flows that ranged from 160 to 3060 cfs (Figure 3-12). Total Coliform concentrations were elevated during the May storm events and were observed to increase through the early part of the season before peaking in July and generally declining through the remainder of the monitoring season (Figure 3-11). All three stations were observed to have one exceedance each of the RWQC for *E. coli* during the 21 May storm event and open estuary conditions with flows at 3060 cfs (Table 3-7 and Figure 3-13). Exceedances of the *Enterococcus* RWQC were also observed to occur at all three monitoring stations during the 21 May storm event. (Tables 3-6 through 3-8). During the latter half of the season the Monte Rio station was observed to have two more *Enterococcus* exceedances, with a maximum concentration of 1119.9 MPN/100mL occurring on 30 July during closed estuary conditions and a flow of 160 cfs (Figure 3-13). The Patterson Point station was observed to have a second *Enterococcus* exceedance on 19 September during summer dam removal and open estuary conditions with a flow of 160 cfs (Figure 3-14). External factors including late May storms, contact recreation, estuary closure, and the late-September removal of summer dams in Guerneville likely had an effect on elevated bacterial concentrations observed in the Vacation Beach to Patterson Point area during the 2019 monitoring season (Figures 3-11 through 3-13).

Table 3-6. 2019 Vacation Beach bacteria concentrations for samples collected by Sonoma Water. This site experiences freshwater conditions.

Vacation Beach	Time	Temperature	pH	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***
MDL*				20		20		2	Flow Rate****
Date		°C		MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)
5/14/2019	11:10	18.0	8.0	>2419.6	3654	4.1	10	5.2	610
5/21/2019	10:10	14.9	7.9	>2419.6	9804	**488.4**	**279**	**325.5**	3060
5/28/2019	10:30	17.0	7.8	1732.9	110	62.4	31	36.8	1300
6/4/2019	9:30	19.1	8.0	>2419.6	3255	23.3	10	38.4	867
6/11/2019	10:10	21.2	8.0	1046.2	1354	14.6	30	11.0	576
6/18/2019	9:40	20.4	8.0	866.4	836	8.6	10	3.1	487
6/25/2019	10:40	22.8	8.0	1119.9	1670	10.9	10	2.0	294
7/2/2019	10:40	22.0	8.0	1413.6	2105	14.8	20	21.6	273
7/9/2019	11:30	22.7	8.1	1553.1	1850	18.9	10	8.5	235
7/16/2019	10:10	24.6	8.0	2419.6	1565	13.4	<10	25.9	184
7/23/2019	10:20	23.3	8.0	1732.9	3448	7.5	<10	7.3	170
7/30/2019	11:00	24.3	7.9	>2419.6	1722	7.8	<10	10.7	160
8/6/2019	11:00	23.9	8.1	1732.9	1935	32.3	<10	5.2	157
8/13/2019	10:10	23.6	7.9	1986.3	1789	10.7	10	15.6	152
8/20/2019	10:30	23.1	8.0	1936.3	1515	19.7	20	11.0	157
8/27/2019	10:40	23.5	8.1	1203.3	1918	16.0	10	8.3	153
9/3/2019	10:50	23.2	8.0	1732.9	1722	39.9	20	13.4	193
9/10/2019	10:20	21.4	7.9	1553.1	1126	4.1	<10	4.1	157
9/17/2019	10:20	21.2	7.9	1203.3	1354	14.6	<10	9.8	158
9/19/2019	9:40	20.2	7.9	1203.3	1236	18.3	20	60.5	163
9/24/2019	11:40	20.7	7.9	1299.7	1046	14.8	20	52.1	148
9/26/2019	9:40	20.8	7.8	1413.6	1553	21.1	10	54.8	150
10/1/2019	10:40	16.9	7.9	920.8	813	11.0	<10	13.4	165
10/8/2019	10:10	16.7	7.9	579.4	594	26.6	20	48.7	165
10/15/2019	10:30	14.1	8.1	613.1	369	12.0	20	48.0	188

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** United States Geological Survey (USGS) Continuous-Record Gaging Station

*** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Recreational Water Quality Criteria - Statistical Threshold Value (STV) and Geomteric Mean (GM)

(Beach posting is recommended when indicator organisms exceed the STV) - Indicated by red text

E. coli (STV): 235 per 100 ml — Enterococcus (STV): 61 per 100 ml

E. coli (GM): 126 per 100mL — Enterococcus (GM): 33 per 100 mL

Table 3-7. 2019 Monte Rio bacteria concentrations for samples collected by Sonoma Water. This site experiences freshwater conditions.

Monte Rio	Time	Temperature	pH	Total Coliforms (Collilert)	Total Coliforms Diluted 1:10 (Collilert)	E. coli (Collilert)	E. coli Diluted 1:10 (Collilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***
MDL*				20		20		2	Flow Rate****
Date		°C		MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)
5/14/2019	10:10	18.4	8.0	>2419.6	3255	18.9	<10	5.2	610
5/21/2019	9:50	15.0	7.8	>2419.6	**14136**	**344.8**	**443**	**328.2**	3060
5/28/2019	9:50	16.8	7.8	2419.6	1223	37.3	20	31.8	1300
6/4/2019	9:00	18.7	8.0	>2419.6	3076	20.1	41	21.1	867
6/11/2019	9:40	21.4	8.0	1299.7	1722	24.3	10	7.5	576
6/18/2019	9:10	20.6	8.0	980.4	1274	18.5	10	7.4	487
6/25/2019	10:00	23.1	8.0	1119.9	1935	42.0	62	8.6	294
7/2/2019	9:00	22.0	8.0	>2419.6	1674	24.3	<10	8.5	273
7/9/2019	11:00	22.9	8.0	1413.6	1259	107.1	134	53.4	235
7/16/2019	9:40	24.2	7.9	>2419.6	7701	30.5	31	8.6	184
7/23/2019	9:50	23.3	8.1	>2419.6	4884	105.0	134	39.7	170
7/30/2019	10:30	24.6	8.0	>2419.6	**24196**	186.0	171	**1119.9**	160
8/6/2019	10:40	23.5	7.8	>2419.6	6131	8.5	10	4.1	157
8/13/2019	9:50	23.5	7.8	>2419.6	3255	4.1	<10	3.0	152
8/20/2019	10:10	23.0	8.0	1046.2	1236	9.8	10	2	157
8/27/2019	10:20	23.2	7.9	1413.6	933	21.6	10	7.4	153
9/3/2019	10:30	23.2	7.9	1986.3	1126	27.5	41	**132**	193
9/10/2019	9:50	21.4	7.9	980.4	1211	6.3	<10	8.4	157
9/17/2019	9:50	21.0	7.9	966.4	932	5.2	<10	4.1	158
9/19/2019	9:20	20.2	7.9	613.1	565	31.3	10	13.2	163
9/24/2019	11:20	20.5	8.0	387.3	546	6.3	10	3.0	148
9/26/2019	9:20	20.9	7.8	816.4	496	6.2	10	12.2	150
10/1/2019	10:10	16.9	7.9	313.0	345	3.1	10	8.4	165
10/8/2019	9:30	16.4	7.8	248.1	428	12.1	52	5.1	165
10/15/2019	10:00	14.0	8.0	579.4	441	64.4	86	11.9	188

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** United States Geological Survey (USGS) Continuous-Record Gaging Station

*** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Recreational Water Quality Criteria - Statistical Threshold Value (STV) and Geomteric Mean (GM)

(Beach posting is recommended when indicator organisms exceed the STV) - Indicated by red text

E. coli (STV): 235 per 100 ml	Enterococcus (STV): 61 per 100 ml
E. coli (GM): 126 per 100mL	Enterococcus (GM): 33 per 100 mL

Table 3-8. 2019 Patterson Point bacteria concentrations for samples collected by Sonoma Water. This site experiences freshwater conditions.

Patterson Point	Time	Temperature	pH	Total Coliforms (Collilert)	Total Coliforms Diluted 1:10 (Collilert)	E. coli (Collilert)	E. coli Diluted 1:10 (Collilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***
MDL*				20		20		2	Flow Rate****
Date		°C		MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	MPN/100mL	(cfs)
5/14/2019	8:30	18.7	7.9	2419.6	2851	6.3	<10	2.0	610
5/21/2019	9:20	14.6	7.8	>2419.6	8664	**435.2**	**295**	**214.2**	3060
5/28/2019	8:50	17.0	7.7	721.5	1565	60.2	52	36.8	1300
6/4/2019	8:40	18.5	7.9	>2419.6	2014	26.2	10	20.9	867
6/11/2019	8:50	21.3	8.1	119.9	1439	13.2	10	15.6	576
6/18/2019	8:40	20.6	7.9	816.4	738	12.2	<10	6.3	487
6/25/2019	8:50	22.7	8.1	1299.7	2064	13.4	<10	2.0	294
7/2/2019	8:30	22.8	8.0	1732.9	1664	24.6	<10	8.6	273
7/9/2019	9:30	22.5	8.1	1986.3	1314	15.8	<10	16.1	235
7/16/2019	8:40	24.5	7.8	>2419.6	4884	17.1	41	17.1	184
7/23/2019	8:40	22.8	7.9	>2419.6	5475	76.3	96	28.1	170
7/30/2019	9:20	24.2	7.8	>2419.6	3873	24.6	63	20.9	160
8/6/2019	9:00	23.1	7.8	>2419.6	5475	5.2	10	4.1	157
8/13/2019	9:00	23.3	7.9	2419.9	1935	4.1	10	6.3	152
8/20/2019	9:00	22.9	7.9	1203.3	1211	8.6	10	6.3	157
8/27/2019	9:40	22.9	8.0	1986.3	1236	28.1	31	6.3	153
9/3/2019	9:20	22.8	7.8	1732.9	1222	15.6	20	3.1	193
9/10/2019	9:10	21.4	7.9	1046.2	9.6	10.7	<10	9.7	157
9/17/2019	8:30	21.1	7.9	770.1	683	7.4	<10	9.8	158
9/19/2019	8:50	20.8	7.8	866.4	836	79.8	86	**69.1**	163
9/24/2019	10:50	20.3	7.8	686.7	703	8.6	<10	5.2	148
9/26/2019	8:50	21.0	7.9	980.4	771	8.6	10	21.3	150
10/1/2019	8:40	17.2	7.8	648.8	441	6.3	<10	12.2	165
10/8/2019	9:00	16.6	7.7	325.5	373	6.3	20	16.9	165
10/15/2019	9:00	14.5	7.8	307.6	262	42.8	52	35.5	188

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** United States Geological Survey (USGS) Continuous-Record Gaging Station

*** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Recreational Water Quality Criteria - Statistical Threshold Value (STV) and Geomteric Mean (GM)

(Beach posting is recommended when indicator organisms exceed the STV) - Indicated by red text

E. coli (STV): 235 per 100 ml — Enterococcus (STV): 61 per 100 ml

E. coli (GM): 126 per 100mL — Enterococcus (GM): 33 per 100 mL

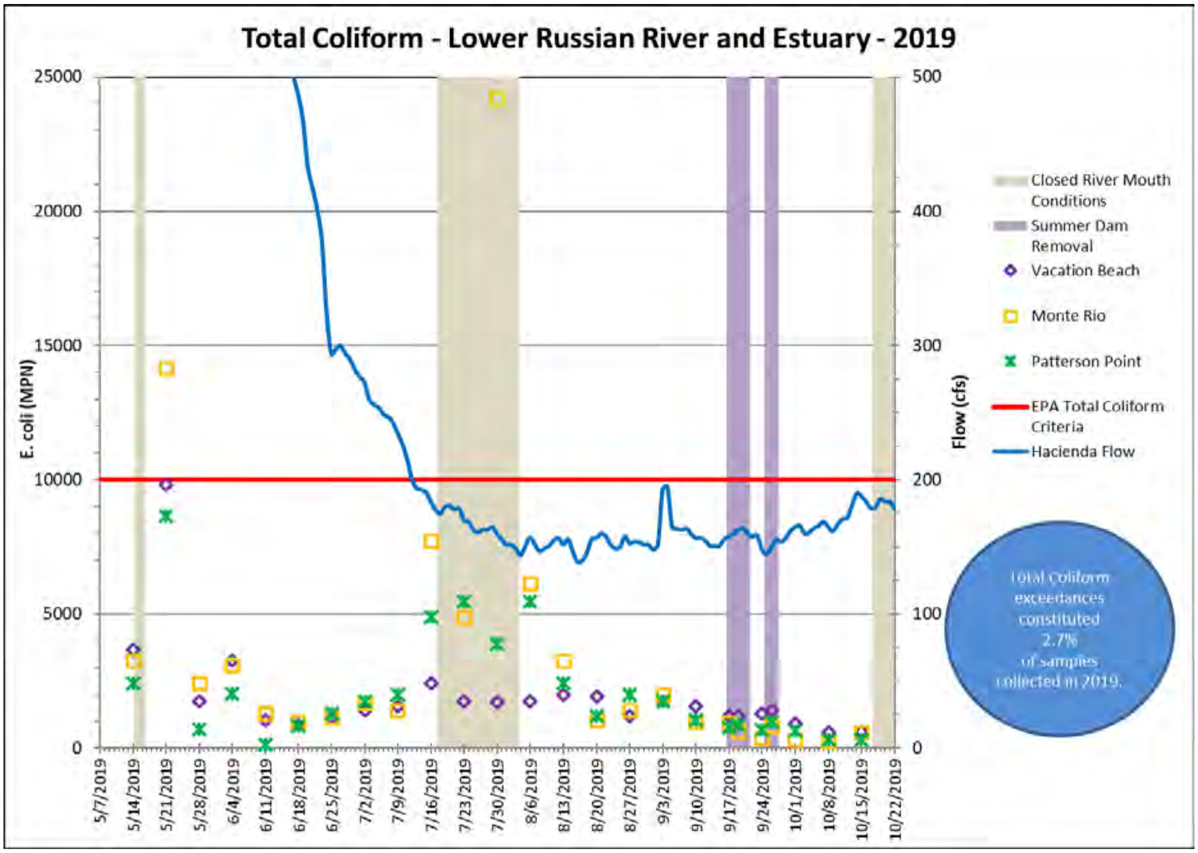


Figure 3-11. Total Coliform results for the Russian River from Vacation Beach to Patterson Point in 2019.

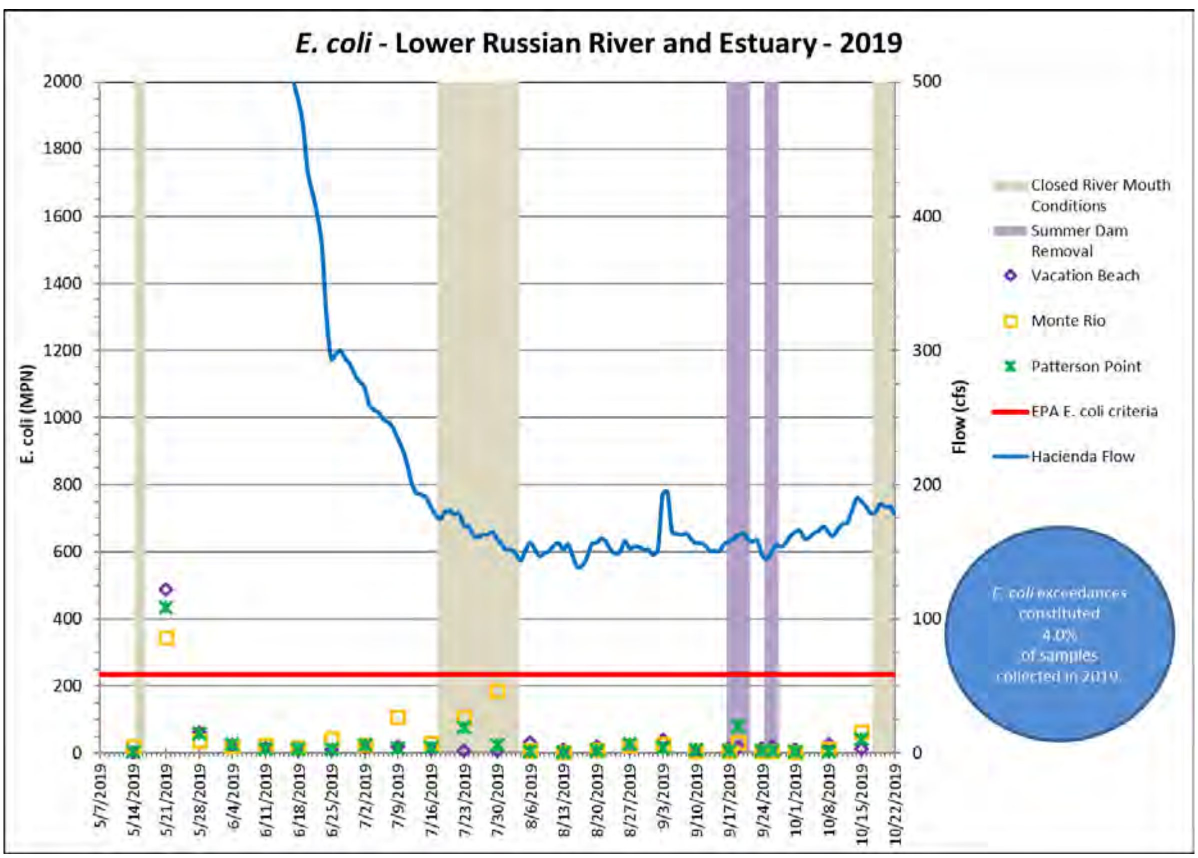


Figure 3-12. *E. coli* results for the Russian River from Vacation Beach to Patterson Point in 2019.

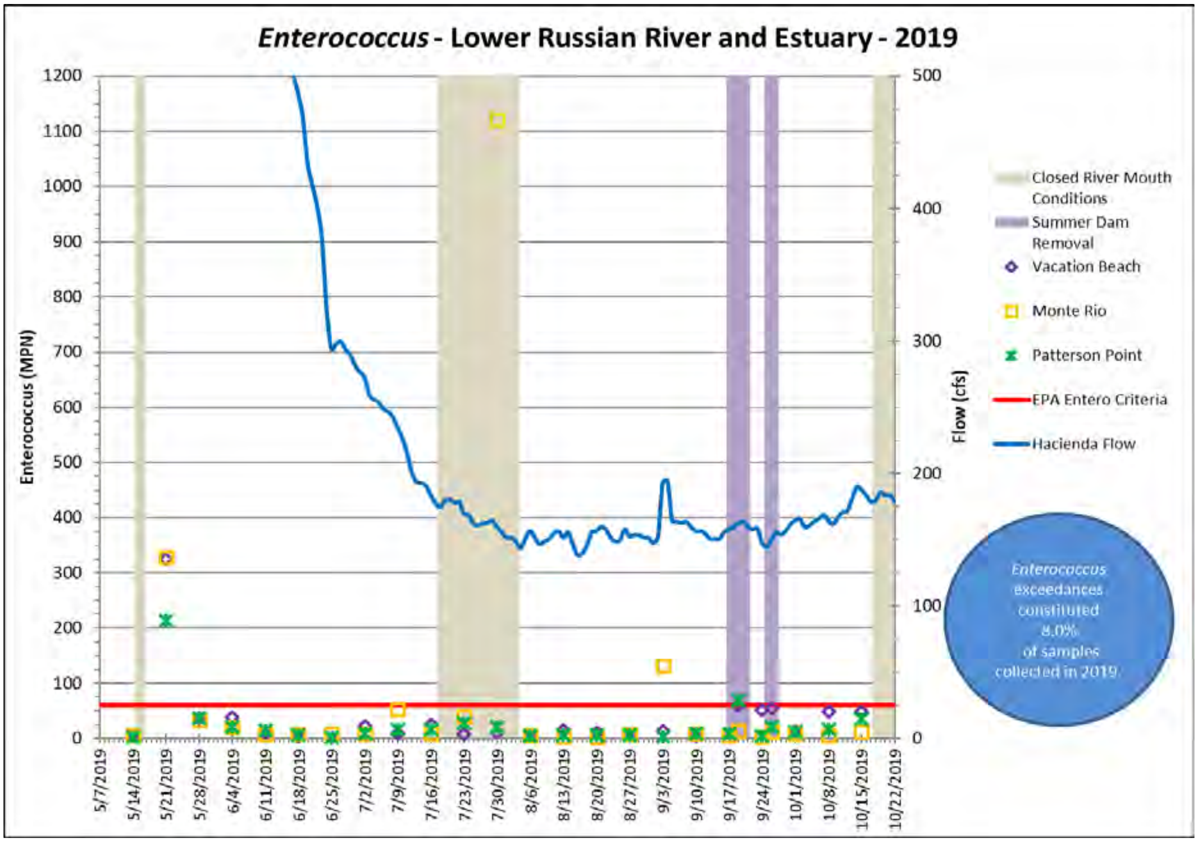


Figure 3-13. ***Enterococcus*** **results for the Russian River from Vacation Beach to Patterson Point in 2019.**

The EPA criteria for Total Nitrogen was exceeded three times at Monte Rio and Patterson Point and twice at Vacation Beach with Hacienda flows ranging from 152 cfs to 3060 cfs (Tables 3-9 through 3-11). All exceedances, except for an anomalous result at Patterson Point, were observed to occur during the May storm events and open estuary conditions at the beginning of the season, with all three stations exceeding the criteria on 14 May and 21 May (Figure 3-14). In contrast, all three stations predominantly exceeded the EPA criteria for Total Phosphorous during the full term of the Order and with flows that ranged from 148 cfs to 3060 cfs, continuing a trend of consistent exceedances observed in previous years (Tables 3-9 through 3-11). Interestingly, all three stations had concentrations below the Total Phosphorus criteria during open estuary conditions in October (Figure 3-15).

The EPA criteria for Turbidity was exceeded periodically at Monte Rio and Patterson Point (primarily during the first half of the season) and predominantly at Vacation Beach throughout the season (Tables 3-9 through 3-11). Exceedances were observed to occur during open and closed estuary conditions with Hacienda flows ranging from 148 cfs to 3060 cfs (Figure 3-16). Streamflow over the Vacation Beach summer dam and through the fish ladder appears to be a contributing factor to the elevated turbidity values at the Vacation Beach station.

Algal (*chlorophyll a*) results exceeded the EPA criteria at all three stations periodically throughout the season, under open and closed conditions and Hacienda flows that ranged from 158 cfs to 3060 cfs (Tables 3-9 through 3-11 and Figure 3-17). However, algal concentrations and exceedances were observed to be more pronounced during the first half of the season when flows were still declining from the May storm events (Figure 3-17).

Table 3-9. 2019 Vacation Beach nutrient grab sample results. This site experiences freshwater conditions.

Vacation Beach	Time	Temperature	pH	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	USGS 11467000 RR near Guerneville (Hacienda)***
MDL*				0.200	0.10	0.00010	0.030	0.030	0.10		0.020	0.020	0.0400	0.0400	4.2	0.020	0.000050	Flow Rate****
Date		°C		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)
5/14/2019	11:10	18.0	8.0	ND	ND	ND	0.20	ND	ND	**0.38**	**0.14**	0.12	1.68	2.06	160	**3.0**	**0.0019**	610
5/21/2019	10:10	14.9	7.9	0.26	ND	ND	0.12	ND	0.26	**0.38**	**0.12**	0.15	3.13	4.23	140	**42**	**0.0019**	3060
5/28/2019	10:30	17.0	7.8	ND	ND	ND	0.19	ND	ND	0.33	**0.069**	0.17	1.64	2.06	140	**15**	**0.0019**	1300
6/4/2019	9:30	19.1	8.0	ND	ND	ND	0.15	ND	ND	0.29	**0.058**	0.14	1.52	1.89	140	**6.3**	**0.0026**	867
6/11/2019	10:10	21.2	8.0	ND	ND	ND	0.052	ND	ND	0.23	**0.039**	0.063	1.47	1.83	150	**3.2**	**0.0050**	576
6/18/2019	9:40	20.4	8.0	ND	ND	ND	0.054	ND	ND	0.16	**0.040**	0.059	1.42	1.83	140	**2.7**	**0.0037**	487
6/25/2019	10:40	22.8	8.0	ND	ND	ND	0.045	ND	ND	0.22	**0.035**	0.056	1.36	1.93	170	2.3	**0.0028**	294
7/2/2019	10:40	22.0	8.0	ND	ND	ND	0.042	ND	ND	0.18	**0.035**	0.048	1.32	1.78	160	1.8	**0.0059**	273
7/9/2019	11:30	22.7	8.1	ND	ND	ND	ND	ND	ND	0.15	**0.036**	0.057	1.25	1.79	140	1.5	**0.0057**	235
7/16/2019	10:10	24.6	8.0	ND	ND	ND	ND	ND	ND	0.18	**0.035**	0.047	1.56	1.79	220	**2.5**	**0.0069**	184
7/23/2019	10:20	23.3	8.0	ND	ND	ND	ND	ND	ND	0.18	**0.034**	0.048	1.34	2.09	160	**3.3**	ND	170
7/30/2019	11:00	24.3	7.9	ND	ND	ND	ND	ND	ND	0.10	**0.033**	0.036	1.36	1.78	170	2.0	**0.0040**	160
8/6/2019	11:00	23.9	8.1	ND	ND	ND	ND	ND	ND	0.14	**0.033**	0.033	1.28	1.79	100	**3.0**	0.0015	157
8/13/2019	10:10	23.6	7.9	ND	ND	ND	ND	ND	ND	0.10	**0.030**	0.040	1.43	1.66	140	**3.0**	0.0014	152
8/20/2019	10:30	23.1	8.0	ND	ND	ND	ND	ND	ND	0.035	**0.031**	0.044	1.31	1.78	140	**3.2**	ND	157
8/27/2019	10:40	23.5	8.1	ND	ND	ND	ND	ND	ND	0.070	**0.033**	0.033	1.33	1.90	140	**3.1**	0.0015	153
9/3/2019	10:50	23.2	8.0	ND	ND	ND	ND	ND	ND	0.10	**0.026**	0.052	1.39	1.84	130	**3.4**	**0.0019**	193
9/10/2019	10:20	21.4	7.9	ND	ND	ND	ND	ND	ND	0.088	**0.028**	0.048	1.33	1.76	120	**2.6**	ND	157
9/17/2019	10:20	21.2	7.9	ND	ND	ND	ND	ND	ND	0.070	**0.023**	0.039	1.43	1.76	130	**3.4**	ND	158
9/19/2019	9:40	20.2	7.9	ND	ND	ND	ND	ND	ND	0.070	**0.033**	0.039	1.28	1.76	140	**4.0**	ND	163
9/24/2019	11:40	20.7	7.9	ND	ND	ND	ND	ND	ND	0.088	**0.030**	0.043	1.29	1.69	120	**3.6**	ND	148
9/26/2019	9:40	20.8	7.8	ND	ND	ND	ND	ND	ND	0.070	**0.026**	0.048	1.31	1.64	130	1.2	ND	150
10/1/2019	10:40	16.9	7.9	ND	ND	ND	ND	ND	ND	0.10	0.021	0.042	1.33	1.72	130	**3.2**	ND	165
10/8/2019	10:10	16.7	7.9	ND	ND	ND	ND	ND	ND	0.070	0.020	ND	1.25	1.61	130	**3.1**	ND	165
10/15/2019	10:30	14.1	8.1	ND	ND	ND	ND	ND	ND	0.070	**0.022**	ND	1.18	1.64	140	**4.0**	ND	188

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

*** United States Geological Survey (USGS) Continuous-Record Gaging Station

**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Total Nitrogen: 0.38 mg/L

Chlorophyll *a*: 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Turbidity: 2.34 FTU/NTU

Table 3-10. 2019 Monte Rio nutrient grab sample results. This site experiences freshwater conditions.

Monte Rio	Time	Temperature	pH	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	USGS 11467000 RR near Guerneville (Hacienda)***
MDL*				0.200	0.10	0.00010	0.030	0.030	0.10		0.020	0.020	0.0400	0.0400	4.2	0.020	0.000050	Flow Rate****
Date		°C		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)
5/14/2019	10:10	18.4	8.0	ND	ND	ND	0.20	ND	ND	**0.38**	**0.14**	0.12	1.56	2.08	170	**3.1**	**0.0045**	610
5/21/2019	9:50	15.0	7.8	0.28	ND	ND	0.12	ND	0.28	**0.40**	**0.12**	0.15	3.27	4.61	140	**50**	**0.0031**	3060
5/28/2019	9:50	16.8	7.8	ND	ND	ND	0.20	ND	ND	**0.38**	**0.068**	0.16	1.52	2.03	140	**14**	**0.0023**	1300
6/4/2019	9:00	18.7	8.0	ND	ND	ND	0.15	ND	ND	0.33	**0.059**	0.18	1.56	1.88	130	**7.3**	**0.0029**	867
6/11/2019	9:40	21.4	8.0	ND	ND	ND	ND	ND	ND	0.17	**0.039**	0.051	1.50	1.91	150	**3.8**	**0.014**	576
6/18/2019	9:10	20.6	8.0	ND	ND	ND	0.040	ND	ND	0.18	**0.034**	0.055	1.42	1.88	150	**2.6**	**0.0062**	487
6/25/2019	10:00	23.1	8.0	ND	ND	ND	ND	ND	ND	0.18	**0.036**	0.056	1.52	1.87	160	**2.5**	**0.0046**	294
7/2/2019	9:00	22.0	8.0	ND	ND	ND	ND	ND	ND	0.17	**0.037**	0.052	1.37	1.80	170	2.1	**0.0060**	273
7/9/2019	11:00	22.9	8.0	ND	ND	ND	ND	ND	ND	0.14	**0.034**	0.049	1.34	1.79	160	1.7	**0.0072**	235
7/16/2019	9:40	24.2	7.9	ND	ND	ND	ND	ND	ND	0.14	**0.039**	0.051	1.59	1.81	160	**2.6**	**0.0069**	184
7/23/2019	9:50	23.3	8.1	ND	ND	ND	ND	ND	ND	0.18	**0.036**	0.048	1.41	2.13	140	**2.5**	**0.0067**	170
7/30/2019	10:30	24.6	8.0	ND	ND	ND	ND	ND	ND	0.13	**0.037**	0.048	1.37	1.85	150	2.0	**0.0036**	160
8/6/2019	10:40	23.5	7.8	ND	ND	ND	ND	ND	ND	0.18	**0.035**	0.052	1.22	1.75	110	2.1	0.0015	157
8/13/2019	9:50	23.5	7.8	ND	ND	ND	ND	ND	ND	0.070	**0.029**	0.044	1.35	1.63	140	1.3	ND	152
8/20/2019	10:10	23.0	8.0	ND	ND	ND	ND	ND	ND	0.035	**0.034**	0.048	1.61	1.87	130	1.8	ND	157
8/27/2019	10:20	23.2	7.9	ND	ND	ND	ND	ND	ND	0.070	**0.035**	0.053	1.27	1.90	140	1.5	ND	153
9/3/2019	10:30	23.2	7.9	ND	ND	ND	ND	ND	ND	0.070	**0.028**	0.052	1.31	1.89	140	1.9	0.0013	193
9/10/2019	9:50	21.4	7.9	ND	ND	ND	ND	ND	ND	ND	**0.025**	0.044	1.26	1.79	130	0.98	ND	157
9/17/2019	9:50	21.0	7.9	ND	ND	ND	ND	ND	ND	0.088	**0.022**	0.031	1.46	1.81	130	1.4	**0.11**	158
9/19/2019	9:20	20.2	7.9	ND	ND	ND	ND	ND	ND	0.035	**0.023**	0.031	1.31	1.80	130	1.2	ND	163
9/24/2019	11:20	20.5	8.0	ND	ND	ND	ND	ND	ND	0.088	0.020	0.036	1.33	1.76	140	1.2	ND	148
9/26/2019	9:20	20.9	7.8	ND	ND	ND	ND	ND	ND	0.035	0.019	0.040	1.30	1.75	120	1.2	ND	150
10/1/2019	10:10	16.9	7.9	ND	ND	ND	ND	ND	ND	0.070	0.020	0.11	1.23	1.70	120	1.4	ND	165
10/8/2019	9:30	16.4	7.8	ND	ND	ND	ND	ND	ND	0.10	0.019	ND	1.16	1.64	130	1.4	ND	165
10/15/2019	10:00	14.0	8.0	ND	ND	ND	ND	ND	ND	0.070	0.019	ND	1.22	1.67	130	2.0	ND	188

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

*** United States Geological Survey (USGS) Continuous-Record Gaging Station

**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Chlorophyll *a*: 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Total Nitrogen: 0.38 mg/L

Turbidity: 2.34 FTU/NTU

Table 3-11. 2019 Patterson Point nutrient grab sample results. This site experiences freshwater conditions.

Patterson Point	Time	Temperature	pH	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	USGS 11467000 RR near Guerneville (Hacienda)***
MDL*				0.200	0.10	0.00010	0.030	0.030	0.10		0.020	0.020	0.0400	0.0400	4.2	0.020	0.000050	Flow Rate****
Date		°C		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	(cfs)
5/14/2019	8:30	18.7	7.9	ND	ND	ND	0.20	ND	ND	**0.38**	**0.11**	0.12	1.55	2.06	170	**3.3**	**0.0031**	610
5/21/2019	9:20	14.6	7.8	0.26	ND	ND	0.12	ND	0.26	**0.38**	**0.13**	0.15	3.39	4.70	150	**50**	ND	3060
5/28/2019	8:50	17.0	7.7	ND	ND	ND	0.20	ND	ND	0.30	**0.063**	0.17	1.51	2.09	140	**13**	**0.0023**	1300
6/4/2019	8:40	18.5	7.9	ND	ND	ND	0.16	ND	ND	0.34	**0.059**	0.15	1.70	1.88	140	**7.1**	**0.0026**	867
6/11/2019	8:50	21.3	8.1	0.26	ND	ND	ND	ND	0.26	0.30	**0.035**	0.059	1.35	2.00	160	**3.3**	**0.0069**	576
6/18/2019	8:40	20.6	7.9	ND	ND	ND	0.050	ND	ND	0.19	**0.032**	0.059	1.28	1.93	130	**2.5**	**0.0021**	487
6/25/2019	8:50	22.7	8.1	ND	ND	ND	ND	ND	ND	0.18	**0.036**	0.060	1.49	1.83	160	**2.6**	**0.0037**	294
7/2/2019	8:30	22.8	8.0	ND	ND	ND	ND	ND	ND	0.21	**0.034**	0.048	1.30	1.78	150	2.2	**0.0074**	273
7/9/2019	9:30	22.5	8.1	ND	ND	ND	ND	ND	ND	0.20	**0.034**	0.049	1.33	1.79	150	1.6	**0.0022**	235
7/16/2019	8:40	24.5	7.8	ND	ND	ND	ND	ND	ND	0.10	**0.038**	0.051	1.53	1.83	170	**3.1**	**0.0062**	184
7/23/2019	8:40	22.8	7.9	ND	ND	ND	ND	ND	ND	0.15	**0.036**	0.044	1.40	2.17	190	**2.7**	**0.0052**	170
7/30/2019	9:20	24.2	7.8	ND	ND	ND	0.040	ND	ND	0.18	**0.043**	0.052	1.38	1.78	140	1.7	**0.0036**	160
8/6/2019	9:00	23.1	7.8	ND	ND	ND	ND	ND	ND	0.070	**0.037**	0.064	1.27	1.74	110	**2.4**	ND	157
8/13/2019	9:00	23.3	7.9	24	ND	ND	ND	ND	24	**24**	**0.059**	0.056	1.57	1.68	160	1.7	ND	152
8/20/2019	9:00	22.9	7.9	ND	ND	ND	ND	ND	ND	0.0047	**0.036**	0.044	1.32	1.77	140	2.0	0.0016	157
8/27/2019	9:40	22.9	8.0	ND	ND	ND	ND	ND	ND	0.14	**0.039**	0.045	1.39	1.93	140	1.6	ND	153
9/3/2019	9:20	22.8	7.8	ND	ND	ND	ND	ND	ND	0.070	**0.033**	0.056	1.22	1.87	130	**2.4**	0.0012	193
9/10/2019	9:10	21.4	7.9	0.26	ND	ND	ND	ND	0.26	0.26	**0.027**	0.048	1.39	1.79	82	0.97	ND	157
9/17/2019	8:30	21.1	7.9	ND	ND	ND	ND	ND	ND	0.10	**0.025**	ND	1.49	1.79	140	1.6	ND	158
9/19/2019	8:50	20.8	7.8	ND	ND	ND	0.14	ND	ND	0.21	**0.024**	0.031	1.30	1.78	160	1.1	ND	163
9/24/2019	10:50	20.3	7.8	ND	ND	ND	0.14	ND	ND	0.18	**0.022**	0.036	1.29	1.75	130	1.0	ND	148
9/26/2019	8:50	21.0	7.9	ND	ND	ND	ND	ND	ND	0.070	0.019	0.31	1.37	1.72	130	1.3	0.0010	150
10/1/2019	8:40	17.2	7.8	ND	ND	ND	ND	ND	ND	0.070	0.020	0.034	1.38	1.68	130	1.3	0.0012	165
10/8/2019	9:00	16.6	7.7	ND	ND	ND	ND	ND	ND	0.10	0.020	ND	1.24	1.67	130	1.4	ND	165
10/15/2019	9:00	14.5	7.8	ND	ND	ND	ND	ND	ND	0.070	0.020	ND	1.26	1.61	110	2.0	ND	188

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.

** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.

*** United States Geological Survey (USGS) Continuous-Record Gaging Station

**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III

Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L

Chlorophyll *a*: 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L

Total Nitrogen: 0.38 mg/L

Turbidity: 2.34 FTU/NTU

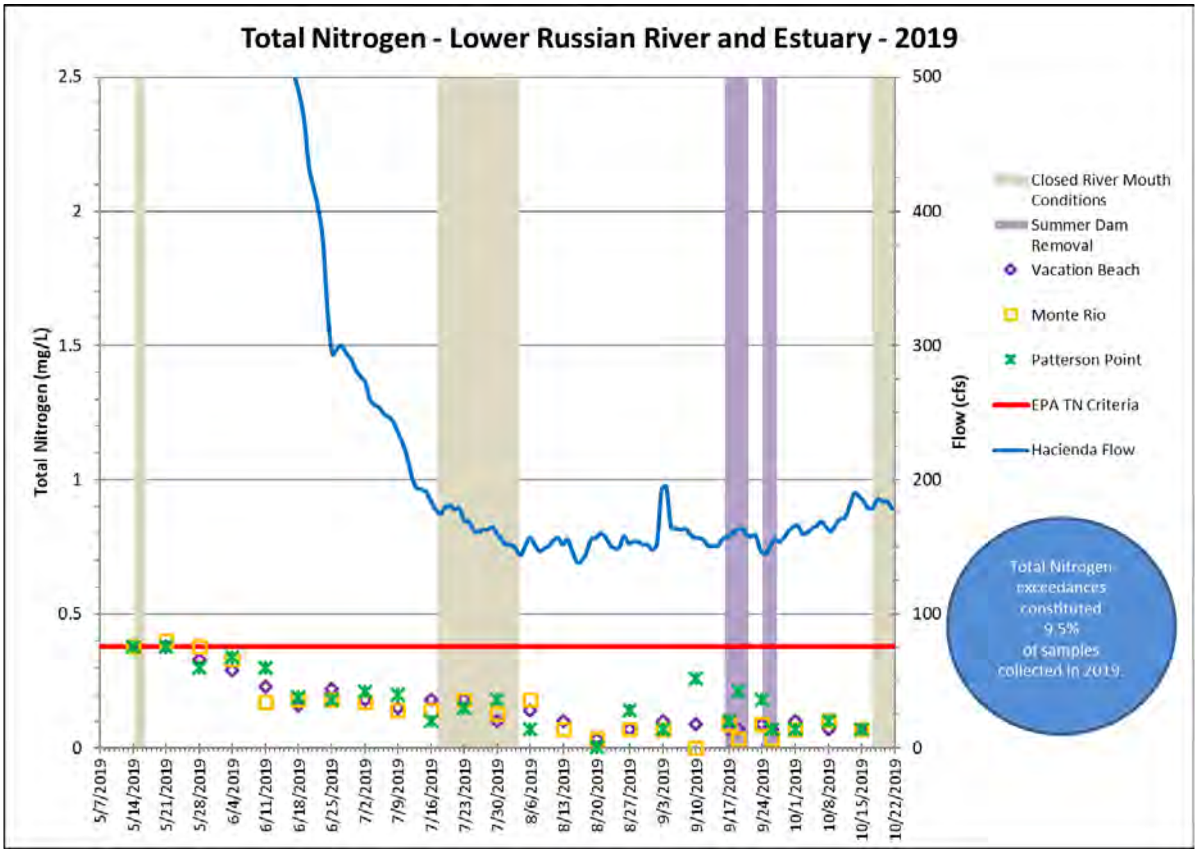


Figure 3-14. Total Nitrogen results for the Russian River from Vacation Beach to Patterson Point in 2019.

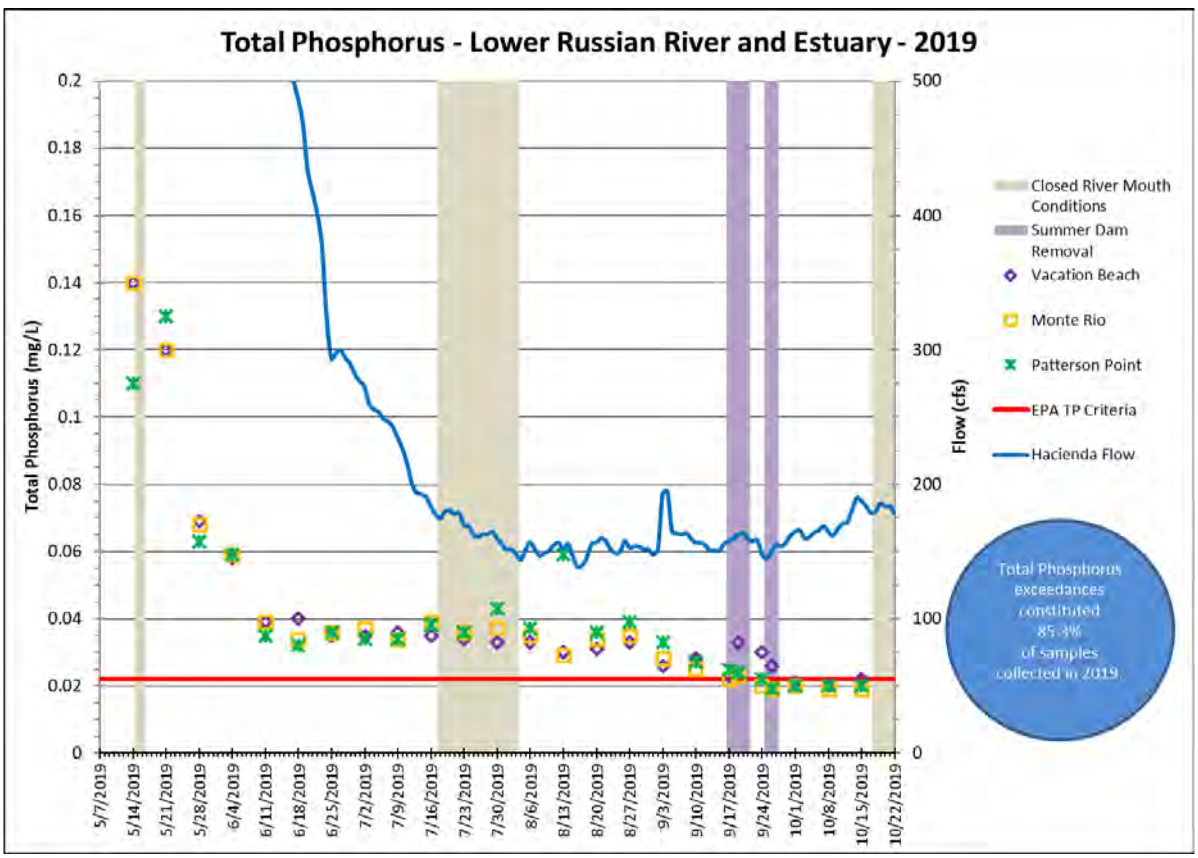


Figure 3-15. Total Phosphorus results for the Russian River from Vacation Beach to Patterson Point in 2019.

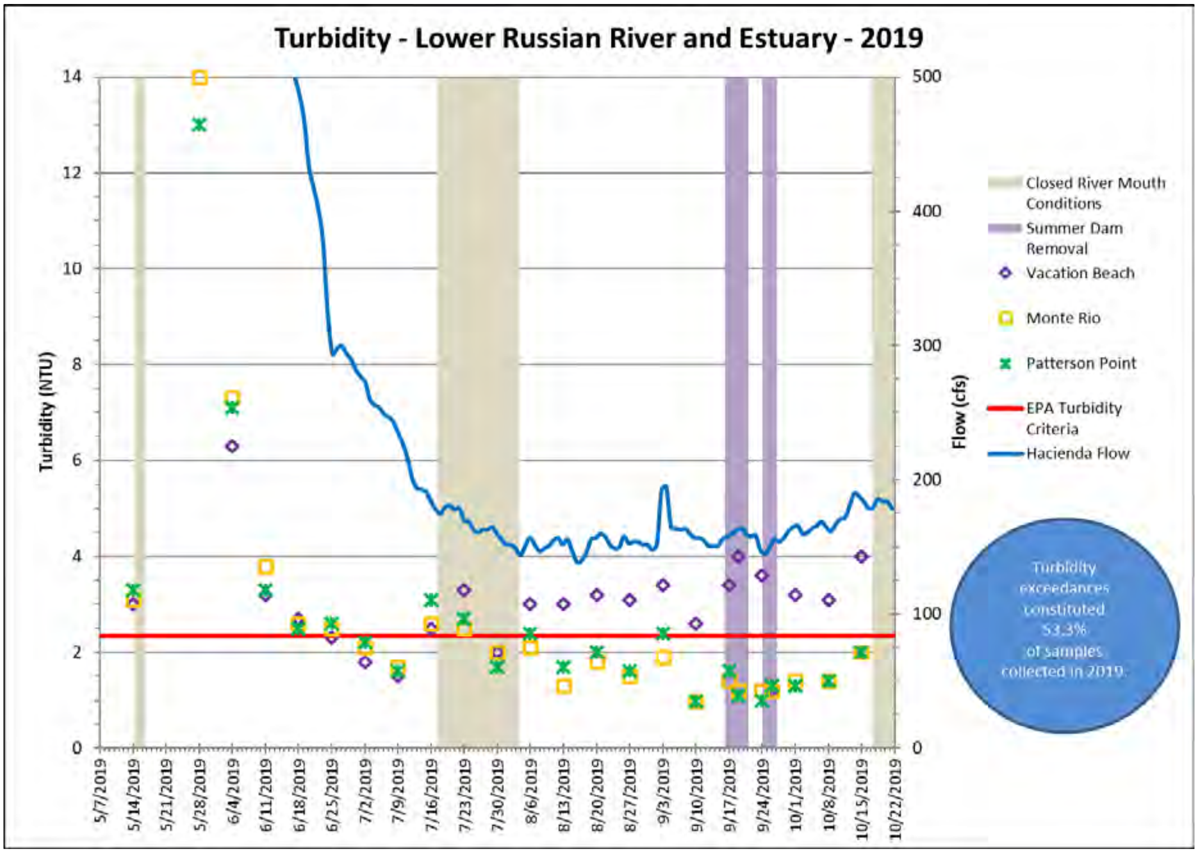


Figure 3-16. Turbidity results for the Russian River from Vacation Beach to Patterson Point in 2019.

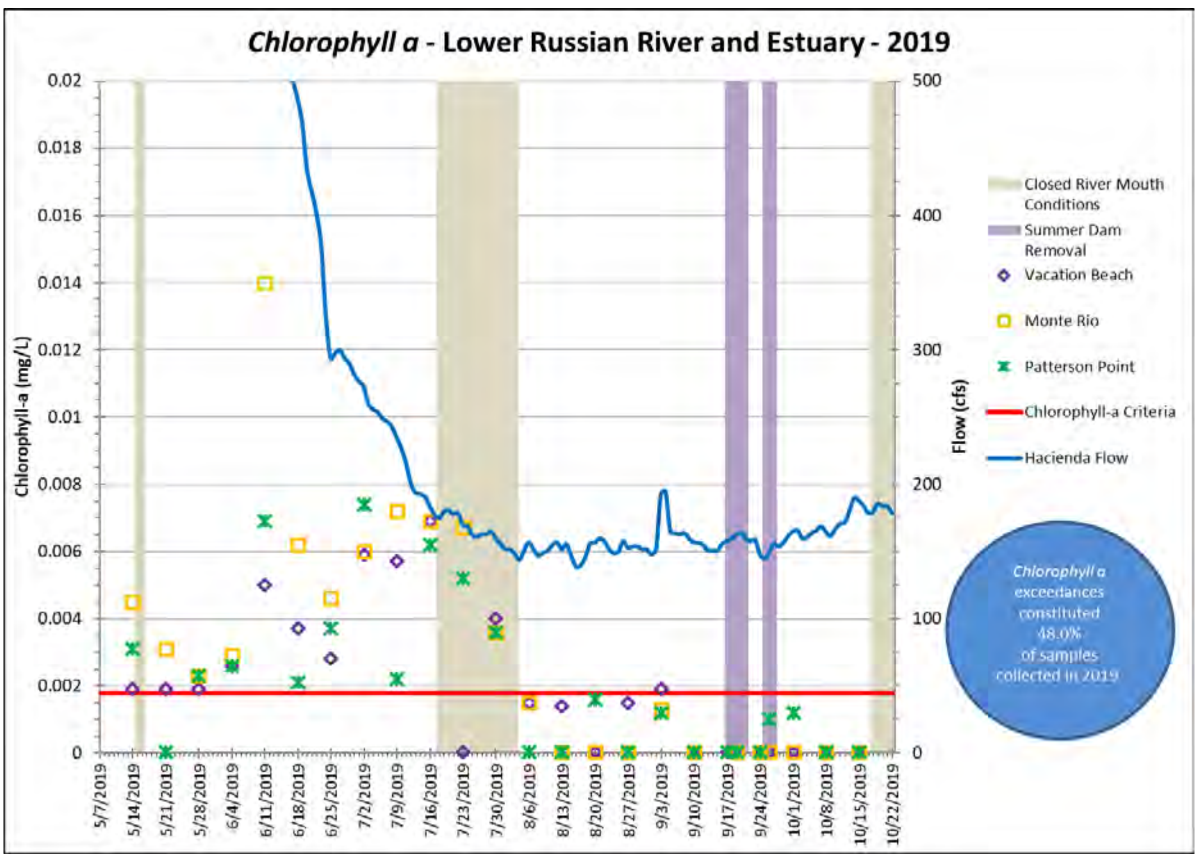


Figure 3-17. *Chlorophyll a* results for the Russian River from Vacation Beach to Patterson Point in 2019.

4.0 Additional Monitoring

4.1 Sonoma Water and USGS Permanent and Seasonal Datasondes

In coordination with the USGS, Sonoma Water maintains three, multi-parameter water quality sondes on the Russian River located at Russian River near Hopland, Russian River at Digger Bend near Healdsburg, and Russian River near Guerneville (aka Hacienda). These three sondes are referred to as "permanent" because Sonoma Water maintains them as part of its early warning detection system for use year-round (Figure 4.1). The sondes take real time readings of water temperature, pH, dissolved oxygen content (DO), specific conductivity, turbidity, and depth, every 15 minutes. In addition, Sonoma Water maintains a permanent sonde on the East Fork of the Russian River approximately one-third of a mile (1/3 mi.) downstream of Lake Mendocino. However, this station is not a real-time station or part of the early warning detection system.

In addition to the permanent sondes, Sonoma Water, in cooperation with the USGS, installed three seasonal sondes with real-time telemetry at the USGS river gage station at Russian River near Cloverdale (north of Cloverdale at Comminsky Station Road), at the gage station at Russian River at Jimtown (Alexander Valley Road Bridge), and at Johnson's Beach in Guerneville (Figure 4.1). The two seasonal sondes at Cloverdale and Jimtown are included by the USGS on its "Real-time Data for California" website: https://waterdata.usgs.gov/ca/nwis/rt.

The data collected by the sondes described above are evaluated in Section 4.2 in response to the terms of the SWRCB TUC Order to evaluate whether and to what extent the reduced flows authorized by the Order caused any impacts to water quality or availability of aquatic habitat for salmonids. In addition, the 2019 data will help provide information to evaluate potential changes to water quality and availability of habitat for aquatic resources resulting from the proposed permanent changes to D1610 minimum instream flows that are mandated by the Biological Opinion and will be included in the Biological Opinion Annual Monitoring Report. The annual report will be available on Sonoma Water's website: http://www.scwa.ca.gov/bo-annual-report/.

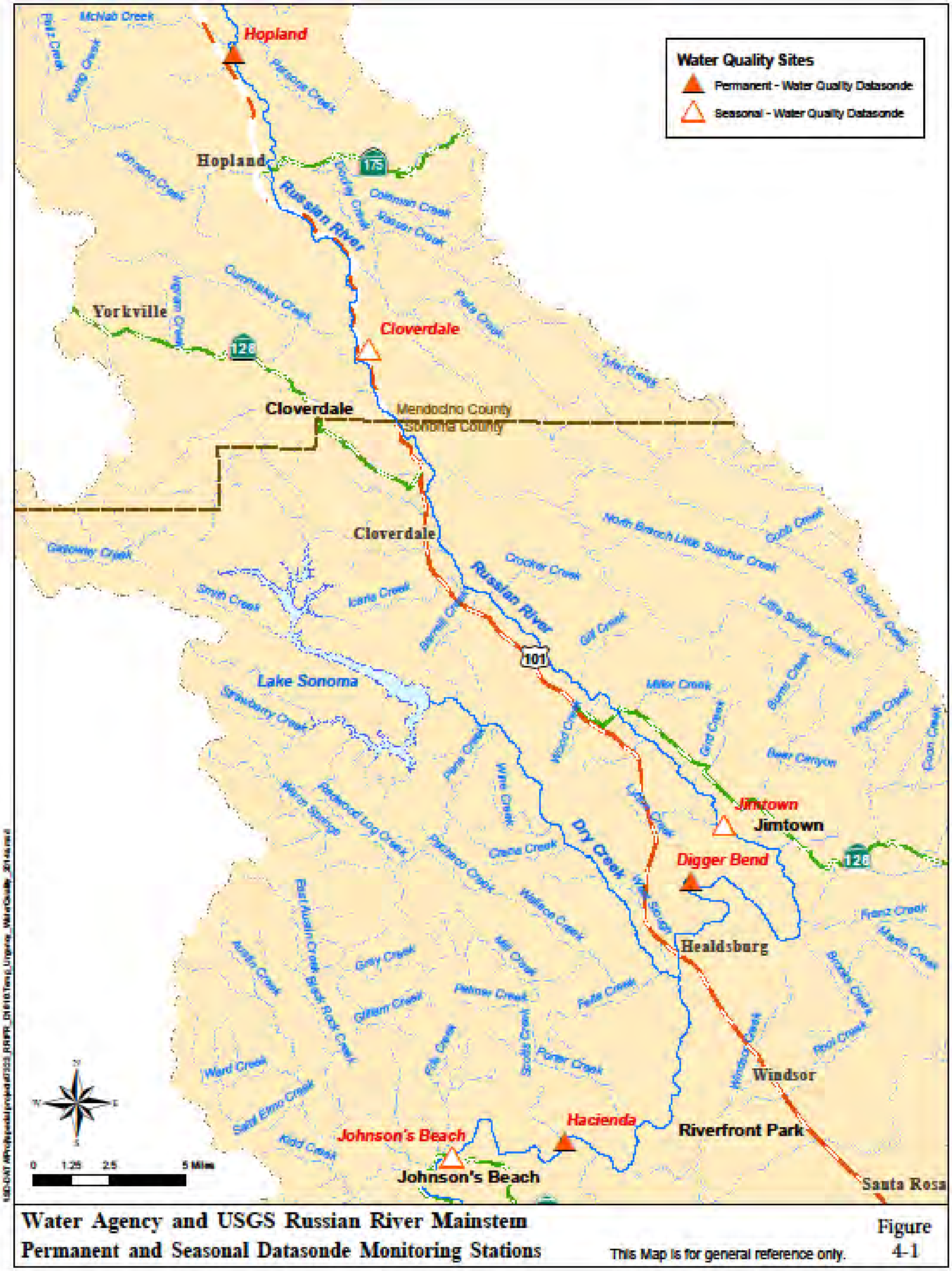


Figure 4-1. 2019 Sonoma Water and USGS Russian River mainstem permanent and seasonal datasonde water quality monitoring stations.

4.2 Aquatic Habitat for Salmonids

4.2.1 Introduction

In Term 6 (b) of the Temporary Urgency Change Order (Order) the State Water Resource Control Board (SWRCB) tasked Sonoma Water with evaluating impacts associated with reductions in minimum instream flows authorized by the Order to water quality and the availability of aquatic habitat for Russian River salmonids. This section of the report summarizes temperature and dissolved oxygen (DO) conditions in the Russian River during the Order and relates these conditions to fisheries monitoring data collected by Sonoma Water.

4.2.2 Russian River Salmonid Life Stages

Salmonids in the Russian River can be affected by flow, temperature, and dissolved oxygen (DO) changes at multiple life stages. The Russian River supports three species of salmonids, coho salmon, steelhead, and Chinook salmon. These species follow similar life history patterns with adults migrating from the ocean to the river and moving upstream to spawn in the fall and winter. Females dig nests called redds in the stream substrate and deposit eggs simultaneously with fertilization by one or more males. Eggs then remain in the redd for several weeks before hatching. After hatching, the larval fish remain in the gravel for several more weeks before emerging. After emerging from the gravel these young salmonids are identified first as fry and then later as parr once they have undergone freshwater growth. Parr rear for a few months (Chinook) to approximately 2 years (steelhead) in freshwater before undergoing a physiological change identified as smoltification. At this stage, fish are identified as smolts and are physiologically tolerant of saltwater, and therefore ready for ocean entry (Quinn 2005). In the Russian River, smolts move downstream to the ocean in the spring (Chase et al. 2005 and 2007, Obedzinski et al. 2006). Salmonids spend several months to a few years at sea before returning to the river to spawn as adults. Because all three species of Russian River anadromous salmonids spend a period of time freshwater, individuals must cope with the freshwater conditions they encounter including flow, temperature, and DO. While all three species follow a similar life history, each species tends to spawn and rear in different locations and are present in the Russian River watershed at slightly different times. These subtle but important differences may expose each species to a different set of freshwater conditions.

Coho Timing and Distribution

Wild coho salmon populations in the Russian River are at alarmingly low levels and recovery measures rely mainly on fish released from Don Clausen Warm Springs Hatchery as part of the Russian River Coho Salmon Captive Broodstock Program (RRCSCBP). Data collected at Sonoma Water's Mirabel inflatable dam on an underwater video camera system from 2011 through 2013 indicate that adult coho salmon begin migrating past the dam in late October and continue through at least January and that the bulk of adult coho migrate through that portion of the river from November through February (in 2013, 97% of coho were observed after November 20 (Martini-Lamb and Manning 2014)). Spawning and rearing occurs in certain tributaries to the Russian River (NMFS 2008) and data from downstream migrant trapping in some of those tributaries indicate that coho smolt emigration starts before April and continues through mid-June (Obedzinski et al. 2006). Although coho smolts have been captured as late as mid-July in downstream migrant traps operated by Sonoma Water on the mainstem Russian River at the Mirabel dam (Martini-Lamb and Manning 2011), most emigrate from the Russian River from March through May. Russian River coho parr and smolt life stages are present in the mainstem during the Order; therefore, only temperature and DO data relating to these two life stages will be analyzed for this report.

Steelhead Timing and Distribution

Based on video monitoring at Sonoma Water's Mirabel inflatable dam and returns to the Warm Springs Hatchery, adult steelhead return to the Russian River later than Chinook. Deflation of the inflatable dam and removal of the underwater video camera system preclude a precise measure of adult return timing or numbers. However, continuous video monitoring at the inflatable dam during late fall through spring in 2006-2007, timing of returns to the hatchery, and data gathered from steelhead angler report cards (SCWA unpublished data, Jackson 2007) suggests that steelhead return to the Russian River from December through March with the majority returning in January and February.

Many steelhead spawn and rear in tributaries of the Russian River while some steelhead rear in the upper mainstem Russian River (NMFS 2008, Cook 2003). Cook (2003) found that summer rearing of steelhead in the mainstem Russian River were distributed in the highest concentrations between Hopland and Cloverdale (Canyon Reach). Steelhead were also found in relatively high numbers (when compared to habitats downstream of Cloverdale) in the section of river between the Coyote Valley Dam and Hopland. The Canyon Reach is the highest gradient section of the mainstem Russian River and contains fast water habitats that include riffles and cascades (Cook 2003). Due to flow releases from Lake Mendocino, both the Canyon and Ukiah reaches generally have cooler water temperatures when compared to other mainstem reaches.

The steelhead smolt migration in the Russian River begins at least as early as March and continues through June, peaking between March and May (SCWA unpublished data, Martini-Lamb and Manning 2011). Russian River steelhead parr and smolt life stages are present in the mainstem during the Order; therefore, only temperature and DO data relating to these two life stages will be analyzed for this report.

Chinook Timing and Distribution

Based on video monitoring at Sonoma Water's Mirabel inflatable dam, adult Chinook are typically observed in the Russian River before coho and steelhead. Chinook enter the Russian River as early as September and the migration is complete by early February. Generally the bulk of Chinook pass the Mirabel dam from October through December. Chinook are mainstem spawners and deposit their eggs into the stream bed of the mainstem Russian River and in Dry Creek during the fall (Chase et al. 2005 and 2007, Cook 2003, Martini-Lamb and Manning 2011). Chinook offspring rear for approximately two to four months before emigrating to sea in the spring. The bulk of Chinook smolt emigration occurs from April through mid-July. Russian River Chinook smolt and adult life stages are present in the mainstem during the Order; therefore, only temperature and DO data relating to these two life stages will be analyzed for this report.

4.2.3 Methods

Sonoma Water uses underwater video, downstream migrant traps, and water quality data collected in the Russian River to summarize Russian River water quality conditions when salmonids where present.

Sonoma Water operates underwater video cameras and DIDSON to enumerate adult salmonids, and downstream migrant traps to enumerate salmonid smolts. USGS stream gages and a Sonoma Water operated data sonde were used to provide water quality data in the mainstem Russian River.

To estimate the number of adult Chinook that return to the Russian River, Sonoma Water typically operates underwater video cameras in two fish ladders located on the east and west sides of the Mirabel inflatable dam. In previous years Sonoma Water operated a DIDSON at Dry Creek (a tributary to the Russian River near Healdsburg) to collect adult salmonid information for a Coastal Monitoring Program (CMP) life cycle monitoring station. However, Sonoma Water determined that the DIDSON in Dry Creek was not providing accurate estimates of adult salmonids and discontinued its use.

Physical habitat conditions (flow, water temperature, and DO) were collected at multiple sites in the Russian River. USGS stream gages located on the Russian River at Hacienda, Digger Bend, Jimtown, and at Hopland provided flow, water temperature, and DO data. A data sonde in the east fork of the Russian River downstream of Lake Mendocino provided water temperature and DO data. These water quality conditions were compared to findings in the literature and were used to construct temperature and DO criteria for Russian River salmonids (Table 4-1 through Table 4-4).

Table 4-1. Adult salmonid water temperature (°C) thresholds used for migration when describing water quality conditions during the term of the May 2016 temporary urgency change order. Criteria is from SCWA (2016).

Description	Chinook	Coho	Steelhead
optimal upper limit	15.6	11.1	11.1
suitable upper limit	17.8	15.0	15.0
stressful upper limit	19.4	21.1	21.1
acutely stressful upper limit	23.8	23.8	23.8
lethal	23.9	23.9	23.9

Table 4-2. Juvenile salmonid rearing temperature (°C) thresholds used for describing water quality conditions during the term of the May 2016 temporary urgency change order. Criteria is from SCWA (2016).

Description	Chinook	Coho	Steelhead
optimal upper limit	16.9	13.9	16.9
suitable upper limit	17.8	16.9	18.9
stressful upper limit	20.0	17.8	21.9
acutely stressful upper limit	23.8	23.8	23.8
lethal	23.9	23.9	23.9

Table 4-3. Salmonid smolting temperature (°C) thresholds used for describing water quality conditions during the term of the May 2016 temporary urgency change order. Criteria is from SCWA (2016).

Description	Chinook	Coho	Steelhead
optimal upper limit	16.9	10.0	11.1
suitable upper limit	17.8	13.9	12.8
stressful upper limit	20.0	16.9	15.0
acutely stressful upper limit	23.8	23.8	23.8
lethal	23.9	23.9	23.9

Table 4-4. Dissolved oxygen (mg/L) thresholds for all salmonid life stages used for describing water quality conditions during the term of the May 2016 temporary urgency change order. Criteria is from SCWA (2016).

Description	Dissolved Oxygen (mg/L)
optimal upper limit	>12
suitable upper limit	8.0-11.9
stressful upper limit	5.0-7.9
acutely stressful upper limit	3.0-4.9
lethal	<3

In order to consider temperature- and DO-related impacts from flow changes to the timing and magnitude of adult and smolt salmonid counts from counting stations, we compared count data to water quality information only where fish would either pass through a water quality station before being detected at a particular counting station. For instance, because Hacienda is downstream of the Mirabel dam, all adult salmonids observed at this site must first pass through the Hacienda water quality station. Therefore, displaying Mirabel adult salmonid counts with Hacienda water quality conditions allows us to relate the timing and magnitude of the adult salmonid run to water quality conditions they likely experienced at Hacienda. Because the majority of steelhead rearing habitat in the mainstem Russian River occurs upstream of Hopland, this report presents the water quality data from the USGS Hopland gaging station when analyzing temperature- and DO-related impacts to juvenile steelhead. Smolts moving downstream out of Dry Creek and the upper Russian River pass our downstream migrant trap on the Russian River at Mirabel then pass the Hacienda USGS stream gage before entering the ocean. Therefore, we paired salmonid smolt data from the Russian River downstream migrant trap to

Hacienda water quality data in order to describe the conditions these fish likely experienced as they moved downstream through the lower Russian River.

4.2.4 Results

Flow

From May 1, 2019 to October 15, 2019 flow in the Russian River at Hacienda ranged from a high of 3,870 cfs at Hacienda on May 20 to a low of 63 cfs in the East Fork Russian River on October 9. Flow during the Order was typically between 147 cfs and 232 cfs (25th and 75th percentiles of the daily average flow when considering all 5 sample sites). During the Order, the Russian River was influenced by tributary in-flow until July, and was generally controlled by reservoir releases from July through October.

Temperature

Adult Salmonid Migration

The underwater video cameras at Mirabel dam were installed on September 1. At Mirabel, 96 Chinook and 6 steelhead adults were observed during the Order. The river mouth remained open and did not restrict Chinook from entering the river during the portion of the adult Chinook run that overlaps with the order (Figure 4-1).

Figure 4-1. Flow in the Russian River at the USGS Hacienda stream gage (11467000). The period of time that the run overlaps the Order is shaded. Also shown are the adult salmonid counts from video collected at Mirabel.

Table 4-5. The number of adult salmonids counted during and after the Order, the percentage of days in each period the river mouth was closed (thus blocking adult salmonids from entering the Russian River), the number of adult salmonids that could not be identified to species, and the number of Chinook observed on the underwater video cameras. The underwater video system was removed from the river on December 2, 2019 when the dam was deflated.

Time period	# of days	% of time river mouth closed	Observed Chinook	Unidentified salmonids
During order	45	0 %	96	0
After order expired	48	29 %	785	43

Water temperatures for Chinook salmon were favorable during the portion of the Order that overlaps with the Chinook adult migration (October). At the Hacienda gage the temperature ranged from optimal to acutely stressful for adult salmonids based on our criteria (Table 4-1 and Figure 4-2). Moving upstream from Hacienda, Chinook would experience water temperatures similar to Hacienda at Digger Bend and Jimtown, but significantly cooler at Hopland and in the East Fork Russian River near Coyote Valley Dam (Figures 4-2 through 6).

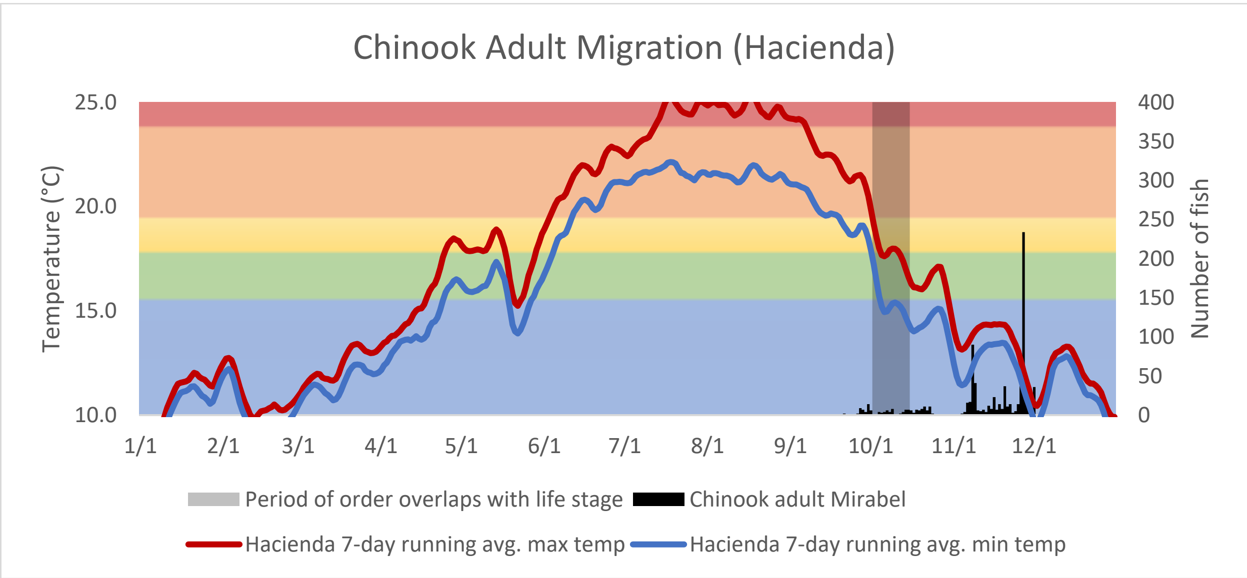


Figure 4-2. The 7-day running average of the minimum and maximum water temperatures collected at Hacienda (USGS gage number 11467000) shown with the Chinook counts from the mainstem Russian River at Mirabel. Also show are optimal, suitable, stressful, acutely stressful, and lethal water temperature thresholds for adult Chinook based on Table 4-1.

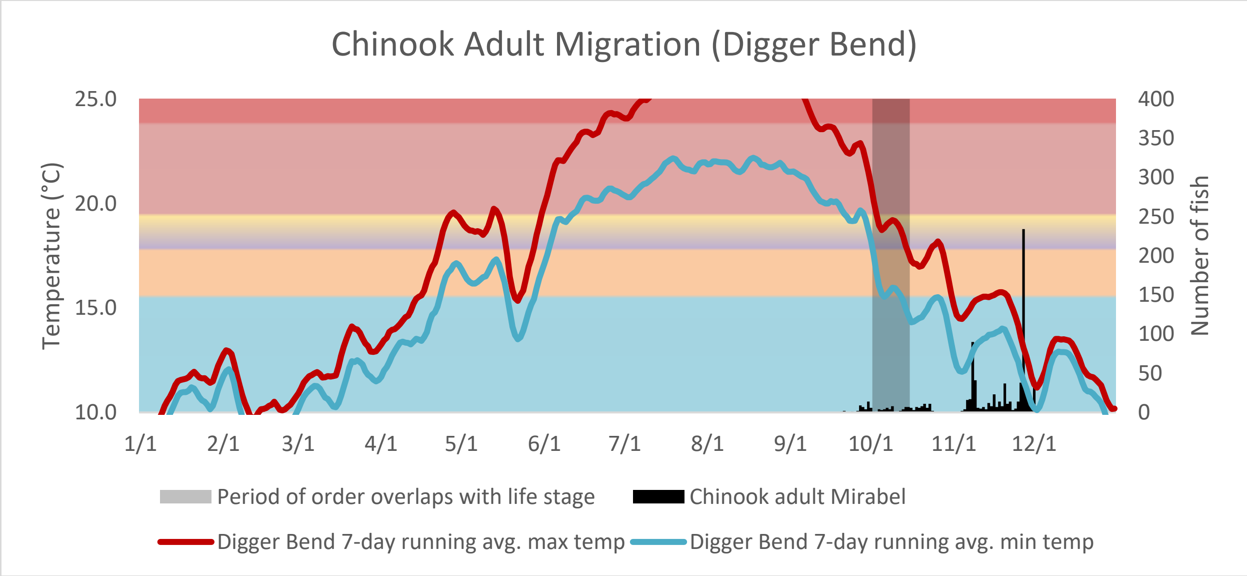


Figure 4-3. The 7-day running average of the minimum and maximum water temperatures collected at the USGS stream gage at Digger Bend (11463980) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook adult migration based on Table 4-1.

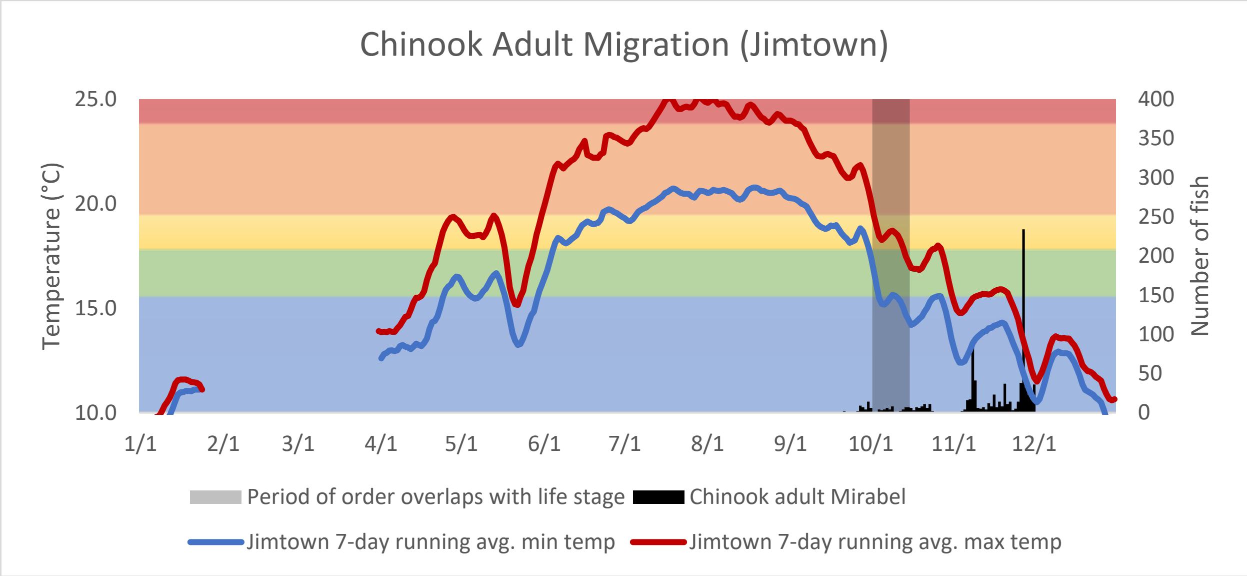


Figure 4-4. The 7-day running average of the minimum and maximum water temperatures collected at the USGS stream gage at Jimtown (USGS gage number 11463682) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook adult migration based on Table 4-1.

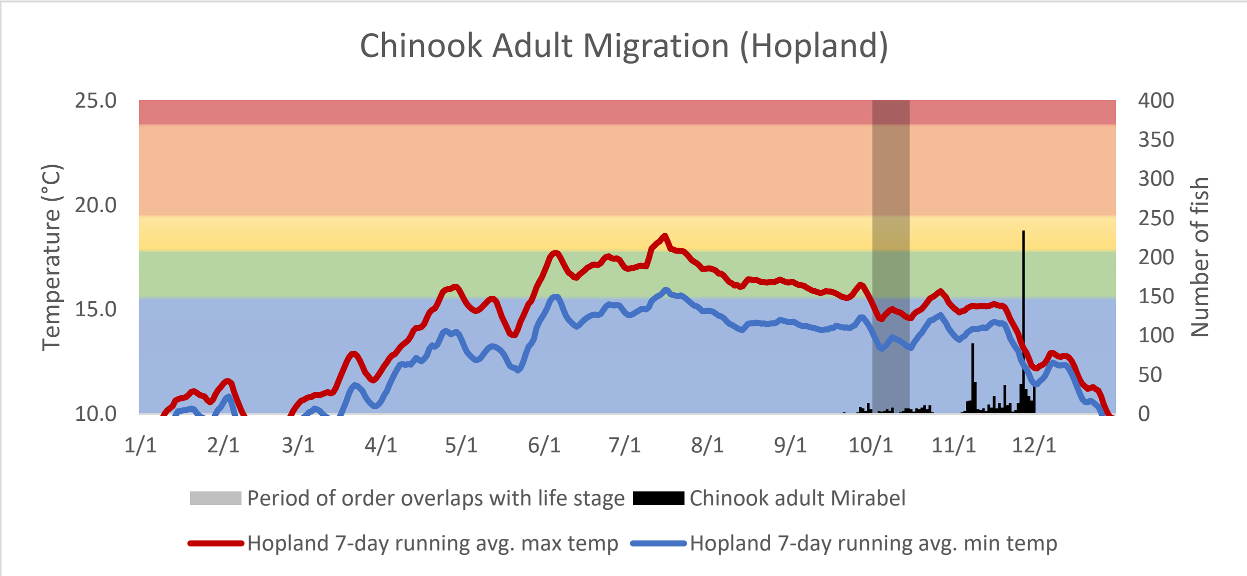


Figure 4-5. The 7-day running average of the minimum and maximum water temperatures collected at the USGS stream gage at Hopland (11462500) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook adult migration based on Table 4-1.

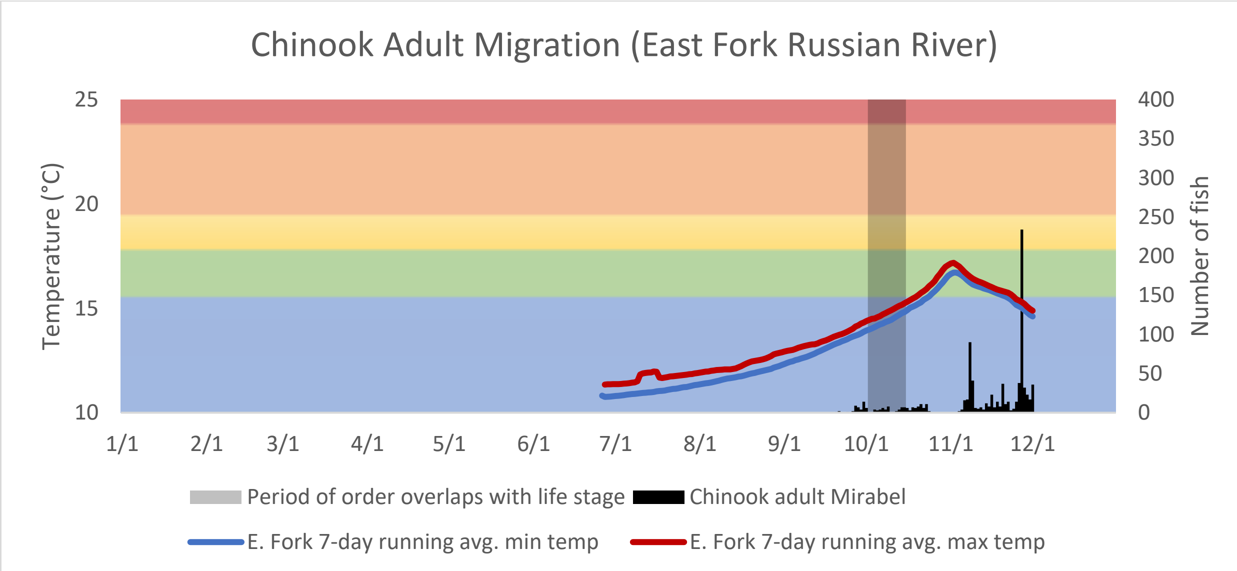


Figure 4-6. The 7-day running average of the minimum and maximum water temperatures collected in the East Fork Russian River approximately 1/3 of a mile downstream of the Coyote Valley Dam shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook adult migration based on Table 4-1.

Salmonid Rearing

Salmonids must cope with water temperatures found at their rearing sites. In the Russian River basin much of the salmonid rearing habitat is located in tributaries to the Russian River including Dry Creek but Chinook and steelhead rear in the mainstem Russian River as well. Chinook emerge from redds constructed in the upper Russian River in the early spring and begin rearing in the shallow portions of the stream margins. In the mainstem Russian River Chinook finish rearing in the early spring when water temperatures are still relatively cool throughout the River. As a result, Chinook rear at more locations in the Russian River, but for a shorter time period than steelhead. Therefore, we relate water temperature at a number of mainstem Russian River sites to Chinook water temperature criteria. Steelhead rear in freshwater for one or more years and are restricted to the portion of Russian River where water is released from the cold-water pool (the bottom portion of the lake) in Lake Mendocino. We relate steelhead water temperature criteria to water temperature collected in the East Fork Russian River and at Hopland as these sites are within the section of the Russian River that can provide year-round rearing opportunities for juvenile steelhead.

Chinook

During 2019 water temperatures for rearing Chinook were favorable in the early spring at all sites and became less favorable in May and June in the mainstem Russian River at Jimtown, Digger Bend, and Hacienda. Water temperatures were generally in the optimal or suitable range for Chinook salmon rearing in the East Fork Russian River and at the USGS stream gage at Hopland (gauge number 11462500, Figure 4-8 and Figure 4-9). At Jimtown, Digger Bend, and Hacienda water temperatures were generally favorable for Chinook rearing until May, then temperatures became stressful and eventually acutely stressful or even potentially lethal by June (Figures 10-12). It is important to note that Chinook have evolved to migrate downstream and out to sea in the spring to avoid rearing at high temperatures.

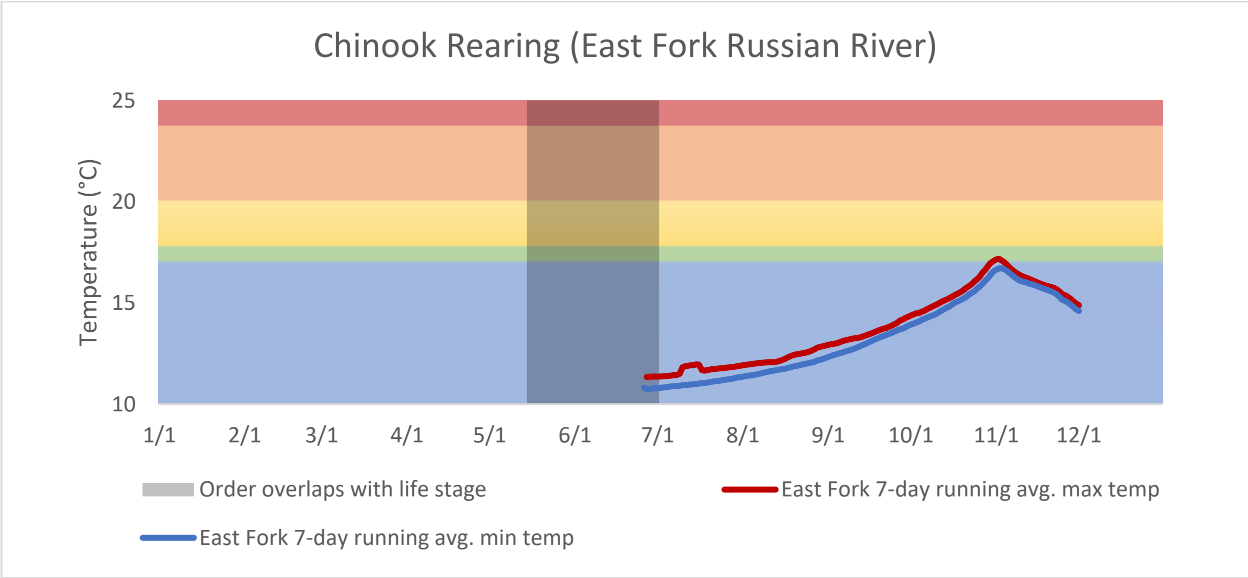


Figure 4-8. The 7-day running average of the minimum and maximum water temperatures collected in the East Fork Russian River approximately 1/3 of a mile downstream of the Coyote Valley Dam shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook rearing based on Table 4-2.

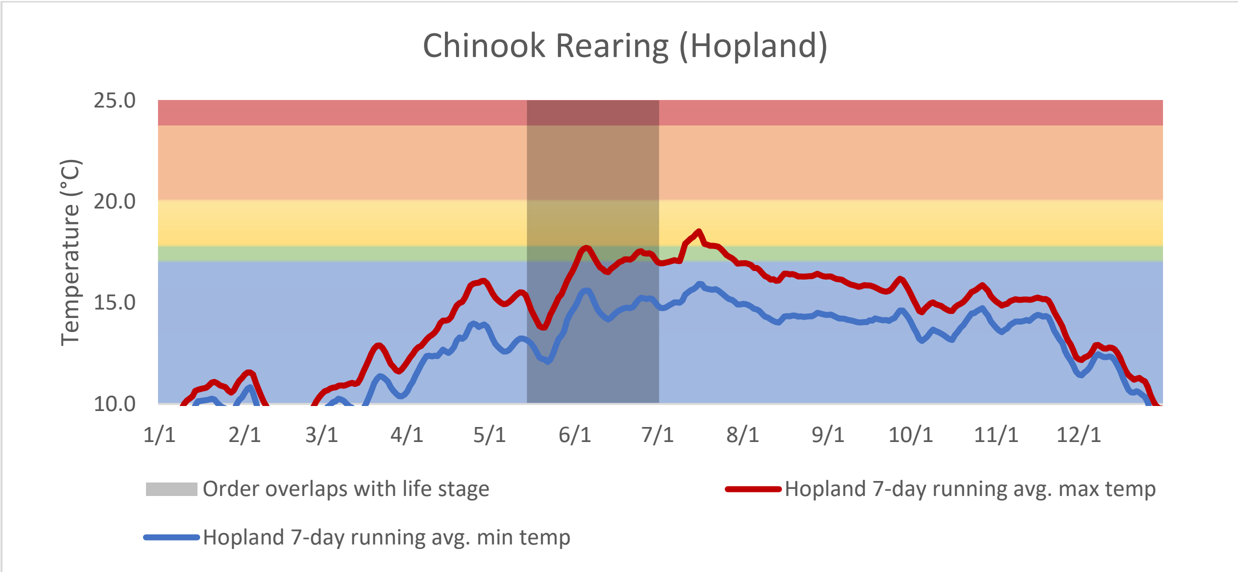


Figure 4-9. The 7-day running average of the minimum and maximum water temperatures collected at the USGS stream gage at Hopland (11462500) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook rearing based on Table 4-2.

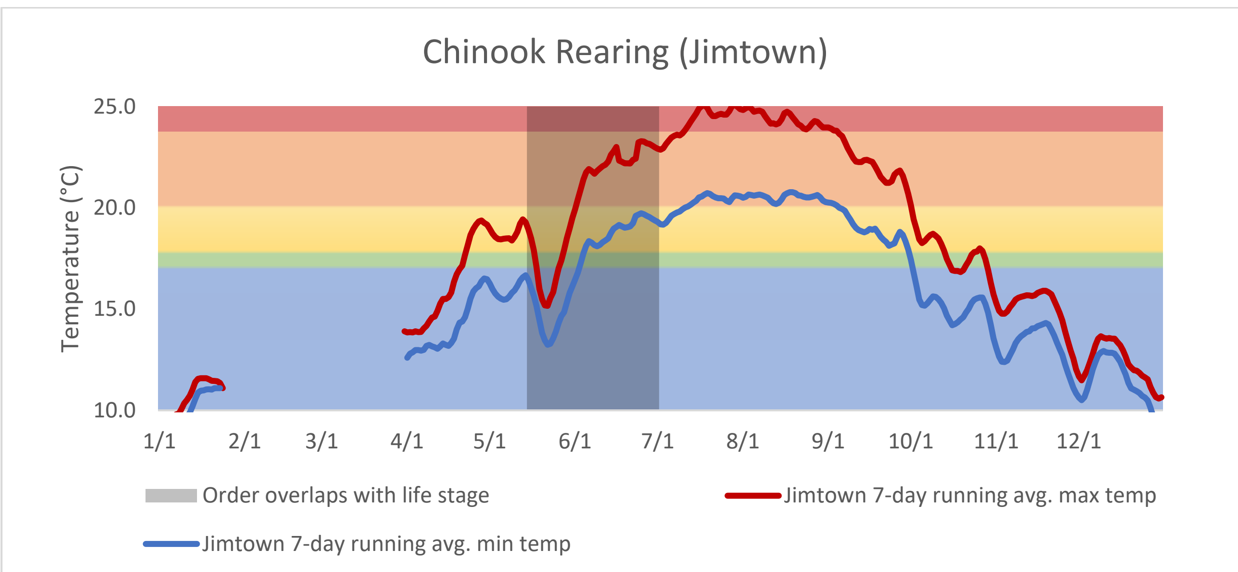


Figure 4-10. The 7-day running average of the minimum and maximum water temperatures collected at the USGS stream gage at Jimtown (USGS gage number 11463682) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook rearing based on Table 4-2.

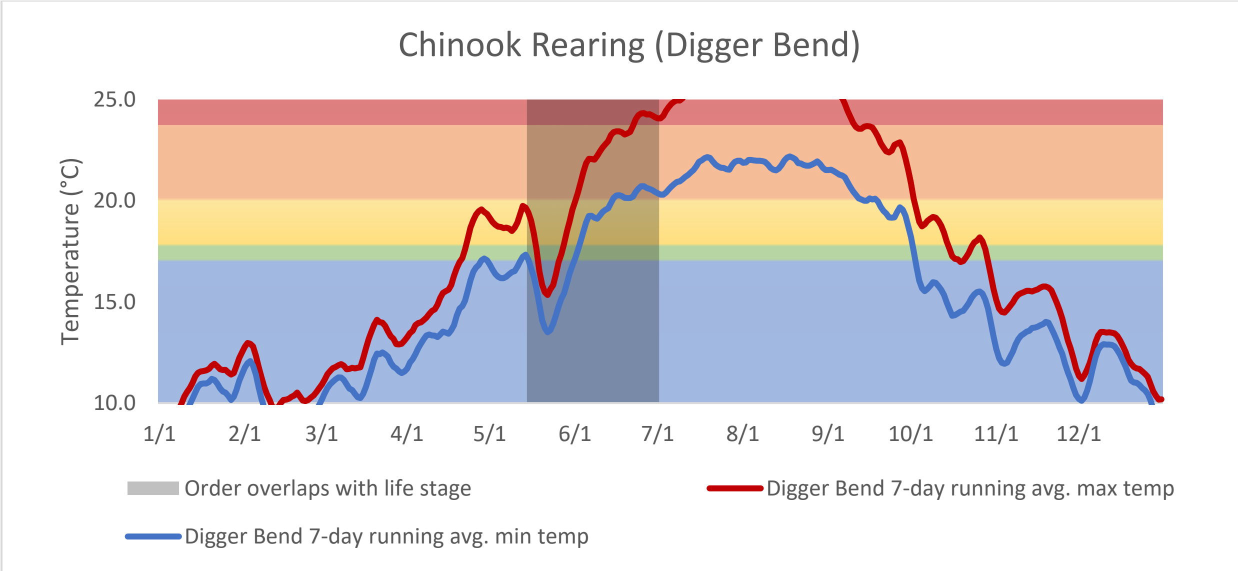


Figure 4-11. The 7-day running average of the minimum and maximum water temperatures collected at the USGS stream gage at Digger Bend (11463980) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook rearing based on Table 4-2.

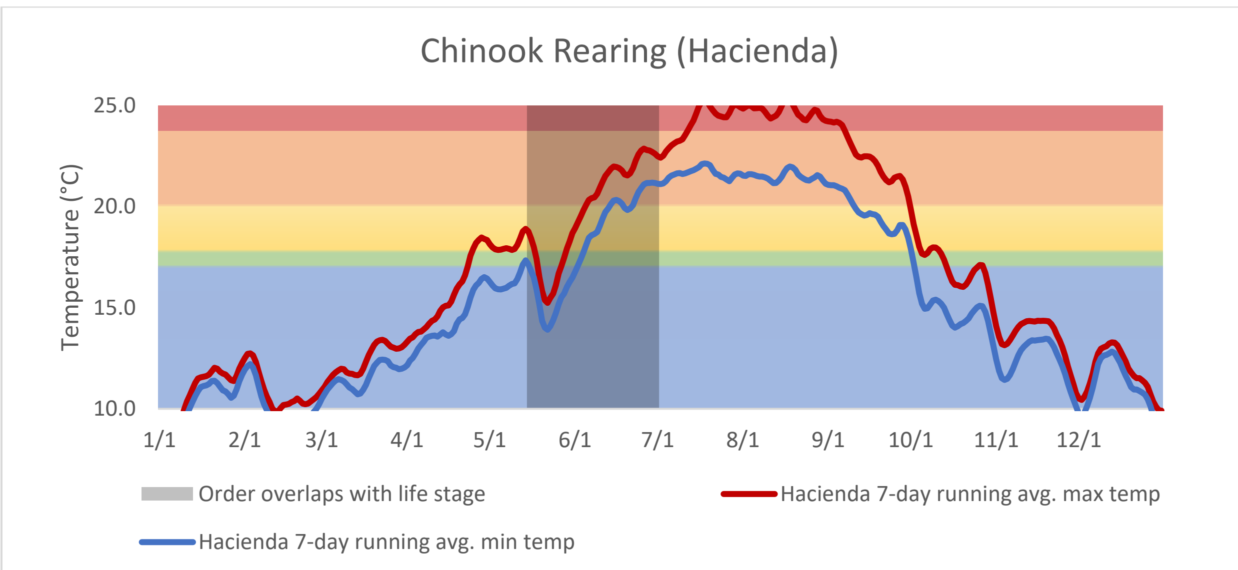


Figure 4-12. The 7-day running average of the minimum and maximum water temperatures collected at the USGS stream gage at Hacienda (gage number 11467000) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook rearing based on Table 4-2.

Steelhead

Steelhead parr rear year-round in the upper Russian River. Water temperature was optimal for most of the Order in the East Fork Russian River (Figure 4-15). During the Order water temperature at the USGS stream gage at Hopland mainly fell in the optimal to suitable range for steelhead parr (Figure 4-16).

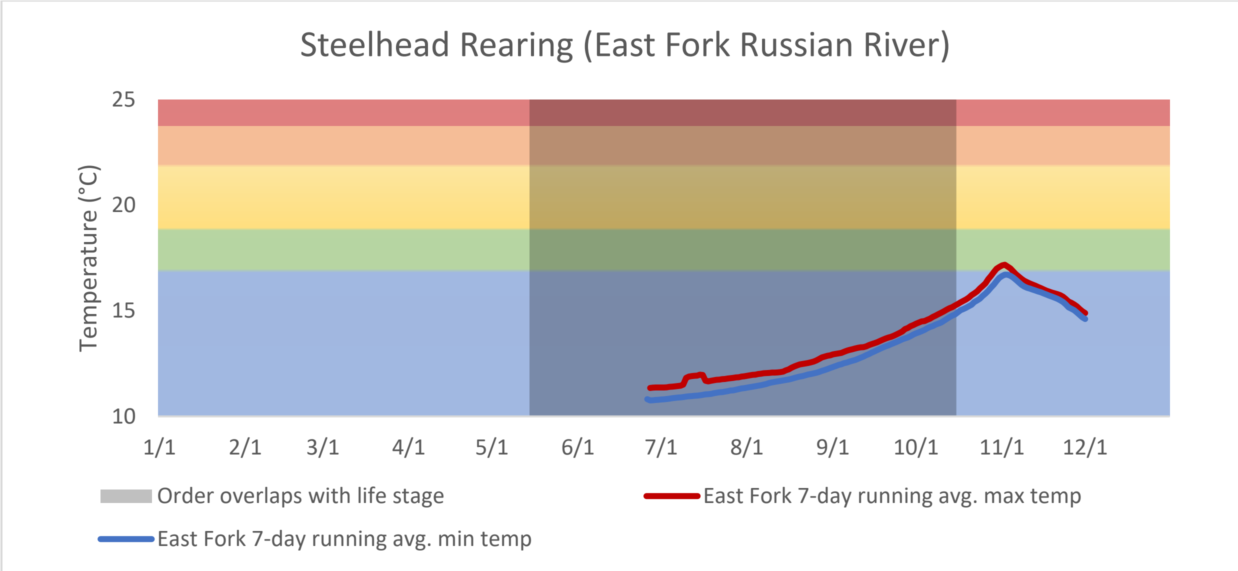


Figure 4-15. The 7-day running average of the minimum and maximum water temperatures collected in the East Fork Russian River. The optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for steelhead parr based on Table 4-2 are also shown.

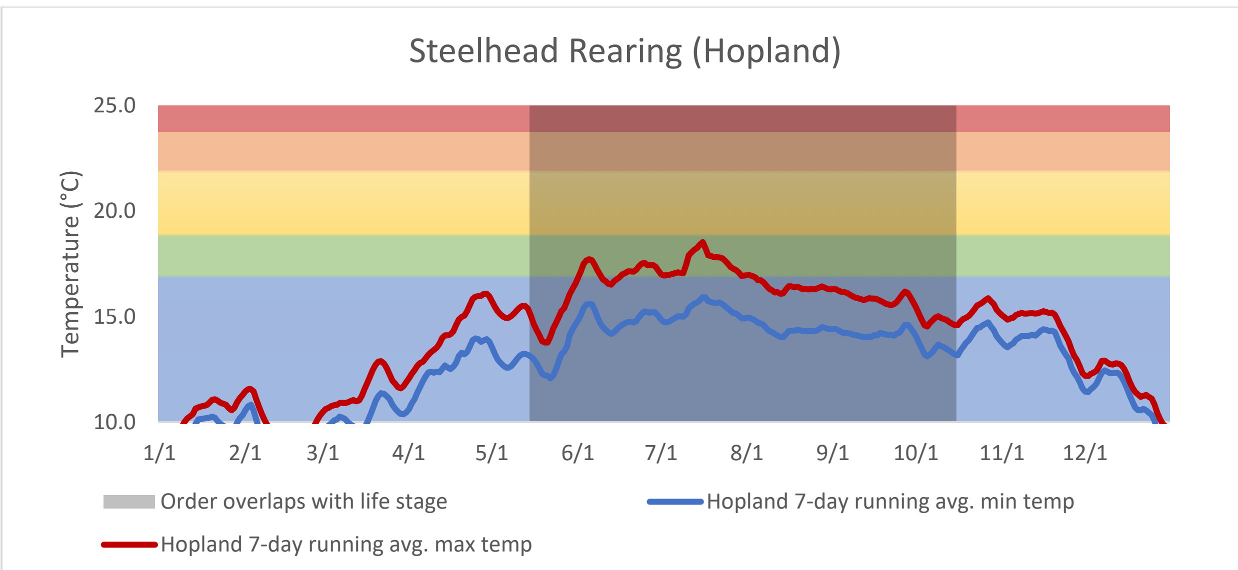


Figure 4-16. The 7-day running average of the minimum and maximum water temperatures collected at Hopland (USGS stream gage number 11462500). The optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for steelhead parr based on Table 4-2 are also shown.

Salmonid Smolt Outmigration

As salmonid smolts emigrate to the ocean they experience river temperatures that are often warmer than their natal habitat conditions. We therefore summarized water temperatures for the East Fork Russian River, Hopland, Jimtown, and Digger Bend gages and show these temperatures with water temperature criteria for Chinook and steelhead. We operated a downstream migrant trap on the Russian River near Mirabel from May 1, 2019, until July 8, 2019. From May 15, 2019 to July 8, 2019 we captured 819 Chinook salmon smolts, 34 coho salmon smolts and 16 wild steelhead smolts at this trapping site. We related these catch data to temperature collected at Hacienda. Hacienda is located approximately 4 km downstream of the trap site and represents temperatures experienced by smolts as they emigrate through the lower river. It is noteworthy that many of these smolts emigrate from Dry Creek where temperatures are significantly cooler than temperatures at Hacienda.

Chinook

Water temperature in the Russian River near the Coyote Valley Dam was favorable for Chinook smolts during the period of time that Chinook are expected to emigrate from that potion of the Russian river (April through June, Figure 4-17 and Figure 4-18). However, water temperature became less favorable in the later part of the migration season at sites located downstream of Hopland (Figure 4-19 through Figure 4-21). It is important to note that Chinook have evolved to emigrate during the spring before water temperatures become lethal.

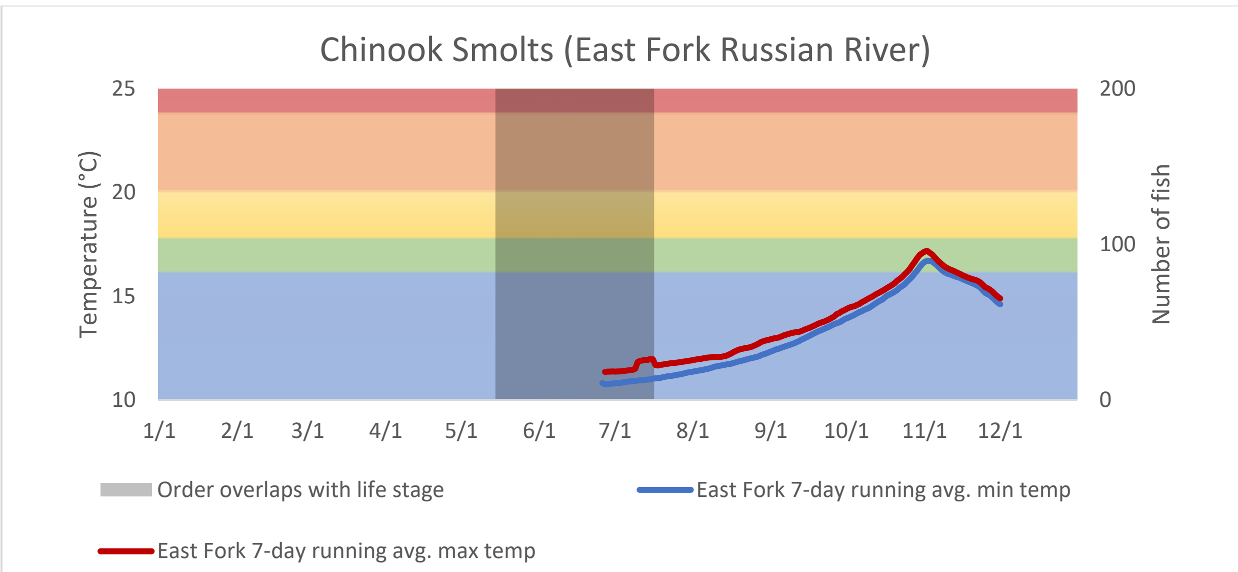


Figure 4-17. The 7-day running average of the minimum and maximum water temperatures collected in the East Fork Russian River shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook smolts based on Table 4-3.

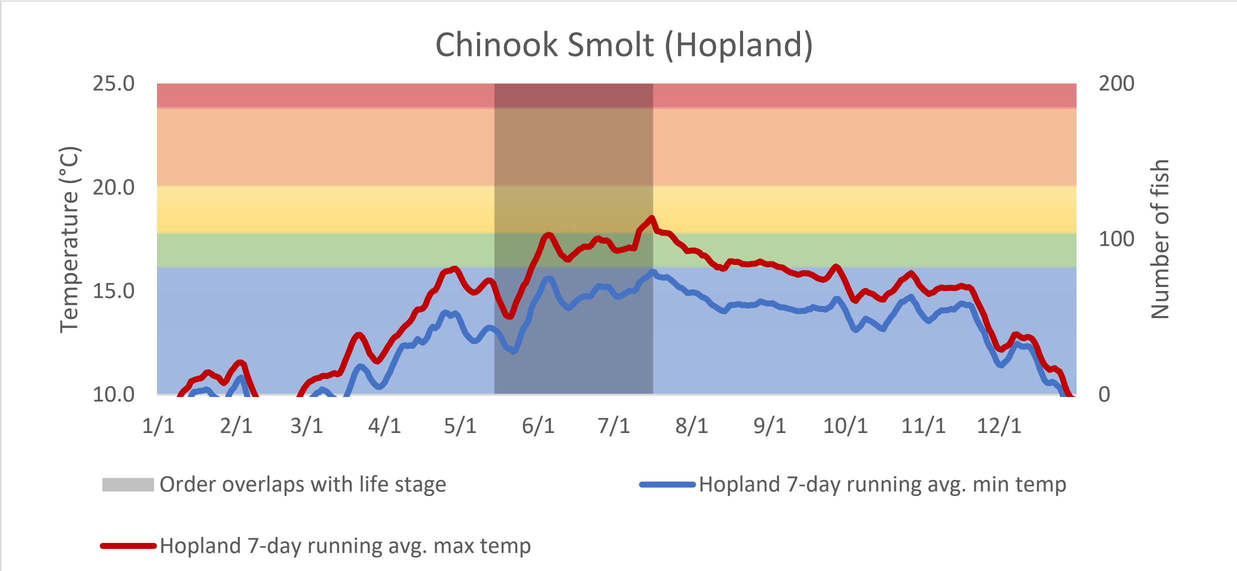


Figure 4-18. The 7-day running average of the minimum and maximum water temperatures collected at Hopland (USGS stream gage number 11462500). Shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook smolts based on Table 4-3.

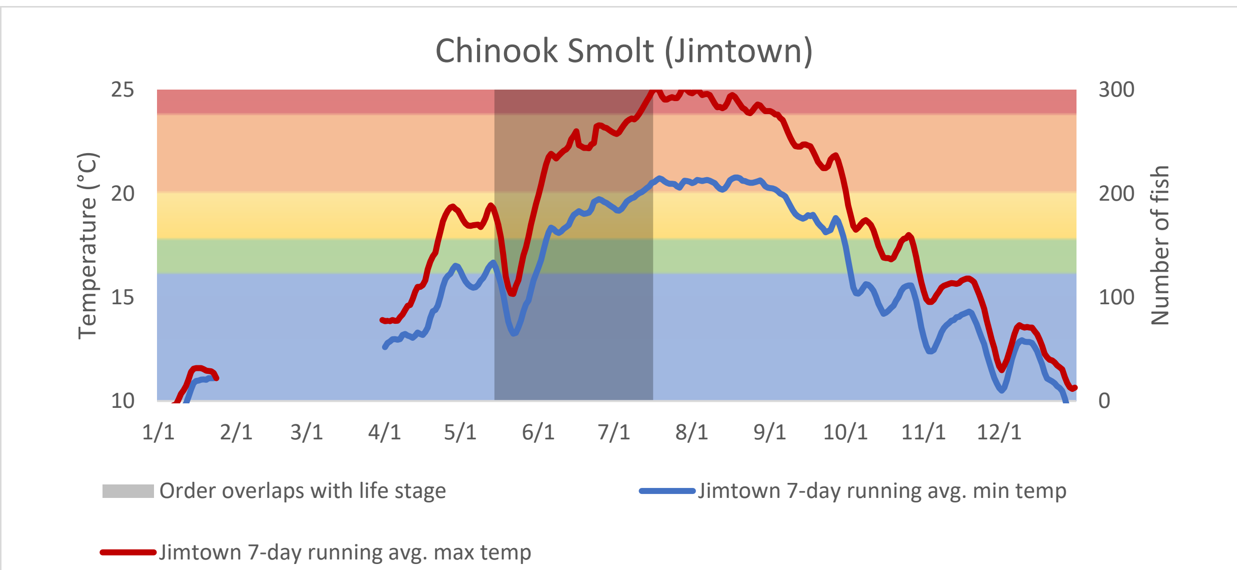


Figure 4-19. The 7-day running average of the minimum and maximum water temperatures collected at the Jimtown USGS stream Gage (1146382) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook smolts based on Table 4-3.

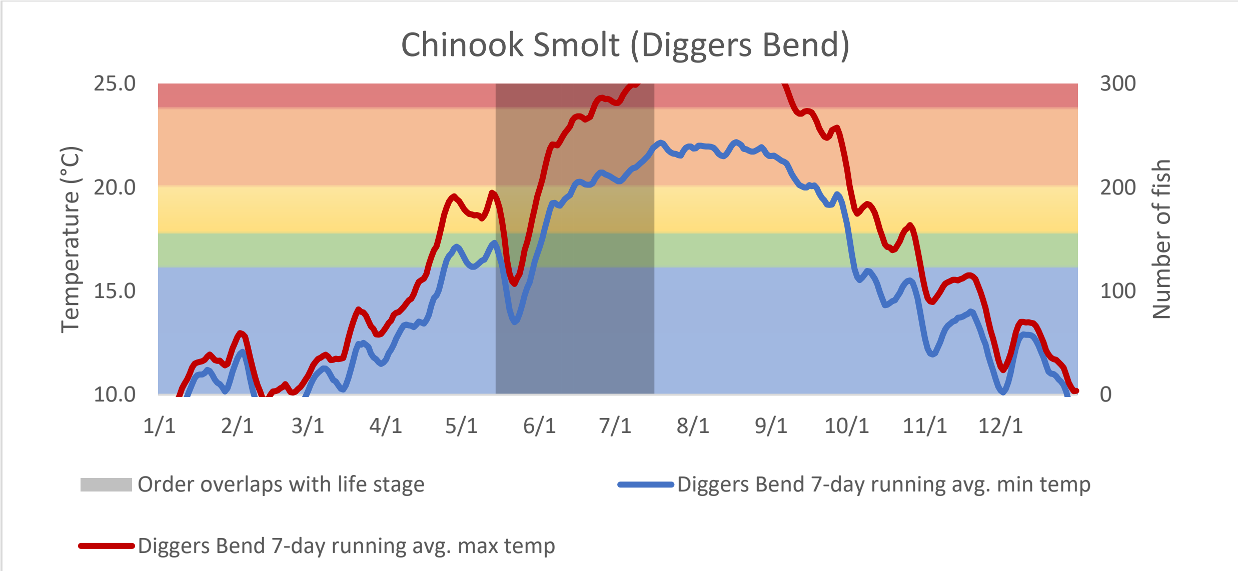


Figure 4-20. The 7-day running average of the minimum and maximum water temperatures collected at the Digger Bend USGS stream gage (11463980) shown with the daily Chinook smolt catch from a fish trap located at Chalk Hill approximately 5 miles upstream of Digger Bend. Also show are the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook smolts based on Table 4-3.

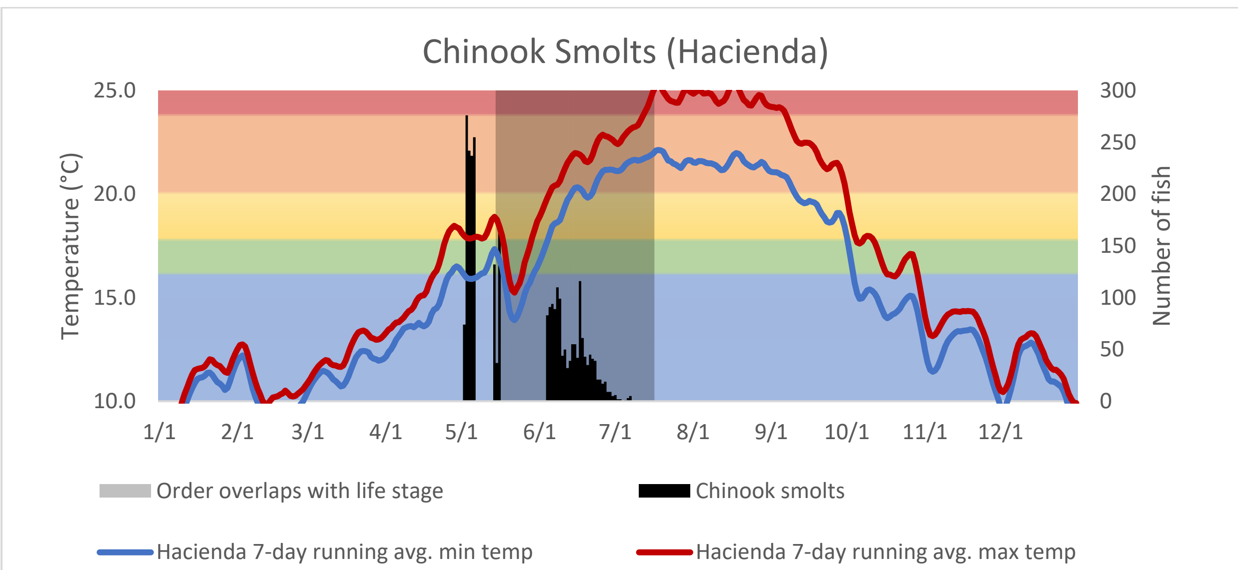


Figure 4-21. The 7-day running average of the minimum and maximum water temperatures collected at Hacienda (USGS gage number 11467000) shown with the Chinook smolt catch from the Mainstem Russian River near Mirabel Also show are the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for Chinook smolts based on Table 4-3.

Coho

A total of 34 Coho smolts were captured at the Mirabel downstream migrant trap from May 15, 2019 until July 8, 2019. The water temperature at Hacienda ranged from 14.0 °C to 22.9 °C during that period. For the days that we captured coho smolts the maximum and minimum daily water temperature were generally in the stressful to acutely stressful range (Figure 4-4).

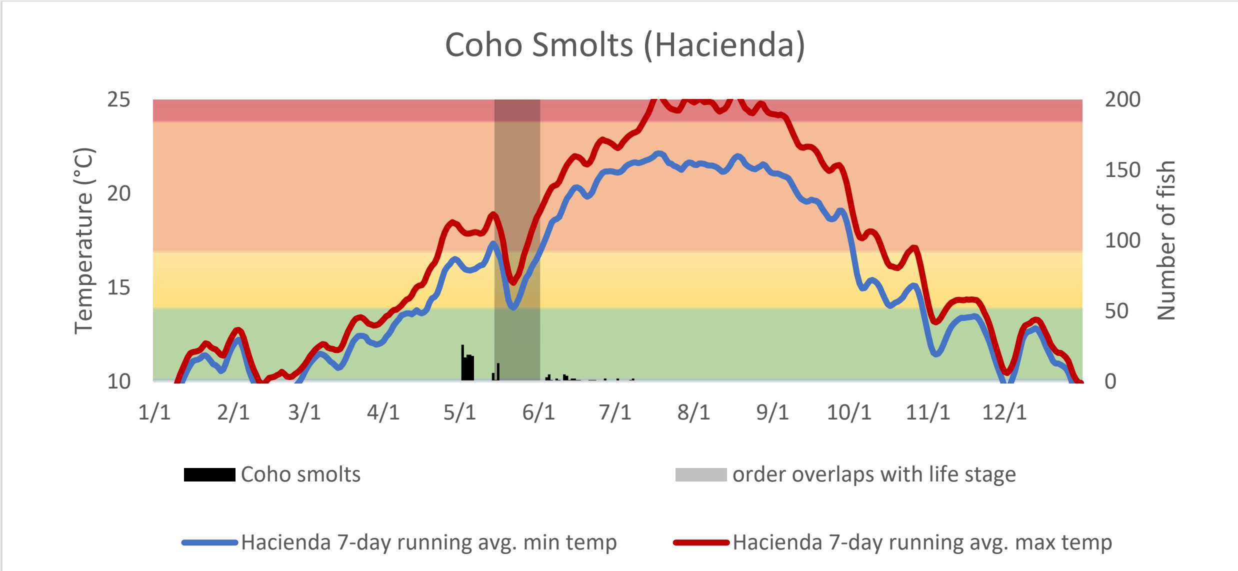


Figure 4-24. The 7-day running average of the minimum and maximum water temperatures collected at Hacienda (USGS gage number 11467000) shown with the coho smolt catch from the mainstem Russian River at Mirabel. Also show are the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for coho smolts based on Table 4-3.

Steelhead

Water temperature for steelhead smolting ranged from suitable to lethal during the time period that steelhead smolts are expected to be in the Russian River (March 1, to May 31). We captured 81 steelhead smolts in the downstream migrant trap at Mirabel from May 2, to July 1, 2019. Water temperatures in the East Fork Russian River were likely suitable for steelhead smolting, but data for that time period was missing from the record (Figure 4-25). At Hopland water temperatures for smolting steelhead were suitable to acutely stressful. At Jimtown and Digger Bend water temperatures for steelhead smolts were stressful to acutely stressful (Figure 4-26 to Figure 4-28). For days that fish were captured during the Order, the minimum and maximum daily water temperature ranged from optimal to acutely stressful at Hacienda (Figure 4-29).

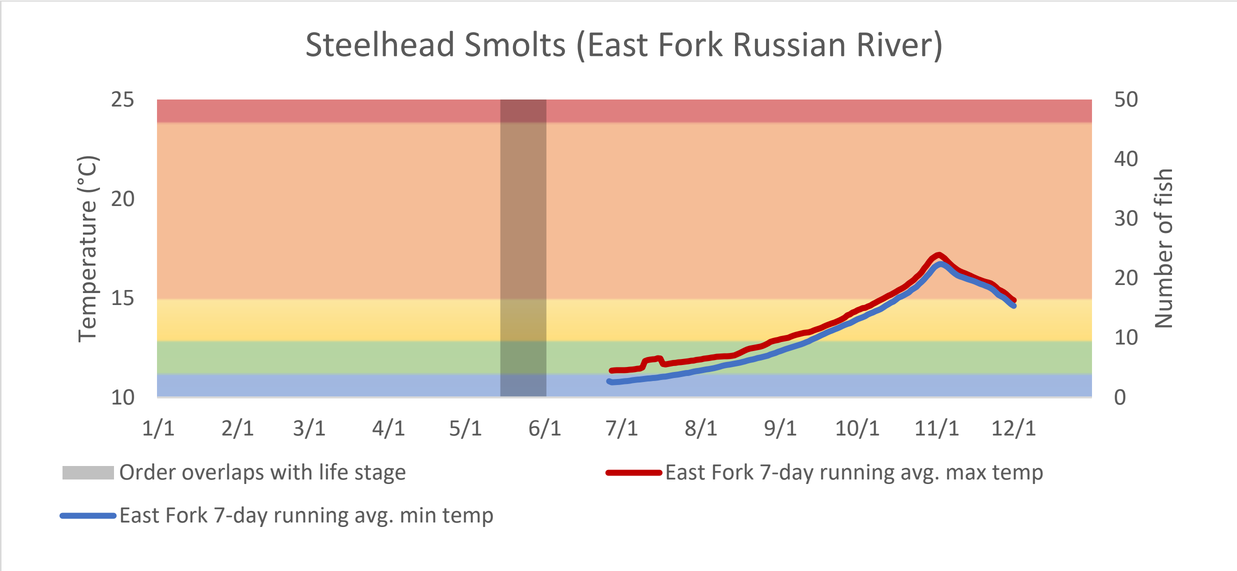


Figure 4-25. The 7-day running average of the minimum and maximum water temperatures collected in the East Fork Russian River shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for steelhead smolts based on Table 4-3.

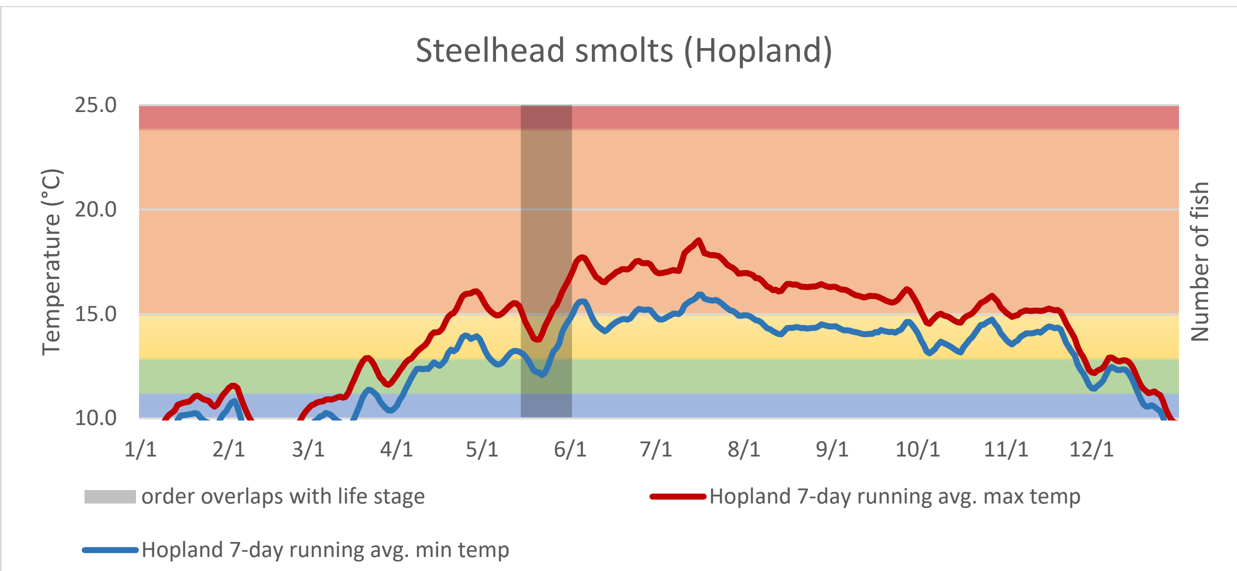


Figure 4-26. The 7-day running average of the minimum and maximum water temperatures collected at the USGS gage at Hopland (gage number 11462500) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for steelhead smolts based on Table 4-3.

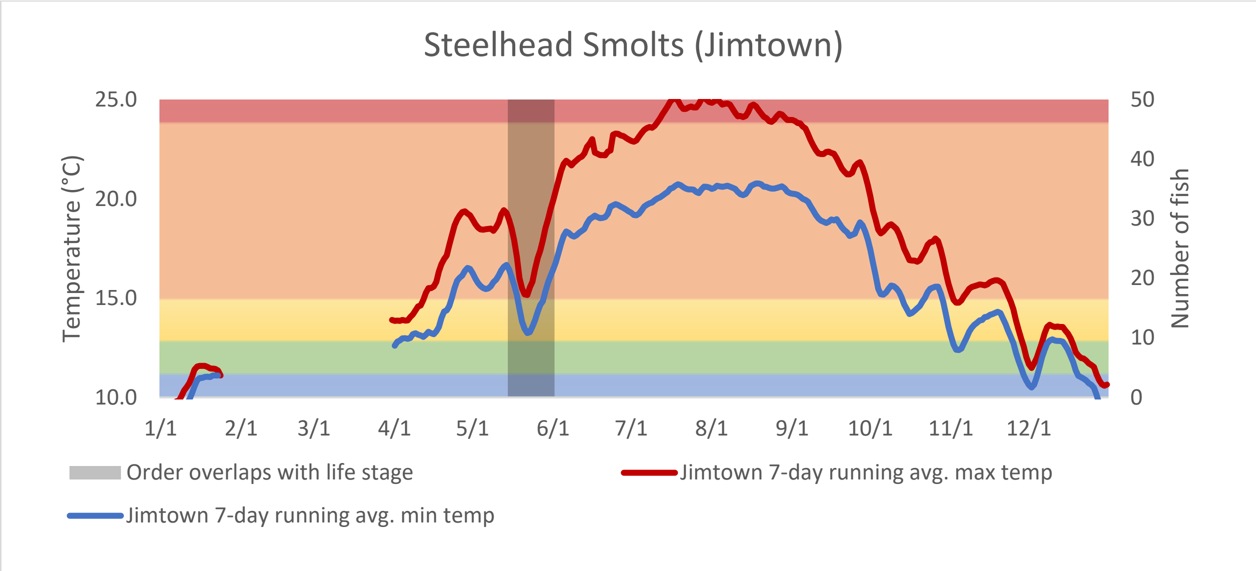


Figure 4-27. The 7-day running average of the minimum and maximum water temperatures collected at the USGS gage at Jimtown (USGS gage number 11463682) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for steelhead smolts based on Table 4-3.

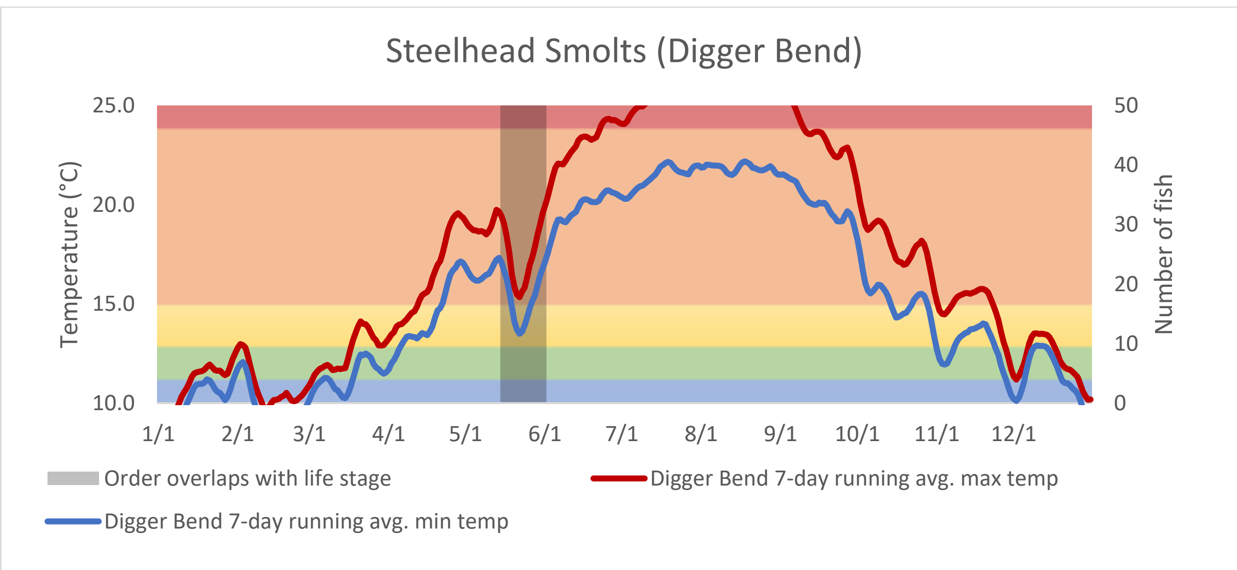


Figure 4-28. The 7-day running average of the minimum and maximum water temperatures collected at the USGS gage at Digger Bend (11463980) shown with the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for steelhead smolts based on Table 4-3.

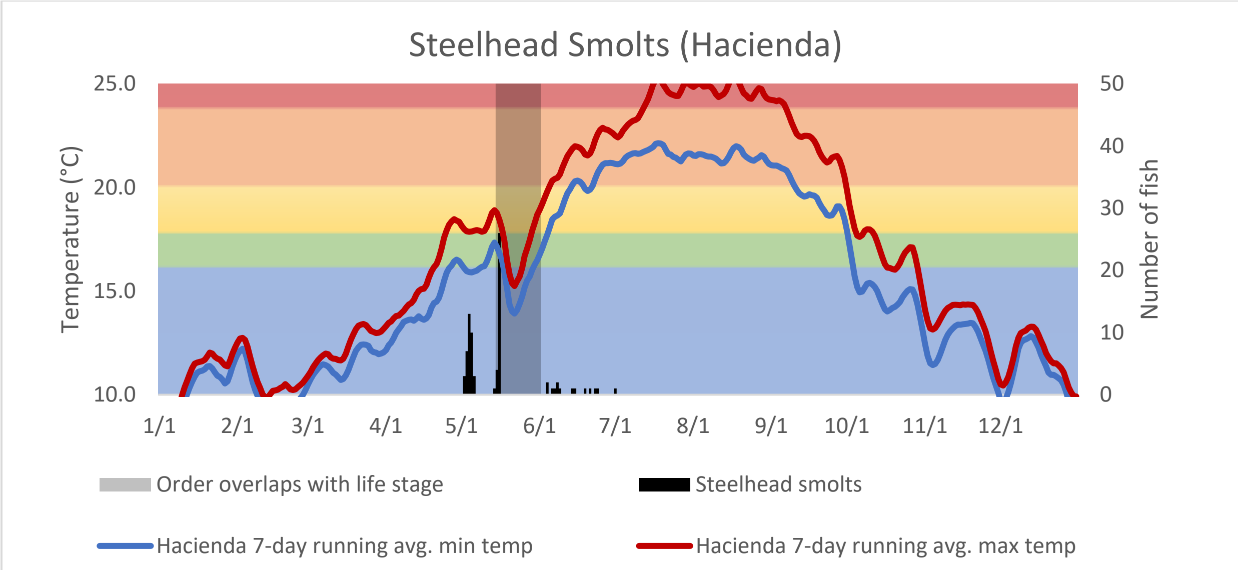


Figure 4-29. The 7-day running average of the minimum and maximum water temperatures collected at Hacienda (USGS gage number 11467000) shown with the steelhead smolt catch from the mainstem Russian River at Mirabel. Also show are the optimal, suitable, stressful, acutely stressful and lethal water temperature thresholds for steelhead smolts based on Table 4-3.

Dissolved Oxygen

At most sites, dissolved oxygen was generally favorable for salmonids in the Russian River throughout the Order. However, dissolved oxygen declined throughout the year in the East Fork of the Russian River to a level that was very poor for salmonids (Figure 4-30). At Hopland, Jimtown, Digger Bend, and at Hacienda, dissolved oxygen levels were generally in the optimal and suitable range although the minimum daily dissolved oxygen levels became stressful at some sites (Figures 4-31 through 4-34).

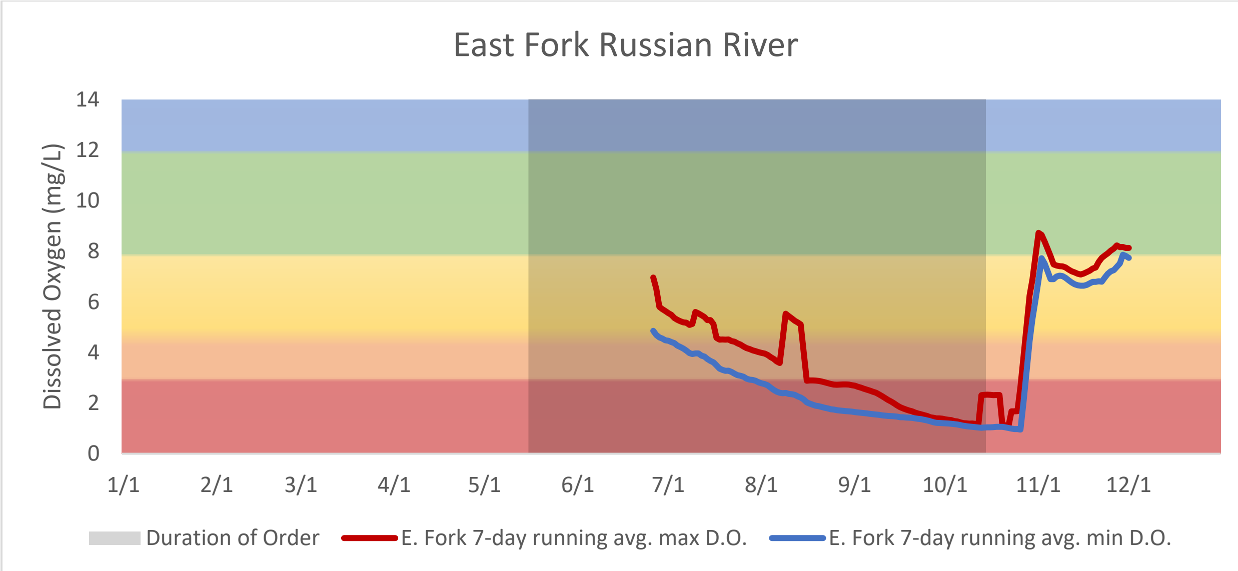


Figure 4-30. The 7-day running average of the minimum and maximum dissolved oxygen collected in the East Fork Russian River approximately 1/3 mile downstream of the Coyote Valley Dam. Shown with the optimal, suitable, stressful, acutely stressful, lethal dissolved oxygen zones based on our criteria. See Table 4-3 for a description of water quality zones.

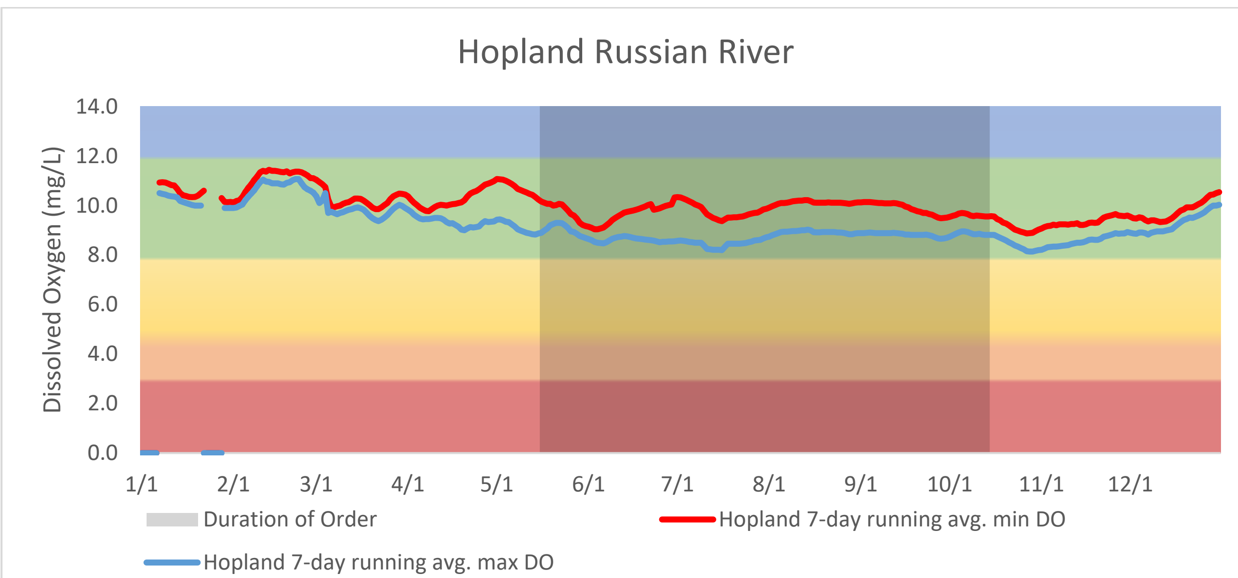


Figure 4-31. The 7-day running average of the minimum and maximum dissolved oxygen collected at Hopland (USGS stream gage number 11462500). Also shown are the optimal, suitable, stressful, acutely stressful, lethal dissolved oxygen zones based on our criteria. See Table 4-4 for a description of water quality zones.

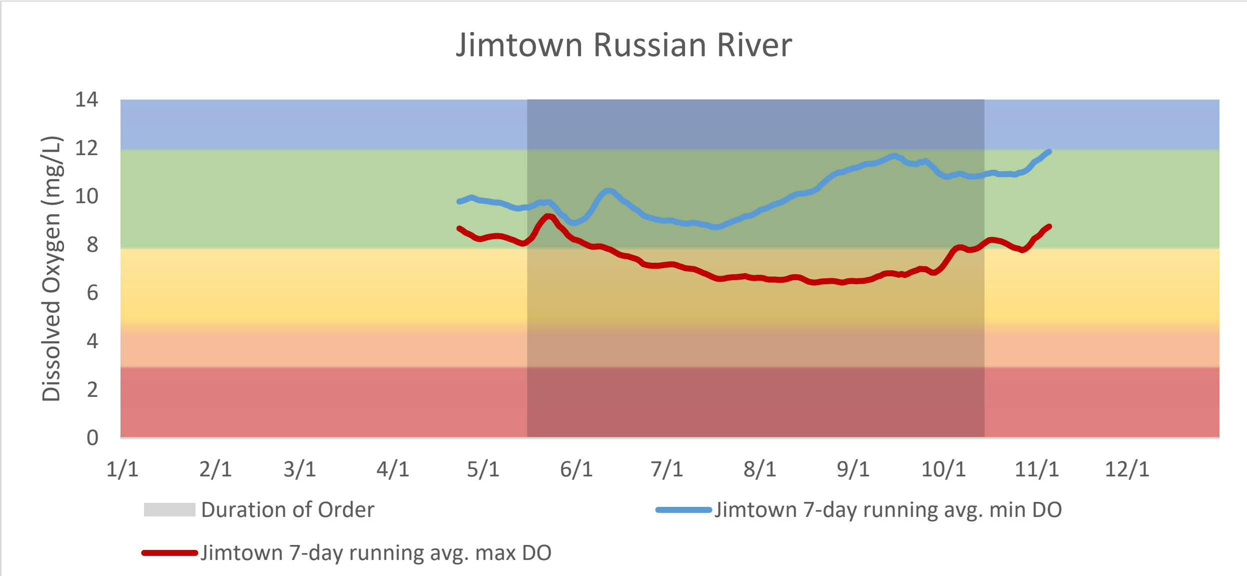


Figure 4-32. The 7-day running average of the minimum and maximum dissolved oxygen collected at the Jimtown USGS stream Gage (1146382). Also shown are the optimal, suitable, stressful, acutely stressful, lethal dissolved oxygen zones based on our criteria. See Table 4-4 for a description of water quality zones.

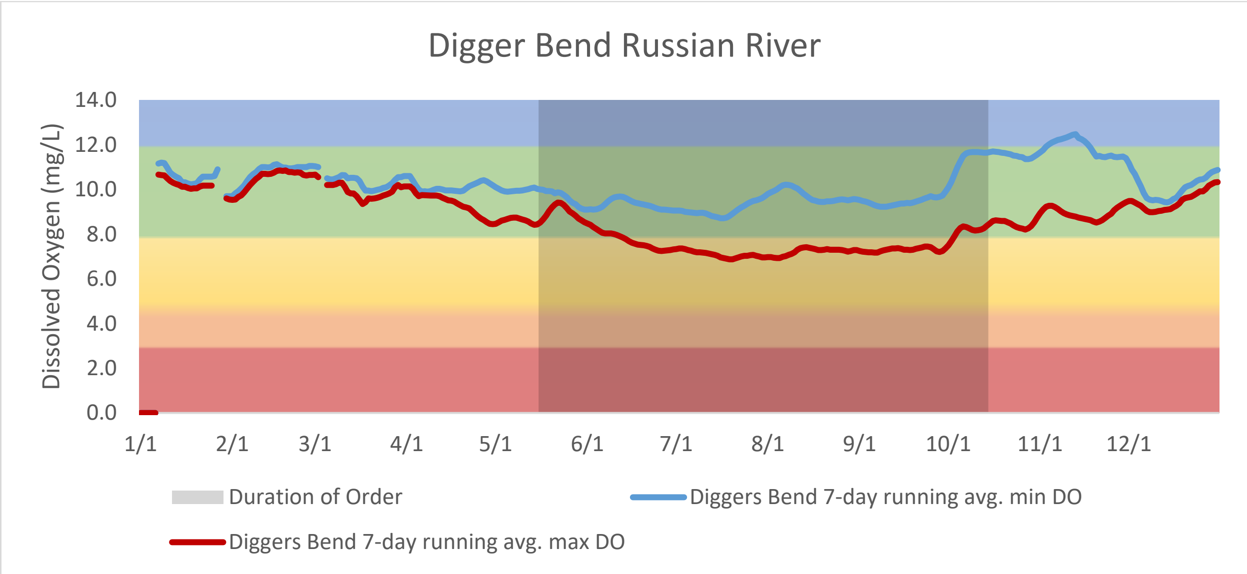


Figure 4-33. The 7-day running average of the minimum and maximum dissolved oxygen collected at the Digger Bend USGS stream gage (11463980). Also shown are the optimal, suitable, stressful, acutely stressful, lethal dissolved oxygen zones based on our criteria. See Table 4-4 for a description of water quality zones.

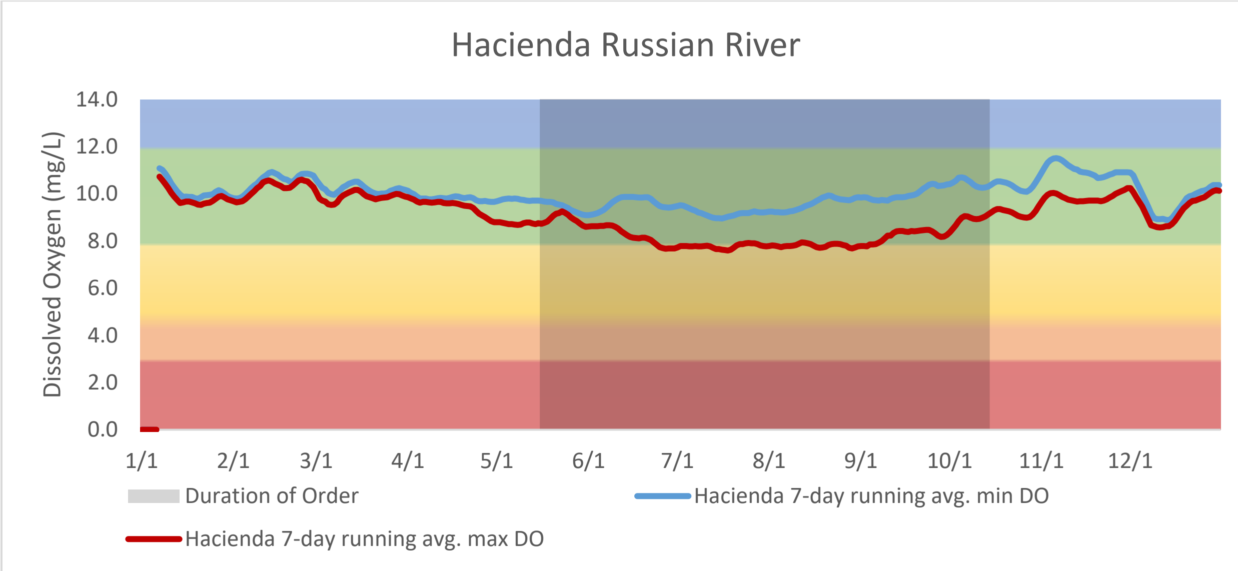


Figure 4-35. The 7-day running average of the minimum and maximum dissolved oxygen collected at the Hacienda USGS stream gage (1146700). Also shown are the optimal, suitable, stressful, acutely stressful, lethal dissolved oxygen zones based on our criteria. See Table 4-4 for a description of water quality zones.

4.2.5 Summary

Compared to the last few years of significant drought, flows in 2019 were higher in the Russian River during the spring, summer, and fall. Adult fish moved past Mirabel during the Order. When Chinook first began migrating upstream in 2019, water temperature at Hacienda was stressful to acutely stressful, but quickly decline to suitable to optimal temperatures. Water temperatures at sites upstream of Hacienda followed a similar trend where temperatures were acutely stressful to stressful then declined as air temperatures declined with the onset of fall. By mid-October Water temperatures were suitable to optimal for adult Chinook at all sites. While temperatures were occasionally unfavorable for adult Chinook it is important to note that (1) Chinook have evolved to cope with seasonally warm water temperatures by returning to the river in the fall when water temperatures are beginning to cool and (2) the vast majority of adult Chinook return to the Russian River after mid-October when water temperatures in the river are becoming favorable.

For Chinook, water temperatures were favorable for rearing in the early spring and at most sites, but became unfavorable by the end of the rearing season. Water temperatures remained suitable to optimal in the East Fork Russian River throughout the rearing season. Fish that remained at these sites to rear and emigrated as smolts late in the rearing season encountered unfavorable water temperatures as they moved downstream and out to sea. It is important to note that Chinook have likely adapted to warm temperatures in the Russian River and have adjusted their run timing to further cope with seasonally warmer water temperatures by emigrating earlier in the year.

Water temperatures were unfavorable for coho in the mainstem Russian River during the Order. However, favorable conditions for coho salmon rearing exist in Dry Creek. Sonoma Water has begun implementing habitat enhancements in Dry Creek (SCWA 2016). In the future there will be additional habitat available for coho rearing in Dry Creek.

Water temperatures near Hopland were favorable for steelhead rearing throughout the Order. In the East Fork Russian River water temperature began to warm from August to the end of the Order as the cold water pool in Lake Mendocino was depleted. However, water temperature in the East Fork Russian River remained below stressful levels for rearing steelhead.

Chinook salmon had favorable water temperatures for smolting at the East Fork Russian River and Hopland. Water temperatures became acutely stressful after June 1. Many Chinook smolts are captured in the Dry Creek downstream migrant trap after June 1, when water temperatures became stressful and acutely stressful at Hacienda. Cold water released from Lake Sonoma may keep Chinook smolts from receiving migration cues they might otherwise receive as the water warmed from changing seasons. This may delay some Chinook from emigrating from Dry Creek. Once these late emigrating fish leave Dry Creek, they would experience stressful and acutely stressful temperatures in the lower Russian River.

According to our criteria water temperatures for coho and steelhead smolts in the Russian River was suitable to acutely stressful, but this criterion may not represent fish that have adapted to local conditions. Recent studies suggest that salmonids may adapt to local conditions and that salmonids may tolerate a much wider range of temperatures than reported in the literature (Verhille et al. 2015). Returning adults are evidence that steelhead and coho successfully smolt in the Russian River basin (SCWA 2016). Russian River steelhead and coho that successfully smolt may either undergo the smoltification process earlier in the year when water is cooler, or they may be able to tolerate warmer water temperatures than reported in the literature.

Dissolved oxygen was favorable for salmonids at all sites and for the duration of the Order, with the exception of the East Fork Russian River. In the East Fork Russian River dissolved oxygen decreased throughout the season eventually reaching lethal levels. This would primarily affect summer rearing steelhead that are restricted by temperature to the upper Russian River. In the summer of 2019, water released from the cold-water pool was hypoxic. However, oxygen levels typically recover by the time the released water reaches the confluence with the West Fork (Jeff Church personal communication). Low dissolved oxygen in this section of river probably has a relatively small impact on the steelhead population since the section of river from Coyote Valley Dam to the confluence with the West Fork Russian River is short. Furthermore, summer rearing steelhead may have left this section of stream when dissolved oxygen became depressed and sought out more favorable habitat downstream. Adult Chinook migrating upstream in the fall could avoid this section of river if dissolved oxygen levels were unfavorable. Therefore, adult Chinook salmon are likely not affected by low dissolved oxygen in the East Fork Russian River.

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