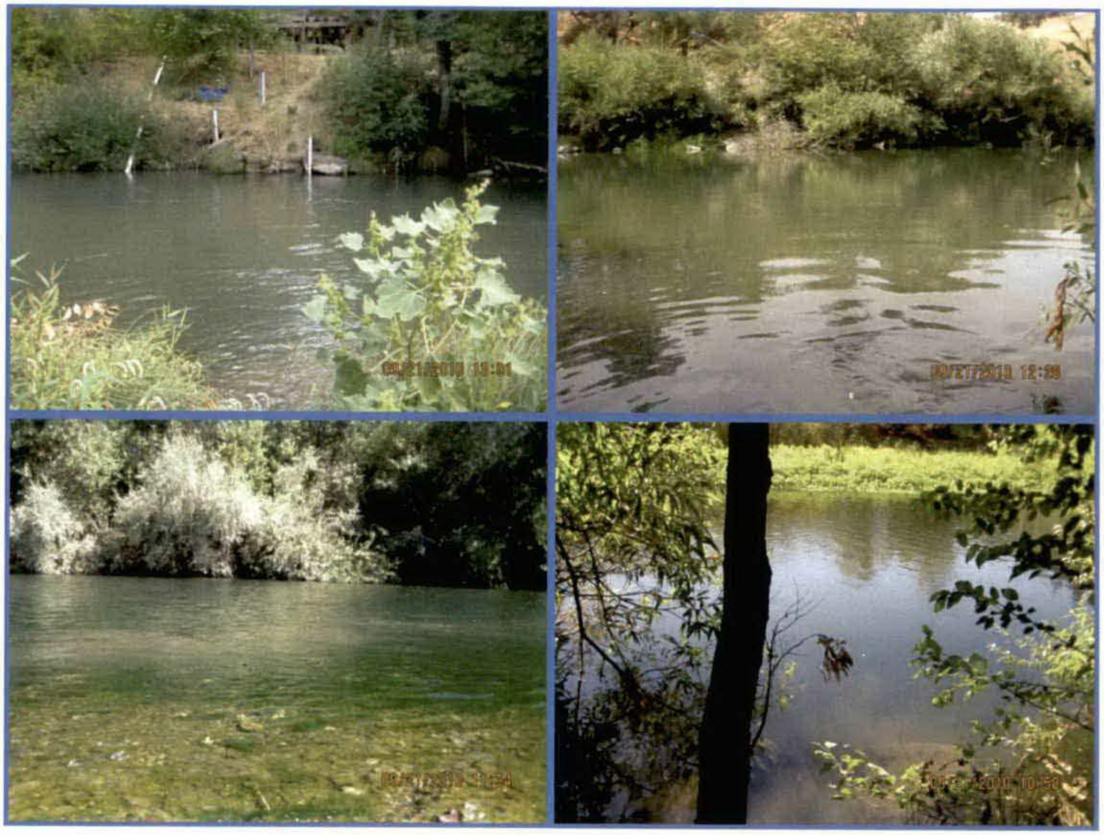
Russian River Water Quality Summary
for the
Sonoma County Water Agency
2010 Temporary Urgency Change (TUC)



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SONOMA COUNTY WATER AGENCY

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1.0 INTRODUCTION

On April 4, 2010, the Sonoma County Water Agency (Water Agency) petitioned the State Water Resources Control Board (SWRCB) to temporarily reduce minimum in-stream flows in the Russian River as required by the National Marine Fisheries Service's (NMFS) *Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation District in the Russian River Watershed* (Russian River Biological Opinion, NMFS 2008).

The Water Agency requested that the SWRCB make the following temporary changes to the Decision 1610 (D1610) in-stream flow requirements:

- From May 1 through October 15, 2010, in-stream flow requirements for the upper Russian River (from the confluence with the East Fork of the Russian River to its Confluence with Dry Creek) be reduced from 185 cfs to 125 cfs,

- From May 1 through October 15, 2010, in-stream flow requirements for the lower Russian River (downstream of its confluence with Dry Creek) be reduced from 125 cfs to 70 cfs with the understanding that the Water Agency will typically maintain approximately 85 cfs at the Hacienda Gauge as practicably feasible.

The SWRCB issued Order WR 2010-0018-DWR (Order) approving the Water Agency's Temporary Urgency Change Petition (TUCP) on May 24, 2010. The Order included several terms and conditions, including requirements for the preparation of a water quality monitoring plan (Term 8). The Water Agency submitted a plan to meet the requirements of Term 8 on June 21, 2010. On August 30, 2010, the SWRCB responded and required changes to the proposed water quality monitoring plan. The Water Agency incorporated the changes and completed the water quality monitoring as required. This report provides and summarizes the data collected by the United States Geological Survey (USGS), the North Coast Regional Water Quality Control Board (NCRWQCB), the Sonoma County Department of Environmental Health, and the Water Agency during the term of the Order.

2.0 2010 RUSSIAN RIVER FLOW SUMMARY

As described in the Order, the Water Agency requested temporary changes to D1610 in-stream flow requirements including reductions from 185 cfs to 125 cfs in the upper Russian River (from its confluence with the East Fork of the Russian River to its confluence with Dry Creek) and from 125 cfs to 70 cfs in the lower Russian River (downstream of its confluence with Dry Creek). The purpose of the 2010 TUCP was to comply with the Biological Opinion which found that stream velocities under D1610 (D1610) flows reduced the amount of available summer rearing habitat in the upper mainstem of the Russian River.

Inflow into Lake Mendocino was sufficiently high enough to classify 2010 as a Normal year under D1610 and storage had improved tremendously over 2009 conditions. Despite the reduced Coyote Valley Dam releases authorized by the Order, flows were above D1610 minimum flows in some sections of the Russian River from tributary inflow due to a relatively wet spring. However, flows in early October were influenced by the need to release stored water from Lake Mendocino. 2010 Flows are summarized in Figure 2-1.

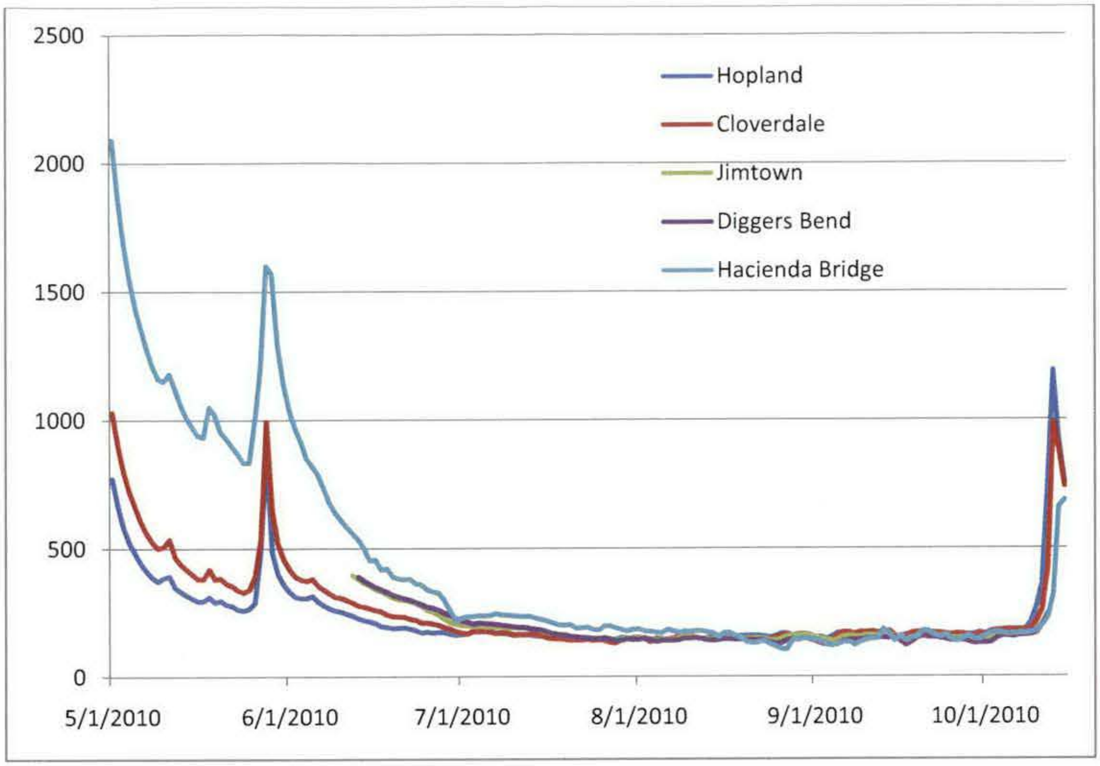

Figure 2-1. 2010 Average Daily Flows USGS Russian River gages, cubic feet per second (cfs)

In the section of the Russian River from Ukiah to the mouth of Dry Creek (upper Russian River) flows dropped below D1610 minimum flow, but remained above minimum flows authorized by the Order. Figure 2-2 shows that flows in the upper Russian River above the Dry Creek confluence did not drop below 185 cfs until mid-June but remained under until early October.

However, flows in the lower Russian River (downstream of the confluence with Dry Creek) were higher than D1610 minimum flows during the entire Order with the exception of a few isolated days (Figure 2-3). This was due to late rains, tributary inflows, and relatively cool summer temperatures. Since sustained flows in the lower river did not drop below D1610 minimum stream flows in 2010 the Water Agency did not analyze the potential impacts of water quality as there was no impact related to the Order. However water quality in the lower Russian River is frequently referenced and discussed in this report.

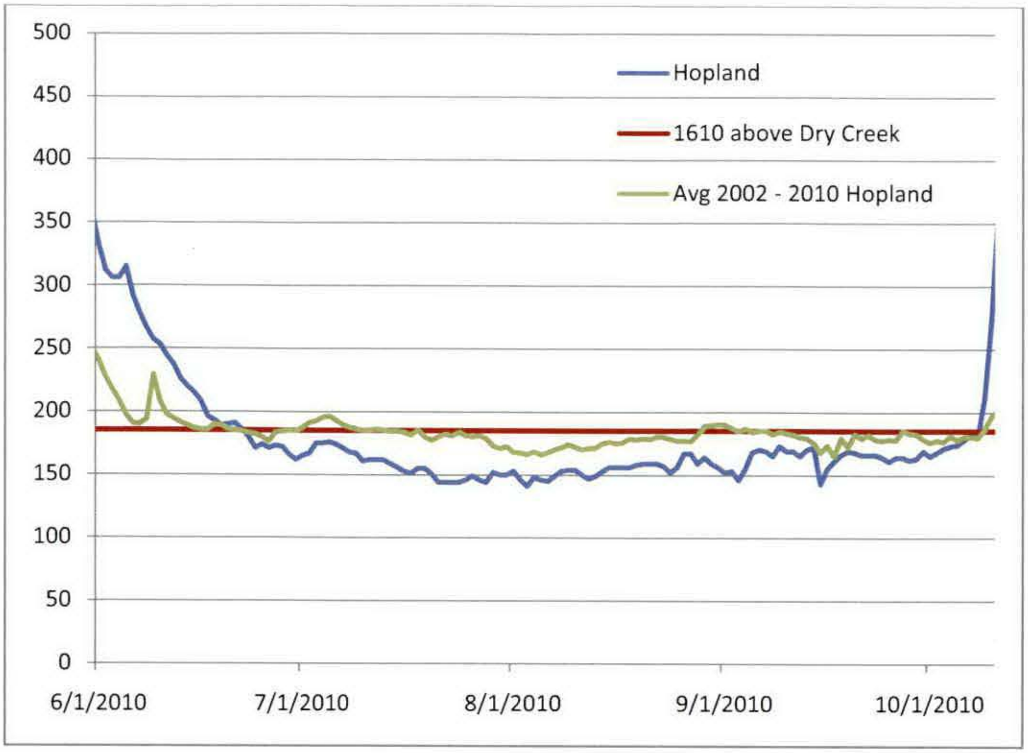

Figure 2-2. 2010 average daily flow above Dry Creek confluence

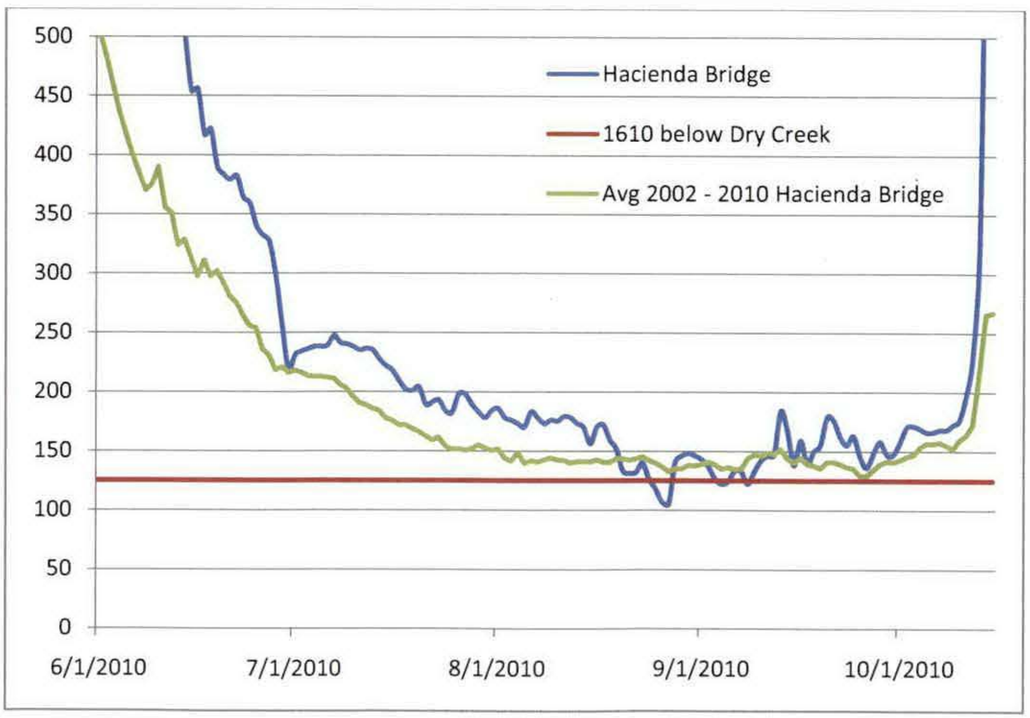

Figure 2-3. 2010 average daily flow below Dry Creek confluence

3.0 WATER QUALITY MONITORING

The collection of water quality data was conducted 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. The resulting 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 in-stream flows that are mandated by the Biological Opinion. A complete analysis and evaluation of the water quality data is being conducted as part of the CEQA requirements associated with establishing permanent changes to D1610 and management of the estuary.

3.1 Mainstem Russian River Water Quality Monitoring

Several agencies conducted water quality monitoring in the mainstem of the Russian River during the term of the Order. The USGS conducted two sampling events; the first in June and the second in September. The NCRWQCB conducted weekly bacteriological sampling in cooperation with the Sonoma County Environmental Health Department at beaches that experience recreational activities involving the greatest body contact. And finally, per the request of the SWRCB and to supplement the USGS and NCRWQCB sampling programs, the Water Agency conducted weekly grab samples from September 21 through October 12 for both pathogens and nutrients.

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. The CDPH draft guideline for total coliform is 10,000 most probable numbers (MPN) per 100 milliliters (ml), 400 MPN per 100 ml for fecal coliforms and 235 MPN per 100 ml for *e coli*. The USGS and Water Agency did not sample for *e coli*. The MPN for Enterococcus is 61 per 100 ml. Exceedances of the draft guidance are highlighted in Table 3-1. However, it must be emphasized that these are draft guidelines, not adopted standards, and are therefore both subject to change (if it is determined that the guidelines are not accurate indicators) and are not currently enforceable. In addition, these draft guidelines were established for and are only applicable to fresh water beaches. Currently, there are no numeric guidelines that have been developed for estuarine areas.

3.1.1 2010 USGS Water Quality Sampling

As described in the monitoring plan, the USGS conducted a large sampling program at eleven surface water sites and four groundwater sites. All samples were analyzed for nutrients, major ions, trace metals, total and dissolved organic carbon, a broad suite of organic compounds (polyaromatic hydrocarbons, disinfection-by-products, selected pesticides and herbicides, and personal care and household products such as fragrances and detergents), by laboratories operated by the USGS. In addition, water samples collected at surface-water sites located at Russian River near Hopland, Russian River at Digger Bend near Healdsburg, Russian River near Guerneville and at Russian River at Casini Ranch were analyzed for human-use pharmaceuticals. The USGS was originally scheduled to conduct three sample events, one sampling event in late spring and two sampling events in summer and early fall. Sampling during the third event was drastically reduced as it occurred during the coordinated effort to release water from Lake Mendocino to reduce levels in the flood pool before the wet season. Flows in the river were too high to conduct in-stream sampling. Table 3-1 provides the results from the USGS pathogen samples collected at the eleven surface water sites. The complete dataset from 2010 is included as Appendix A.

The USGS completed their data report in October 2011. "DS610, Water-Quality Data for the Russian River Basin, Mendocino and Sonoma Counties, California, 2005-2010" is a compilation of the hydrologic and water-quality data collected from 14 Russian River sites, 8 tributary sites, 1 gravel-terrace pit site, 14 groundwater wells, and a wastewater treatment plant between the city of Ukiah and the town of Duncans Mills for the period August 2005 through October 2010. DS610 can be found at both the USGS publication website: http://pubs.usgs.gov/ds/610/ and at Water Agency's website: http://www.scwa.ca.gov/tucp/ . The USGS data report is being evaluated as part of the CEQA requirements associated with establishing permanent changes to D1610 and should be referred to for the complete 2010 water quality dataset.

Bacteria analysis for the USGS and Water Agency was conducted by Alpha Laboratories in Ukiah, California. Bacteria samples were analyzed by Alpha Labs using multiple tube fermentation. This analysis takes several days to complete and thus is not used for public beach posting. The methods utilized by the NCRWQCB as discussed in Section 3.1.2 can provide a result in as little as 18 hours and therefore are more commonly used to provide public beach postings. The two methods, while both approved, may not provide comparative results. As shown in Table 3-1, the sample results did not include an absolute value for high counts of bacteria and were reported by the lab as being greater than 1,600 MPN (>1,600).

Table 3-1. Bacteria concentrations for samples collected by USGS in 2010 using multiple tube fermentation analysis. Highlighted values indicate those values exceeding the California Department of Public Health Draft Guidance for Fresh Water Beaches.

USGS station no.	Station name	Date	Total coliform, (MPN/100 mL)	Enterococci, (MPN/100 mL)	Fecal coliform (MPN/100 mL)
11462500	Russian River near Hopland CA	06/14/2010	>1600	11	30
		08/23/2010	170	24	130
11463000	Russian River near Cloverdale CA	06/14/2010	>1600	14	50
		08/23/2010	350	8.0	50
11463980	Russian River at Digger Bend near Healdsburg CA	06/15/2010	>1600	4.0	70
		08/24/2010	240	22	22
11465400	Russian River at Wohler Bridge	06/16/2010	>1600	27	50
		08/25/2010	170	240	50
11467000	Russian River near Guerneville	06/17/2010	500	90	26
		08/26/2010	280	90	70
11467002	Russian River at Johnsons Beach	06/17/2010	1600	17	17
		08/26/2010	500	8.0	9.0
		10/14/2010	>1600	900	500
382754123030501	Russian River at Casini Ranch	06/18/2010	900	4.0	17
		08/27/2010	140	8.0	2.0
382757123003801	Russian River at Monte Rio	06/17/2010	300	2.0	4.0
		08/26/2010	80	7.0	8.0
382959122535601	Russian River at Steelhead Beach	06/16/2010	300	33	22
		08/25/2010	34	50	17
383132122514901	Russian River at River Front Park	06/15/2010	250	4.0	13
		08/24/2010	500	49	30
11466800	Mark West Creek near Mirabel Heights	06/16/2010	>1600	17	80
		08/25/2010	>1600	>1600	900

3.1.2 2010 Seasonal Bacterial Sampling (Beach Sampling)

The NCRWQCB, in cooperation with the Sonoma County Environmental Health Department (DEH) conducts seasonal bacteriological sampling at Russian River beaches which experience the greatest body contact recreation.

The NCRWQCB seasonal sampling locations consist of: Camp Rose Beach; Healdsburg Veterans Memorial Beach; Steelhead Beach; Forestville Access Beach; Johnson's Beach; and Monte Rio Beach. Bacteriological samples were collected weekly beginning in June and continuing through September. The samples were analyzed using the Colilert quantitray MPN method for total coliform and e. *coli* and the Enterolert quantitray method for Enterococcus. Results from the sampling program are reported by the NCRWQCB and the DEH at their respective websites and on the DEH Beach Sampling Hotline. The 2010 seasonal results are shown in Table 3-2 and Figures 3-1 through Figure 3-3.

The analysis resulting from the 2010 beach sampling program and prior years are being evaluated as part of the CEQA requirements associated with establishing permanent changes to D1610.

Table 3-2. Sonoma County Seasonal Beach Results collected by the NCRWQCB. Highlighted values indicate those values exceeding the California Department of Public Health Draft Guidance for Fresh Water Beaches.

	Camp Rose Beach			Healdsburg Vet's Beach			Steelhead Beach			Forestville Access			Johnson's Beach			Monte Rio Beach		
	T. coli	*e. coli*	Entero.	T. coli	*e. coli*	Entero.	T. coli	*e. coli*	Entero.	T. coli	*e. coli*	Entero.	T. coli	*e. coli*	Entero.	T. coli	*e. coli*	Entero.
6/4/2010	7270	<10	10	4611	20	10	2481	30	20	2755	20	20	2481	52	10	1354	63	<10
6/8/2010 *	10462	10	<10	17329	63	<10	5475	10	<10	3654	10	<10	3873	10	<10	2359	10	30
6/8/2010 *				7,270	31	20												
6/15/2010	3076	10	<10	2359	20	10	1076	20	10	1126	31	<10	1989	10	<10	2359	20	<10
6/22/2010	2046	41	<10	2247	63	31	1054	20	<10	1607	10	10	1450	110	<10	1017	<10	<10
6/29/2010	2481	<10	10	2359	108	41	1918	52	10	1607	31	10	2143	10	<10	2143	20	10
7/6/2010	2247	10	<10	2247	20	31	1935	52	30	1720	10	20	1670	<10	10	2481	31	20
7/13/2010	1266	41	30	2909	161	20	1670	52	20	1054	20	<10	1565	75	20	2613	30	20
7/20/2010	2046	41	10	1616	41	41	2613	10	10	1607	<10	10	1850	<10	<10	1872	10	<10
7/27/2010	2902	20	10	1860	<10	20	1935	<10	20	1314	41	52	1989	173	50	4611	<10	<10
8/3/2010	2247	10	20	2613	97	30	1467	52	132	1401	20	<10	2723	<10	10	5794	20	20
8/10/2010	1935	31	10	1918	31	20	657	10	<10	1291	<10	<10	1616	<10	31	1850	<10	<10
8/17/2010	1722	20	<10	1785	41	20	1081	10	10	1162	10	10	1050	52	<10	1178	31	<10
8/24/2010	2014	10	52	2187	10	20	1019	10	86	1529	10	41	733	10	10	2014	10	10
8/31/2010	2755	<10	41	2187	31	<10	1106	<10	10	2046	<10	20	932	20	20	1725	20	<10
9/7/2010	4106	10	10	3448	30	20	1333	<10	63	1017	20	20	933	20	<10	1860	10	<10

* Note that Healdsburg Veterans Memorial Beach was posted on June 10, 2010 due to the average of both samples taken on June 8, 2010: an average of 12,300 MPN which is greater than the state guidelines for an exceedance of Total Coliform.

Single Sample Values

Beach posting is recommended when indicator organisms exceed any of the following levels:

Total coliforms: 10,000 per 100 ml

e coli: 235 per 100 ml

Enterococcus: 61 per 100 ml

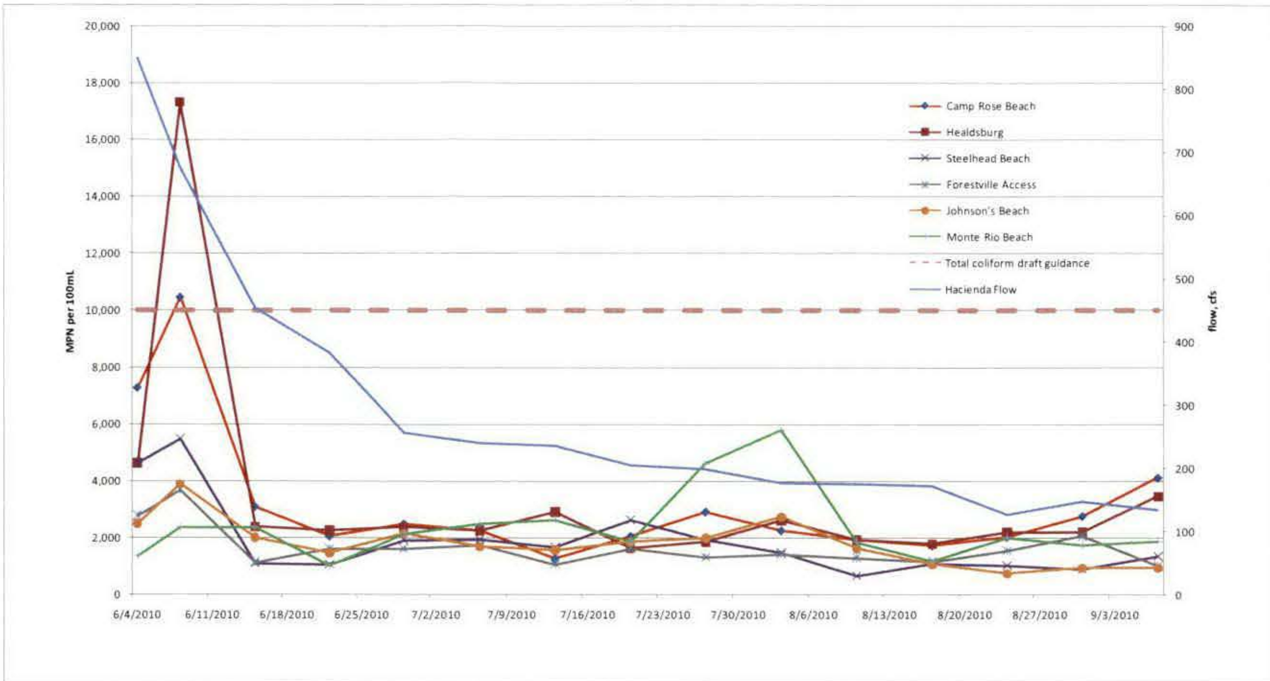

Figure 3-1. Sonoma County Beach Bacteria Sample Results for Total Coliform

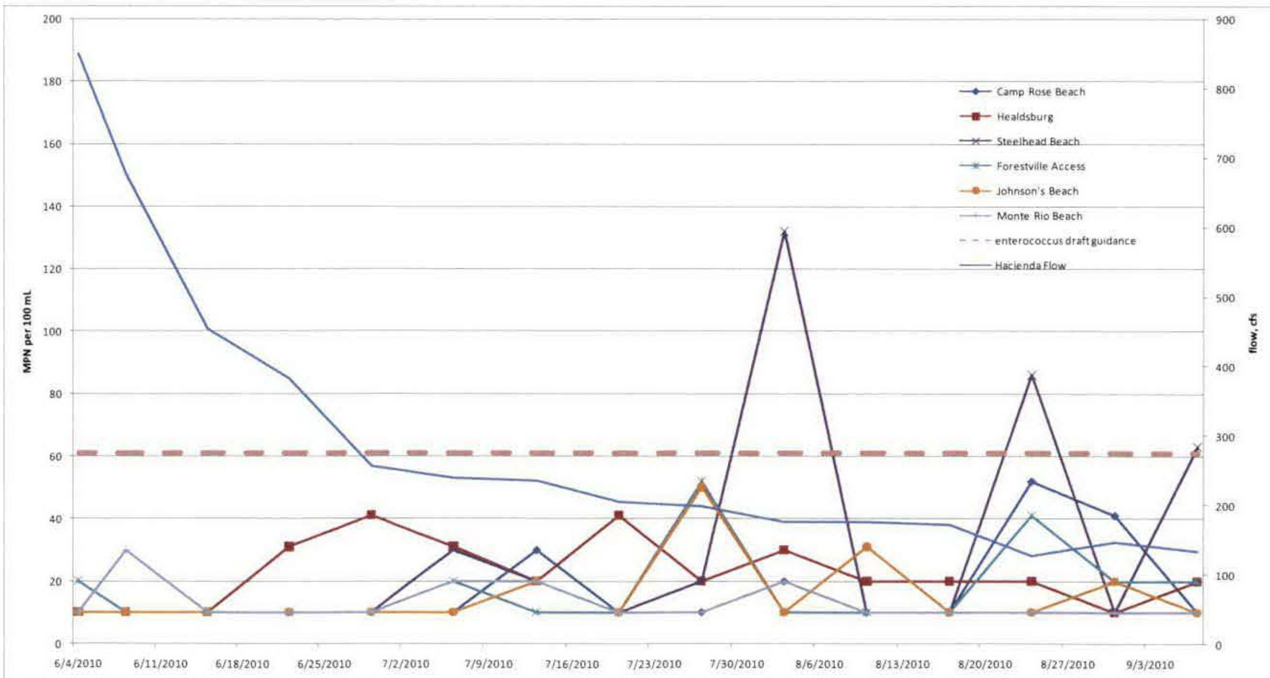

Figure 3-2 - Sonoma County Beach Pathogen Sample Results for Enterococcus

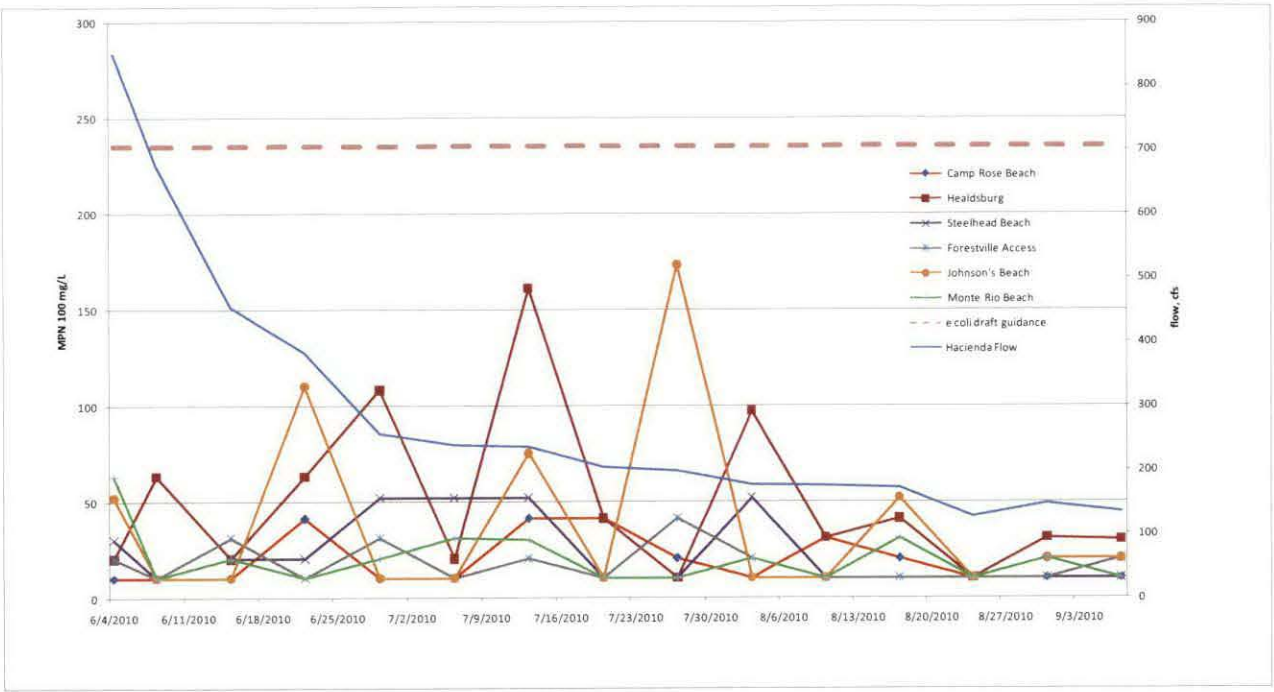

Figure 3-3. Sonoma County Beach Pathogen Sample Results for *e coli*

3.1.3 2010 Seasonal Sampling (Water Agency)

At the request of the SWRCB the Water Agency supplemented its Water Quality Monitoring Plan to include water temperature, pH, dissolved oxygen, specific conductance, bacteria, nutrients, and algae at the five permanent USGS sonde stations described below. From September 21 through October 12, 2010, the Water Agency collected weekly grab samples from the USGS sonde stations (further described in Section 4.1) at Hopland, Diggers Bend, RDS (Water Agency's diversion facility at Mirabel), Hacienda Bridge and Johnsons Beach, plus the stations at Cloverdale and Jimtown (Figure 3-4). The resulting data is provided in Tables 3-3 and 3-4.

3.1.4 Seasonal Sampling Summary

Based upon the CDPH guidance for fresh water beaches, Enterococcus exceedances varied throughout the term of the Order, regardless of which organization collected the sample. However, as the season progressed it appears that CDPH guidance for Enterococcus was exceeded more often. As the flows increased in early October the results from the upper Russian River gage samples appear to indicate bacteria exceedances for all pathogens. This may be indicative of a "first flush" and the resulting re-suspension of colloidal deposition. Nutrient and algae results collected in late September through the term of the Order were varied, with exceedances of EPA criteria for Total Phosphorus in most samples at all sample sites.

Table 3-3. 2010 Water Agency Bacteria Sample Results. Highlighted values indicate those values exceeding the California Department of Public Health Draft Guidance for Fresh Water Beaches.

	Flow	Temperature	pH	Total Coliforms (MTF)	Fecal Coliforms (MTF)	Enterococcus (MTF)
Method Detection Limit (MDL)				2.0	2.0	2.0
Date	cfs	°C		MPN/100mL	MPN/100mL	MPN/100mL
Hopland*						
9/21/2010	166	14.3	7.96	> 1600	110	50
9/28/2010	162	15.2	8.49	900	50	23
10/5/2010	174	13.6	7.61	900	50	50
10/12/2010	749	13.6	7.25	> 1600	900	> 1600
Cloverdale Commisky*						
9/21/2010	173	15.9	8.06	1600	280	26
9/28/2010	158	18	8.28	1600	70	12
10/5/2010	183	14.5	7.73	900	23	70
10/12/2010	424	14	7.41	> 1600	500	> 1600
RR @ Jimtown*						
9/21/2010	158	18.4	7.82	280	11	9
9/28/2010	145	NA	8.14	300	13	30
10/5/2010	161	16.6	7.77	240	17	33
10/12/2010	246	16.3	7.84	1600	170	30
Diggers Bend*						
9/21/2010	152	18.6	7.91	900	11	70
9/28/2010	135	19.8	8.35	500	50	14
10/5/2010	158	16.7	7.82	240	8	14
10/12/2010	239	17.2	7.75	500	50	120
RDS*						
9/21/2010	176	18.9	7.99	240	50	300
9/28/2010	158	19.5	7.70	300	110	130
10/5/2010	166	16.8	7.87	220	30	110
10/12/2010	228	18.2	7.55	500	50	30
Hacienda Bridge*						
9/21/2010	176	18.2	7.91	130	17	70
9/28/2010	158	18.4	7.79	240	23	300
10/5/2010	166	16.3	7.52	500	30	130
10/12/2010	228	17.3	7.53	300	110	33
Johnsons Beach*						
9/21/2010	176	19.6	7.37	220	130	50
9/28/2010	158	19.5	7.26	240	11	50
10/5/2010	166	16.9	7.48	500	50	170
10/12/2010	228	17.1	7.57	1600	70	500

* results are preliminary and subject to final revision.
MTF - multiple tube fermentation

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
Fecal coliforms: 400 per 100 ml
Enterococcus: 61 per 100 ml

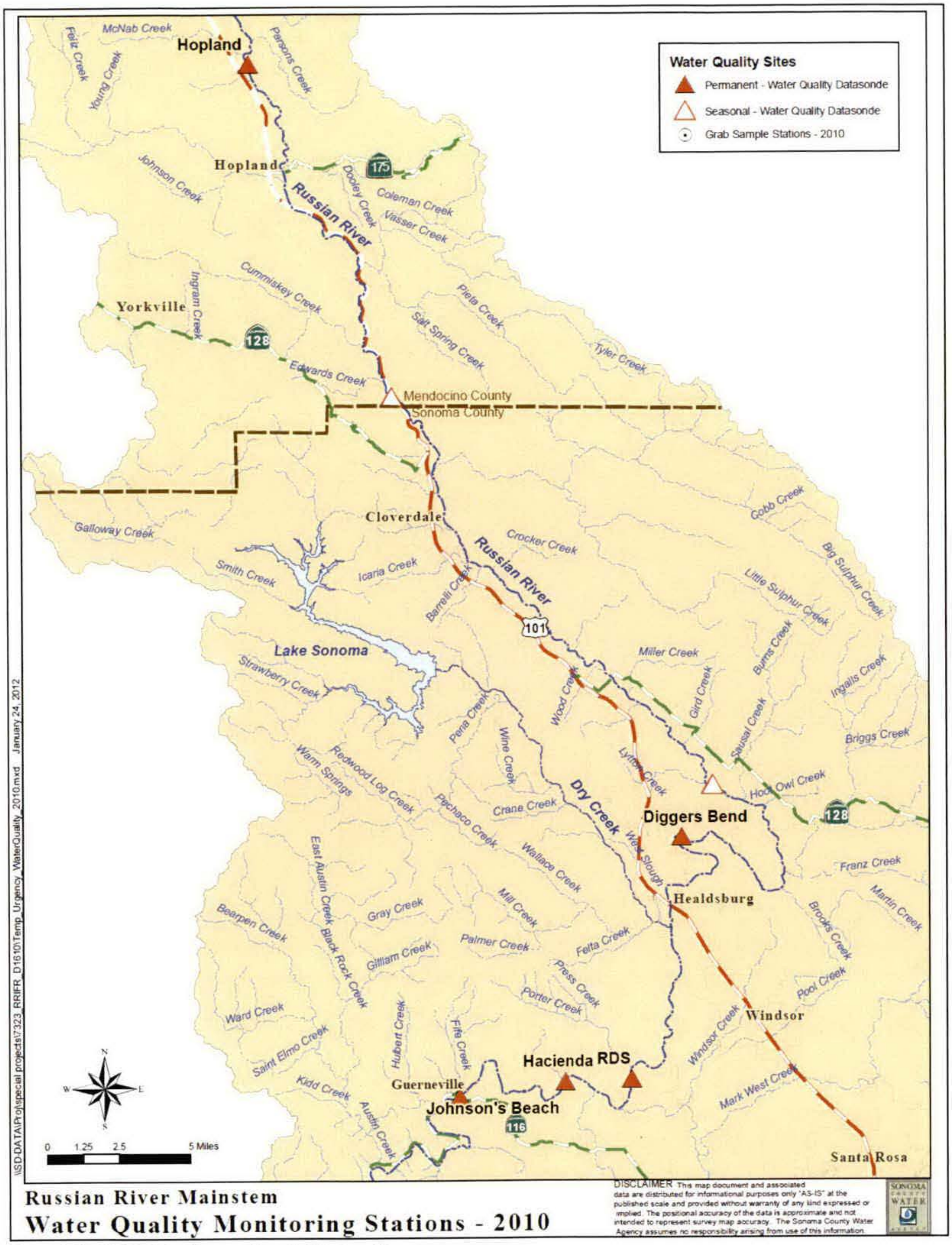

Figure 3-4. 2010 Water Agency Sample Site Locations

Table 3-4. 2010 Water Agency Nutrient Sample Results. Highlighted values indicate those values exceeding the recommended EPA criteria based on Aggregate Ecoregion III.

	Flow	Temperature	pH	Total Organic Nitrogen	Ammonia as N (NH_4^+)	Ammonia as N Unionized	Nitrate as N (NO_3^-)	Nitrite as N	Nitrate/Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Chlorophyll-a
Method Detection Limit (MDL)				0.200	0.10	0.00010	0.030	0.020	0.013	0.10		0.020	0.020	0.0400	0.0400	4.2	0.00050
Date	cfs	°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	mg/L	mg/L
Hopland*																	
9/21/2010	166	14.3	7.96	ND	ND	ND	0.150	ND	0.150	0.14	0.29	0.043	0.100	2.40	3.14	110	0.00100
9/28/2010	162	15.2	8.49	0.224	ND	0.00280	0.130	ND	0.130	0.26	0.39	0.054	0.120	2.12	2.74	100	0.00150
10/5/2010	174	13.6	7.61	ND	0.19	0.00069	0.170	0.044	0.210	0.26	0.43	0.079	0.160	2.50	3.32	100	0.00270
10/12/2010	749	13.6	7.25	0.455	0.10	0.00045	0.150	ND	0.150	0.56	0.71	0.130	0.240	2.39	3.48	110	0.01300
Cloverdale Commisky*																	
9/21/2010	173	15.9	8.06	ND	0.14	0.00430	0.120	ND	0.120	0.22	0.34	0.031	0.075	2.24	2.95	120	0.00130
9/28/2010	158	18	8.28	ND	ND	0.00210	0.110	ND	0.110	0.21	0.32	0.040	0.044	1.88	2.46	120	0.00039
10/5/2010	183	14.5	7.73	ND	0.14	0.00097	0.170	0.044	0.210	0.21	0.38	0.051	0.110	2.38	3.02	110	0.00094
10/12/2010	424	14	7.41	ND	0.25	0.00043	0.210	ND	0.210	0.32	0.53	0.073	0.180	2.31	3.51	120	0.00220
RR @ Jimtown*																	
9/21/2010	158	18.4	7.82	ND	ND	0.00074	0.110	ND	0.110	0.20	0.31	ND	0.029	1.67	2.16	120	0.00092
9/28/2010	145	NA	8.14	ND	ND	0.00170	0.110	ND	0.110	0.17	0.28	ND	0.021	1.38	1.82	140	0.00077
10/5/2010	161	16.6	7.77	ND	0.10	0.00062	0.100	ND	0.100	0.14	0.24	0.023	0.022	1.76	2.33	140	0.00130
10/12/2010	246	16.3	7.84	0.210	ND	0.00027	0.130	ND	0.130	0.22	0.35	0.034	0.069	1.89	2.87	130	0.00240
Diggers Bend*																	
9/21/2010	152	18.6	7.91	ND	ND	0.00098	0.074	ND	0.074	0.14	0.21	ND	0.021	14.4	14.9	130	0.00014
9/28/2010	135	19.8	8.35	ND	ND	ND	0.077	ND	0.077	0.17	0.25	0.020	ND	1.27	1.95	140	0.00039
10/5/2010	158	16.7	7.82	ND	ND	0.00069	0.075	ND	0.075	0.11	0.19	0.023	ND	1.69	2.31	120	0.00047
10/12/2010	239	17.2	7.75	ND	ND	ND	0.120	ND	0.120	0.18	0.30	0.027	ND	1.77	2.67	180	0.00170
RDS*																	
9/21/2010	176	18.9	7.99	0.718	ND	0.00120	0.078	ND	0.078	0.75	0.83	0.076	ND	1.55	1.79	130	0.00014
9/28/2010	158	19.5	7.70	ND	ND	0.00039	0.075	ND	0.075	0.13	0.21	ND	ND	1.08	1.63	110	0.00019
10/5/2010	166	16.8	7.87	ND	ND	ND	0.076	ND	0.076	ND	0.08	ND	ND	1.53	1.98	130	0.00019
10/12/2010	228	18.2	7.55	0.490	0.10	0.00120	0.120	ND	0.120	0.60	0.72	ND	ND	1.39	2.18	140	0.00092
Hacienda Bridge*																	
9/21/2010	176	18.2	7.91	ND	ND	0.00091	0.075	ND	0.075	0.18	0.26	0.027	0.037	1.38	1.78	130	0.00025
9/28/2010	158	18.4	7.79	ND	ND	ND	0.076	ND	0.076	0.15	0.23	0.024	ND	1.00	1.42	130	0.00029
10/5/2010	166	16.3	7.52	ND	ND	0.00032	0.076	ND	0.076	ND	0.08	0.025	ND	1.46	1.87	140	0.00100
10/12/2010	228	17.3	7.53	ND	ND	0.00071	0.110	ND	0.110	0.18	0.29	ND	0.025	1.15	1.71	160	0.00110
Johnsons Beach*																	
9/21/2010	176	19.6	7.37	ND	ND	ND	0.076	ND	0.076	ND	0.08	0.024	0.041	1.34	1.81	130	0.00014
9/28/2010	158	19.5	7.26	ND	ND	0.00017	0.290	ND	0.290	ND	0.29	ND	ND	0.982	1.46	130	0.00010
10/5/2010	166	16.9	7.48	ND	ND	0.00032	0.078	ND	0.078	ND	0.08	0.087	0.034	1.33	1.75	140	0.00009
10/12/2010	228	17.1	7.57	ND	ND	0.00078	0.120	ND	0.120	ND	0.12	ND	0.025	1.16	1.70	130	0.00073

* results are preliminary and subject to final revision.

Recommended EPA Criteria based on Aggregate Ecoregion III:
Total Phosporus: 0.02188 mg/L (21.88 ug/L)
Total Nitrogen: 0.38 mg/L
Chlorophyll *a*: 0.00178 mg/L (1.78 ug/L)

3.2 Russian River Estuary Water Quality Monitoring

Although flows in the lower Russian River did not reach allowable miniumu flows as noted in the Order and they did not drop below D1610 flows as discussed in Section 2, water quality monitoring continued to be conducted in the lower, middle, and upper reaches of the Russian River Estuary between the mouth of the river at Jenner and Monte Rio, including in two tributaries. Water Agency staff collected data to establish baseline information on water quality in the Estuary to gain a better understanding of the longitudinal and vertical water quality profile during the ebb and flow of the tide, and to track changes to the water quality profile that may occur during periods of barrier beach closure and reopening.

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 (May 15 to October 15), 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 summer low flow conditions and barrier beach closure. Additionally, river flows, tides, topography, and wind action affect the amount of mixing of the water column at various longitudinal and vertical positions within the Estuary.

In 2010, the Estuary experienced three closures during the lagoon management period. The barrier beach formed and the Estuary closed for a period of 7 days from 4 July to 11 July, 10 days from 21 September to 1 October, and 9 days from 3 October to 12 October. During these closures, the Water Agency was able to monitor the partial development of a freshwater lagoon system as freshwater inflows increased the depth of the surface layer and the volume of denser saltwater in the lower layer of the water column began to decline, presumably as it seeped through the barrier beach.

The Water Agency submits an annual report to the National Marine Fisheries Service and California Department of Fish and Game, documenting the status updates of the Water Agency's efforts in implementing the Biological Opinion. The water quality monitoring data for 2010 was compiled and is discussed in the "Russian River Biological Opinion Status and Data Report Year 2010-11". The Water Quality Monitoring section begins on page 16 of the annual report and can be found on the Water Agency's website: http://www.scwa.ca.gov/bo-annual-report/ and is included as Appendix B. As with the other datasets, the estuary data was evaluated as part of the CEQA requirements associated with revised management of the estuary. The grab sample sites are shown in Figure 3-5, the results are summarized in Tables 3-5 through 3-9 and the entire dataset can be found as noted, in the 2010-2011 Russian River Biological Opinion Status and Data Report.

Figure 3-5. 2010 Estuary Sample Sites

Table 3-5. 2010 Monte Rio Station Grab Sample Results. Highlighted values indicate those values exceeding the California Department of Public Health Draft Guidance for Fresh Water Beaches.

Monte Rio*	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N (NO_3^-)	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Fecal Coliforms	Enterococcus	
MDL**	0.200	0.10	0.00010	0.030	0.020	0.10		0.020	0.000050	2.0	2.0	2.0	Estuary
Unit of Measure	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
6/22/2010	0.203	ND	--	0.20	ND	0.21	0.41	0.047	0.0012	130	8.0	30	open
7/6/2010	ND	ND	0.0029	0.13	ND	0.16	0.29	0.035	0.0025	900	170	130	closed
7/20/2010	ND	ND	0.0024	0.13	ND	ND	0.13	0.042	0.0018	30	23	7.0	open
8/3/2010	ND	ND	0.0019	0.073	ND	0.14	0.21	0.026	0.00099	170	50	9.0	open
8/17/2010	ND	ND	ND	0.074	ND	0.18	0.25	0.024	0.00071				open
8/19/2010										170	13	13	open
8/31/2010	ND	ND	ND	0.076	ND	0.17	0.25	0.030	0.00019	140	17	8.0	open
9/14/2010	ND	ND	0.00096	0.073	ND	0.18	0.25	0.028	0.00025	280	90	33	open
9/28/2010	ND	ND	0.0015	0.081	ND	0.16	0.24	0.027	0.00019	300	130	130	closed
9/30/2010	ND	ND	0.0018	0.075	ND	0.20	0.28	0.027	0.000097	>1600	350	210	closed
10/5/2010	ND	ND	0.0016	0.076	ND	0.18	0.26	0.025	ND	80	17	30	closed
10/7/2010	ND	0.14	0.0046	0.076	ND	0.25	0.33	0.029	0.00037	240	50	240	closed
10/12/2010	0.520	0.18	0.0048	0.13	ND	0.70	0.83	0.021	0.00027	300	80	300	closed
10/14/2010	ND	ND	0.0011	0.12	ND	0.20	0.32	0.027	0.0015	500	240	240	open

* results are preliminary and subject to final revision.
** Method Detection Limit

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

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
Fecal coliforms: 400 per 100 ml
Enterococcus: 61 per 100 ml

Table 3-6. 2010 Casini Ranch Station Grab Sample Results. Highlighted values indicate those values exceeding the California Department of Public Health Draft Guidance for Fresh Water Beaches. However, estuarine conditions may exist at this site when in closed conditions and currently there are no numeric guidelines that have been developed for estuarine areas

Casini Ranch*	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N (NO_3^-)	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Fecal Coliforms	Enterococcus	
MDL**	0.200	0.10	0.00010	0.030	0.020	0.10		0.020	0.000050	2.0	2.0	2.0	Estuary
Unit of Measure	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
6/22/2010	ND	ND	--	0.19	ND	0.21	0.40	0.055	0.0026	240	17	4.0	open
7/6/2010	ND	ND	ND	0.13	ND	0.18	0.31	0.037	0.0023	300	30	23	closed
7/20/2010	ND	ND	0.0066	0.13	ND	0.25	0.38	0.046	0.00080	240	17	17	open
8/3/2010	ND	ND	ND	0.074	ND	ND	0.07	0.028	0.00069	80	2.0	7.0	open
8/17/2010	ND	ND	ND	0.076	ND	0.1	0.18	0.032	0.0011				open
8/19/2010										900	2.0	ND	open
8/31/2010	ND	ND	0.018	0.092	ND	0.13	0.22	0.034	0.00028	33	7.0	8.0	open
9/14/2010	ND	ND	ND	0.074	ND	0.14	0.21	0.025	0.00047	140	23	140	open
9/28/2010	ND	ND	0.0022	0.097	ND	0.10	0.20	0.026	0.00039	>1600	140	900	closed
9/30/2010	ND	ND	ND	0.076	ND	0.18	0.26	0.027	0.00077	>1600	70	1600	closed
10/5/2010	ND	ND	ND	0.074	ND	0.14	0.21	0.026	0.00028	900	17	17	closed
10/7/2010	ND	0.10	0.0034	0.077	ND	0.20	0.28	0.028	0.000091	500	21	30	closed
10/12/2010	ND	ND	0.0011	0.11	ND	0.14	0.25	ND	0.000091	1600	70	30	closed
10/14/2010	ND	ND	0.00097	0.12	ND	ND	0.12	0.021	0.0037	>1600	60	80	open

* results are preliminary and subject to final revision.
** Method Detection Limit

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

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
Fecal coliforms: 400 per 100 ml
Enterococcus: 61 per 100 ml

Table 3-7. 2010 Duncans Mills Station Grab Sample Results. Highlighted values indicate those values exceeding the California Department of Public Health Draft Guidance for Fresh Water Beaches. However, estuarine conditions may exist at this site when in closed conditions and currently there are no numeric guidelines that have been developed for estuarine areas.

Duncans Mills*	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N (NO_3)	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Fecal Coliforms	Enterococcus	
MDL**	0.200	0.10	0.00010	0.030	0.020	0.10		0.020	0.000050	2.0	2.0	2.0	Estuary
Unit of Measure	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
6/22/2010	ND	ND	--	0.18	ND	0.21	0.39	0.047	0.0005	300	8.0	4.0	open
7/6/2010	ND	ND	0.0018	0.14	ND	0.20	0.34	0.038	0.0027	50	50	30	closed
7/20/2010	ND	0.14	0.020	0.14	ND	0.14	0.28	0.041	0.00092	300	8.0	6.0	open
8/3/2010	ND	ND	0.0034	0.096	ND	0.14	0.24	0.032	0.00059	50	13	2.0	open
8/17/2010	ND	ND	0.0082	0.078	ND	0.14	0.22	0.023	0.00059				open
8/19/2010										140	13	4.0	open
8/31/2010	ND	ND	ND	0.077	ND	0.17	0.25	0.030	0.00028	47	32	4.0	open
9/14/2010	0.245	ND	ND	0.082	ND	0.24	0.32	0.034	0.0013	170	23	14	open
9/28/2010	ND	ND	0.0046	0.10	ND	0.16	0.26	0.034	0.00087	430	140	80	closed
9/30/2010	ND	ND	0.0056	0.075	ND	0.16	0.24	ND	0.0011	>1600	500	240	closed
10/5/2010	0.683	ND	0.0031	0.075	ND	0.75	0.83	0.025	0.00056	500	30	22	closed
10/7/2010	ND	ND	0.0023	0.076	ND	0.25	0.33	0.032	0.00027	130	23	17	closed
10/12/2010	ND	ND	0.0024	0.15	ND	0.21	0.36	ND	0.00055	1600	23	17	closed
10/14/2010	ND	ND	0.00089	0.12	ND	0.11	0.23	ND	0.0037	170	23	23	open

* results are preliminary and subject to final revision.
** Method Detection Limit

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

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
Fecal coliforms: 400 per 100 ml
Enterococcus: 61 per 100 ml

Table 3-8. 2010 Bridgehaven Station Grab Sample Results. Estuarine conditions exist at this site, currently, there are no numeric guidelines that have been developed for estuarine areas.

Jenner Boat Ramp*	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N (NO_3)	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Fecal Coliforms	Enterococcus	
MDL**	0.200	0.10	0.00010	0.030	0.020	0.10		0.020	0.000050	2.0	2.0	2.0	Estuary
Unit of Measure	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
6/22/2010	0.35	ND	--	0.15	ND	0.35	0.50	0.05	0.001	110	23	8.0	open
7/6/2010	0.273	ND	0.0086	0.13	ND	0.28	0.41	0.035	0.0033	500	240	50	closed
7/20/2010	ND	ND	ND	0.13	ND	0.40	0.53	0.041	0.00023	170	30	4.0	open
8/3/2010	0.210	ND	ND	ND	ND	0.21	0.21	0.043	0.0017	220	50	4.0	open
8/17/2010	ND	ND	ND	ND	ND	0.18	0.18	0.032	0.00071				open
8/19/2010										70	22	ND	open
8/31/2010	0.203	ND	0.0036	0.097	ND	0.24	0.34	0.039	0.0014	27	11	ND	open
9/14/2010	0.224	ND	ND	0.53	ND	0.22	0.75	0.029	0.0013	140	13	6.0	open
9/28/2010	0.231	ND	0.0032	0.081	ND	0.27	0.35	0.031	0.0015	>1600	80	500	closed
9/30/2010	ND	ND	0.0037	ND	ND	0.20	0.20	0.027	0.00097	>1600	240	1600	closed
10/5/2010	ND	ND	0.0015	ND	ND	0.18	0.18	0.033	0.00028	>1600	500	1600	closed
10/7/2010	0.217	ND	0.0010	0.084	ND	0.25	0.33	0.036	0.0017	>1600	300	1600	closed
10/12/2010	ND	ND	0.0034	0.13	ND	0.18	0.31	ND	0.0015	>1600	70	130	closed
10/14/2010	ND	ND	0.00062	0.22	ND	0.18	0.40	0.024	0.00046	300	23	8.0	open

* results are preliminary and subject to final revision.
** Method Detection Limit

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

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
Fecal coliforms: 400 per 100 ml
Enterococcus: 61 per 100 ml

Table 3-9. 2010 Jenner Boat Ramp Station Grab Sample Results. Estuarine conditions exist at this site, currently, there are no numeric guidelines that have been developed for estuarine areas.

Jenner Boat Ramp*	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N (NO_3^-)	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Fecal Coliforms	Enterococcus	
MDL**	0.200	0.10	0.00010	0.030	0.020	0.10		0.020	0.000050	2.0	2.0	2.0	Estuary
Unit of Measure	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
6/22/2010	0.35	ND	--	0.15	ND	0.35	0.50	0.05	0.001	110	23	8.0	open
7/6/2010	0.273	ND	0.0086	0.13	ND	0.28	0.41	0.035	0.0033	500	240	50	closed
7/20/2010	ND	ND	ND	0.13	ND	0.40	0.53	0.041	0.00023	170	30	4.0	open
8/3/2010	0.210	ND	ND	ND	ND	0.21	0.21	0.043	0.0017	220	50	4.0	open
8/17/2010	ND	ND	ND	ND	ND	0.18	0.18	0.032	0.00071				open
8/19/2010										70	22	ND	open
8/31/2010	0.203	ND	0.0036	0.097	ND	0.24	0.34	0.039	0.0014	27	11	ND	open
9/14/2010	0.224	ND	ND	0.53	ND	0.22	0.75	0.029	0.0013	140	13	6.0	open
9/28/2010	0.231	ND	0.0032	0.081	ND	0.27	0.35	0.031	0.0015	>1600	80	500	closed
9/30/2010	ND	ND	0.0037	ND	ND	0.20	0.20	0.027	0.00097	>1600	240	1600	closed
10/5/2010	ND	ND	0.0015	ND	ND	0.18	0.18	0.033	0.00028	>1600	500	1600	closed
10/7/2010	0.217	ND	0.0010	0.084	ND	0.25	0.33	0.036	0.0017	>1600	300	1600	closed
10/12/2010	ND	ND	0.0034	0.13	ND	0.18	0.31	ND	0.0015	>1600	70	130	closed
10/14/2010	ND	ND	0.00062	0.22	ND	0.18	0.40	0.024	0.00046	300	23	8.0	open

* results are preliminary and subject to final revision.
** Method Detection Limit

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

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
Fecal coliforms: 400 per 100 ml
Enterococcus: 61 per 100 ml

4.0 ADDITIONAL MONITORING

4.1 Permanent Datasondes

In coordination with the USGS the Water Agency maintains five multi-parameter water quality sondes on the Russian River located at Russian River near Hopland, Russian River at Diggers Bend near Healdsburg and Russian River near Guerneville (aka Hacienda Bridge), the Water Agency's water supply facility at Mirabel (RDS), and Johnson's Beach. These five sondes are referred to as "permanent" because the Water Agency maintains them as part of its early warning detection system for use year-round. The sondes take real time readings of water pH, temperature, dissolved oxygen content (DO), specific conductivity, turbidity, and depth, every 15 minutes.

In addition to the permanent sondes, the Water Agency in cooperation with the USGS installed seasonal sondes with real-time telemetry at the USGS river gage station at Russian River near Cloverdale (north of Cloverdale at Commisky Station Road) and at the gage station at Russian River at Jimtown (Alexander Valley Road Bridge). These two additional sondes are included by the USGS on its "Real-time Data for California" website.

The data collected by the sondes described above are evaluated in Section 4.2 in response to the SWRCB request 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 2010 dataset and historical sonde data will be evaluated to support the Water Agency's future CEQA compliance documents.

4.2 Aquatic Habitat for Salmonids

4.2.1 Introduction

Altered flow regimes in rivers have the potential to change the environmental conditions experienced by salmonids occupying mainstem habitats. NMFS (2008) found that high summer time flows related to reservoir releases can increase velocities to the point that there is a reduction in the amount of optimal habitat available to summer rearing salmonids. However summer flows can be reduced to the point that water temperature could increase and dissolved oxygen could decrease, thereby degrading summer salmonid rearing habitat. In the State Water Resource Control Board's (SWRCB) Order WR 2010-0018-DWR (Order) the Water Agency was tasked with evaluating impacts to water quality and the availability of aquatic habitat for salmonids in the Russian River associated with reductions in minimum in-stream flows in the Order. The period covered by the Order is May 25 through October 15, 2010. In this report the Water Agency summarizes Russian River flow, temperature, dissolved oxygen, and salmonid monitoring data in order to evaluate the potential effect of reducing minimum in-stream flows on salmonid habitat.

4.2.2 Life stages

Salmonids in the Russian River can be affected by flow, temperature, and dissolved oxygen changes at multiple life stages. There are three species of salmonids, coho salmon, steelhead, and Chinook salmon found in the Russian River (Martini-Lamb and Manning 2011). These species follow a similar life history where adults migrate from the ocean to the river and move upstream to spawn in the fall and winter. Females dig nests called redds in the stream substrate on riffles and pool tail crests. As eggs are deposited into the nest they are fertilized by males. The eggs are covered with gravel by the female and the eggs remain in the nest for 8-10 weeks before hatching. After hatching the larval fish, identified as alevins, remain in the gravel for another 4-10 weeks before emerging. After emerging these young salmonids are identified first as fry and then later as parr once they have undergone some freshwater growth. Parr, rear for from a few months (Chinook) to 3 years (steelhead) in freshwater before undergoing a physiological change identified as smoltification. At this stage, fish are identified as smolts meaning their organs and tissues can handle exposure to sea water and are 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 1 to 3 years at sea before returning to the river to spawn as adults (Moyle 2002). Because all life stages of all three species of Russian River salmonids spend a period of time in the Russian River watershed, they must cope with the freshwater conditions they encounter including flow, temperature, and dissolved oxygen levels. While broadly 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; consequently, these subtle but important differences may expose each species to a different set of freshwater conditions.

Coho timing

Wild coho have become scarce in the Russian River and monitoring data relies mainly on fish released from the hatchery as part of the Russian River Coho Salmon Captive Broodstock Program (RRCSCBP). Data collected on the Mirabel dam video camera system in 2011 indicate that the adult coho salmon run may start in late October and continue through at least January (SCWA unpublished data) and that spawning and rearing occurs in the tributaries to the Russian River (NMFS 2008). Downstream migrant trapping in tributaries of the Russian River indicate that the coho smolt out-migration starts before April and continues through mid-June (Obedzinski et al. 2006). Coho salmon have been detected as late as mid-July in the mainstem Russian River downstream migrant traps operated by the Water Agency (Martini-Lamb and Manning 2011). For coho, only the temperature and dissolved oxygen data relating to the adult and smolt life stages will be summarized for this report. Spawning and rearing take place in the tributaries which are outside of the spatial boundaries governed by the Order (Table 4-1).

Steelhead timing

Based on video monitoring at the Water Agency'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 Mirabel 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 although a very few adult steelhead may return as early September in some years, the vast majority of returns occur between January and April. Additionally, during coho spawner surveys conducted by the University of California Cooperative Extension (UCCE) steelhead have been observed spawning in tributaries of the Russian River in January, but more often in February and March (Obedzinski 2012).

Many steelhead spawn and rear in the tributaries of the Russian River while some steelhead rear in the upper mainstem Russian River (NMFS 2008, Cook 2003). The steelhead smolt migration in the Russian River begins at least as early as March and continues through June, peaking between mid-March and mid-May (Martini-Lamb and Manning 2011). For Russian River steelhead, only the adult migratory, parr, and smolt life stage are present in the mainstem during the time period covered by the Order and only these life stages will be analyzed for the potential effect of altered temperature and dissolved oxygen levels related to the Order (Table 4-1).

Chinook timing

Based on video monitoring at the Water Agency's inflatable dam in Mirabel, adult Chinook are typically observed in the Russian River before coho and steelhead. Chinook enter the Russian River as early as September, but are typically not present in high numbers until mid-October. Generally the Chinook run peaks in mid-November and is over in late December (Chase et al. 2005 and 2007). 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, Martini-Lamb and Manning 2011). Chinook offspring rear for less than one year before out migrating to sea as smolts in the spring. Based on downstream migrant trapping data the majority of the Chinook smolt out-migration appears to be complete by mid to late June (Chase et al. 2005 and 2007, Martini-Lamb and Manning 2011). Only the adult migratory and smolt life stages are present in the mainstem of the Russian River during the time period covered by the Order. Therefore, temperature and dissolved oxygen levels during the time period related to the Order will be analyzed for these Chinook life stages in this report (Table 4-1).

Table 4-1. **The species and life stage of salmonids found in the Russian River watershed that will be analyzed for this report during the period covered by the Order (May 25, 2010 to October 15, 2010) and the justification for excluding certain life stages from the analysis. The Order only applies to the Mainstem Russian River and not its tributaries.**

Species	Life stage	Summarized in report	Comments
Chinook	adult	x	September to late December
	spawning		Fall/winter
	egg		Winter/early spring
	alevin		Winter/early spring
	fry		Winter/early spring
	smolt	x	Spring/early summer
steelhead	adult		Fall/winter
	spawning		Winter/early spring
	egg		Winter/early spring
	alevin		Winter/early spring
	fry		Spring/early summer
	parr	x	spring/summer/fall/possibly winter
	smolt	x	Winter/early spring
coho	adult	x	Fall/winter
	spawning		spawns in tributaries
	egg		eggs deposited tributaries
	alevin		Alvin emerge in tributaries
	fry		freshwater rearing takes place in tributaries
	parr		freshwater rearing takes place in tributaries
	smolt	x	Spring/early summer

4.2.3 Flow

The purpose of the 2010 TUCP was to request a change in minimum in-stream flow requirements under D1610 in order to improve salmonid rearing habitat in the Russian River as outlined in the Biological Opinion. The Russian River Biological Opinion concludes that reducing minimum in-stream flow requirements under D1610 minimum will enable alternative flow management scenarios which will increase available rearing habitat in Dry Creek and the upper Russian River. These flow changes are intended to provide a lower, closer-to-natural inflow to the estuary between late spring and early fall, thereby enhancing the potential for maintaining a seasonal freshwater lagoon that would likely support increased production of juvenile steelhead and salmon (NMFS 2008). The Biological Opinion found that flows lower than those required by D1610 (approximately 125 cfs) in the section of the Russian River from Ukiah to the mouth of Dry Creek (upper Russian River) would improve habitat for summer rearing steelhead, specifically upstream of Cloverdale. Upper Russian River flows were below D1610 minimum, but above the minimum flows authorized by the 2010 Order (Figures 2-1 and 2-2). While the flow of 125 cfs was not realized through the upper Russian River during the period the Order was in effect in 2010, flows lower than D1610 minimums were implemented. Flows in the lower Russian River (downstream of the confluence with Dry Creek) were higher than D1610 minimum flows during the entire Order with the exception of a few isolated days (Figure 2-3). This was likely due to late rains and relatively cool summer temperatures in 2010 which caused high tributary inflow.

Because sustained flows in the lower river did not drop below D1610 minimum stream flows in 2010 the Water Agency did not analyze the potential impact of water temperature and dissolved oxygen levels on salmonids in the lower river as there was no impact related to the Order. Despite the fact that flows in 2010 were generally close to normal D1610 flows (i.e., higher than those requested in the TUCP), water temperatures at some locations remained at levels that were not the most conducive for juvenile steelhead growth and survival. This finding suggests that factors in addition to flow (e.g., ambient air temperature) may be important drivers of water temperature in the mainstem Russian River.

The Order may have been a contributing factor to the earlier timing of adult Chinook entering the Russian River in 2010. The Coyote Valley Dam release rates outlined in the Order were lower than D1610 releases thus conserving water in Lake Mendocino. In 2010, Lake Mendocino had storage in October that was occupying a portion of the flood control pool. In order to increase storage in Lake Mendocino and prepare the reservoir for potential flood control operations during the fall, the Army Corps of Engineers increased releases from Coyote Valley Dam. Increased releases began in early October, peaked at approximately 1,000 cfs in mid-October and began ramping down after the completion of the Order. During this time a pulse of 804 adult Chinook was observed at the Mirabel fish counting station (Martini-Lamb and Manning 2011) (Figure 4-1). The upstream movement of these fish may have been the result of a variety of factors (including breaching of the estuary on October 1 and again on October 12, as well as other unknown factors) we suspect that the pulsed flow was an important influence.

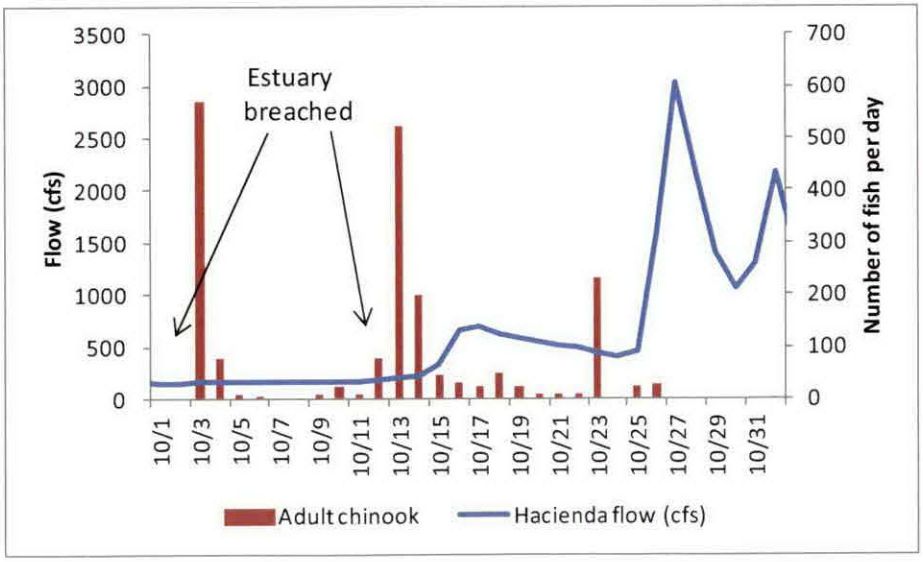

Figure 4-1. The daily count of adult Chinook at Mirabel, the discharge at Hacienda, days that the estuary was breached.

4.2.4 Temperature

Temperature requirements for salmonids differ by species and life stage as do the period and the location of residency within the upper mainstem of the Russian River. For example, steelhead parr may rear in the mainstem throughout the year, but during summer they primarily utilize the upper portion of the river upstream of Hopland. While Chinook adults may be found in any portion of the river, but are generally only present in the Russian River from September through January. Therefore it is necessary to examine each life stage of these species separately when assessing the effects of temperature on salmonids.

The water temperature ranges and thresholds reported in the literature for a particular life stage and species of salmonid vary by author. The California Regional Water Quality Control Board, North Coast Region (Regional Water Board) conducted an extensive literary search (Klampt 2000) on water quality effects on salmonids and listed recommendations for the Russian River. The Water Agency has used the information summarized in Klampt (2000) to examine the potential impacts that the Order may have had on water quality for salmonids. The Water Agency has cited other literature when appropriate.

Suggested water temperatures for Russian River salmonids are listed in Klampt (2000), but are based on Maximum Weekly Average Water Temperature (MWAT). Water temperature data collected at Hopland, Cloverdale, Jimtown, Diggers Bend, and Hacienda are only published as daily minimum and maximum values. Therefore the Water Agency used other portions of the Klampt literature review for this report. Because of this there is some variability in the ways that the criteria are set between life stages and species. The potentially lethal temperature criteria are slightly different between some of the species and life phases. Lethal temperatures are described in three ways: 1) The upper incipient lethal temperature which is the temperature that falls between the highest temperatures a fish can be acclimated to and the lowest of the extreme upper temperatures that will kill fish acclimated to warm water; 2) The water temperature where 50 % of the population will perish if exposed to this temperature for an unlimited period of time; and 3) The chronic lethal water temperature which is the water temperature where fish will perish if exposed to this temperature for a long period of time.

Coho

Coho spawn, rear, and spend most of their freshwater life phases in cold water tributaries. Coho use the mainstem of the Russian River only as migratory habitat (NMFS 2008). Because coho do not rear or spawn in the mainstem Russian River, water temperature data is only summarized in relation to the migratory requirements for this species (Table 4-1). Most tributaries that support coho in the Russian River are downstream of Dry Creek or within the Dry Creek basin.

Adult coho were observed in the Russian River during the Order, but in low numbers. The first coho in 2010 was observed on the Mirabel camera system on October 1. In total, 6 coho were observed on the Mirabel camera system before the Order expired on October 15, 2010 (SCWA unpublished data). From October 1 to October 15, 2010, water temperatures at Hopland, Cloverdale, Jimtown, Diggers Bend, and Hacienda ranged from a low at Hopland of 12.5 °C to a high of 21.9 °C at Diggers Bend.

During the period of the Order when adult coho were present in the upper Russian River, water temperatures at most sites were generally below the temperatures that would block upstream migration or cause mortality. The Klampt (2000) literature review found that the coho migration could be blocked at 21°C. Klampt (2000) also found that adult coho had an upper incipient lethal temperature limit of 21°C.

It is important to note that there is little known coho spawning that takes place upstream of Diggers Bend; rather, smolts and adults use the mainstem as a migration corridor. Water temperatures were collected at Hopland, Cloverdale, Jimtown, Diggers Bend, and Hacienda during the Order. At Hopland, water temperatures remained in the adult coho preferred water temperature range during the portion of the Order that adult coho where upstream of Mirabel (October 1 to October 15). Daily minimum and maximum water temperature were not above 21 °C which could limit migration and increase the chance of mortality except for one day at Diggers Bend when the daily maximum water temperature was above 21.0 °C (Figures 4-2 and 4-3).

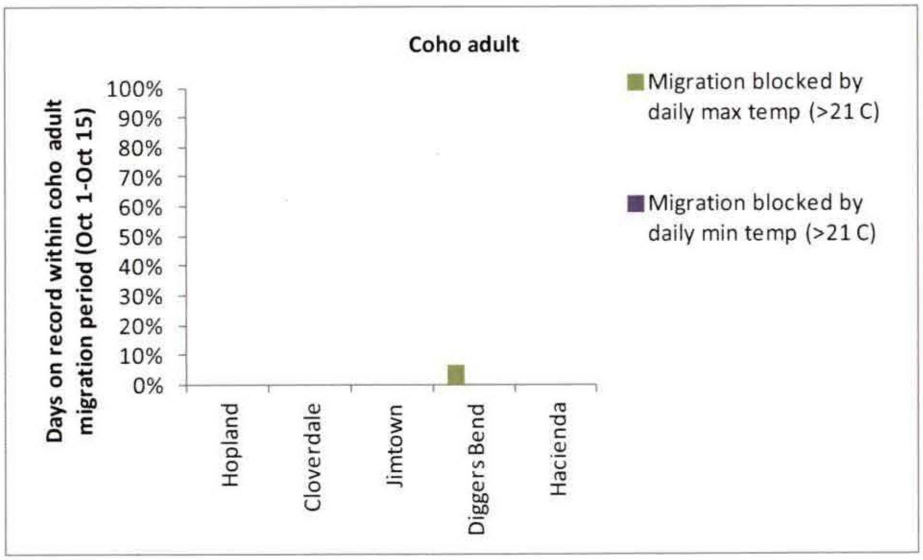

Figure 4-2. Portion of days within the adult coho migration period that overlap with the 2010 Order (October 1 to October 15, 2010) where the daily maximum or daily minimum water temperatures exceeded 21.0 °C.

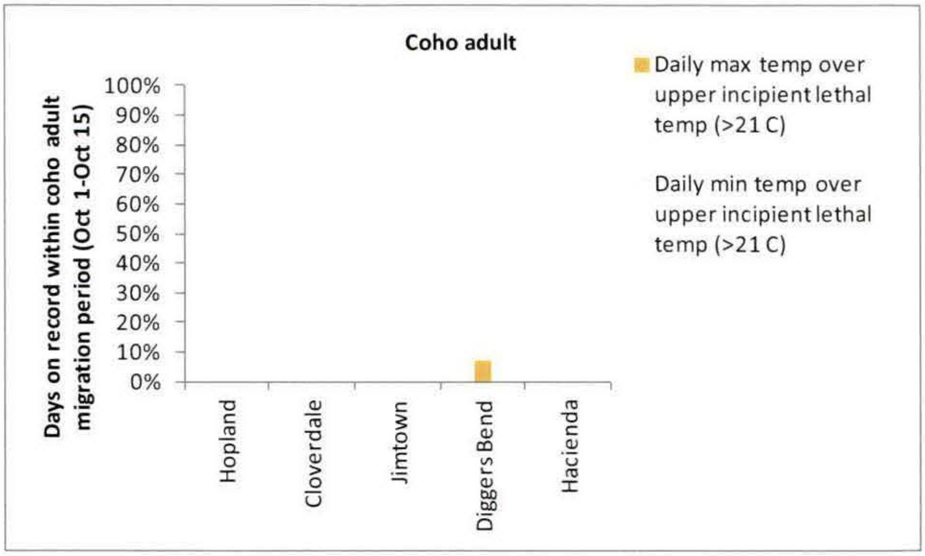

Figure 4-3. Portion of days within the adult coho migration period that overlap with the 2010 Order (October 1 to October 15, 2010) where the daily maximum or daily minimum water temperatures exceeded 21.0 °C.

Coho smolts were migrating through the mainstem Russian River during the beginning portion of the Order. Based on downstream migrant trapping data in tributaries to the Russian River, the out-migration of coho smolts peaks in early to late May and continues through mid-June depending on the year and tributary (Obedzinski 2007). Based on downstream migrant trapping at Mirabel in 2010, coho smolts were present in the mainstem Russian River until at least July 11. At Mirabel, 51 coho smolts were captured after the beginning of the Order (May 25, 2010).

During the period of the Order and when coho smolts were observed at the Mirabel dam (May 25 through July 11), water temperatures were generally below the temperatures that can cause mortality in coho. Juvenile coho in other river systems have an upper lethal temperature limit of 25 °C (Carter 2005).

Water temperatures were collected at Hopland, Cloverdale, Jimtown, Diggers Bend, and Hacienda during the coho smolt migration. From May 25to July 11, 2010, daily water temperatures ranged from a low at Hopland of 10.8 °C to a high of 26.3 °C at Diggers Bend. Daily maximum water temperatures never reached 25 °C at Hopland, Cloverdale, or Hacienda. At Jimtown and Diggers Bend, the daily maximum water temperature was above 25 °C during 5 % and 8% of the days on record, respectively (note that Jimtown has an incomplete record and is missing temperature data from May 25 through June 22, 2010) (Figure 4-4). The daily minimum water temperature was never above 25 °C at any of the five sites. Therefore, if coho smolts were emigrating through the Alexander Valley in late spring or early summer, it is unlikely they experienced lethal temperature conditions.

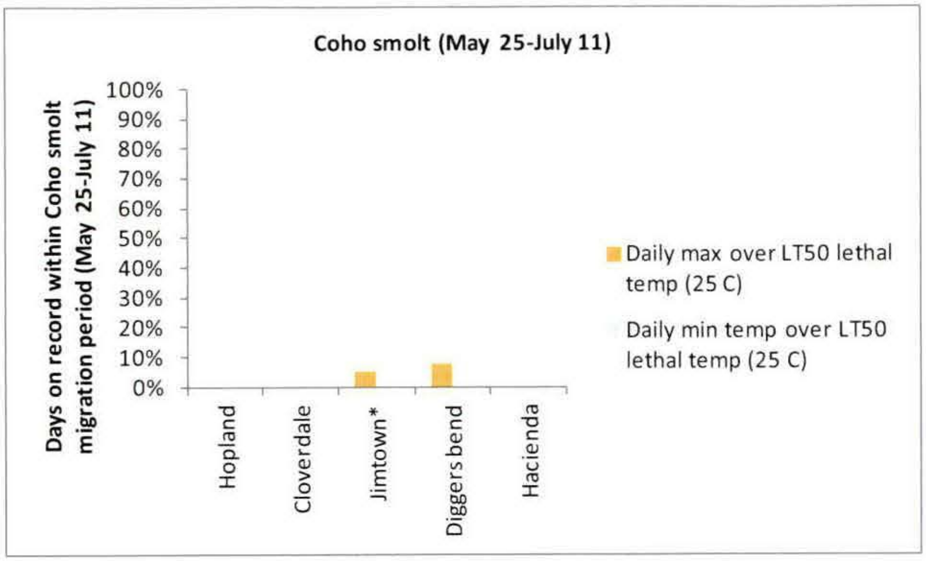

Figure 4-4. The portion of days within the coho smolt out-migration time period that overlap with the 2010 Order (May 25 to July 11, 2010) where the daily maximum or daily minimum water temperatures exceeded 25.0 °C(note that Jimtown is missing data from May 25 to June 22, 2010).

Steelhead

Few adult steelhead were found in the Russian River during the time period that the Order was in effect. The first adult steelhead of the 2010 video monitoring season was observed on October 14. A total of eight adult steelhead were estimated to have passed the Mirabel dam in the 2-day period before the end of the Order on October 15 (SCWA unpublished data). During this time water temperatures in the Russian River at the five sites where data was collected ranged from a low of 14.0 °C at Hopland to a high of 17.6 °C at Jimtown. Water temperatures at Hacienda, which is approximately 4.8 river kilometers (rKM) downstream from where steelhead were observed on the Water Agency's underwater video camera system, ranged from 16.2 °C to 17.5 °C.

The water temperatures during the portion of the Order that steelhead adults were observed in the Russian River were below the daily maximums and similar to the maximum weekly maximum temperatures, MWMT, listed in the literature (MWMT is the highest average of maximum daily water temperatures over any 7 day period). The Klampt (2000) literature review found that the migration of steelhead may be blocked at 21 °C, but concluded that a short term daily maximum of 23.9 °C is protective of all three species of Russian River salmonids during the adult migration, freshwater rearing, and seaward migration (smolt) life stages. The Carter (2005) literature review suggests that in order to fully protect adult steelhead during migration, a MWMT of 17 °C to 18 °C and a daily maximum water temperature of 21 °C to 22 °C should not be exceeded. During October 14-15, when adult steelhead were present in the Russian River, the maximum water temperature was below the short term daily maximum of 23.9 °C listed by Klampt (2000) and fell within the upper temperature limits listed by Carter (2005). It is important to note that only a few individual adult steelhead were detected during the period that the Order was in effect and that the bulk of the adult steelhead migration occurred much later in the year from December through April when water temperatures were much cooler (Chase 2005, Jackson 2007).

Steelhead in the Russian River are tributary spawners, but steelhead are also known to rear in the upper Russian River where water temperatures are adequate for over-summer survival (NMFS 2008). Cook (2003) found that summer rearing steelhead were distributed in the highest concentrations in the reach of the Russian River 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 (Ukiah Reach), but at a lower density than in the Canyon Reach. 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). Both the Canyon and Ukiah reaches have cooler water temperatures when compared to water temperatures between Cloverdale and the Russian River estuary. The cool water found in these reaches is a direct result of releases made at the Coyote Valley Dam. Therefore, for steelhead parr, water temperature data will only be summarized at Hopland and Cloverdale because they are the only sites where water temperature data was collected that are within the section of the upper Russian River known to be used by summer rearing steelhead parr.

In reaches that are considered steelhead rearing habitat (Ukiah to Cloverdale), water temperatures often remained below stressful levels. During the time period that the Order was in effect, daily water temperatures measured at the USGS gage (11462500) near Hopland ranged from 10.8°C to 18.5°C. Elevated levels of heat shock protein 72 were found in Navarro River steelhead occupying streams with daily maximum water temperatures in the range of 20-22.5 °C (Werner et al 2005). This suggests that water temperatures in this range are high enough to cause steelhead physiological stress. At Hopland, the daily maximum water temperatures never reached 20 °C during the duration of the order. At Cloverdale daily maximum water temperatures were above 20 °C 39 % of the days, but no days had a daily maximum above 22.5 °C. While water temperatures reached stressful levels for steelhead at Cloverdale for a portion of the order it is important to note that the Cloverdale gage is at the downstream limit of the reaches considered to be steelhead habitat and that water temperatures are likely gradually cooler as one moves upstream from Cloverdale towards Hopland.

Water temperatures remained below lethal levels in reaches that are considered steelhead rearing habitat (Ukiah to Cloverdale). The upper lethal limit for juvenile steelhead is reportedly 23.9°C (Carter 2005). Water temperatures at Hopland and at Cloverdale remained below the upper lethal limit of 23.9 °C for the duration of the order.

Steelhead smolts were present in the Russian River during the time period that the Order was in effect, although probably in low numbers. Based on 11 years of downstream migrant trapping at Mirabel Dam, the steelhead smolt migration in the Russian River appears to begin at least as early as March and peaks between mid-March and mid-May. During 2010, 18 steelhead smolts were captured between May 25 and June 13 at Mirabel. During this time period the water temperature at Hopland ranged from 10.8 °C to 16.6 °C and water temperatures at Cloverdale ranged from 11.7 °C to 20 °C. There were no records for water temperature at Jimtown during this time period. Water temperatures at Diggers Bend near Healdsburg ranged from 12.7 °C to 23.6 °C and water temperatures at Hacienda (approximately 4.8 river kilometers (rKM) downstream of the Water Agency's mainstem downstream migrant trapping site) ranged from 13.3 °C to 22.8 °C. Summarizing the effect of these temperatures on steelhead smolts is not practical as there is little information on the specific temperature requirements of steelhead smolts in the literature (Klampt 2000).

Chinook

Chinook are found in the Russian River at all life stages, but only the adult and smolt life stages are present during the time period when the Order was in effect. Chinook adults were present in the Russian River during the latter portion of the time span regulated by the Order. The first Chinook adult of 2010 was observed on September 25. By October 15, a total of 1,523 Chinook were estimated to have passed the dam, representing approximately 60 % of the minimum number of Chinook estimated to pass the dam in 2010. During this time period daily water temperatures at the five sites where data was collected ranged from a low at Hopland of 12.5°C to a high of 22.9 °C at Diggers Bend.

Water temperatures where generally favorable for adult Chinook in 2010, although there were periods of time where the daily maximum water temperature was above the threshold that can block upstream migration. Based on a literature review by Klampt (2000) the adult Chinook migration is reportedly blocked at 21.2 °C. The portion of days in 2010 where the daily maximum water temperature was above the temperature that has the potential to block the Chinook migration (21.2 °C) during September 25, 2010 through October 15, 2010 occurred 14 %, 33 %, and 19% of the days at Jimtown, Diggers Bend, and Hacienda respectively (Figure 4-5) . None of the days at Hopland and Cloverdale had daily maximum water temperatures above the temperature that can potentially block the upstream migration of adult Chinook. Dry Creek is an important spawning area for Chinook salmon and that many Chinook may have entered Dry Creek after passing the Mirabel dam rather than continue traveling up the Russian River past Healdsburg to Diggers Bend and Jimtown. Water temperatures in Dry Creek are much cooler than the mainstem Russian River during the summer and fall and more favorable for adult Chinook.

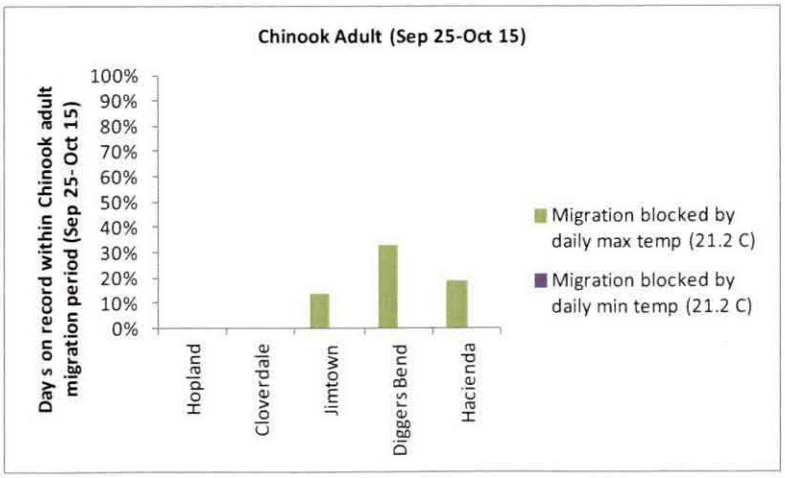

Figure 4-5. The portion of days within adult Chinook migration time period that overlap with the 2010 Order (September 25 to October 15, 2010) where the daily maximum or daily minimum water temperatures exceeded 21.2 °C.

Chinook smolts are present in the Russian River during the early part of the Order and migrate to the sea in water temperatures that occur during late spring and early summer. Between May 25, 2010 and when the traps were removed on July 15, 2010, a total of 1,415 Chinook smolts were captured at Mirabel. During this time period daily water temperatures at the five sites where data was collected ranged from a low at Hopland of 10.8 °C to a high of 26.3 °C at Diggers Bend.

Excellent growth rates for juvenile Chinook salmon have been reported to occur at temperatures ranging between 15 ˚C and 19 ˚C (Brett et al. 1982, cited by Raleigh et al. 1986).The maximum and minimum water temperatures were often within this temperature range during May 25, 2010 to July 15, 2010. The maximum daily water temperature at Hopland, Cloverdale, Jimtown, Diggers bend, and Hacienda where within this temperature range 90 %, 31 %, 0 %, 12 %, and 12% of the days on record, respectively (Figure 4-6). The minimum daily water temperature were within this range at Hopland, Cloverdale, Jimtown, Diggers bend, and Hacienda 37 %, 88 %, 54 %, 31 %, and 23 % of the days on record respectively.

The upper temperature limit that blocks Chinook smolts from migration was above by the daily maximum and minimum water temperatures during some portions of the time between May 25 and July 15, 2010. The upper lethal long term exposure limit is reportedly 25.8 °C (Klampt 2000). The portion of the days on record from May 25 to July 15, 2010, where the daily maximum water temperatures were above the upper limit that may block Chinook smolts from migrating (21.0 °C) at Hopland, Cloverdale, Jimtown, Diggers bend, and Hacienda, was 0%, 17 %, 100 %, 77 %, and 74 % respectively (Figure 4-7). Only Diggers Bend and Hacienda had daily minimum water temperatures above the upper limit that may block Chinook smolts from migrating (21.0 °C) during this same time period. This occurred on 6 % of the days at both sites.

The upper lethal long term temperature limit (25.0 °C) for Chinook salmon smolts was only rarely above the daily maximum water temperature and only at 2 sites during the May 25, 2010 to July 15, 2010 time period. The daily minimum water temperature was never above this threshold at any of the sites (Figure 4-8). Only Jimtown and Diggers Bend had daily maximum water temperatures above the upper lethal long term limit for Chinook salmon smolts during this same time period, which occurred 4 % and 11 % of the time, respectively. The daily minimum water temperature was never above 25 °C at any of the five sites. Therefore, Chinook smolts had temporal thermal refuge during a portion of each day which would help protect them from mortality related to chronic exposure to water temperatures above 25 °C.

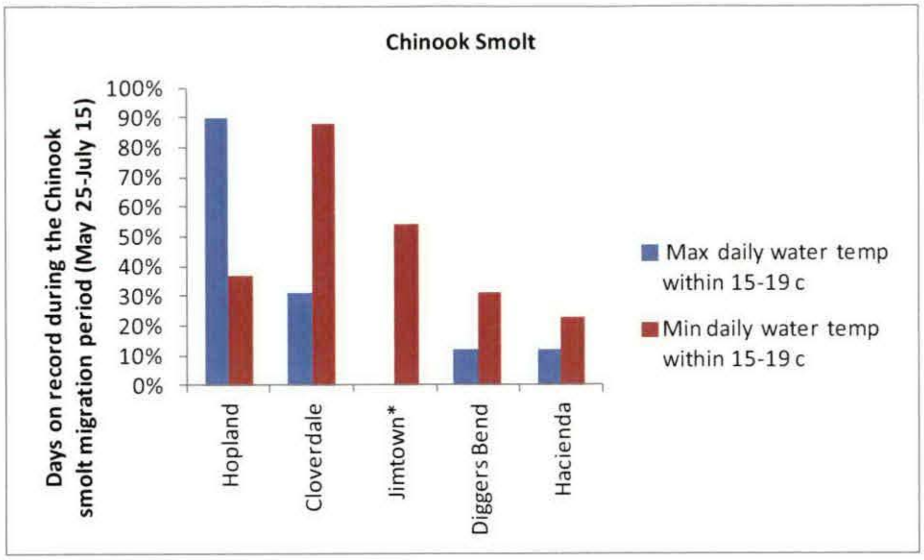

Figure 4-6. The portion of days within adult Chinook migration time period that overlap with the 2010 Order (May 25 to July, 15 2010) where the daily maximum or daily minimum water temperatures fall within the range that is reported to have excellent growth rates for Chinook smolts (15 °C to 19 °C) (Brett et al. 1982, cited by Raleigh et al. 1986).

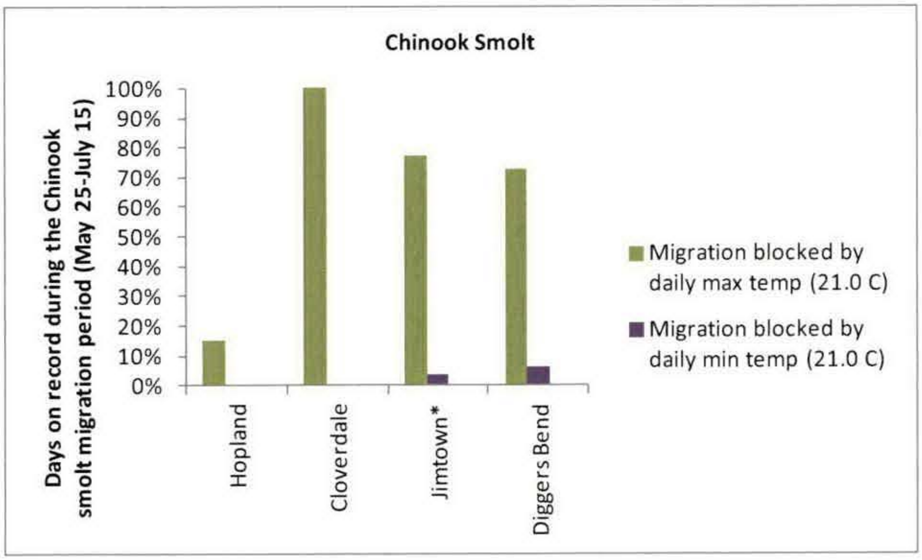

Figure 4-7. The portion of days within Chinook smolt out-migration time period that overlap with the 2010 Order (May 25, 2010 to July 15, 2010) where the daily maximum or daily minimum water temperatures exceeded 21.0 °C.

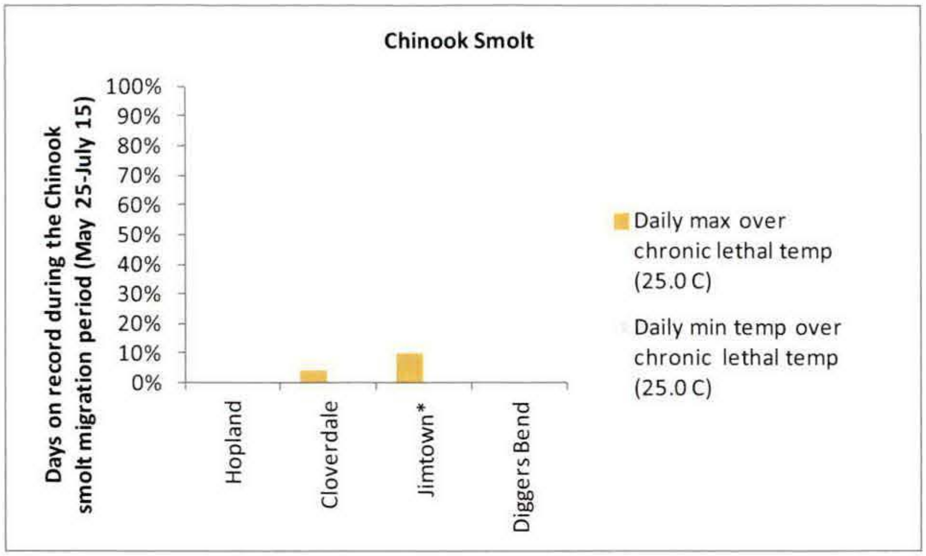

Figure 4-8. The portion of days within the coho smolt out-migration time period that overlap with the 2010 Order (May 25 to July 15, 2010) where the daily maximum or daily minimum water temperatures exceeded 25.0 °C (note that Jimtown is missing data from May 25 to June 22, 2010).

4.2.5 Dissolved Oxygen

Salmonids are fish species that are known to be particularly sensitive to low levels of dissolved oxygen. Depressed levels of dissolved oxygen can affect swimming performance, growth rates and survival. Unlike temperature requirements, dissolved oxygen requirements are similar for the 3 species and all of the life stages of salmonids found in the Russian River. Klampt (2000) conducted a literature review on water quality requirements of salmonids and suggested minimum levels of dissolved oxygen for the Russian River for each salmonid life stage that would avoid impacts to Chinook, steelhead, and coho. Klampt (2000) found dissolved oxygen levels should not drop below 7.0 mg/L or 80 % saturation whichever is greater for salmonids of all life stages. The data for the dissolved oxygen section of this report has been summarized for the time period when the Order overlaps the presence of each salmonid life stage found in the upper mainstem of the Russian River.

Adult Salmonids

All three species of adult salmonid were present in the Russian River during a portion of the Order and they encountered various dissolved oxygen levels at different locations on the river. The first adult salmonid observed in 2010 at the Mirabel dam was a Chinook observed on September 25. A total of 1,523 Chinook were estimated to have passed the Mirabel dam before the Order expired on October 15, 2010 (Martini-Lamb and Manning 2011). During this time six adult coho and eight adult steelhead were also observed on the Mirabel camera system (SCWA unpublished data). From September 25 to October 15, 2010, the lowest minimum dissolved oxygen readings at Hopland, Cloverdale, Jimtown, Diggers Bend, and Hacienda were 8.7, 8.6, 5.6, 7.4, and 7.9 mg/L, respectively.

Daily minimum dissolved oxygen levels at Jimtown were low enough to cause moderate impairment to adult salmonids during the portion of some of the days during the Order according to the standards reported by Klampt (2000). Jimtown was the only monitoring station that had daily minimum dissolved oxygen levels below 7.0 mg/L during the September 25 and October 15, 2010 time period. Daily minimum dissolved oxygen levels were below 7 mg/L for 12 days of the 21 day period between September 25 and October 15, 2010. Klampt (2000) reported that dissolved oxygen levels below 6.3 mg/L can block the upstream movement of adult salmonids and that dissolved oxygen levels below 6.0 mg/L can cause moderate production impairment for adult salmonids. There were 8 days at Jimtown when the dissolved oxygen levels were below 6.3 mg/L and 7 days when the dissolved oxygen levels were below 6 mg/L during the September 25 and October 15, 2010, time period.

While daily minimum dissolved oxygen levels at Jimtown were below the standards reported by Klampt (2000) adults may have been able to avoid these low levels by using other portions of the basin or by migration past Jimtown later in the year. During the 21 day long portion of the Order when adult salmonids were observed passing the Mirabel dam the lowest daily maximum dissolved oxygen level at Jimtown was 10 mg/L. This suggests that adult salmonids would be able to migrate past Jimtown during a portion of each day during the Order. The Russian River and Dry Creek confluence is located downstream of Jimtown. It is important to note that Dry Creek is heavily used by Chinook, steelhead, and coho (Martini-Lamb and Manning 2011) and that Dry Creek may have been the destination of many of these adult fish during the September 25 to October 15 time period. Furthermore, daily minimum dissolved oxygen levels reached 7 mg/L by October 7 at Jimtown and remained above 7 mg/L until at least when the gage went offline on October 31.

Juvenile freshwater rearing

Steelhead parr were likely present in the mainstem of the Russian River during the Order, but steelhead habitat is generally thought to be limited to the Ukiah and Canyon reaches (the section of river from the Coyote Valley Dam to Cloverdale) in the upper Russian River (NMFS 2008). During the order the lowest daily minimum dissolved oxygen readings at Hopland, Cloverdale, Jimtown, Diggers Bend, and Hacienda were 8.5, 7.4, 5.3, 7.2, and 7.4 mg/L, respectively. Jimtown was the only monitoring station to have dissolved oxygen levels below 7.0 mg/L during the Order, which is the threshold reported by Klampt (2000) that may impair salmonids. However, Jimtown is outside of the section of the upper Russian River that is typically considered steelhead summer rearing habitat.

Smolts

Salmonid smolts were observed in the mainstem Russian River during a portion of the Order. Downstream migrant traps were installed at the Mirabel Dam in 2010 before the Order went into effect and were operated until July 15, 2010. The traps were ultimately removed because the daily catch of salmonids was diminishing. In total 1,549 Chinook smolts, 51 coho smolts, and 18 steelhead smolts were captured in the downstream migrant traps from May 25 to July 15, 2010. During this time period daily minimum dissolved oxygen readings at Hopland, Cloverdale, Jimtown, Diggers Bend, and Hacienda were 8.5, 7.4, 6.1, 7.2, and 7.4 mg/L, respectively. At the five upper Russian River sites where dissolved oxygen data was collected only Jimtown had dissolved oxygen levels below 7.0 mg/L from May 25 to July 15, 2010 which is below the threshold that Klampt (2000) reports can cause impairment to salmonids. During this 116 day period, 107 days had a daily minimum dissolved oxygen level below 7 mg/L. During the 116 day long portion of the Order where salmonids smolts were captured at the Mirabel dam downstream migrant traps the lowest daily maximum dissolved oxygen level at Jimtown was 8.3 mg/L.

This suggests that salmonid smolts would be able to migrate past Jimtown during a portion of each day during the smolt migration.

4.3 Summary

The Water Agency was tasked with evaluating impacts to water quality and the availability of aquatic habitat for salmonids in the Russian River associated with flow reductions outlined in the Order. However due to a relatively small temperature and dissolved oxygen data set coupled with climate variability it is difficult to determine, in most cases, if changes in temperature or dissolved oxygen were due to flow changes related to the Order. Therefore the Water Agency summarized the environmental conditions experienced by salmonids during the Order and compared these conditions to standards outlined in the literature.

Flow

Flows were effectively reduced in summer steelhead rearing habitat in the upper portion of the Russian River during a portion of the time period covered by the Order. While flows in the upper Russian River never reached the minimum in-stream flow of 125 cfs, they were lower than D1610 flows. However flows in the lower Russian River remained above D1610 minimum in-stream flows for all but a few isolated days in 2010 due to an unusually wet year and high tributary inflow (Figures 2-1, 2-2 and 2-3).

The Order may have facilitated adult Chinook entering the Russian River earlier in 2010. Water was conserved in Lake Mendocino due to the flow regime outlined in the Order was releases by the U.S. Army Corps of Engineers in the fall, which may have stimulated adult Chinook to migrate upstream. However there were other factors that may have led to this pulsed upstream movement in October such as breaching the Estuary, naturally occurring early run timing, or other unknown environmental triggers.

Temperature

In the upper Russian River near Hopland, water temperatures remained cooler into the fall than during many other years. During late September, the warmest period in 2010, water temperatures were 5.2 °C cooler than in previous years (Figure 4-9). This is likely due to the cold water pool (the portion of the lake below the thermocline) in Lake Mendocino being depleted under D1610 releases, but being preserved under the flow regime outlined in the Order. Flow is not the only factor in determining water temperature. Ambient air temperature is likely an important factor in determining mainstem Russian River water temperatures. However, preserving the cold water pool into the fall likely provides adult Chinook, as well as summer rearing steelhead, with cooler temperatures in the upper reaches of the mainstem Russian River.

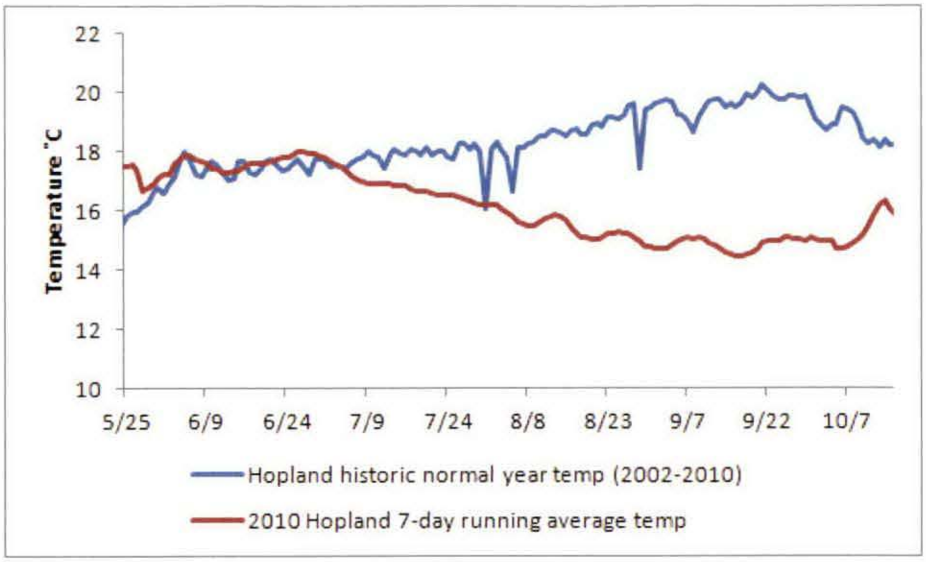

Figure 4-9. The 7 day running average of the daily maximum water temperature in 2010 and the historic daily maximum water temperature (the average of the daily maximum water temperature from D1610 normal water years (2002, 2003, 2005, 2006, 2008).

Coho

Adult coho were observed in the Russian River during the Order, but in low numbers. During the period of the Order, water temperatures observed in the Russian River were generally below the temperatures that would block upstream migration or cause mortality. While all adult coho observed at Mirabel must pass Hacienda, it is important to note that coho do not spawn in all tributaries to the Russian River and many of the coho may never have been exposed to the water temperatures at Diggers Bend, Jimtown, Cloverdale, or Hopland. In 2010 the only Russian River tributary upstream of the confluence of the Russian River and Dry Creek that coho were known to inhabit was Redwood Creek in the Maacama Creek watershed (Obedzinski 2012). It is likely that once coho passed Hacienda and Mirabel many coho entered the Dry Creek watershed, which has much cooler water temperatures than the mainstem Russian River.

Coho smolts use the mainstem Russian River as migratory habitat and were in the river during the beginning portion of the Order. Occasionally the daily maximum water temperature was warmer than the water temperature where 50 % of the population will perish if exposed to this temperature for an unlimited period of time regulated by the Order. However, the daily minimum water was always below this level. Therefore coho smolts were only exposed to these temperatures for a portion of each day. Therefore, coho smolts had temporal thermal refuge during a portion of each day which would help protect them from mortality related to chronic exposure to warm water temperatures.

Steelhead

Adult steelhead were observed in the Russian River during the time period that the Order was in effect. However, it is important to note that only a few individual adult steelhead were detected during the Order and that the bulk of the adult steelhead migration occurs later in the year from December through April when water temperatures are cooler. The water temperatures during the portion of the order that steelhead adults were observed in the Russian River were below the daily maximums and similar to the MWMTs listed in the literature as upper limits for adult steelhead.

Steelhead parr are known to rear throughout the summer in a section of the upper Russian River near Ukiah and Hopland. During this time the water temperatures in this section of river were below the upper lethal limit. Water temperatures in this section of the river are influenced by the temperature of water released from the Coyote Valley Dam. The flow regime outlined by the Order may have preserved the cold water pool in Lake Mendocino later into the year than under D1610 releases (Figure 4-9). Juvenile steelhead that reared between Ukiah and Hopland may have benefited from the releases remaining cooler later into the year.

Steelhead smolts were present in the Russian River during the time period that the Order was in effect, although probably in low numbers. Summarizing the effect of these temperatures on steelhead smolts is not practical as there is little information on the specific temperature requirements of steelhead smolts in the literature.

Chinook

Chinook are found in the Russian River at all life stages, but only the adult and smolt life stages were present during the time period in which the Order was in effect. Chinook adults were present in the Russian River during the latter portion of the time span regulated by the Order. Water temperatures where generally favorable for adult Chinook in 2010, although there were periods of time in some sections of the river where the daily maximum water temperature was above the threshold that can block upstream migration. However the daily minimum water temperatures were always below the threshold that can block upstream migration so it is likely that Chinook adults could migrate in these sections of the river during the cooler parts of the day.

Chinook smolts are present in the Russian River during the early part of the Order and migrate to the sea in water temperatures that occur during the late spring and early summer. During this time the daily maximum water temperatures at 4 of the 5 sites where water temperature data was collected was often above the temperature that is reported to block the Chinook smolt migration, but daily minimum water temperatures were rarely above this threshold. Two sites (Jimtown and Diggers Bend) had daily maximum water temperatures that were above the water temperature where Chinook smolts will perish if exposed to this temperature for a long period of time. However these warm water temperatures did not occur for long periods of time and the daily minimum water temperature was always below this threshold. Therefore Chinook smolts were not continuously exposed to these high temperatures. Chinook smolts had temporal thermal refuge during a portion of each day which would help protect them from mortality related to chronic exposure to high water temperatures.

Dissolved oxygen

Only one site where dissolved oxygen data was collected had daily minimum dissolved oxygen levels that were below the standards for salmonids outlined in the literature. While this site had daily minimum dissolved oxygen levels that were below the standards for salmonids during much of the Order not all life stages or all species occupy this section of the river. Furthermore the daily maximum dissolved oxygen levels were always above the standards for salmonids outlined in the literature.

Therefore, if there were salmonids occupying this section of the river during the period of depressed dissolved oxygen levels they likely had some temporal refugia from these conditions.

Daily minimum and maximum dissolved oxygen levels where published by the USGS, but hourly dissolved oxygen levels would allow for more in depth analysis. The Water Agency may summarize hourly dissolved oxygen measurements in future reports. This would be particularly useful at Jimtown where dissolved oxygen levels were often below 7 mg/l during a portion of the day. Hourly measurements may answer some of the questions about the duration of these depressed dissolved oxygen events.

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Appendix A

2010 USGS Water Quality Results

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations**: no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene, HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide, ft^3/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury; mm, millimeter, µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter: <, actual value less than value shown; E, estimated value; –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Discharge, inst. (ft^3/s) (00061)	Turbidity, IR LED (FNU) (63680)	Barometric pressure, (mm of Hg) (00025)	Dissolved oxygen, (mg/L as O_2) (00300)	Dissolved oxygen, (percent saturation) (00301)	pH, field (standard units) (00400)	Specific conductance, field (µS/cm) (00095)
2	11462500	Russian River near Hopland	06/14/2010	13:00	221 [b]	14	750	10.1	105	7.7	212
			08/23/2010	11:30	–	6.6	–	9.9	–	7.8	189
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	271	6.8	754	12.3	136	8.6	234
			08/23/2010	15:00	144 [b]	4.9	–	11.0	–	8 4	204
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	360 [b]	2.2	760	8.1	89	8.0	297
			08/24/2010	09:00	132 [b]	0.7	–	7.8	–	8.1	272
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	502	2.1	761	9.0	101	8.0	279
			08/24/2010	13:00	218	0.9	–	9.4	–	8.1	246
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	([a])	2.9	762	8.2	88	7.9	277
			08/25/2010	09:00	([a])	1.5	–	7.9	–	7.9	248
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	410	3.6	763	9.1	101	8.0	289
			08/25/2010	13:00	124	1.3	–	9 7	–	8.3	256
9	11467000	Russian River near Guerneville	06/17/2010	10:00	385 [b]	3.2	762	7.8	86	7.9	288
			08/26/2010	09:00	103 [b]	2.9	–	7.4	–	7 8	255
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	([a])	1.9	763	8.1	90	7.9	290
			08/26/2010	12:00	([a])	3 4	–	8 8	–	8.2	255
			10/14/2010	12:30	623	2.1	768	9.3	100	7.3	147
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	419	1.7	763	9.2	106	8.1	291
			08/26/2010	13:30	113	3.1	–	8.7	–	8.0	259
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	–	1.8	761	8.2	92	8.0	292
			08/27/2010	09:30	–	1.5	–	7.3	–	7.9	259
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	27	6.1	774	6.2	65	7.7	452
			08/25/2010	10.30	3 [b]	5.8	–	6 1	–	7 8	572
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	–	0 2	762	1 2	–	7.5	253
			08/25/2010	19:00	–	0.1	–	2.7	–	7.5	261
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	–	0.3	761	6.5	–	7.4	270
			08/25/2010	17:30	–	0.3	–	1.3	–	7.6	262
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	–	0 6	–	3.4	–	6.7	507
			08/24/2010	15.00	–	0.5	–	3.0	–	6.7	505

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.–Continued

[[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations**: no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide; ft³/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury; mm, millimeter, µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, actual value less than value shown; E, estimated value, –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Temperature, water (°C) (00010)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesium, dissolved (mg/L as Mg) (00925)	Potassium, dissolved (mg/L as K) (00935)	Sodium, dissolved (mg/L as Na) (00930)	Acid neutralizing capacity, lab (mg/L as $CaCO_3$) (90410)	Bromide, dissolved (mg/L as Br) (71870)
2	11462500	Russian River near Hopland	06/14/2010	13:00	16.6	20.8	9.38	1.11	9.06	90	E0.01
			08/23/2010	11:30	14.6	18.5	8.35	1 05	7.00	84	E0.01
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	19.7	22.4	11.6	1.14	9.39	103	E0.02
			08/23/2010	15:00	18.8	19.3	9 41	99	7.43	92	E0.01
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09.30	19.9	28.5	16.1	1.17	9.55	132	E0.02
			08/24/2010	09:00	20.7	26.1	14 3	1 05	8.72	126	0.03
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	20.7	26.5	15.3	1.16	10.0	122	0.02
			08/24/2010	13:00	21.7	22.5	12.7	97	8.87	109	0.02
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	18.5	25.4	14.7	1.03	9.28	122	0.03
			08/25/2010	09:00	21.2	22.6	12.9	1.00	9.25	110	0.02
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	20.4	26.1	15.5	1.24	10.3	126	0.03
			08/25/2010	13:00	23.7	21 9	12.8	1.00	9.93	112	0.03
9	11467000	Russian River near Guerneville	06/17/2010	10:00	19.6	26.4	15.7	1.24	10.6	126	0.03
			08/26/2010	09:00	21.1	22.3	13.6	1.04	9.20	114	0.03
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	20.8	26.9	15.9	1.31	10.8	126	0.03
			08/26/2010	12:00	22 6	23.8	14.0	1.09	9.44	115	0.03
			10/14/2010	12:30	19.1	20.6	11.1	1.05	7.95	97	–
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	22.2	25.5	15.2	1.24	10.5	127	0.03
			08/26/2010	13:30	23.3	23.1	14.2	1.12	9.00	116	0.03
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	21 0	26.7	16.2	1.30	10.9	128	0.03
			08/27/2010	09:30	21.3	23.2	14.5	1.20	9.70	117	0.03
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	18.9	33.2	24.1	3.08	27.4	188	0 09
			08/25/2010	10:30	19.1	39 5	31.2	3 18	38.1	250	0.12
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	15.2	23.4	13 4	0.94	8.6	113	0.03
			08/25/2010	19:00	17 2	25.2	13 7	1 00	8 9	120	0.03
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	20 5	24.8	14.0	1.18	9.2	117	0.03
			08/25/2010	17:30	20.4	25.4	13 9	1 10	8.9	120	0.04
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	16.0	47.3	36.2	1.35	7.44	214	0.03
			08/24/2010	15:00	16.7	46.7	35.2	1 28	7.30	217	0.03

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.–Continued

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations** no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide; ft³/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury; mm, millimeter, µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, actual value less than value shown; E, estimated value, –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Sulfate, dissolved (mg/L as SO_4) (00945)	Solids, residue at 180°C dissolved (mg/L) (70300)	Nitrogen, ammonia, dissolved (mg/L as N) (00608)	Nitrogen, ammonia +organic, dissolved (mg/L as N) (00623)
2	11462500	Russian River near Hopland	06/14/2010	13:00	5.36	0.09	12.2	10.1	136	0.388	1.3
			08/23/2010	11:30	3.97	E0.08	11.3	8.47	112	<0.020	0.18
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	5.59	0.11	11.8	11.3	132	<0.020	0.22
			08/23/2010	15:00	4.38	0.08	9.79	9.07	120	<0.020	0.19
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	5.67	0.10	12.4	15.9	176	E0.014	0.14
			08/24/2010	09:00	5.52	0.09	11.5	13.9	144	<0.020	0.12
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	6.71	0.10	13.1	14.8	161	E0.014	0.17
			08/24/2010	13:00	6.19	0.09	12.9	12.4	135	<0.020	0.12
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	5.81	0.11	13.3	14.9	160	E0.015	0.12
			08/25/2010	09:00	6.67	0.10	13.1	12.4	141	<0.020	0.13
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	6.90	0.10	14.1	15.0	164	E0.017	0.16
			08/25/2010	13:00	8.06	0.09	13.2	12.5	141	<0.020	0.23
9	11467000	Russian River near Guerneville	06/17/2010	10:00	7.02	0.10	14.4	15.2	171	0.021	0.16
			08/26/2010	09:00	6.97	0.10	13.7	12.6	147	<0.020	0.10
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	7.12	0.10	14.0	14.9	153	0.020	0.15
			08/26/2010	12:00	6.22	0.11	14.1	12.7	154	0.028	0.10
			10/14/2010	12:30	5.01	0.11	12.7	10.9	133	<0.01	0.13
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	7.32	0.12	13.9	14.9	166	E0.016	0.17
			08/26/2010	13:30	6.48	0.01	14.5	12.6	–	<0.020	0.11
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	7.28	0.11	14.2	14.7	166	0.027	0.20
			08/27/2010	09:30	6.83	0.10	15.1	12.5	161	<0.020	0.11
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	22.9	0.12	28.8	15.4	288	0.047	0.41
			08/25/2010	10:30	32.2	0.15	33.3	17.5	359	0.037	0.33
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	5.78	0.09	12.80	11.80	132	<0.020	E0.05
			08/25/2010	19:00	5.74	0.10	13.90	13.60	148	<0.020	<0.10
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	5.99	0.11	14.10	15.00	176	<0.020	E0.06
			08/25/2010	17:30	5.65	0.13	14.20	12.50	147	<0.020	E0.05
33	383132122514501	8N/9W-21F1	06/15/2010	17.30	5.98	E0.07	23.0	47.9	303	<0.020	E0.07
			08/24/2010	15:00	6.15	E0.07	22.7	51.3	291	<0.020	<0.10

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.–Continued

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Map site no.	USGS station no.	Station name	Date	Time	Nitrogen, ammonia + organic, total (mg/L as N) (00625)	Nitrogen, NO_2+NO_3, dissolved (mg/L as N) (00631)	Nitrogen, nitrite, dissolved (mg/L as N) (00613)	Phosphorous, dissolved (mg/L as P) (00666)	Phosphorus, ortho-phosphate, dissolved (mg/L as P) (00671)	Phosphorous, total (mg/L as P) (00665)	Carbon, organic, dissolved (mg/L as C) (00681)
2	11462500	Russian River near Hopland	06/14/2010	13:00	0.27	0.41	0.005	0.028	E0.004	0.083	2.4
			08/23/2010	11:30	0.23	0.24	0.006	0.054	0.050	0.069	2.7
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	0.19	0.28	0.005	0.038	0.038	0.053	2.2
			08/23/2010	15:00	0.25	0.11	0.002	0.032	0.028	0.049	2.5
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	0.15	0.12	0.003	0.009	0.011	0.018	1.8
			08/24/2010	09:00	0.17	<0.04	<0.002	E0.004	0.009	0.010	1.7
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	0.16	0.11	0.002	0.009	0.012	0.017	1.7
			08/24/2010	13:00	0.15	<0.04	<0.002	0.007	0.010	0.013	1.6
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	0.14	0.12	E0.004	0.009	0.013	0.017	1.8
			08/25/2010	09:00	0.12	<0.04	<0.002	0.006	0.011	0.014	1.5
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	0.15	0.12	0.003	0.034	0.035	0.048	1.9
			08/25/2010	13:00	0.12	<0.04	<0.002	0.013	0.016	0.023	1.5
9	11467000	Russian River near Guerneville	06/17/2010	10:00	0.17	0.13	0.003	0.035	0.036	0.050	1.7
			08/26/2010	09:00	0.13	<0.04	<0.002	0.014	0.017	0.025	1.6
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	0.14	0.09	0.003	0.035	0.038	0.048	–
			08/26/2010	12:00	0.15	<0.04	<0.002	0.016	0.018	0.025	1.6
			10/14/2010	12:30	0.20	<0.02	<0.001	00.02	0.02	0.04	2.1
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	0.15	0.06	0.003	0.035	0.037	0.046	1.8
			08/26/2010	13:30	0.14	<0.04	<0.002	0.020	0.021	0.029	1.6
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	0.27	0.06	0.003	0.037	0.037	0.048	1.8
			08/27/2010	09:30	0.19	<0.04	<0.002	0.026	0.026	0.034	1.7
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	0.53	0.07	0.006	0.410	0.413	0.513	4.9
			08/25/2010	10:30	0.37	0.08	0.004	0.332	0.310	0.379	3.9
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	–	0.11	<0.002	<0.04	0.021	–	0.7
			08/25/2010	19:00	–	0.15	<0.002	<0.04	0.023	–	E0.4
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	–	0.13	<0.002	E0.03	0.043	–	1.0
			08/25/2010	17:30	–	0.06	<0.002	0.05	0.043	–	E0.6
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	–	1.11	E0.001	<0.04	0.023	–	0.7
			08/24/2010	15:00	–	0.99	<0.002	<0.04	0.020	–	E0.5

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.–Continued

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations** no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide; ft^3/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury; mm, millimeter; µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, actual value less than value shown; E, estimated value, –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Carbon, organic, total (mg/L as C) (00680)	Aluminum, dissolved (µg/L as Al) (01106)	Antimony, dissolved (µg/L as An) (01095)	Arsenic, dissolved (µg/L as As) (01000)	Barium, dissolved (µg/L as Ba) (01005)	Beryllium, dissolved (µg/L as Be) (01010)	Boron, dissolved (µg/L as B) (01020)
2	11462500	Russian River near Hopland	06/14/2010	13:00	2.8	15.7	0.21	0.75	61	<0.01	251
			08/23/2010	11:30	2.4	25.4	0.20	0.89	52	<0.01	215
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	–	9.1	0.08	0.68	68	E0.01	324
			08/23/2010	15:00	3.0	11.0	0.14	0.81	63	<0.01	306
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	–	3.8	0.13	0.70	92	E0.01	332
			08/24/2010	09:00	2.2	<3.4	0.18	0.62	90	<0.01	340
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	1.9	4.0	0.10	0.72	80	<0.01	258
			08/24/2010	13:00	1.9	3.5	0.09	0.55	73	<0.01	238
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	1.7	3.8	0.10	0.61	81	<0.01	258
			08/25/2010	09:00	2.0	E2.5	0.15	0.61	74	<0.01	241
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	1.9	4.7	0.10	0.72	81	<0.01	284
			08/25/2010	13:00	2.1	7.0	0.13	0.61	71	<0.01	227
9	11467000	Russian River near Guerneville	06/17/2010	10:00	1.9	E3.0	0.09	0.75	80	E0.01	256
			08/26/2010	09:00	2.1	E2.1	0.13	0.63	74	<0.01	231
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	2.1	E3.0	0.11	0.82	79	<0.01	267
			08/26/2010	12:00	2.1	E2.3	0.13	0.72	69	<0.01	241
			10/14/2010	12:30	3.2	3.9	0.18	0.86	63	<0.01	216
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	2.0	E2.0	0.11	0.91	78	<0.01	261
			08/26/2010	13:30	1.8	E2.5	0.15	0.87	73	<0.01	228
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	2.0	E2.9	0.11	0.94	78	<0.01	260
			08/27/2010	09:30	1.9	10.3	0.18	0.97	74	<0.01	229
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	5.7	5.3	0.23	2.3	60	<0.01	152
			08/25/2010	10:30	4.9	E2.5	0.12	2.1	86	<0.01	195
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	–	–	–	–	–	–	–
			08/25/2010	19:00	–	–	–	–	–	–	–
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	–	–	–	–	–	–	–
			08/25/2010	17:30	–	–	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	–	–	–	–	–	–	–
			08/24/2010	15:00	–	–	–	–	–	–	–

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations**: no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide, ft³/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury; mm, millimeter; µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, actual value less than value shown; E, estimated value; –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Cadmium, dissolved (µg/L as Cd) (01025)	Chromium, dissolved (µg/L as Cr) (01030)	Cobalt, dissolved (µg/L as Co) (01035)	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Lithium, dissolved (µg/L as Li) (01130)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<0.02	0.31	2.4	1.2	28	0.04	2.4
			08/23/2010	11:30	<0.02	0.28	1.2	2.2	42	0.03	2.1
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<0.02	0.29	0.37	E0.80	18	E0.02	2.7
			08/23/2010	15:00	<0.02	0.21	0.60	2.2	22	E0.02	2.3
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<0.02	0.44	0.26	E0.92	E6	E0.02	2.6
			08/24/2010	09:00	<0.02	0.24	0.73	E0.88	8	<0.03	3.0
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<0.02	0.44	0.19	1.2	9	<0.03	2.7
			08/24/2010	13:00	<0.02	0.36	0.15	1.8	19	E0.02	2.3
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<0.02	0.41	0.15	E0.72	13	0.03	2.7
			08/25/2010	09:00	<0.02	0.28	0.63	E0.98	12	<0.03	2.3
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	<0.02	0.42	0.13	E0.97	12	E0.02	3.2
			08/25/2010	13:00	<0.02	0.25	0.24	1.4	11	<0.03	2.3
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<0.02	0.41	0.13	E0.91	10	E0.02	2.9
			08/26/2010	09:00	<0.02	0.26	0.39	E0.80	11	E0.02	2.4
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	<0.02	0.43	0.15	E0.54	9	<0.03	2.5
			08/26/2010	12:00	<0.02	0.24	0.42	E0.78	7	<0.03	2.4
			10/14/2010	12:30	<0.02	0.19	1.0	1.2	17	<0.01	1.9
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<0.02	0.37	0.26	E0.81	7	<0.03	2.4
			08/26/2010	13:30	<0.02	0.21	0.58	1.5	12	E0.02	2.3
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<0.02	0.33	0.18	E0.53	10	E0.02	2.4
			08/27/2010	09:30	<0.02	0.26	0.49	1.2	10	<0.03	2.4
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<0.02	0.24	2.7	E0.95	44	0.04	6.1
			08/25/2010	10:30	<0.02	E0.10	0.31	1.2	18	<0.03	7.9
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	–	–	–	–	<6	–	–
			08/25/2010	19:00	–	–	–	–	<6	–	–
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	–	–	–	–	<6	–	–
			08/25/2010	17:30	–	–	–	–	<6	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	–	–	–	–	<6	–	–
			08/24/2010	15:00	–	–	–	–	E4	–	–

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

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Map site no.	USGS station no.	Station name	Date	Time	Manganese, dissolved (µg/L as Mn) (01056)	Mercury, dissolved (µg/L as Hg) (71890)	Molybdenum, dissolved (µg/L as Mo) (01060)	Nickel, dissolved (µg/L as Ni) (01065)	Selenium, dissolved (µg/L as Se) (01145)	Silver, dissolved (µg/L as Ag) (01075)	Strontium, dissolved (µg/L as Sr) (01080)
2	11462500	Russian River near Hopland	06/14/2010	13:00	13.8	<0.010	0.3	1.8	0.08	<0.010	196
			08/23/2010	11:30	7.8	<0.010	0.3	1.6	0.09	<0.010	184
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	4.4	<0.010	0.3	1.5	0.09	<0.010	221
			08/23/2010	15:00	4.4	<0.010	0.3	1.4	0.07	<0.010	193
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	3.6	<0.010	0.4	2.0	0.10	<0.010	272
			08/24/2010	09:00	3.4	<0.010	0.4	1.5	0.07	<0.010	248
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	7.6	<0.010	0.4	1.7	0.09	<0.010	237
			08/24/2010	13:00	7.3	<0.010	0.4	1.4	0.06	<0.010	203
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	6.3	<0.010	0.4	1.7	0.08	<0.010	241
			08/25/2010	09:00	5.5	<0.010	0.4	1.4	0.07	<0.010	203
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	14.0	<0.010	0.4	1.7	0.06	<0.010	241
			08/25/2010	13:00	5.4	<0.010	0.4	1.3	0.06	<0.010	198
9	11467000	Russian River near Guerneville	06/17/2010	10:00	8.8	<0.010	0.4	1.8	0.06	<0.010	235
			08/26/2010	09:00	9.8	<0.010	0.4	1.4	0.06	<0.010	206
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	2.1	<0.010	0.4	2.0	0.08	<0.010	239
			08/26/2010	12:00	3.8	<0.010	0.4	1.4	0.06	<0.010	205
			10/14/2010	12:30	5.5	–	0.3	1.5	0.06	<0.005	198
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	5.7	<0.010	0.4	2.0	0.06	<0.010	238
			08/26/2010	13:30	13.2	<0.010	0.4	1.6	0.07	<0.010	207
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	7.6	<0.010	0.4	2.0	0.08	<0.010	236
			08/27/2010	09:30	21.5	<0.010	0.4	1.6	0.07	<0.010	208
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	208	<0.010	0.6	3.5	0.12	<0.010	192
			08/25/2010	10:30	241	<0.010	0.8	3.2	0.08	<0.010	232
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	E0.2	–	–	–	–	–	–
			08/25/2010	19:00	0.2	–	–	–	–	–	–
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	0.2	–	–	–	–	–	–
			08/25/2010	17:30	0.2	–	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	0.2	–	–	–	–	–	–
			08/24/2010	15:00	0.3	–	–	–	–	–	–

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

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Map site no.	USGS station no.	Station name	Date	Time	Thallium, dissolved (µg/L as Tl) (01057)	Vanadium, dissolved (µg/L as V) (01085)	Zinc, dissolved (µg/L as Zn) (01090)	1,4-Dichloro-benzene, dissolved (µg/L) (34572)	1-Methyl-naphthalene, dissolved (µg/L) (62054)	2,6-Di-methyl-naph-thalene, dissolved (µg/L) (62055)	2-Methyl-naphthalene, dissolved (µg/L) (62056)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<0.02	0.86	<2.8	<0.040	<0.022	<0.1	<0.036
			08/23/2010	11:30	<0.02	0.77	<2.8	<0.040	<0.022	<0.1	<0.036
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<0.02	0.78	<2.8	<0.040	<0.022	<0.1	<0.036
			08/23/2010	15:00	<0.02	0.75	<2.8	<0.040	<0.022	<0.1	<0.036
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<0.02	0.94	4.6	<0.040	<0.022	<0.1	<0.036
			08/24/2010	09:00	<0.02	0.88	<2.8	<0.040	<0.022	<0.1	<0.036
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<0.02	0.98	<2.8	<0.040	<0.022	<0.1	<0.036
			08/24/2010	13:00	<0.02	0.88	<2.8	<0.040	<0.022	<0.1	<0.036
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<0.02	0.95	<2.8	<0.040	<0.022	<0.1	<0.036
			08/25/2010	09:00	<0.02	0.94	<2.8	<0.040	<0.022	<0.1	<0.036
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	<0.02	1.1	<2.8	<0.040	<0.022	<0.1	<0.036
			08/25/2010	13:00	<0.02	0.99	<2.8	<0.040	<0.022	<0.1	<0.036
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<0.02	1.0	<2.8	<0.040	<0.022	<0.1	<0.036
			08/26/2010	09:00	<0.02	1.0	<2.8	<0.040	<0.022	<0.1	<0.036
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	E0.02	1.2	<2.8	<0.040	<0.022	<0.1	<0.036
			08/26/2010	12:00	<0.02	1.3	<2.8	<0.040	<0.022	<0.1	<0.036
			10/14/2010	12:30	<0.01	0.98	<1.4	<0.040	<0.022	<0.1	<0.036
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<0.02	1.1	<2.8	<0.040	<0.022	<0.1	<0.036
			08/26/2010	13:30	<0.02	1.4	<2.8	<0.040	<0.022	<0.1	<0.036
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<0.02	1.2	<2.8	<0.040	<0.022	<0.1	<0.036
			08/27/2010	09:30	<0.02	1.4	<2.8	<0.040	<0.022	<0.1	<0.036
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<0.02	2.6	E1.4	<0.040	<0.022	<0.1	<0.036
			08/25/2010	10:30	<0.02	2.7	<2.8	<0.040	<0.022	<0.1	<0.036
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	–	–	–	<0.040	<0.022	<0.1	<0.036
			08/25/2010	19:00	–	–	–	<0.040	<0.022	<0.1	<0.036
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	–	–	–	<0.040	<0.022	<0.1	<0.036
			08/25/2010	17:30	–	–	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	–	–	–	<0.040	<0.022	<0.1	<0.036
			08/24/2010	15:00	–	–	–	<0.040	<0.022	<0.1	<0.036

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and three groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

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Map site no.	USGS station no.	Station name	Date	Time	3-β-Coprostanol, dissolved (µg/L) (62057)	3-Methyl-1H-indole, dissolved (µg/L) (62058)	3-*tert*-Butyl-4-hydroxyanisole, dissolved (µg/L) (62059)	4-Cumylphenol, dissolved (µg/L) (62060)	4-n-Octylphenol, dissolved (µg/L) (62061)	4-Nonylphenol, dissolved (µg/L) (62085)	4-Nonylphenol diethoxylates dissolved (µg/L) (62083)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<2	<0.036	<8	<0.06	<0.16	<2	<5
			08/23/2010	11:30	<2	<0.036	–	<0 06	<0 16	<2	<5
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<2	<0.036	<8	<0 06	<0.16	<2	<5
			08/23/2010	15:00	<2	<0.036	–	<0 06	<0 16	<2	<5
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<2	<0.036	<8	<0.06	<0.16	<2	<5
			08/24/2010	09:00	<2	<0.036	–	<0.06	<0 16	<2	<5
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<2	<0.036	<8	<0.06	<0.16	<2	<5
			08/24/2010	13:00	<2	<0.036	–	<0.06	<0.16	<2	<5
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<2	<0.036	<8	<0.06	<0.16	<2	<5
			08/25/2010	09:00	<2	<0.036	–	<0.06	<0.16	<2	<5
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	<2	<0.036	<8	<0.06	<0.16	<2	<5
			08/25/2010	13:00	<2	<0.036	–	<0.06	<0 16	<2	<5
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<2	<0.036	<8	<0 06	<0.16	<2	<5
			08/26/2010	09:00	<2	<0 036	–	<0 06	<0.16	<2	<5
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	<2	<0.036	<8	<0 06	<0.16	<2	<5
			08/26/2010	12:00	<2	<0.036	–	<0 06	<0.16	<2	<5
			10/14/2010	12:30	<2	<0.036	–	<0.06	<0.16	<2	<5
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<2	<0.036	<8	<0.06	<0.16	<2	<5
			08/26/2010	13:30	<2	<0.036	–	<0.06	<0.16	<2	<5
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<2	<0.036	<8	<0 06	<0.16	<2	<5
			08/27/2010	09:30	<2	<0.036	<8	<0 06	<0 16	<2	<5
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<2	<0.036	<8	<0.06	<0.16	<2	<5
			08/25/2010	10:30	<2	<0.036	–	<0.06	<0.16	<2	<5
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	<2	<0.036	<8	<0.06	<0.16	<2	<5
			08/25/2010	19:00	<2	<0.036	<8	<0 06	<0.16	<2	<5
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	<2	<0.036	<8	<0.06	<0.16	<2	<5
			08/25/2010	17:30	–	–	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	<2	<0.036	<8	<0.06	<0.16	<2	<5
			08/24/2010	15:00	<2	<0.036	–	<0.06	<0.16	<2	<5

v

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

[[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations** no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide; ft³/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury, mm, millimeter; µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, actual value less than value shown; E, estimated value; –, no data]

Map site no.	USGS station no.	Station name	Date	Time	4-Octyl-phenol di-ethoxylates dissolved (µg/L) (61705)	4-Octyl-phenol mono-ethoxylates dissolved (µg/L) (61706)	4-*tert*-Octyl-phenol, dissolved (µg/L) (62062)	5-Methyl-1H-benzo-triazole, dissolved (µg/L) (62063)	9,10-Anthra-quinone, dissolved (µg/L) (62066)	Aceto-phenone, dissolved (µg/L) (62064)	AHTN, dissolved (µg/L) (62065)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<1	<1	<0 14	<1	<0.2	<0.4	<0.028
			08/23/2010	11:30	<1	<1	<0.14	<1	<0.2	<0 4	<0.028
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<1	<1	<0.14	<1	<0.2	<0.4	<0 028
			08/23/2010	15:00	<1	<1	<0.14	<1	<0.2	<0 4	<0 028
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<1	<1	<0.14	<1	<0 2	<0.4	<0.028
			08/24/2010	09:00	<1	<1	<0.14	<1	<0 2	<0 4	<0.028
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			08/24/2010	13:00	<1	<1	<0.14	<1	<0 2	<0.4	<0.028
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			08/25/2010	09:00	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			08/25/2010	13:00	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			08/26/2010	09:00	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			08/26/2010	12:00	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			10/14/2010	12:30	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			08/26/2010	13:30	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			08/27/2010	09:30	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			08/25/2010	10:30	<1	<1	<0.14	<1	<0.2	<0.4	<0 028
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			08/25/2010	19:00	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	<1	<1	<0.14	<1	<0.2	<0.4	<0.028
			08/25/2010	17:30	–	–	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17 30	<1	<1	<0 14	<1	<0.2	<0.4	<0.028
			08/24/2010	15:00	<1	<1	<0.14	<1	<0 2	<0.4	<0.028

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations**: no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide; ft³/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury, mm, millimeter; µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, actual value less than value shown, E, estimated value; –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Anthracene, dissolved (µg/L) (34221)	Benzo-[a]-pyrene, dissolved (µg/L) (34248)	Benzophenone, dissolved (µg/L) (62067)	β-Sitosterol, dissolved (µg/L) (62068)	β-Stigmastanol, dissolved (µg/L) (62086)	Bromacil, dissolved (µg/L) (04029)	Caffeine, dissolved (µg/L) (50305)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/23/2010	11:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/23/2010	15:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/24/2010	09:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/24/2010	13:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/25/2010	09:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/25/2010	13:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/26/2010	09:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/26/2010	12:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			10/14/2010	12:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/26/2010	13:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/27/2010	09:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/25/2010	10:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/25/2010	19:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/25/2010	17:30	–	–	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1
			08/24/2010	15:00	<0.028	<0.1	<0.1	<4	<3	<0.4	<0.1

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations**: no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide; ft³/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury, mm, millimeter; µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, actual value less than value shown; E, estimated value, –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Camphor, dissolved (µg/L) (62070)	Carbaryl, dissolved (µg/L) (82680)	Carbazole, dissolved (µg/L) (62071)	Chlorpyrifos, dissvolved (µg/L) (38933)	Cholesterol, dissolved (µg/L) (62072)	Cotinine, dissolved (µg/L) (62005)	DEET, dissolved (µg/L) (62082)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/23/2010	11:30	<0.044	<0.38	<0.030	<0.2	<2	<0.038	<0.1
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/23/2010	15:00	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<0.044	<0.38	<0.030	<0.2	<2	<0.038	<0.1
			08/24/2010	09:00	<0.044	<0.38	<0.030	<0.2	<2	<0.038	<0.1
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/24/2010	13:00	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/25/2010	09:00	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/25/2010	13:00	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<0.044	<0.38	<0.030	<0.2	<2	<0.038	<0.1
			08/26/2010	09:00	<0.044	<0.38	<0.030	<0.2	<2	<0.038	<0.1
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/26/2010	12:00	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			10/14/2010	12:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/26/2010	13:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<0.044	<0.38	<0.030	<0.2	<2	<0.038	<0.1
			08/27/2010	09:30	<0.044	<0.38	<0.030	<0.2	<2	<0.038	<0.1
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/25/2010	10:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/25/2010	19:00	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/25/2010	17:30	–	–	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1
			08/24/2010	15:00	<0.044	<0.38	<0.030	<0.2	<2	<0.600	<0.1

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property **Abbreviations**: no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide; ft^3/s, cubic feet per second, FNU, formazine nephelometric units, NTU, nephelometric turbidity units; Hg, mercury; mm, millimeter; µS/cm, microsiemens per centimeter; °C, degrees Celsius, mg/L, milligrams per liter; µg/L, micrograms per liter, <, actual value less than value shown; E, estimated value: –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Diazinon, dissolved (µg/L) (39572)	*d*-Limonene, dissolved (µg/L) (62073)	Fluoranthene, dissolved (µg/L) (34377)	HHCB, dissolved (µg/L) (62075)	Indole, dissolved (mg/L) (62076)	Isoborneol, dissolved (µg/L) (62077)	Isophorone, dissolved (µg/L) (34409)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/23/2010	11:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/23/2010	15:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/24/2010	09:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/24/2010	13:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/25/2010	09:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/25/2010	13:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/26/2010	09:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/26/2010	12:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			10/14/2010	12:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/26/2010	13:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/27/2010	09:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/25/2010	10:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/25/2010	19:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/25/2010	17:30	–	–	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1
			08/24/2010	15:00	<0.2	<0.1	<0.024	<0.1	<0.1	<0.2	<0.1

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations**: no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide; ft^3/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury; mm, millimeter, SC, specific conductance; µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter, <, actual value less than value shown; E, estimated value; –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Isopropyl-benzene, dissolved (µg/L) (62078)	Isoquinoline, dissolved (µg/L) (62079)	Menthol, dissolved (µg/L) (62080)	Metalaxyl, dissolved (µg/L) (50359)	Methyl salicylate, dissolved (µg/L) (62081)	Metolachlor, dissolved (µg/L) (39415)	Naphthalene, dissolved (µg/L) (34443)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/23/2010	11:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/23/2010	15:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/24/2010	09:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/24/2010	13:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/25/2010	09:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/25/2010	13:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/26/2010	09:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/26/2010	12:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			10/14/2010	12:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/26/2010	13:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/27/2010	09:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/25/2010	10:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/25/2010	19:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/25/2010	17:30	–	–	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040
			08/24/2010	15:00	<0.3	<0.046	<0.03	<0.1	<0.044	<0.1	<0.040

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations**: no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide; ft^3/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury; mm, millimeter, µS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, actual value less than value shown; E, estimated value; –, no data]

Map site no.	USGS station no.	Station name	Date	Time	p-Cresol, dissolved (µg/L) (62084)	Phenanthrene, dissolved (µg/L) (34462)	Prometon, dissolved (µg/L) (04037)	Pyrene, dissolved (µg/L) (34470)	Tetrachloroethene, dissolved (µg/L) (34476)	Tribromomethane, dissolved (µg/L) (34288)	Tributyl phosphate, dissolved (µg/L) (62089)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/23/2010	11:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/23/2010	15:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/24/2010	09:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/24/2010	13:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/25/2010	09:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/25/2010	13:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/26/2010	09:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/26/2010	12:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			10/14/2010	12:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/26/2010	13:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/27/2010	09:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/25/2010	10:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/25/2010	19:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/25/2010	17:30	–	–	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2
			08/24/2010	15:00	<0.08	<0.032	<0.1	<0.042	<0.1	<0.1	<0.2

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property. **Abbreviations**: no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide, ft^3/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury; mm, millimeter, µS/cm, microsiemens per centimeter, °C, degrees Celsius; mg/L, milligrams per liter, µg/L, micrograms per liter; <, actual value less than value shown; E, estimated value, –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Triclosan, dissolved (µg/L) (62090)	Tri-ethyl citrate, dissolved (µg/L) (62091)	Tri-phenyl phosphate, dissolved (µg/L) (62092)	Tris(2-butoxyethyl) phosphate, dissolved (µg/L) (62093)	Tris(2-chloroethyl) phosphate, dissolved (µg/L) (62087)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<0.20	<0.4	<0.1	<0.8	<0.1
			08/23/2010	11:30	<0.20	<0.4	<0.1	<0.8	<0.1
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<0.20	<0.4	<0.1	<0.8	<0.1
			08/23/2010	15:00	<0.20	<0.4	<0.1	<0.8	<0.1
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<0.20	<0.4	<0.1	<0.8	<0.1
			08/24/2010	09:00	<0.20	<0.4	<0.1	<0.8	<0.1
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<0.20	<0.4	<0.1	<0.8	<0.1
			08/24/2010	13:00	<0.20	<0.4	<0.1	<0.8	<0.1
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<0.20	<0.4	<0.1	<0.8	<0.1
			08/25/2010	09:00	<0.20	<0.4	<0.1	<0.8	<0.1
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	<0.20	<0.4	<0.1	<0.8	<0.1
			08/25/2010	13:00	<0.20	<0.4	<0.1	<0.8	<0.1
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<0.20	<0.4	<0.1	<0.8	<0.1
			08/26/2010	09:00	<0.20	<0.4	<0.1	<0.8	<0.1
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	<0.20	<0.4	<0.1	<0.8	<0.1
			08/26/2010	12:00	<0.20	<0.4	<0.1	<0.8	<0.1
			10/14/2010	12:30	<0.20	<0.4	<0.1	<0.8	<0.1
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<0.20	<0.4	<0.1	<0.8	<0.1
			08/26/2010	13:30	<0.20	<0.4	<0.1	<0.8	<0.1
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<0.20	<0.4	<0.1	<0.8	<0.1
			08/27/2010	09:30	<0.20	<0.4	<0.1	<0.8	<0.1
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<0.20	<0.4	<0.1	<0.8	<0.1
			08/25/2010	10:30	<0.20	<0.4	<0.1	<0.8	<0.1
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	<0.20	<0.4	<0.1	<0.8	<0.1
			08/25/2010	19:00	<0.20	<0.4	0.11	<0.8	<0.1
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	<0.20	<0.4	E0.1	<0.8	<0.1
			08/25/2010	17:30	–	–	–	–	–
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	<0.20	<0.4	<0.1	<0.8	<0.1
			08/24/2010	15:00	<0.20	<0.4	0.11	<0.8	<0.1

Table 15. Discharge measurements and water-quality data collected from 10 Russian River sites, Mark West Creek, and 3 groundwater sites in the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.—Continued

[Number below the constituent or property is the U.S. Geological Survey (USGS) parameter code, which is a 5-digit number used in the USGS National Water Information System (NWIS), to uniquely identify a specific constituent or property **Abbreviations**: no., number; AHTN, acetyl hexamethyl tetrahydronaphthalene; HHCB, hexahydrohexamethyl cyclopentabenzopyran; DEET, *N,N*-diethyl-meta-toluamide, ft³/s, cubic feet per second; FNU, formazine nephelometric units; NTU, nephelometric turbidity units; Hg, mercury; mm, millimeter; µS/cm. microsiemens per centimeter; °C, degrees Celsius; mg/L. milligrams per liter; µg/L, micrograms per liter; <, actual value less than value shown; E, estimated value; –, no data]

Map site no.	USGS station no.	Station name	Date	Time	Tris(dichloroisopropy) phosphate, dissolved (µg/L) (62088)	Hydrogen-2/1, (per mil) (82082)	Oxygen-18/16, (per mil) (82085)
2	11462500	Russian River near Hopland	06/14/2010	13:00	<0 2	−53.50	−8.12
			08/23/2010	11:30	<0.2	−57 60	−8.26
3	11463000	Russian River near Cloverdale	06/14/2010	15:30	<0 2	−53.00	−7 91
			08/23/2010	15:00	<0.2	−54 40	−8.20
4	11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	<0 2	−48.70	−7.53
			08/24/2010	09.00	<0.2	−52 70	−7.70
6	383132122514901	Russian River at River Front Park	06/15/2010	13:30	<0 2	−47.00	−7.06
			08/24/2010	13.00	<0.2	−46.80	−6.97
7	11465400	Russian River at Wohler Bridge	06/16/2010	08:00	<0.2	−45.60	−7.06
			08/25/2010	09:00	<0.2	−47 40	−6.94
8	382959122535601	Russian River at Steelhead Beach	06/16/2010	13.30	<0.2	−45 90	−6.95
			08/25/2010	13:00	<0.2	−46.00	−6.88
9	11467000	Russian River near Guerneville	06/17/2010	10:00	<0.2	−45 10	−6.89
			08/26/2010	09:00	<0.2	−46.20	−6.90
11	11467002	Russian River at Johnson's Beach	06/17/2010	11:30	<0.2	−45.40	−6.90
			08/26/2010	12:00	<0.2	−45.90	−6.76
			10/14/2010	12:30	<0.2	−51.50	−7.69
13	382757123003801	Russian River at Monte Rio	06/17/2010	14:00	<0.2	−43.90	−6.94
			08/26/2010	13:30	<0.2	−43.20	−6.69
14	382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	<0.2	−42.30	−6.75
			08/27/2010	09:30	<0.2	−43.90	−6.51
22	11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	<0.2	−36 30	−5.49
			08/25/2010	10:30	<0.2	−35.10	−4.82
26	383002122530601	8N/9W-32C1	06/16/2010	17:30	<0.2	−42.60	−6.47
			08/25/2010	19:00	<0 2	−46.40	−6.85
30	383045122525701	8N/9W-29F1	06/16/2010	16:30	<0.2	−46 10	−7.10
			08/25/2010	17:30	–	−46.70	−6.90
33	383132122514501	8N/9W-21F1	06/15/2010	17:30	<0.2	−36.60	−5.78
			08/24/2010	15:00	<0.2	−37.60	−5.69

[a] Grab sample.

[b] Daily stsreamflow measurement obtained from NWISweb.

Table 16. Bacteria concentrations for water samples collected from 10 Russian River sites and Mark West Creek in the Russian River Basin, and quality-control data detected in field blanks from the Russian River Basin, Mendocino and Sonoma Counties, California, 2010.

[**Abbreviations**: no., number; MPN, most probable number; ND, analyte not detected at or above the reporting limit; mL, milliliter; >, actual value greater than value shown]

USGS station no.	Station name	Date	Time	Total coliform, (MPN/100 mL)	Fecal coliform (MPN/100 mL)	Enterococci, (MPN/100 mL)
11462500	Russian River near Hopland	06/14/2010	13:00	>1,600	30	11
		08/23/2010	11:30	170	130	24
11463000	Russian River near Cloverdale	06/14/2010	15:30	>1,600	50	14
		08/23/2010	15:00	350	50	8.0
11463980	Russian River at Digger Bend near Healdsburg	06/15/2010	09:30	>1,600	70	4.0
		08/24/2010	09:00	240	22	22
11465400	Russian River at Wohler Bridge	06/16/2010	08:00	>1,600	50	27
		08/25/2010	09:00	170	50	240
11467000	Russian River near Guerneville	06/17/2010	10:00	500	26	90
		08/26/2010	09:00	280	70	90
11467002	Russian River at Johnson's Beach	06/17/2010	11:30	1,600	17	17
		08/26/2010	12:00	500	9.0	8.0
		10/14/2010	12:30	>1,600	500	900
382754123030501	Russian River at Casini Ranch	06/18/2010	09:30	900	17	4.0
		08/27/2010	09:30	140	2.0	8.0
382757123003801	Russian River at Monte Rio	06/17/2010	14:00	300	4.0	2.0
		08/26/2010	13:30	80	8.0	7.0
382959122535601	Russian River at Steelhead Beach	06/16/2010	13:30	300	22	33
		08/25/2010	13:00	34	17	50
383132122514901	Russian River at River Front Park	06/15/2010	13:30	250	13	4.0
		08/24/2010	13:00	500	30	49
11466800	Mark West Creek near Mirabel Heights	06/16/2010	10:30	>1,600	80	17
		08/25/2010	10:30	>1,600	900	>1,600
		Blank sample				
11465400	Russian River at Wohler Bridge	06/16/2010	13:40	ND	ND	ND
		08/25/2010	08:10	ND	ND	ND

Appendix B

2010 Estuary Water Quality Monitoring

4.1 Water Quality Monitoring

Water quality monitoring was conducted in the lower, middle, and upper reaches of the Russian River Estuary between the mouth of the river at Jenner and Monte Rio, including two tributaries. Water Agency staff continued to collect data to establish baseline information on water quality 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 barrier beach closure and reopening.

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 (May 15 to October 15), 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 summer low flow conditions and barrier beach closure. Additionally, river flows, tides, topography, and wind action affect the amount of mixing of the water column at various longitudinal and vertical positions within the Estuary.

In 2010, the Estuary experienced three closures during the lagoon management period. The barrier beach formed and the Estuary closed for a period of 7 days from 4 July to 11 July, 10 days from 21 September to 1 October, and 9 days from 3 October to 12 October. During these closures, the Water Agency was able to monitor the partial development of a freshwater lagoon system as freshwater inflows increased the depth of the surface layer and the volume of denser saltwater in the lower layer of the water column began to decline, presumably as it seeped through the barrier beach.

Methods

Continuous Multi-Parameter Monitoring

Water quality was monitored using YSI Series 6600 multi-parameter datasondes. Hourly salinity (parts per thousand, ppt), water temperature (degrees Celsius), dissolved oxygen (milligrams per liter, mg/L), and pH (hydrogen ion) data were collected. Datasondes were cleaned and recalibrated periodically following the YSI User Manual procedures, and data was downloaded during each calibration event.

Nine stations were established for continuous water quality monitoring, including seven stations in the mainstem and two tributary stations (Figure 4.1.1). One mainstem station was located in the lower reach at the mouth of the Russian River at Goat Rock State Beach (Mouth Station). Three mainstem stations were placed in the middle reach: Patty's Rock upstream of Penny Island (Patty's Rock Station); Bridgehaven just downstream from the Highway 1 Bridge (Bridgehaven Station); and in the pool downstream of Sheephouse Creek (Sheephouse Creek Station). One tributary station was located in the mouth of Willow Creek, which flows into the middle reach of the estuary (Willow Creek Station). Two mainstem stations were located in the upper reach; a pool next to an area known as Heron Rookery located halfway between Sheephouse Creek and Duncans Mills (Heron Rookery Station), and downstream of Freezeout Creek in Duncans Mills (Freezeout Creek Station). The other tributary station was located downstream of the first steel bridge in lower Austin Creek, which flows into the mainstem above Duncans Mills (Austin Creek Station). The furthest upstream mainstem station was located in Monte Rio, outside of the influence of saline water, but within the upper extent of inundation and backwatering during lagoon formation (Monte Rio Station).

The rationale for choosing Estuary sites was to locate the deepest holes at various points throughout the Estuary to obtain the fullest vertical profiles possible, and to monitor hypoxic and/or anoxic events and temperature or salinity stratification. Sondes were located in the mouths of Willow and Austin Creeks to collect baseline water quality conditions and monitor potential changes to water quality, including salinity intrusion, during estuary closure and inundation. The Monte Rio station was established to monitor potential changes to water quality conditions in the upstream extent of the river that can become inundated during barrier beach closure, also referred to as the maximum backwater area (Figure 4.1.1).

Mainstem estuary monitoring stations were comprised of a concrete anchor attached to a steel cable suspended from the surface by a large buoy (Figure 4.1.2). All mainstem estuary stations had a vertical array of two datasondes to collect water quality profiles. Stations in the lower and middle reaches of the Estuary that are predominantly saline had sondes placed at the surface (~1m) and mid-depth (~3m) portions of the water column.

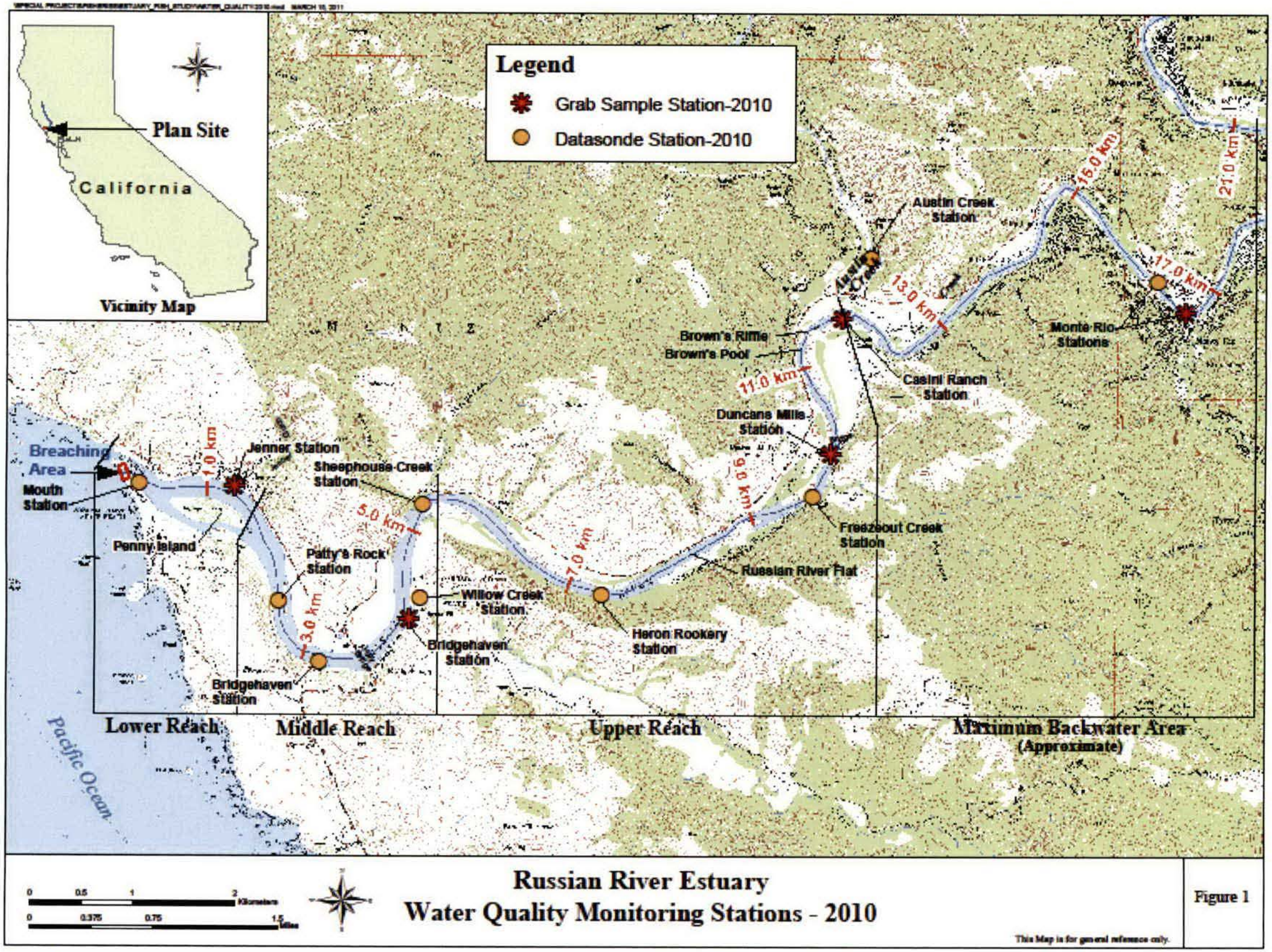

Figure 4.1.1. 2010 Russian River Estuary Water Quality Monitoring Stations

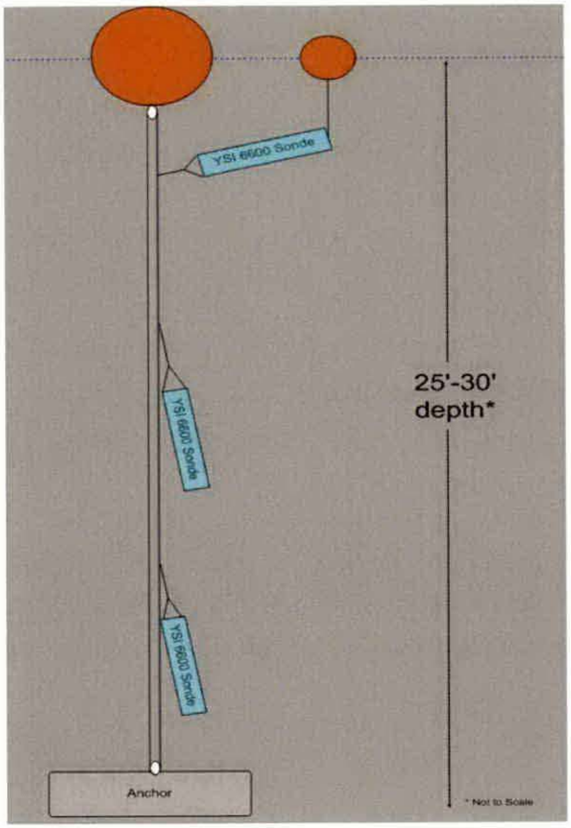

Figure 4.1.2. Typical Russian River Estuary monitoring station datasonde array.

The two stations in the upper reach of the Estuary, where water is predominantly fresh to brackish, were located in the lower half of the water column at mid-depth (~3-4m) and the bottom (~6-8m). Sondes were located in this manner to track vertical and longitudinal changes in water quality characteristics, including periods of barrier beach closure and reopening.

Monitoring stations in the tributaries and at Monte Rio consisted of one datasonde suspended at approximately mid-depth (during open conditions) in the thalweg at each respective site.

Monitoring stations at the Mouth, Patty's Rock, Bridgehaven, Sheephouse Creek, Heron Rookery, and Freezeout Creek stations were deployed from the end of April to the end of October. The Willow Creek and Austin Creek stations were deployed from the first week of May to the end of October, and the Monte Rio Station was deployed from the first week of June to the end of October. All stations were retrieved earlier than typical years due to strong storm events and resultant high flows that occurred in late October.

Grab Sample Collection

Five stations were established in 2010 for nutrient and indicator bacteria grab sampling: the Jenner Boat Ramp (Jenner Station); Bridgehaven at the mouth of Willow Creek (Bridgehaven Station); Moscow Road Bridge in Duncans Mills (Duncans Mills Station); Casini Ranch across from the mouth of Austin Creek (Casini Ranch Station); and just downstream of the Monte Rio Bridge (Monte Rio Station). This sampling was included in the *Russian River Water Quality Monitoring Plan for the Sonoma County Water Agency2010 Temporary Urgency Change (TUC)* (Appendix A-5). Refer to Figure 4.1.1 for grab sampling locations.

Water Agency staff collected grab samples once every two weeks from 22 June to 14 October. Additional focused sampling (collecting three samples over a ten-day period), was conducted following or during specific river management and operational events including: removal of Vacation Beach dam, sandbar breaching, and lagoon outlet channel implementation. All grab samples were analyzed at Alpha Analytical Labs in Ukiah.

Nutrient sampling was conducted for total organic nitrogen, ammonia, unionized ammonia, nitrate, nitrite, total Kjeldahl nitrogen, total nitrogen (calculated), and total phosphorus, as well as for *chlorophyll a*, which is a measurable parameter of algal growth that can be tied to excessive nutrient concentrations. Grab samples were collected for presence of indicator bacteria including total coliforms, fecal coliforms, and *Enterococcus*. These bacteria are considered indicators of water quality conditions that may be a concern for water contact recreation and public health. The results of sampling conducted for total orthophosphate, dissolved organic carbon, total organic carbon, total dissolved solids, and turbidity are included as an appendix; however, an analysis and discussion of these constituents is not included in this report. Temperature and pH were recorded during grab sampling events and are included in the appendix.

Results

Water quality conditions in 2010 were similar to trends observed in sampling from 2004 to 2009. The lower and middle reaches are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater layer. The upper reach transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates up and downstream and appears to be affected in part by freshwater inflow rates, tidal inundation, barrier beach closure, and subsequent tidal cycles following reopening of the barrier beach. The lower and middle reaches of the Estuary are subject to tidally-influenced fluctuations in water depth and inundation during barrier beach closure, as is the upper reach to a lesser degree. The river upstream of Duncans Mills is considered freshwater habitat that is subject to inundation and backwatering during barrier beach closure.

Table 4.1.1 presents a summary of minimum, mean, and maximum values for temperature, depth, dissolved oxygen (DO), pH, and salinity recorded at the various datasonde monitoring stations. Data associated with malfunctioning datasonde equipment has been removed from

Table 4.1.1. Russian River Estuary 2010 water quality monitoring results. Minimum, mean, and maximum temperature (degrees C), depth (m), dissolved oxygen (mg/L), hydrogen ion (pH), and salinity (ppt).

Monitoring Station ***Sonde***	**Temperature** (°C)	**Depth** (m)	**Dissolved Oxygen** (%) saturation	**Dissolved Oxygen** (mg/L)	**Hydrogen Ion** (pH)	**Salinity** (ppt)
Mouth						
Surface						
April 23 - October 22						
Min	9.7	0.5	58.7	5.4	7.5	0.1
Mean	16.8	0.9	104.7	9.4	8.2	10.5
Max	**23.0**	**1.0**	**192.4**	**16.8**	**9.0**	**33.9**
Mid-Depth						
April 23 - October 22						
Min	9.3	2.8	51.3	4.5	7.3	0.2
Mean	13.7	3.0	102.1	9.1	7.9	24.9
Max	**20.8**	**3.1**	**294.6**	**25.3**	**8.9**	**34.2**
Patty's Rock						
Surface						
April 28 - October 24						
Min	11.5	0.6	62.6	5.7	7.3	0.1
Mean	17.1	0.8	103.3	9.8	8.2	4.1
Max	**23.0**	**0.9**	**248.5**	**24.2**	**9.1**	**31.1**
Mid-Depth						
April 28 - October 20						
Min	10.0	2.3	51.0	4.3	7.4	0.1
Mean	14.1	2.7	96.3	8.4	8.0	25.9
Max	**20.9**	**2.8**	**229.7**	**18.8**	**8.7**	**33.5**
Bridgehaven						
Surface						
April 28 - October 26						
Min	12.4	0.6	40.3	3.7	7.2	0.1
Mean	18.0	0.8	101.3	9.2	8.1	6.7
Max	**23.2**	**1.1**	**345.4**	**34.7**	**9.0**	**31.0**
Mid-Depth						
April 28 - October 26						
Min	10.5	2.4	1.3	0.1	7.1	0.1
Mean	14.4	3.4	99.6	8.7	7.9	25.2
Max	**20.6**	**5.9**	**164.5**	**14.0**	**8.7**	**32.8**
Willow Creek						
Mid-Depth						
May 3 - October 27						
Min	8.7	0.4	0.0	0.0	6.5	0.1
Mean	16.5	1.1	75.8	7.4	7.6	3.5
Max	**24.3**	**2.9**	**198.3**	**16.1**	**9.3**	**24.6**
Sheephouse Creek						
Surface						
April 23 - October 26						
Min	12.6	0.8	39.9	3.4	6.8	0.1
Mean	19.2	0.9	97.9	9.1	8.0	2.3
Max	**23.9**	**1.0**	**233.3**	**22.9**	**9.4**	**30.2**
Mid-Depth						
April 23 - October 26						
Min						
Mean						
Max						

Table 4.1.1. (cont.)

Monitoring Station *Sonde*	Temperature (°C)	Depth (m)	Dissolved Oxygen (%) saturation	Dissolved Oxygen (mg/L)	Hydrogen Ion (pH)	Salinity (ppt)
Heron Rookery						
Mid-Depth						
April 29 - October 24						
Min	12.0	2.7	42.3	3.6	7.3	0.1
Mean	18.5	3.4	88.0	8.1	8.1	3.3
Max	**23.6**	**4.8**	**167.6**	**15.9**	**8.9**	**28.3**
Bottom						
April 29 - October 24						
Min	12.6	7.6	0.5	0.1	5.5	0.1
Mean	17.3	8.6	56.6	5.2	7.1	15.2
Max	**23.1**	**9.4**	**163.3**	**15.3**	**8.7**	**26.5**
Freezeout Creek						
Mid-Depth						
April 29 - October 26						
Min	12.7	3.5	57.0	5.2	7.3	0.2
Mean	19.8	3.8	95.0	8.7	8.1	0.7
Max	**24.2**	**7.8**	**151.3**	**14.1**	**8.8**	**9.0**
Bottom						
April 29 - October 26						
Min	12.6	4.6	0.0	0.0	5.5	0.1
Mean	19.6	6 3	74.6	6.8	7.7	2.5
Max	**23.7**	**8.4**	**169.4**	**14.8**	**8.7**	**11.0**
Austin Creek						
Mid-Depth						
May 5 - October 27						
Min	11.0	0 3	29.4	3 0	7.3	0.0
Mean	16.4	0.7	84.4	8.3	7.8	0.1
Max	**21.3**	**2.7**	**120.9**	**11.6**	**8.3**	**0.2**
Monte Rio						
Mid-Depth						
June 7 - October 28						
Min	10.6	0.8	66.3	6.2	7.2	0.1
Mean	17.8	1.1	100.3	9.5	7.9	0.1
Max	**22.1**	**2.7**	**231.3**	**21.2**	**9.1**	**0.2**

the data sets, resulting in the data gaps observed in the graphs presented as Figures 4.1.3 through 4.1.38. These data gaps may affect minimum, mean, and maximum values of the various monitored constituents, including at the Patty's Rock Surface Sonde in July and September, the Bridgehaven Mid-Depth Sonde in October, the Willow Creek Sonde in May, the Sheephouse Creek Surface Sonde for the entire monitoring season, the Heron Rookery Bottom Sonde from late July to early August and late August to late September, the Freezeout Creek Bottom Sonde from mid- to late May, and the Austin Creek Sonde in May and early to mid-August.

Although gaps exist in the 2010 data that affect sample statistics, long time-series data has been collected on an hourly frequency for several years at most of these stations, and it is unlikely that the missing data appreciably affected the broader understanding of water quality conditions within the estuary. The following sections provide a brief discussion of the results observed for each parameter monitored.

Salinity

Full strength seawater has a salinity of approximately 35 ppt, with salinity decreasing from the ocean to the upstream limit of the Estuary, which is considered freshwater at approximately 0.5 ppt (Horne 1994). All of the mid-depth sondes in the lower and middle reaches were located in a predominantly saline environment, whereas the surface sondes were located at the saltwater-freshwater interface (halocline or salt wedge) and recorded both freshwater and saltwater conditions. In the middle reach of the Estuary, salinities can range as high as 30 ppt in the saltwater layer, with brackish conditions prevailing at the upper end of the salt wedge, to less than 1 ppt in the freshwater layer on the surface. The Willow Creek sonde was located just upstream of the confluence with the Russian River, where predominantly freshwater conditions observed during higher springtime flows transitioned to a brackish environment during lower dry season flows.

In the upper reach, the Estuary begins to transition to a predominantly brackish and freshwater environment in the Heron Rookery area. The Freezeout Creek station is located in a predominantly freshwater environment; however, saltwater does occur in the lower half of the water column during open estuary conditions with lower instream flows, as well as during barrier beach closure.

The Austin Creek and Monte Rio stations are located in freshwater habitat above the upper reach of the Estuary (in the maximum backwater area) that becomes partially inundated during barrier beach closure. Salinity was not observed at these stations during either open or closed conditions.

Lower and Middle Reach Salinity

The surface sondes at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek stations were suspended at a depth of approximately 1 meter, and experienced frequent hourly fluctuations in salinity during open conditions after springtime flows receded in early July. These fluctuations are caused by tidal movement and expansion and contraction of the salt wedge. The freshwater layer was persistent at the surface sondes before spring flows receded. The surface sondes at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek had mean salinity values of 10.5, 4.1, 6.7, and 2.3 ppt, respectively (Table 4.1.1).

Salinity concentrations were observed to decrease at the surface sondes in response to barrier beach closure (Figures 4.1.3 through 4.1.6). This is due to a combination of freshwater inflows

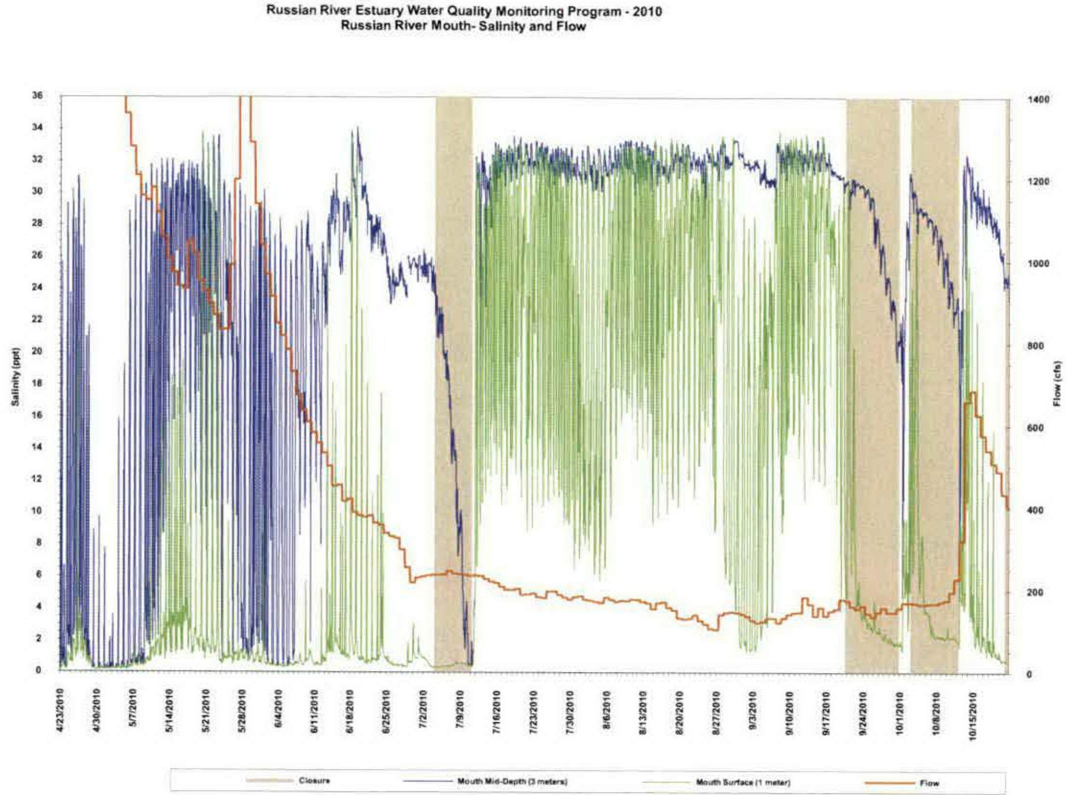

Figure 4.1.3. 2010 Russian River Mouth Salinity and Flow Graph

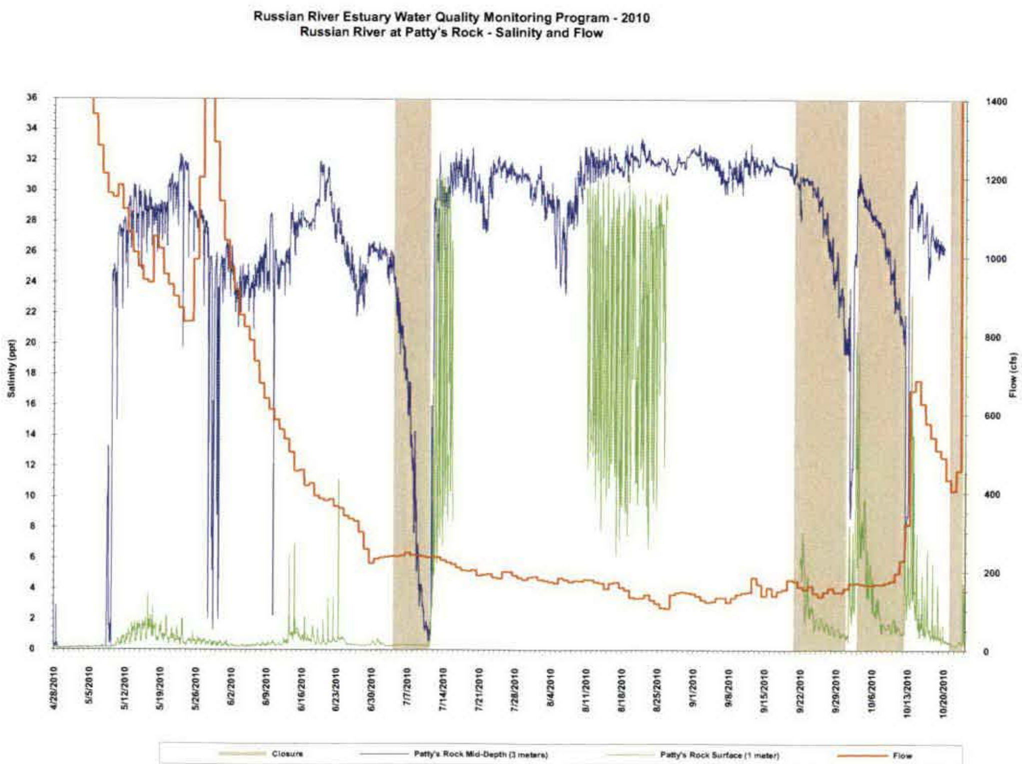

Figure 4.1.4. 2010 Russian River at Patty's Rock Salinity and Flow Graph

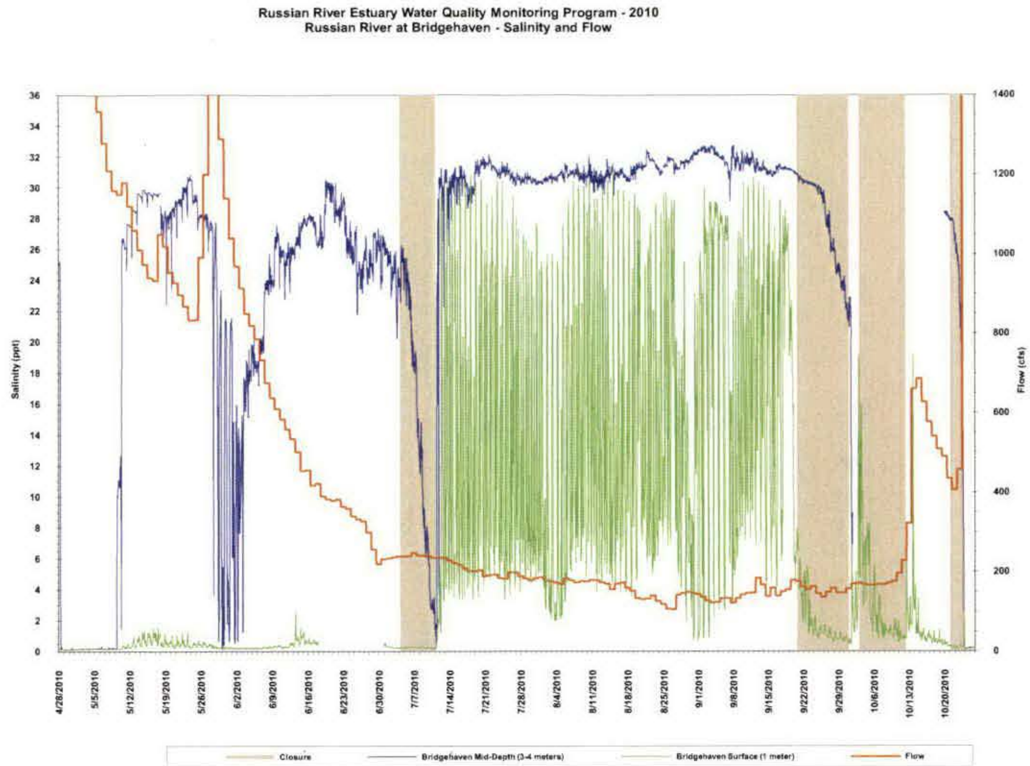

Figure 4.1.5. 2010 Russian River at Bridgehaven Salinity and Flow Graph

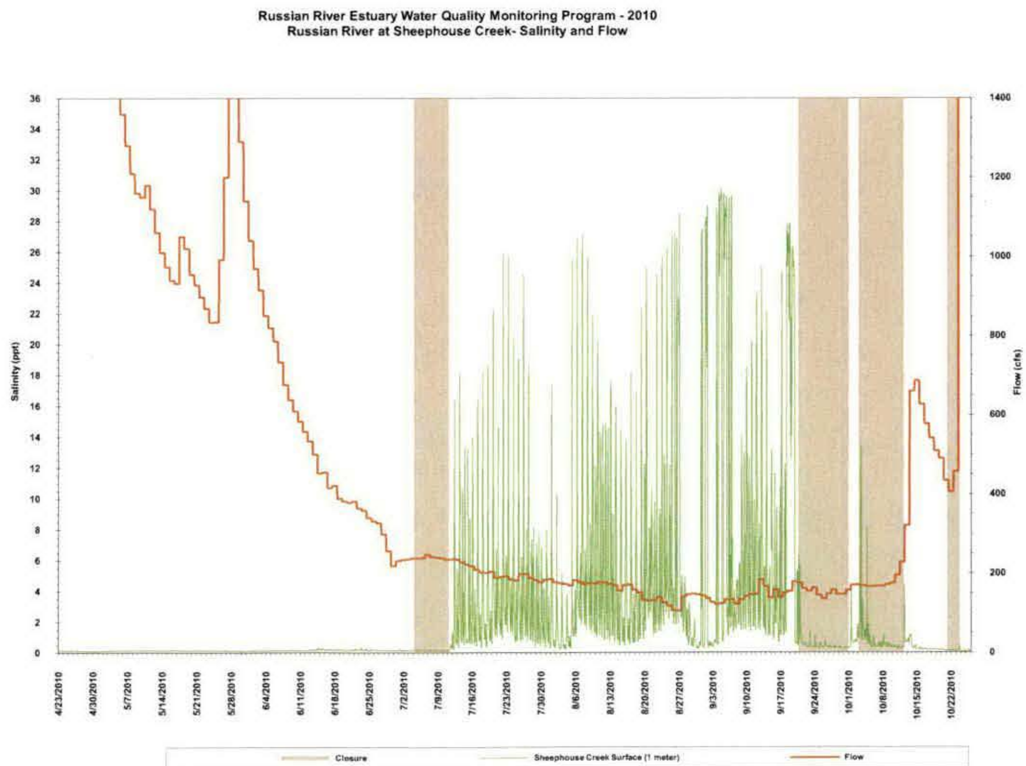

Figure 4.1.6. 2010 Russian River at Sheephouse Creek Salinity and Flow Graph

increasing the depth of the freshwater layer over the salt layer, the resulting compression and leveling out of the salt layer during stratification, and seepage of saline water through the barrier beach. Salinity returned to pre-closure levels after the mouth was breached, although the time required to return to pre-breach conditions varied at each site and differed between closure events. This variability was related to the strength of subsequent tidal cycles, freshwater inflow rates, topography, relative location within the Estuary, and to a lesser degree, wind mixing.

The Sheephouse Creek mid-depth sonde experienced an equipment malfunction during the entire monitoring period and no data were collected for this station in 2010. The mid-depth sondes at the Mouth, Patty's Rock, and Bridgehaven had mean salinity values near 25 ppt (Table 4.1.1). Minimum values at the Mouth mid-depth sonde were observed to occur with hourly fluctuations during high springtime flows, similar to what is observed at the surface sondes during open conditions later the monitoring period (Figure 4.1.3). Minimum salinity values were also observed at all mid-depth stations in the lower and middle reaches when freshwater flows temporarily displaced the saltwater at these stations during: spring storm events in late-April and May, barrier beach closure, and flushing events after the barrier beach was breached (Figures 4.1.3 through 4.1.6).

The Willow Creek sonde was located in a predominantly freshwater habitat during higher mainstem flows that persisted through June. Freshwater conditions remained at the station during and immediately following the 4 July to 11 July closure, however saline water migrated to this location on a high tide on 13 July and remained for the rest of the season (Figure 4.1.7). Once present, salinity at this site varied over the season, but remained primarily brackish in concentration (Table 4.1.1).

Upper Reach Salinity

Two stations were monitored in the upper reach in 2010: Heron Rookery and Freezeout Creek. Both stations included a bottom sonde and a mid-depth sonde. Sondes were located in this manner to track changes in concentration of salinity in the water column.

The Heron Rookery station is located approximately 7.5 km upstream from the mouth of the river in a deep pool. This station is situated where the Estuary begins to transition from predominantly saline conditions to brackish and freshwater conditions. The bottom and mid-depth sondes at Heron Rookery had mean salinity concentrations of 15.2 ppt and 3.3 ppt, respectively (Table 4.1.1). The high value at the mid-depth sonde was associated with a spike in concentration that occurred during barrier beach closure on 23 September (Figure 4.1.8).

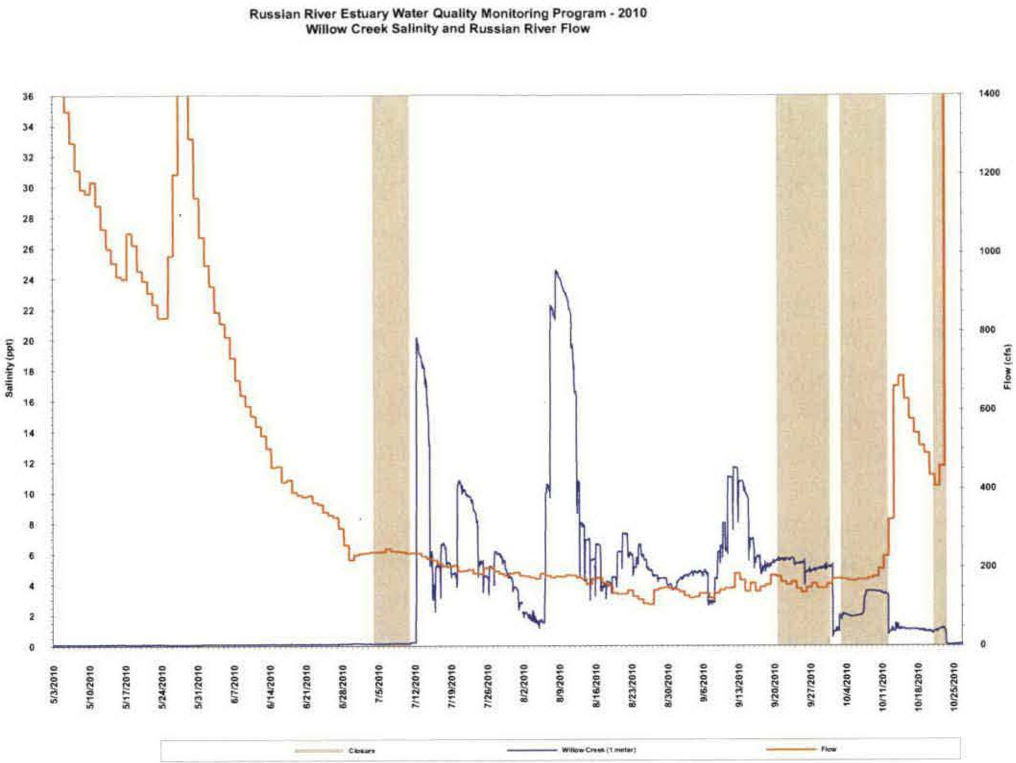

Figure 4.1.7. 2010 Willow Creek Salinity and Russian River Flow Graph

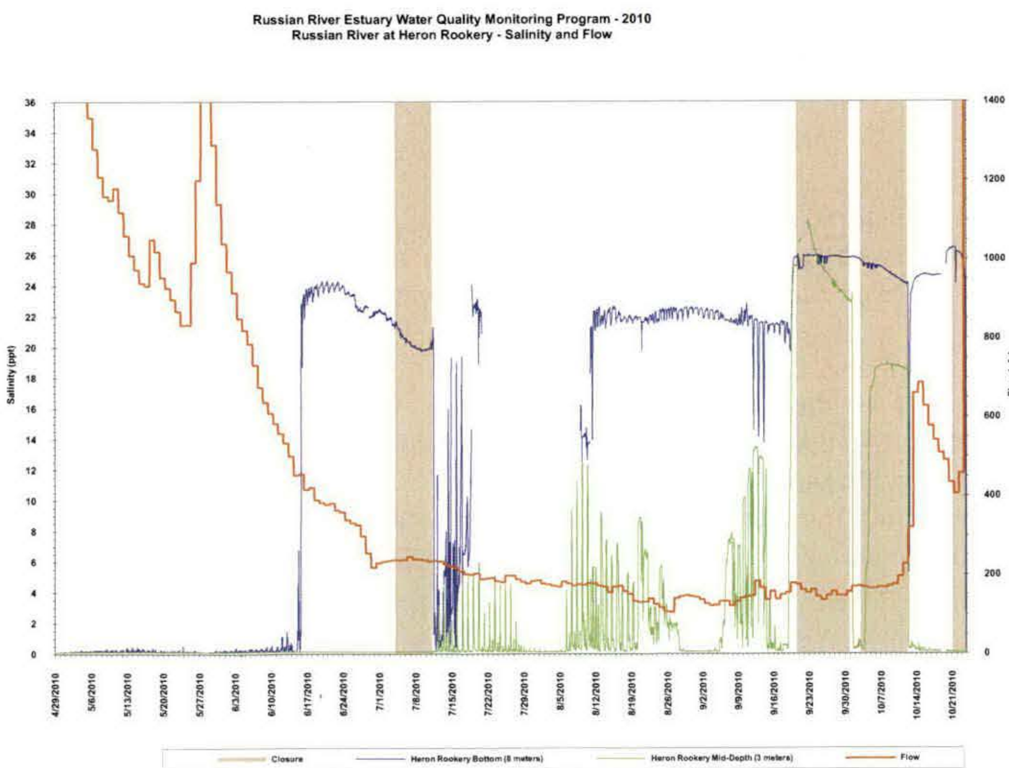

Figure 4.1.8. 2010 Russian River at Heron Rookery Salinity and Flow Graph

The Freezeout Creek station is located in a predominantly freshwater habitat that was occasionally subject to elevated salinity levels as the salt wedge migrated up the Estuary during both open and closed conditions (Figure 4.1.9). The bottom and mid-depth sondes at Freezeout Creek had mean salinity concentrations of 2.5 and 0.7 ppt (Table 4.1.1).

The salt wedge migrated to the Heron Rookery station during open conditions in mid-June when freshwater inflows decreased below 500 cfs (Figures 4.1.8). The salt wedge was not observed at the Freezeout Creek station until mid-July when freshwater inflows decreased to approximately 200 cfs (Figures 4.1.9). However, concentrations varied during open conditions due to tidal cycles and changes in freshwater inflow. Additionally, saline conditions increased and persisted at the mid-depth and bottom sondes at Heron Rookery and Freezeout Creek during barrier beach closures in September and early October as the salt layer stratified and flattened out underneath the deepening freshwater layer. Salinity was generally observed to decrease after the mouth was breached, although the time required to return to pre-breach conditions varied at each site and differed between closure events. This variability was related to the strength of subsequent tidal cycles, freshwater inflow rates, topography, relative location within the Estuary, and to a lesser degree, wind mixing.

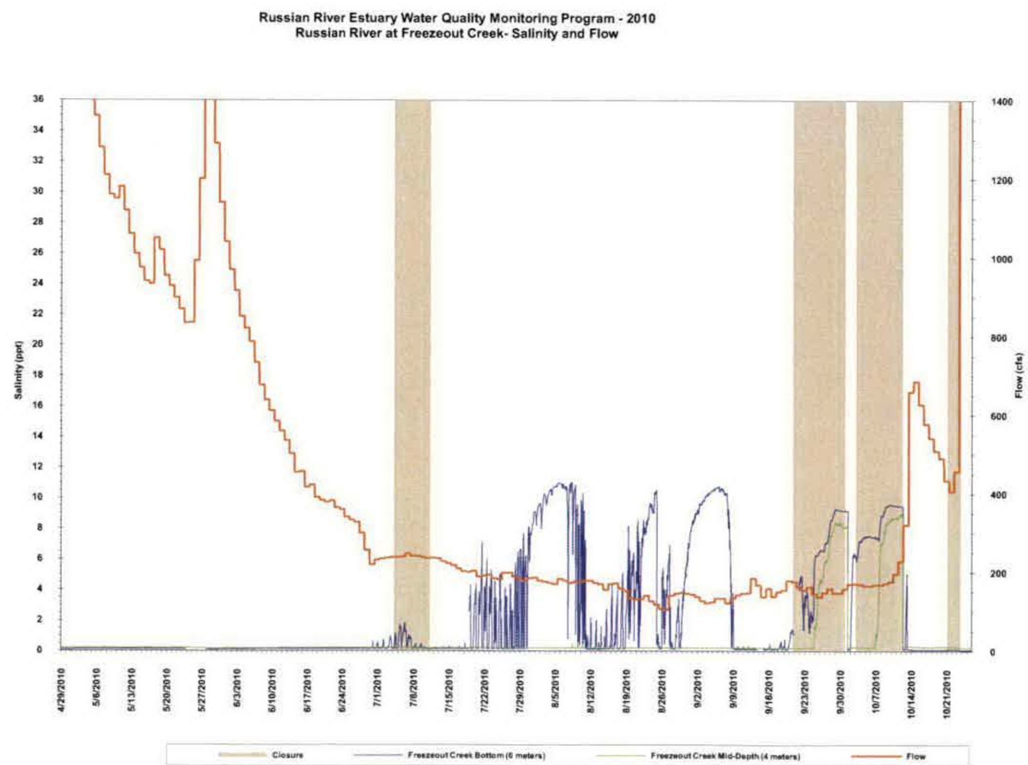

Figure 4.1.9. 2010 Russian River at Freezeout Creek Salinity and Flow Graph

The Freezeout Creek station and mid-depth sonde at Heron Rookery transitioned to a predominantly freshwater habitat following early season storms that produced flows over 600 cfs on 14 October; however salinity persisted at the Heron Rookery bottom sonde until another storm produced inflows over 3,000 cfs on 24 October (Figures 4.1.8 and 4.1.9). Consequently, both storm events coincided with the breaching of the barrier beach, first by the Water Agency on 12 October and then naturally on 24 October. The natural breach on 24 October appeared to be a result of the high storm flows.

Maximum Backwater Area Salinity

Two stations were located in the maximum backwater area including one tributary station located in lower Austin Creek, and one mainstem Russian River station located in Monte Rio Figure 4.1.1). The Austin Creek station was located approximately 0.6 km upstream from the confluence with the Russian River. The Monte Rio station was located approximately 0.5 km downstream of the Monte Rio Bridge.

Neither station was observed to have salinity levels above normal background conditions expected in freshwater habitat, during both open and closed barrier beach conditions (Figures 4.1.10 and 4.1.11). Both stations had mean salinity concentrations of 0.1 ppt, with concentrations ranging from 0.1 to 0.2 ppt at Monte Rio, and 0.0 to 0.2 ppt at Austin Creek (Table 4.1.1).

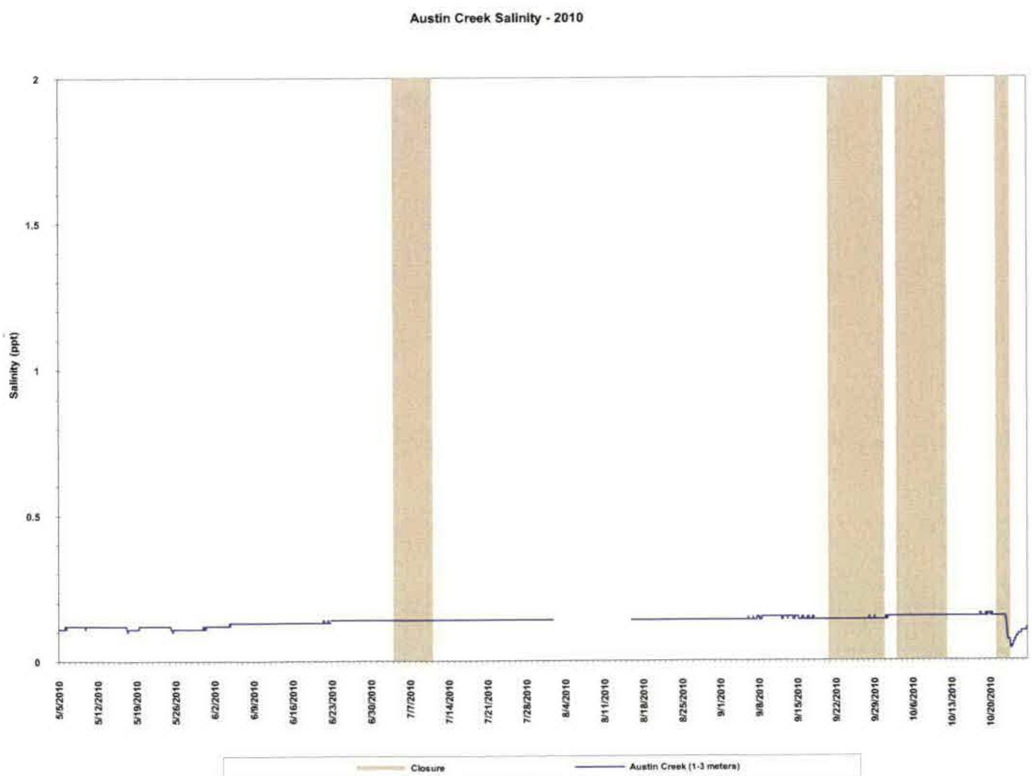

Figure 4.1.10. 2010 Austin Creek Salinity Graph

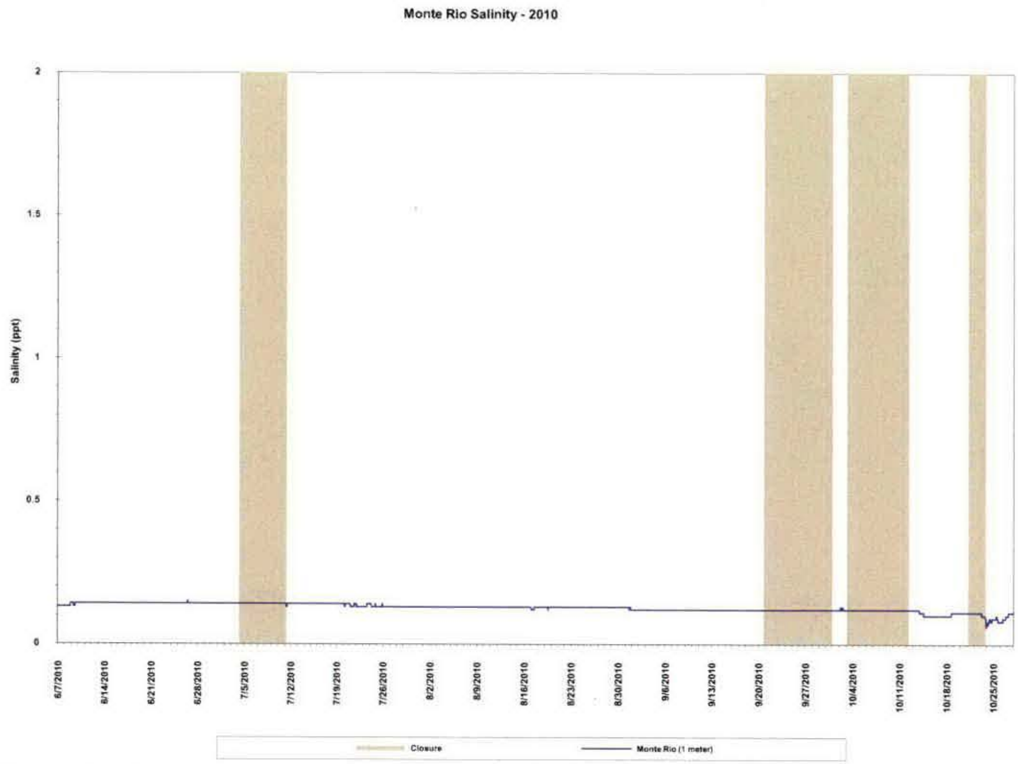

Figure 4.1.11. 2010 Russian River at Monte Rio Salinity Graph

Temperature

During open estuary conditions, water temperatures were reflective of the halocline[5], with lower mean and maximum temperatures typically being observed in the saline layer at the bottom and mid-depth sondes compared to temperatures recorded in the freshwater layer at the mid-depth and surface sondes (Figures 4.1.12 through 4.1.17). The differences in maximum temperatures between the underlying saline layer and the overlying freshwater layer can be attributed in part to the source of saline and fresh water. During open estuary conditions, the saline water from the Pacific Ocean, with temperatures typically around 10 degrees C, enters the Estuary. Whereas, the mainstem Russian River, with temperatures reaching as high as 25 degrees C in the interior valleys, is the primary source of freshwater into the Estuary.

However, during barrier beach closure, fresh/salt water stratification occurred. Density and temperature gradients between freshwater and saltwater play a role in stratification and serve to prevent/minimize mixing of the freshwater and saline layers. Over time, solar radiation heats the mid-depth saline layer, and the overlying surface freshwater layer restricts the release of heat. This often resulted in higher water temperatures in the mid-depth saline layer than in the overlying surface freshwater layer and underlying bottom saline layer located below the effects of solar heating (Figures 4.1.12 through 4.1.18). This stratification-based heating also

[5] A vertical salinity gradient in a body of water.

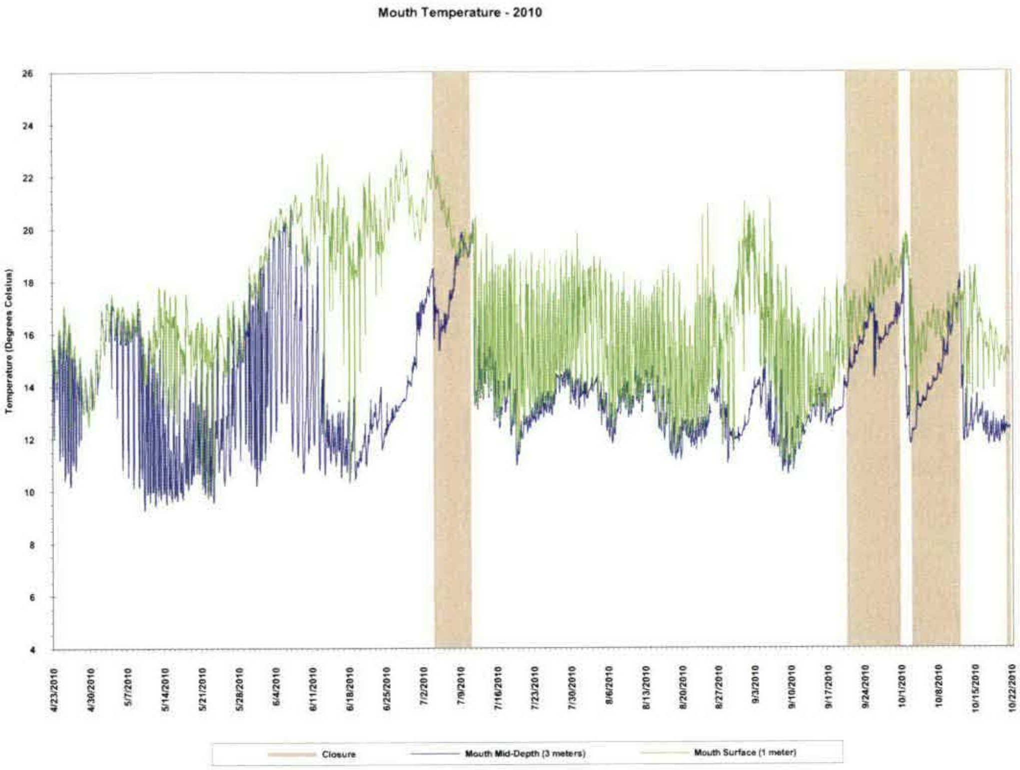

Figure 4.1.12. 2010 Russian River Mouth Temperature Graph

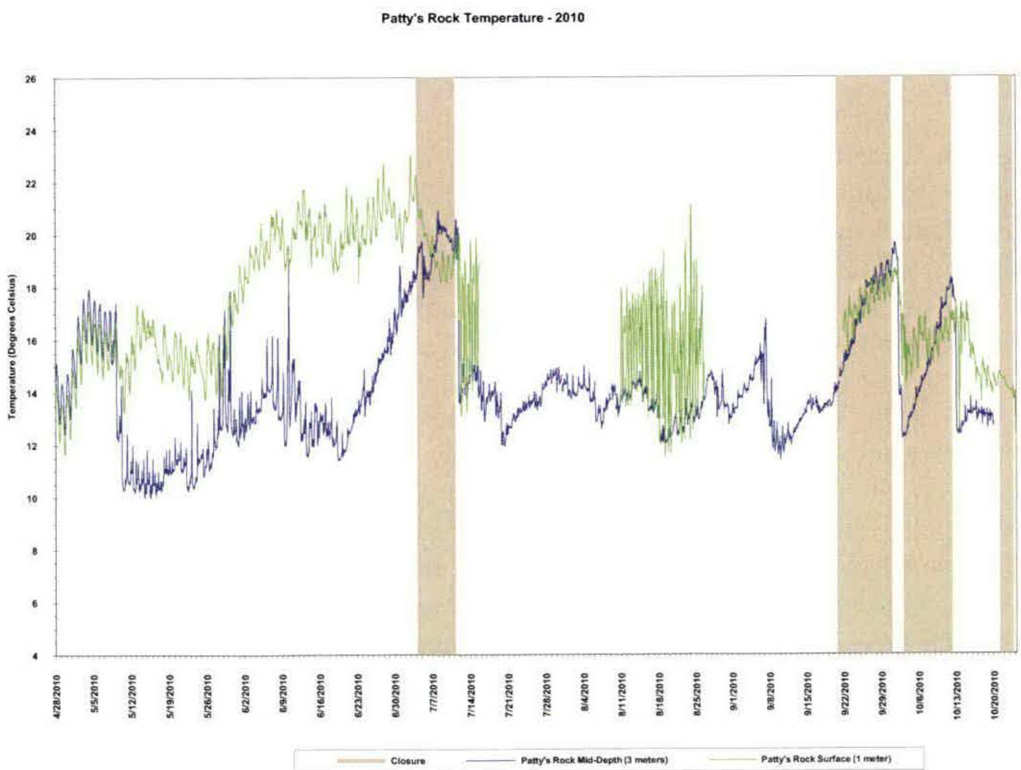

Figure 4.1.13. 2010 Russian River at Patty's Rock Temperature Graph

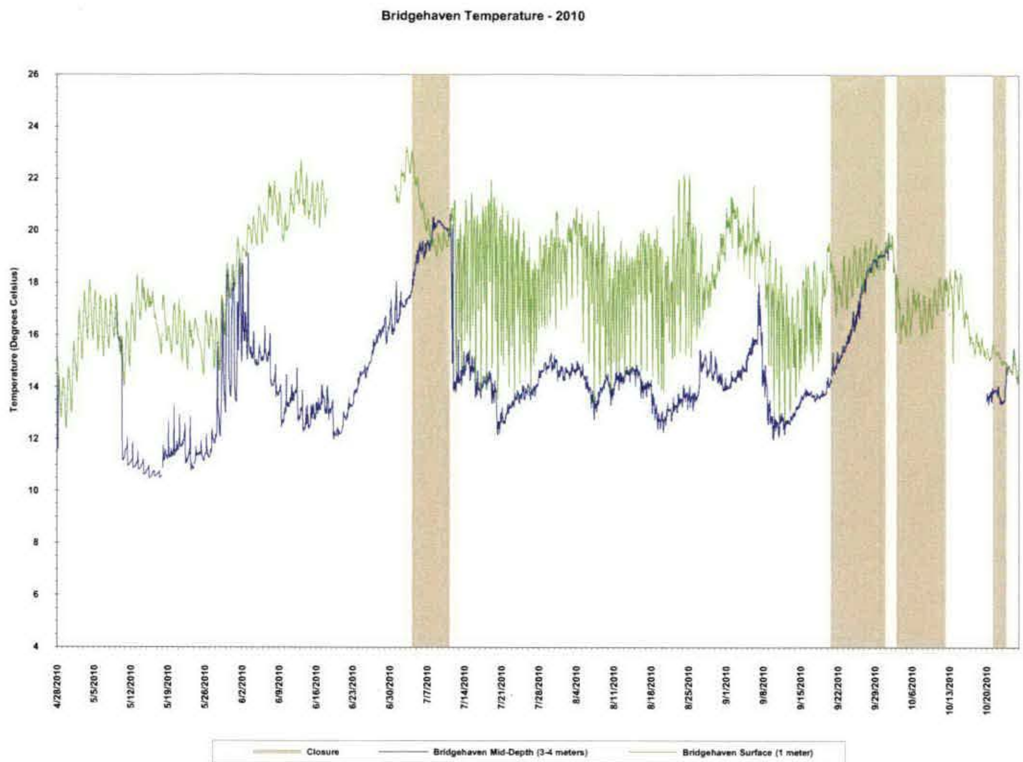

Figure 4.1.14. 2010 Russian River at Bridgehaven Temperature Graph

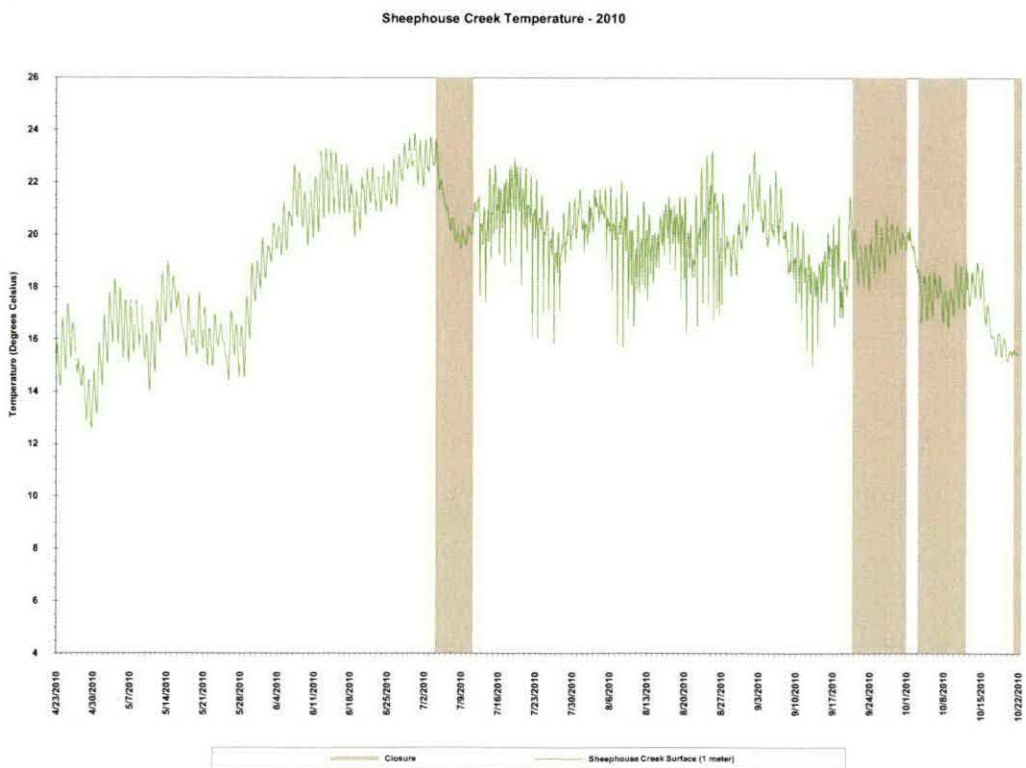

Figure 4.1.15. 2010 Russian River at Sheephouse Creek Temperature Graph

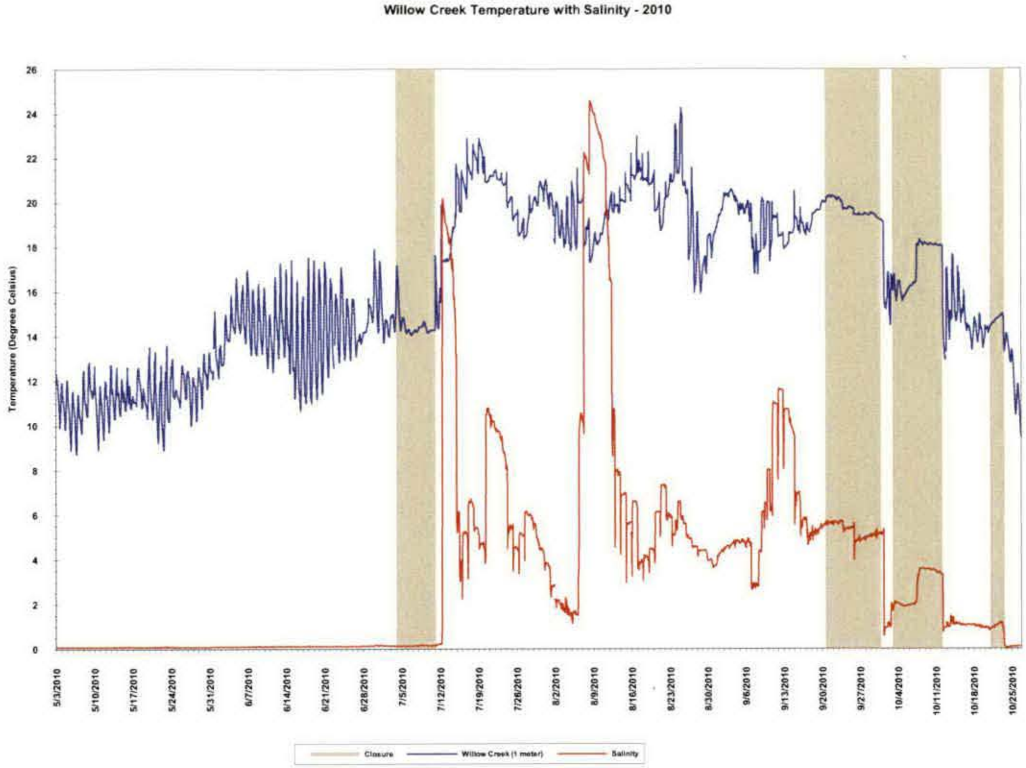

Figure 4.1.16. 2010 Willow Creek Temperature with Salinity Graph

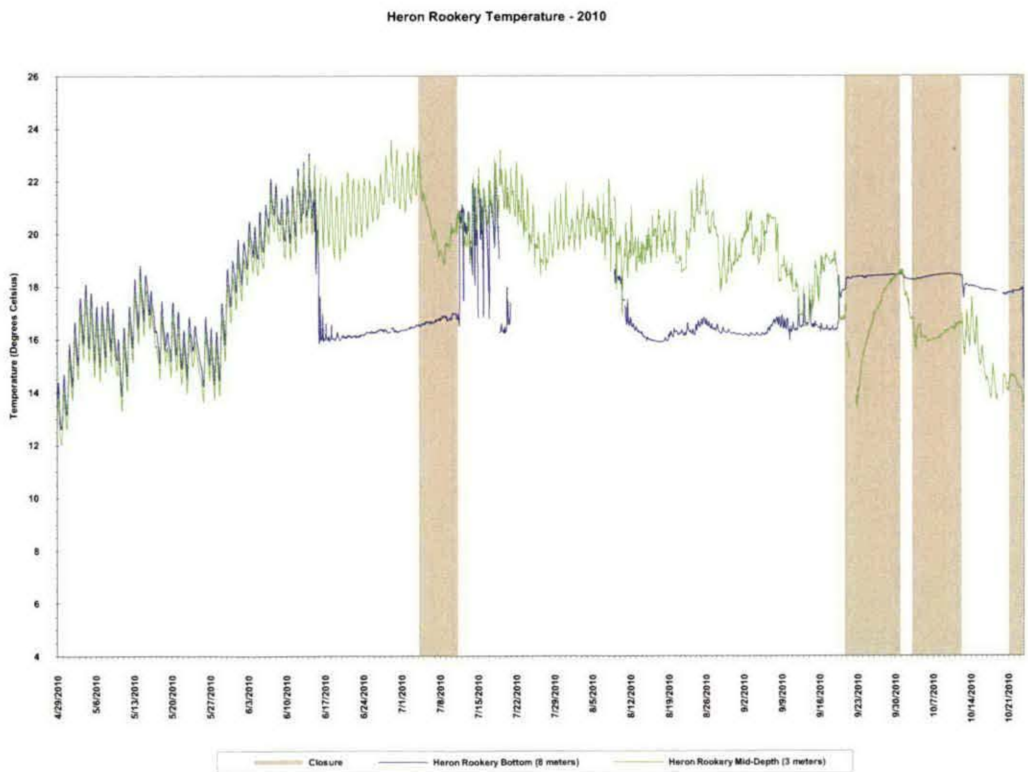

Figure 4.1.17. 2010 Russian River at Heron Rookery Temperature Graph

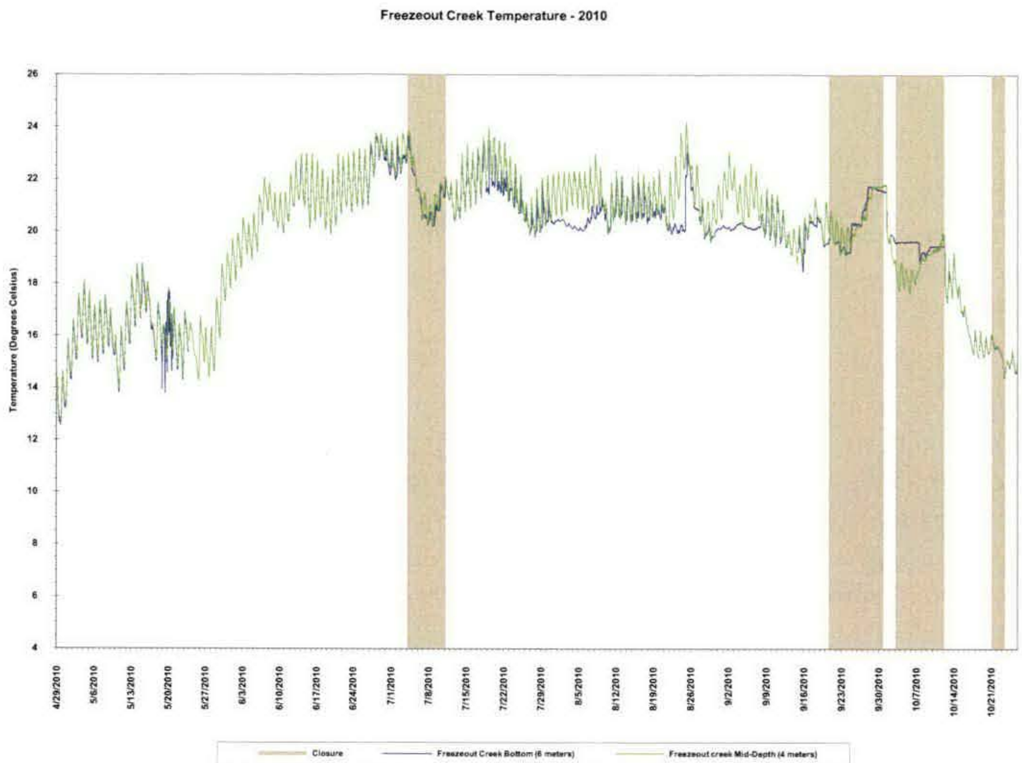

Figure 4.1.18. 2010 Russian River at Freezeout Creek Temperature Graph

contributed to higher seasonal mean and maximum temperatures in the mid-depth saline layer than would be expected to occur under open conditions.

Lower and Middle Reach Temperature

The surface sondes were located at the freshwater/saltwater interface. The Sheephouse Creek surface sonde tends to have the highest temperatures (Table 4.1.1), given that it is the furthest upstream of the lower and middle reach stations, where the freshwater layer has the least amount of cooling time as the river leaves the warmer canyons around Guerneville and Monte Rio and enters the cooler climate near the coastline. The Sheephouse Creek station is approximately 5.1 km (3.2 mi) upstream from the Mouth Station, 2.7 km (1.7 mi) inland from the coastline, and behind two ridgelines to the west and south that provide additional protection from the influences of marine fog and wind.

The mid-depth sondes were located primarily in saltwater and had maximum temperatures of approximately 20 degrees C at the Mouth, Patty's Rock, and Bridgehaven, respectively (Table 4.1.1).

The Sheephouse Creek mid-depth sonde experienced an equipment malfunction during the entire monitoring period and no valid data were collected at this station in 2010 (Figure 4.1.15).

The Willow Creek sonde was located in primarily freshwater habitat until after the first barrier beach closure and reopening in July. At this point, the station transitioned to a brackish system and temperatures were observed to increase, on average, until storm-related flows at the end of October flushed out the brackish water (Figure 4.1.16). Minimum temperatures were observed at the beginning and the end of the monitoring period during periods of cooler weather and storm related flow events that contributed cooler freshwater into the system. Maximum temperatures were observed mid-season in brackish water. Temperature response to barrier beach closure was variable, cooling slightly during the July closure, heating and then cooling during the September closure, and heating considerably during the October closure. It should be noted that the July closure occurred under freshwater conditions and the September and October closure occurred during brackish conditions, with an increase in salinity corresponding with the temperature increase during the October closure.

Upper Reach Temperature

Overall temperatures in both the saline layer and freshwater layer were typically hottest at the furthest upstream stations, as recorded at Heron Rookery and Freezeout Creek, and became progressively cooler as the water flows downstream, closer to the cooling effects of the coast and ocean. For example, during open conditions on 24 June, a maximum freshwater temperature of 23.1 degrees C was observed at the Freezeout Creek station (Figure 4.1.18); whereas a maximum freshwater temperature of 20.8 degrees C was observed at the Mouth station (Figure 4.1.12).

The bottom sondes at Heron Rookery and Freezeout Creek had mean temperatures of 17.3 and 19.6 degrees C, respectively (Table 4.1.1). The lower mean temperature can be partially attributed to the presence of cooler tidally-mixed saline water for a longer time period at Heron Rookery than at Freezeout Creek (Figures 4.1.8 and 4.1.9).

The mid-depth sondes at Heron Rookery and Freezeout Creek had mean temperatures of 18.5 and 19.8 degrees C, respectively (Table 4.1.1). The lower mean and minimum temperatures at Heron Rookery were also due to the presence of cooler saline water that was not present at the Freezeout Creek station with as much frequency.

During open estuary conditions in the lagoon management period, water temperatures in the upper reach of the Estuary were cooler in the saline layer than the overlying freshwater layer (Figures 4.1.17 and 4.1.18). Upon closure of the barrier beach, stratification-related heating of the saline layer was observed in the upper reach similar to that observed in the lower and middle reaches (Figures 4.1.12 through 4.1.14). While temperatures initially decreased during several closures at both stations, this was usually associated with freshwater conditions, whereas temperature increases corresponded with the presence of salinity (Figures 4.1.8 and 4.1.9).

Temperatures generally decreased after the barrier beach was breached, although the time required to return to pre-breach conditions varied at each site and differed between closure events. This variability was related to the presence of salinity, strength of subsequent tidal cycles, freshwater inflow rates, topography, relative location within the Estuary, and to a lesser degree, wind mixing.

Maximum Backwater Area Temperature

Austin Creek had a maximum temperature of 21.3 degrees C, a mean temperature of 16.4 degrees C, and a minimum temperature of 11.0 degrees C. Temperatures at this station did not appear to be affected by barrier beach closure during the July closure. The diurnal cycle of heating and cooling appeared to increase during the September and October closures, when freshwater inflows from Austin Creek were at their lowest point (<5cfs) for the season; however the diurnal cycle was not as large as was observed earlier in the season during open conditions (Figure 4.1.19).

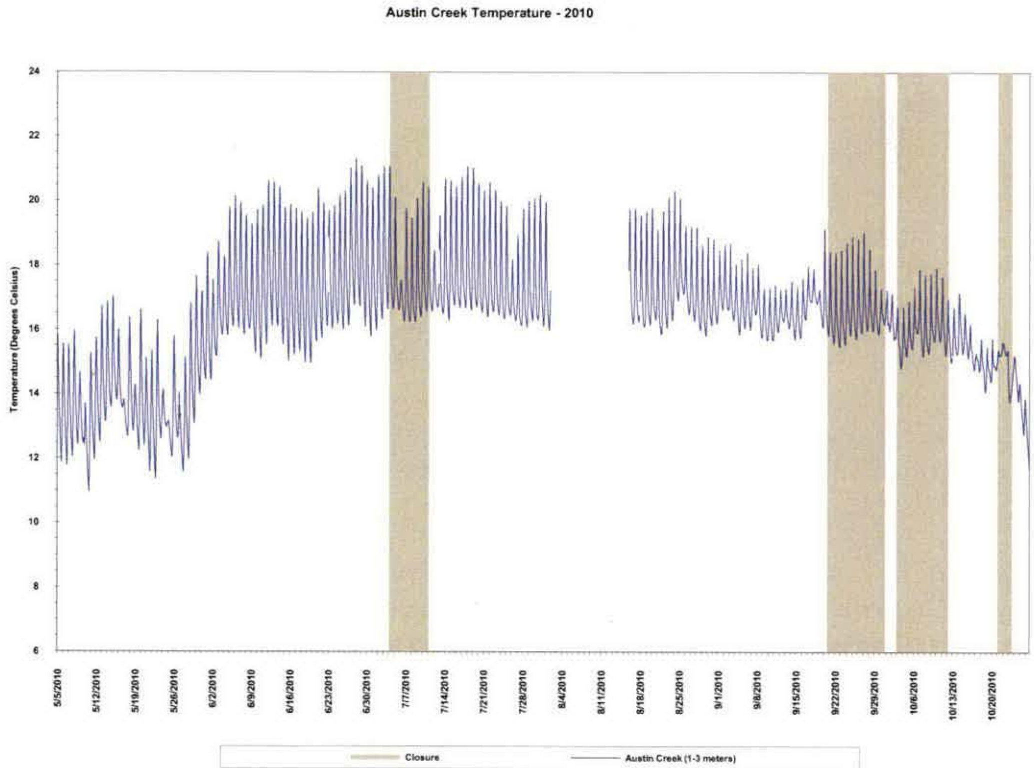

Figure 4.1.19. 2010 Austin Creek Temperature Graph

The Monte Rio station had a maximum temperature of 22.1 degrees C, a mean temperature of 17.8 degrees C, and a minimum temperature of 10.6 degrees C (Table 4.1.1). The highest temperatures were observed to occur during open conditions. The affect of barrier beach closure on temperature was insignificant and variable, with minor increases and decreases observed to occur during barrier beach closure and reopening (Figure 4.1.20). This variability was likely related to differences in air temperatures and freshwater inflow rates, and to a lesser degree, wind mixing.

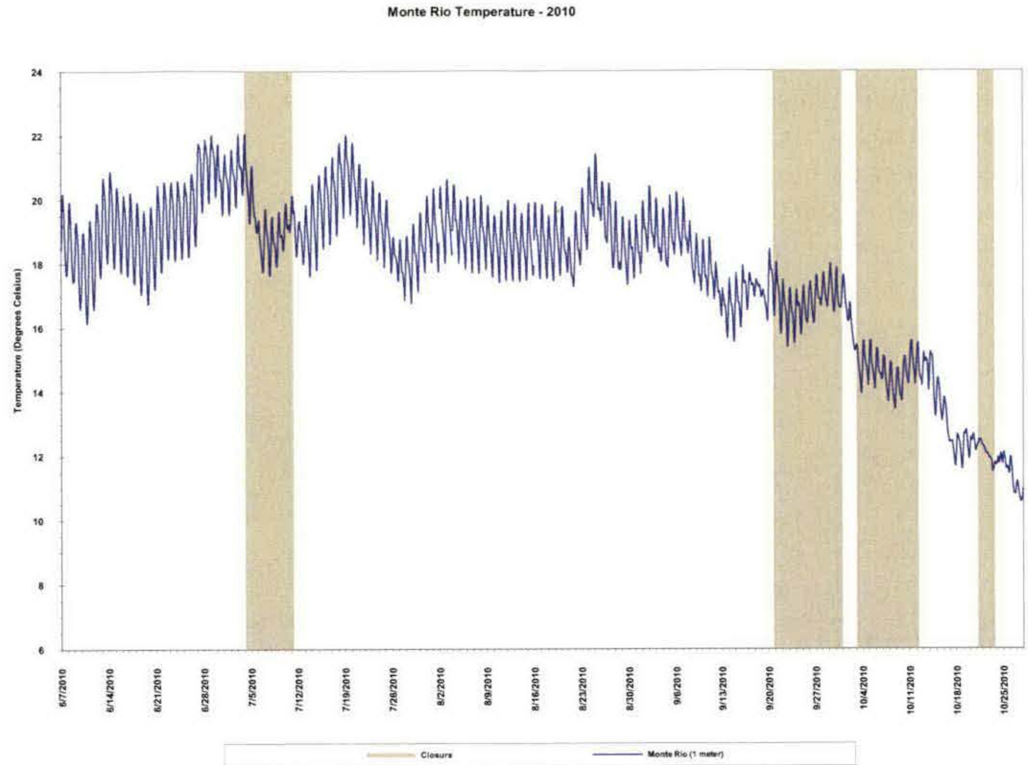

Figure 4.1.20. 2010 Russian River at Monte Rio Temperature Graph

Dissolved Oxygen

Dissolved oxygen (DO) levels in the Estuary, including the maximum backwater area, depend upon factors such as the extent of diffusion from surrounding air and water movement, including freshwater inflow. DO is affected by salinity and temperature stratification, tidal and wind mixing, abundance of aquatic plants, and presence of decomposing organic matter. DO affects fish growth rates, embryonic development, metabolic activity, and under severe conditions, stress and mortality. Cold water has a higher saturation point than warmer water; therefore cold water is capable of carrying higher levels of oxygen.

DO levels are also a function of nutrients, which can accumulate in water and promote plant and algal growth that both consume and produce DO during respiration and photosynthesis. Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where runoff enters the marine environment in a confined channel.[6] Upwelling in coastal systems also promotes increased productivity by conveying deep, nutrient-rich waters to the surface, where the nutrients can be assimilated by algae. Excessive nutrient concentrations and plant and algal growth can overwhelm eutrophic systems and lead to a reduction in DO levels that can affect the overall ecological health of the Estuary.

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[6] *National Estuarine Eutrophication Assessment* by NOAA National Centers for Coastal Ocean Science (NCCOS) and the Integration and Application Network (IAN), 1999.

Dissolved oxygen concentrations in the lower and middle reaches were generally higher at the surface sondes compared to the mid-depth sondes at a given sampling station (Figures 4.1.21 through 4.1.24). The surface sondes typically had the highest mean DO concentrations, as well as the highest maximum and minimum concentrations, when compared with the mid-depth sondes (Table 4.1.1). Supersaturation conditions observed at the surface sondes contributed to the higher maximum and mean DO concentrations, with the most significant events occurring at Patty's Rock and Bridgehaven during open estuary conditions (Figures 4.1.22 and 4.1.23).

However, supersaturation events were also observed at the mid-depth sondes, with the most significant events occurring at the Mouth (Figure 4.1.21). Supersaturation events at the mid-depth sondes were typically less significant and occurred less frequently than events at the corresponding surface sondes, except during the September and October closures, when they were observed to exceed DO concentrations at the corresponding surface sondes (Figures 4.1.21 through 4.1.23). However, these values did not exceed the season high values observed at the corresponding surface sondes, except at the Mouth station, where a data gap at the surface station during a supersaturation event in late-June may have contributed to this exception (Figure 4.1.21).

Dissolved oxygen concentrations in Willow Creek were reflective of the presence of salinity, with higher values being observed in freshwater habitat and lower values being observed in brackish conditions. However, the lowest DO concentrations were observed during estuary closure, in both freshwater and brackish conditions, with hypoxic to anoxic conditions being observed in brackish water during the September closure (Figure 4.1.25).

The upper reach DO concentrations at the mid-depth sondes were fairly consistent with conditions at the mid-depth sondes in the lower and middle reaches. However, it should be noted that the mid-depth sondes in the upper reach were located in predominantly freshwater habitat, whereas the mid-depth sondes in the lower and middle reaches were located in predominantly brackish to saline habitat. Upper reach DO concentrations were typically lower in the saline layer, as observed at the bottom sondes during both open and closed Estuary conditions, than DO concentrations observed in the saline layer in the lower and middle reaches. This can partially be attributed to the location of these sondes at the bottom of deep holes where the saline layer becomes trapped. There is less mixing of the saline layer in these deep holes, especially further up in the estuary where the influence of the tidal cycle is reduced, resulting in recurring hypoxic and anoxic conditions.

Lower and Middle Reach DO

The Surface Sondes had fairly consistent mean DO concentrations in the lower and middle reaches (Table 4.1.1). Mean DO concentrations at the mid-depth sondes were also fairly consistent from station to station, with mean DO concentrations of 9.1, 8.4, and 8.7 mg/L at the Mouth, Patty's Rock, and Bridgehaven, respectively (Table 4.1.1). The Sheephouse Creek mid-depth sonde experienced an equipment malfunction during the entire monitoring period and no valid data were collected at this station in 2010 (Figure 4.1.24).

Significant fluctuations in DO concentrations were observed at all stations in the lower and middle reaches during open Estuary conditions, with more pronounced events occurring during

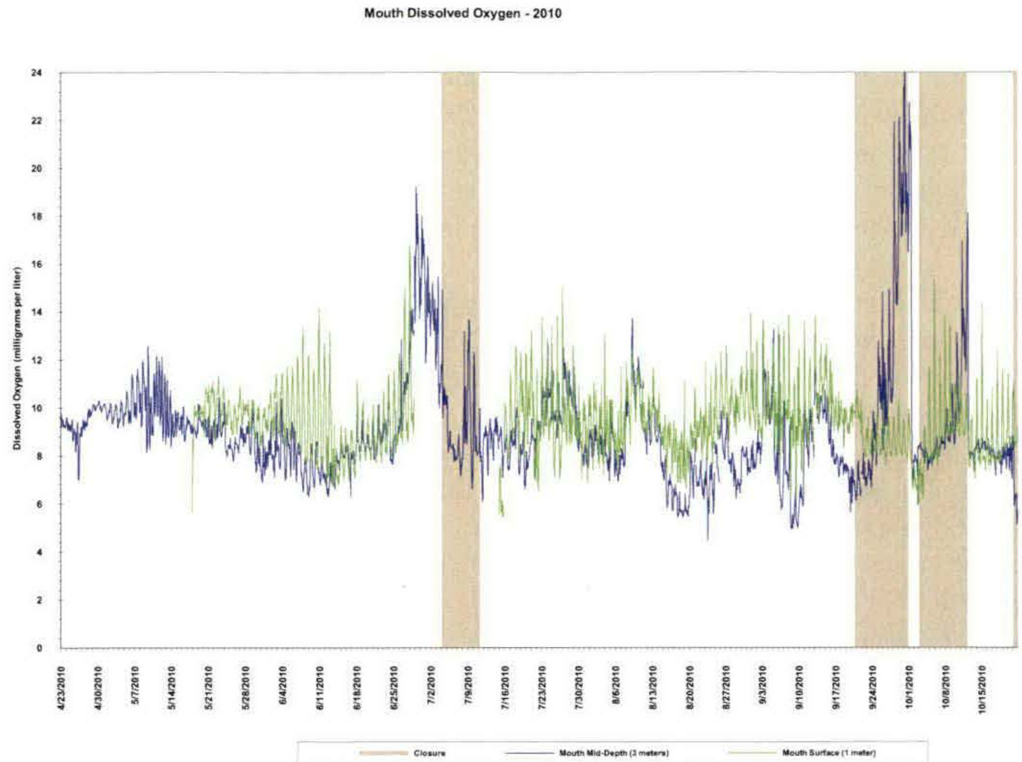

Figure 4.1.21. 2010 Russian River Mouth Dissolved Oxygen Graph

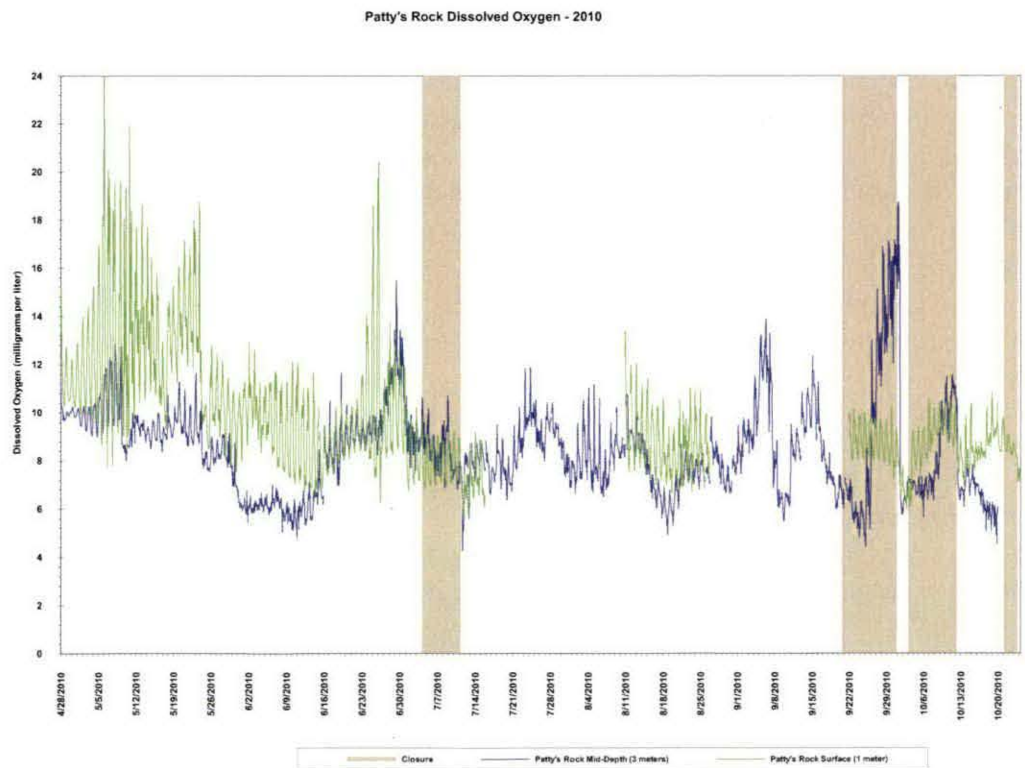

Figure 4.1.22. 2010 Russian River at Patty's Rock Dissolved Oxygen Graph

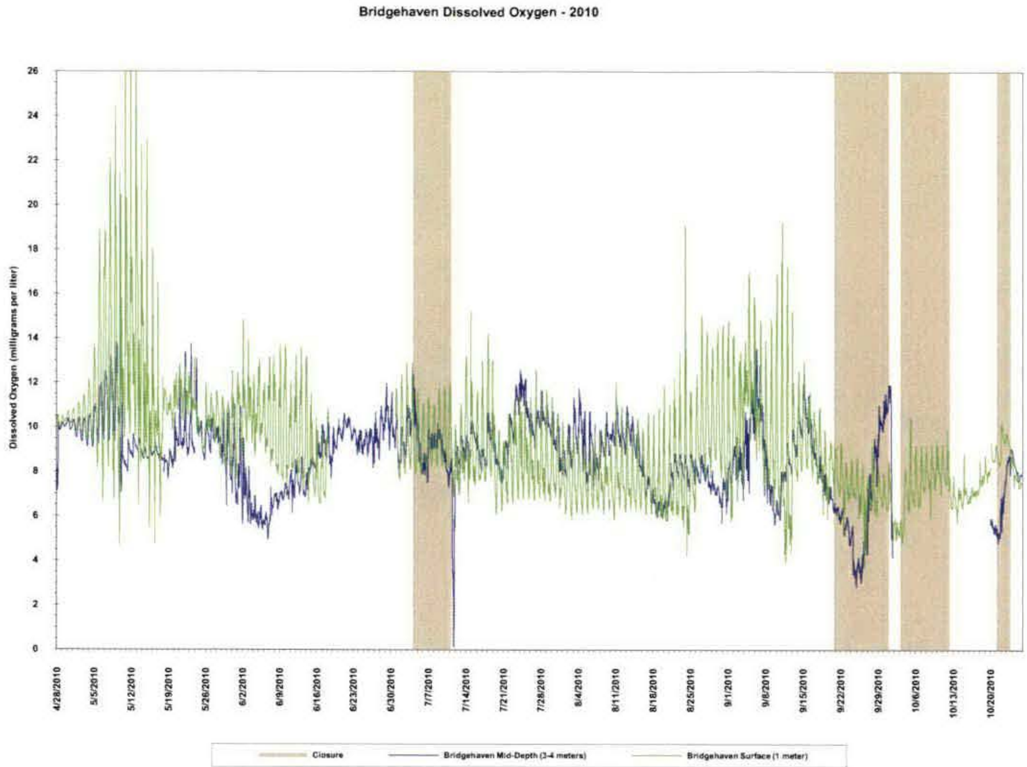

Figure 4.1.23. 2010 Russian River at Bridgehaven Dissolved Oxygen Graph

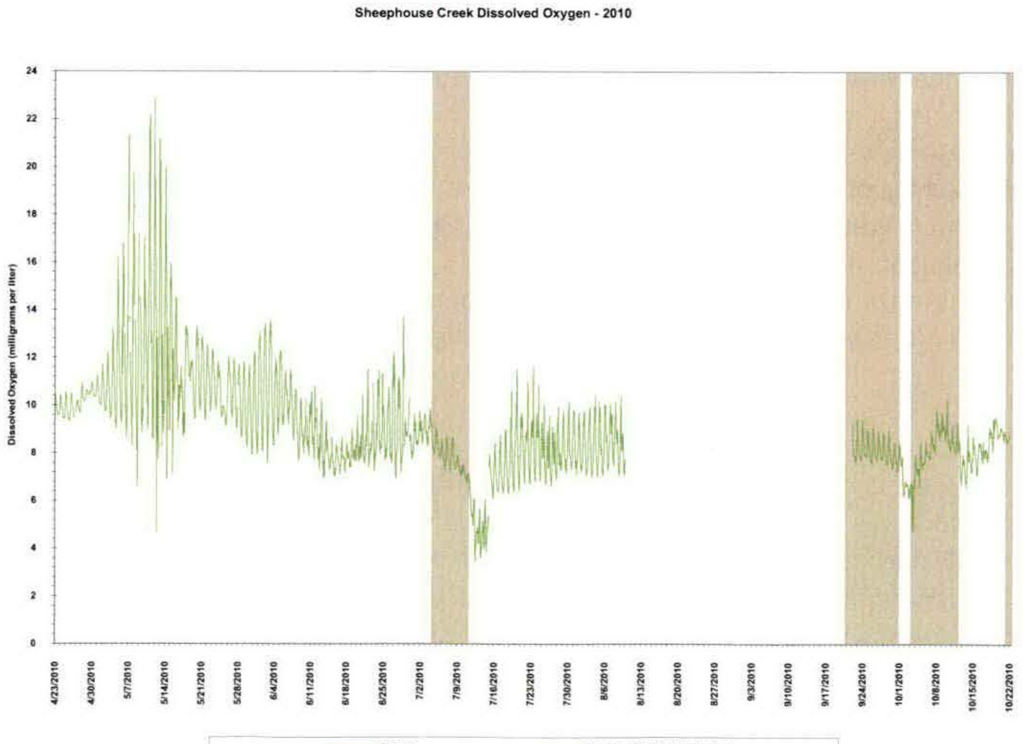

Figure 4.1.24. 2010 Russian River at Sheephouse Creek Dissolved Oxygen Graph

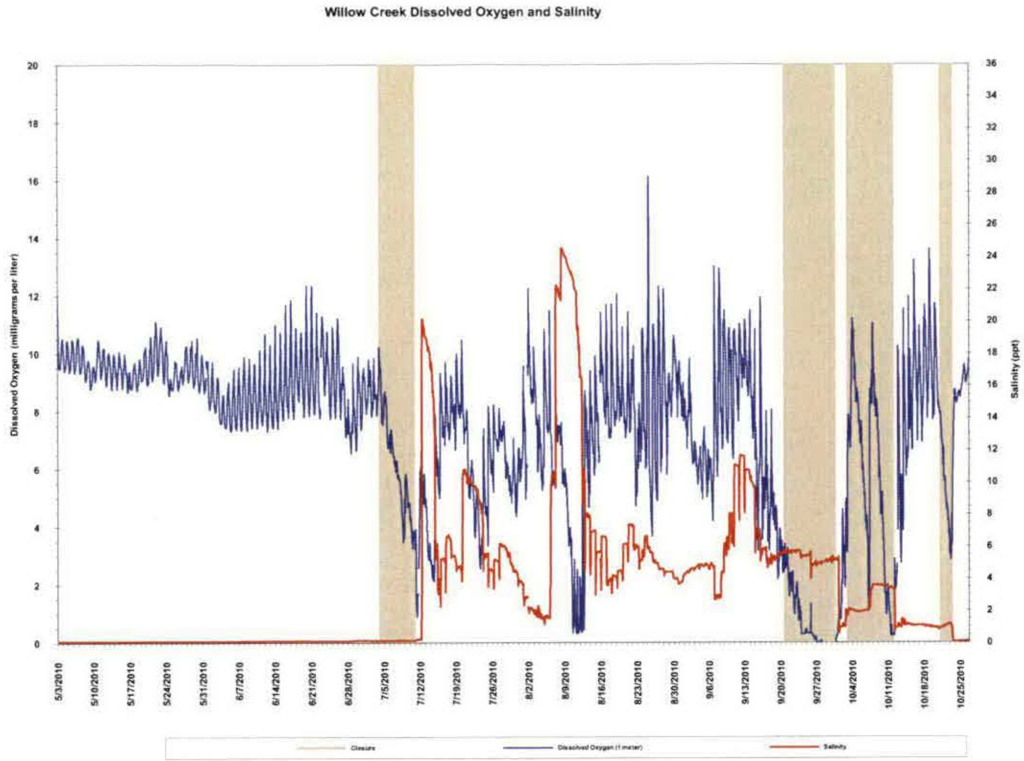

Figure 4.1.25. 2010 Willow Creek Dissolved Oxygen and Salinity Graph

periods of barrier beach closure. Short-term hypoxic and/or anoxic events observed at some of the mid-depth sondes in 2009 were not observed during 2010. DO concentrations at the mid-depth sondes declined during estuary closure, but not to hypoxic or anoxic levels. However, DO concentrations became temporarily anoxic at the Bridgehaven mid-depth sonde immediately following the breaching of the barrier beach in July (Figure 4.1. 23) and may have been affected by the downstream migration of hypoxic to anoxic water from Willow Creek, which is located about 1km upstream of the Bridgehaven station (Figure 4.1.25). Minimum DO concentrations occurred either during or immediately following barrier beach closure and were observed to be 4.5, 4.3, and 0.1 mg/L at the Mouth, Patty's Rock, and Bridgehaven mid-depth sondes, respectively.

Consequently, all sondes at all depths experienced some degree of fluctuating DO concentrations, especially during periods of barrier beach closure. However, the effect of barrier beach closure was variable as DO concentrations at the surface sondes remained unaffected, slightly decline, or increase in some instances. Although the surface sondes at the Mouth, Patty's Rock, Bridgehaven, and Sheephouse Creek had minimum seasonal DO concentrations of 5.4, 5.7, 3.7 and 3.4 mg/L, most of these values did not coincide with any of the barrier beach closures (Table 4.1.1). However, temporary decreases in DO concentrations were observed at the stations immediately following reopening of the barrier beach. These decreases in DO concentration may have also been affected by the downstream migration of hypoxic and/or anoxic water from Willow Creek and/or the upper reach of the estuary (Figures 4.1.25 through 4.1 27).

Recovery of DO concentrations following reopening of the barrier beach was variable in timing and relative concentration among stations and sondes, but typically occurred within several days of the barrier beach being opened.

Again, differences between stations can be partially attributed to data gaps associated with equipment malfunctions, as well as different monitoring periods. Additional data collection and analysis would be needed to further explore whether any of these conditions represent trends.

The surface sondes, and mid-depth sondes to a lesser degree, also experienced hourly fluctuating supersaturation events. At times when oxygen production exceeds the diffusion of oxygen out of the system, supersaturation may occur (Horne, 1994). DO concentrations exceeding 100% saturation in the water column are considered supersaturated conditions. Because the ability of water to hold oxygen changes with temperature, there are a range of concentration values that correspond to 100% saturation. For instance, at sea level, 100% saturation is equivalent to approximately 11 mg/L at 10 degrees C, but only 8.2 mg/L at 24 degrees C. Consequently, these two temperature values roughly represent the range of temperatures observed in the Estuary during the 2009 monitoring season.

The most significant supersaturation event was observed at the Bridgehaven surface sonde (Figure 4.1.23). The maximum DO concentration at the Bridgehaven surface sonde was approximately 34.7 mg/L (345%), compared to 16.8 mg/L (192%), 24.2 mg/L (249%) , and 22.9 mg/L (233%) at the Mouth, Patty's Rock, and Sheephouse Creek surface sondes, respectively (Table 4.1.1). Maximum DO concentrations at the Mid-Depth sondes were approximately 25.3 mg/L (295%) at the Mouth, 18.8 mg/L (230%) at Patty's Rock, and 14.0 mg/L (164.5%) at Bridgehaven.

The Willow Creek sonde had a mean DO concentration of 7.4 mg/L, a maximum DO concentration of 16.1 mg/L, and a minimum DO concentration of 0.0 mg/L (Table 4.1.1). Minimum values were observed to occur during and/or following barrier beach closure, with more pronounced hypoxic to anoxic conditions being observed during closure in the presence of saline water. However, low DO values were also observed during open conditions in the presence of saline water (Figure 4.1.25).

Upper Reach DO

Dissolved oxygen concentrations at the mid-depth sondes in the upper reach were slightly lower overall compared to concentrations in the lower and middle reaches (Table 4.1.1), with less significant supersaturation events contributing to this difference. The mid-depth sondes at Heron Rookery and Freezeout Creek had mean DO concentrations of 8.1 and 8.7 mg/L (Table 4.1.1).

The bottom sondes at Heron Rookery and Freezeout Creek had mean DO concentrations of 5.2 and 6.8 mg/L, maximum concentrations of 15.3 and 14.8 mg/L, and minimum concentrations of 0.1 and 0.0 mg/L, respectively (Table 4.1.1). However, the Heron Rookery bottom sonde experienced equipment malfunctions that produced data gaps in July and September, which may have affected minimum, mean, and maximum DO values (Figure 4.1.26).

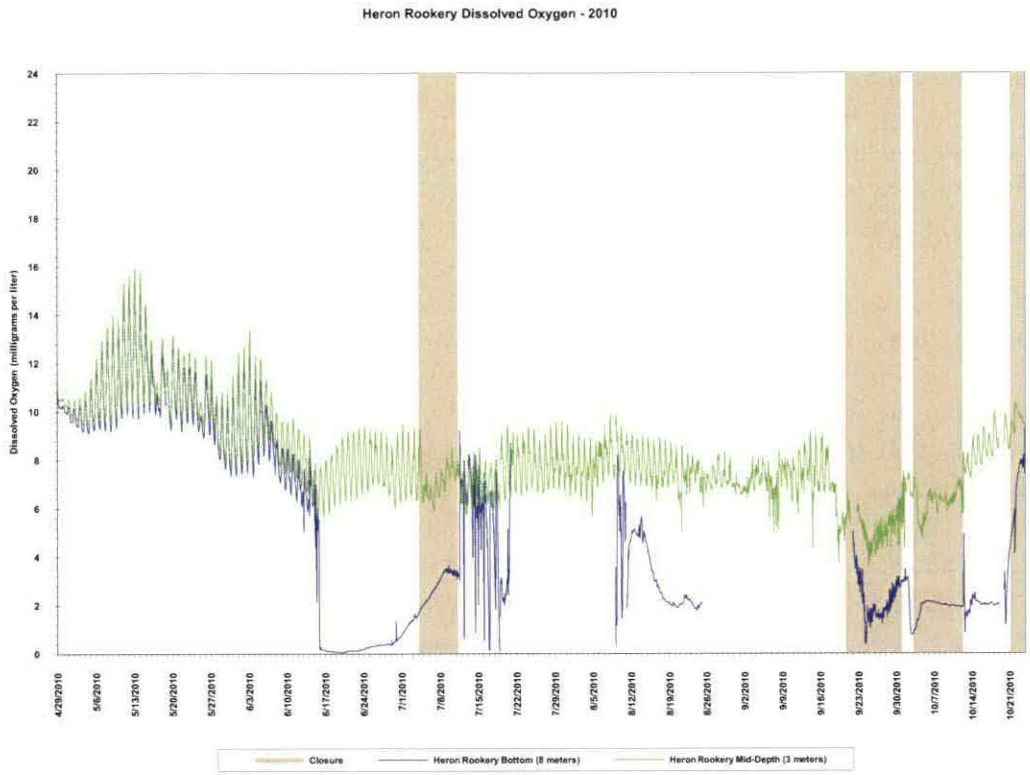

Figure 4.1.26. 2010 Russian River at Heron Rookery Dissolved Oxygen Graph

The salt wedge migrated upstream in mid-June and displaced the freshwater in the lower portion of the water column at the Heron Rookery station when late-spring storm flows dropped below approximately 500 cfs (Figures 4.1.26). This was not observed until late July at the Freezeout Creek station when flows dropped to approximately 200 cfs (Figure 4.1.27). The salt wedge then became persistent in the deep pools during open conditions from early July to early October; however, salinity concentrations continued to fluctuate at the two stations with changes to freshwater inflow rates, tidal inundation and mixing.

During open conditions, DO levels periodically became hypoxic in the saline layer at the bottom sondes. Whereas, DO levels at the mid-depth sondes remained at acceptable levels for salmonids during open conditions (Figures 4.1.26 and 4.1.27).

DO response to barrier beach closure and reopening was also variable throughout the season and dependent on the presence of salinity, the length of time of the closure, the timing of subsequent closure events, freshwater inflow rates and subsequent tidal inundation and mixing. During the July closure, DO levels at the bottom sondes became hypoxic to anoxic, while DO levels at the mid-depth sondes remained at acceptable levels (Figures 4.1.26 and 4.1.27). During this closure, the bottom sondes were located in the saline layer and the mid-depth sondes were located in the freshwater layer.

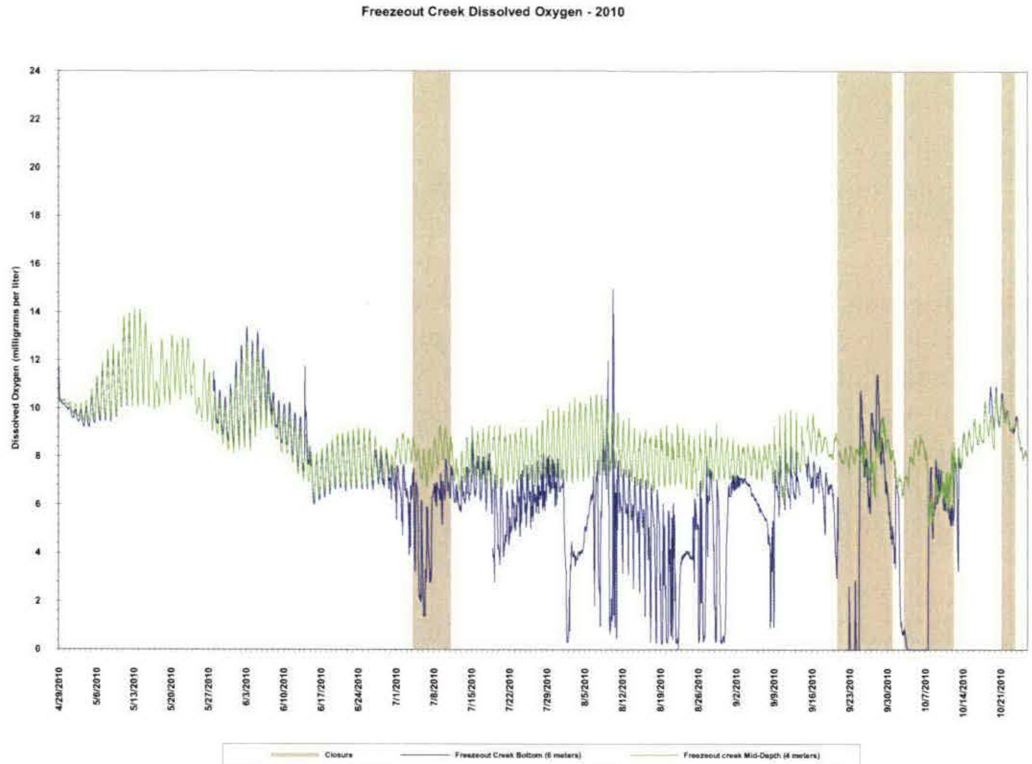

Figure 4.1.27. 2010 Russian River at Freezeout Creek Dissolved Oxygen Graph

Whereas, during the closures in September and October, the salt wedge had migrated further upstream placing the mid-depth sondes within the salt layer and DO levels decreased slightly, with concentrations becoming temporarily hypoxic at Heron Rookery during the September closure and at Freezeout Creek during the first October closure. Low DO concentrations persisted at the bottom of the Freezeout Creek and Heron Rookery stations until mid-October, when increased freshwater storm flows began to push the saline layer out of these stations.

The presence of salinity would typically coincide with the presence of depressed DO levels, but not always, suggesting that variability is dependent on changes in the length of time of closures, the timing of subsequent closure events, freshwater inflow rates and subsequent tidal inundation and mixing.

It is important to note that highly anoxic conditions observed at the Freezeout Creek bottom sonde, and to a lesser degree at the Heron Rookery bottom sonde, included the release of hydrogen sulfide (H_2S) into the water column, whereby equipment was observed with staining and odors consistent with releases of H_2S. According to the manufacturer, H_2S releases can be read by the YSI dissolved oxygen sensor as a false positive for dissolved oxygen. These H_2S releases were directly observed by staff during maintenance and calibration efforts and also recorded in the data set, where DO levels were observed to spike from hypoxic and/or anoxic conditions to fully saturated and supersaturated conditions during the same time that these observations were made (Figures 4.1.26 and 4.1.27).

Maximum Backwater Area DO

The Austin Creek station had a mean DO concentration of 8.3 mg/L, a maximum concentration of 11.6 mg/L, and a minimum concentration of 3.0 mg/L (Table 4.1.1). Minimum values were observed in mid-October during open estuary conditions when flow became intermittent (measured at less than 2 cfs at the upstream USGS gauging station) and several pools in lower Austin Creek (including the station pool) became isolated from one another, with only subsurface flow occurring between pools (Figure 4.1.28).

Dissolved oxygen concentrations were observed to increase at the Austin Creek station during a subsequent short closure event that began on 21 October, and continued to increase to approximately 10 mg/L during storm flows that began on 23 October and peaked at approximately 1,700 cfs on 24 October (Figure 4.1.28). Consequently, the river mouth reopened on 24 October during these high flows.

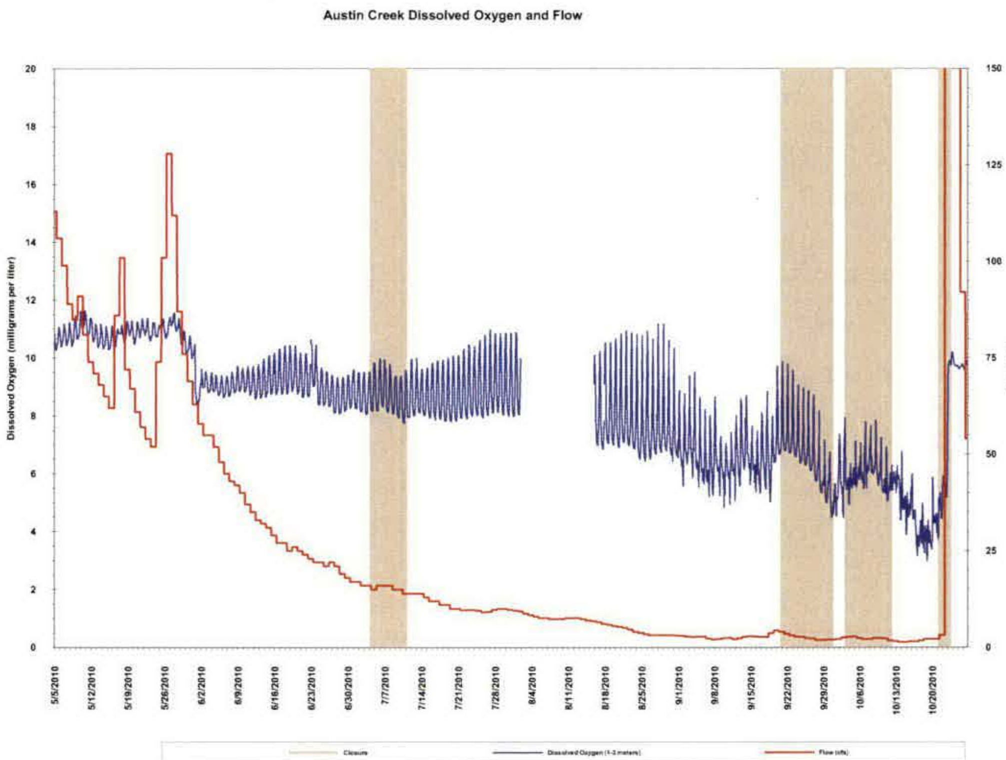

Figure 4.1.28. 2010 Austin Creek Dissolved Oxygen and Flow Graph

The Monte Rio Station had a mean DO concentration of 9.5 mg/L, a maximum concentration of 21.2 mg/L, and a minimum concentration of 6.2 mg/L (Table 4.1.1). Dissolved oxygen concentrations were observed to initially increase and then decrease slightly during estuary closure or reopening events. However, concentrations remained above 8 mg/L, on average, during both closed and open estuary summer flow conditions (Figure 4.1.29).

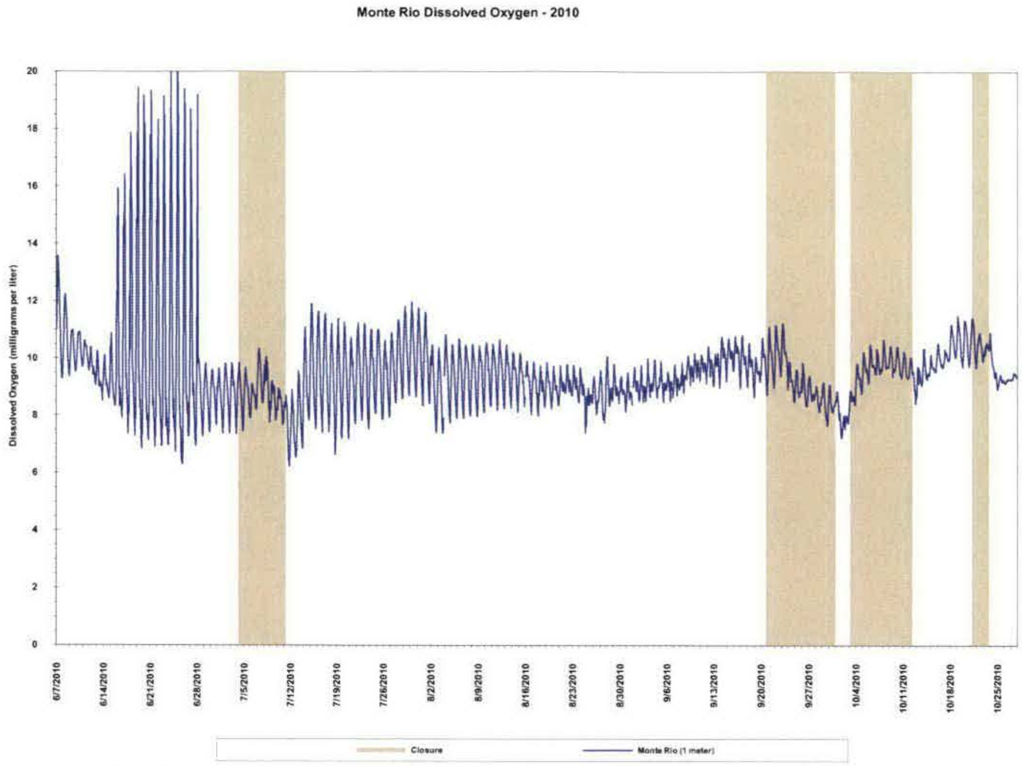

Figure 4.1.29. 2010 Russian River at Monte Rio Dissolved Oxygen Graph

Hydrogen Ion (pH)

The acidity or alkalinity of water is measured in units called pH, an exponential scale of 1 to 14 (Horne, 1994).[7] A pH value of 7 is considered neutral, freshwater streams generally remain at a pH between 6 and 9, and ocean-derived salt water is usually at a pH between 8 and 9. When the pH falls below 6 over the long term, there is a noticeable reduction in the abundance of many species, including snails, amphibians, crustacean zooplankton, and fish such as salmon and some trout species (Horne, 1994).

Lower and Middle Reach pH

Hydrogen ion (pH) values were fairly consistent among all stations at all depths in the lower and middle reaches, with mean values ranging from 7.9 pH at the Mouth and Bridgehaven mid-depth sondes to 8.2 pH at the Mouth and Patty's Rock surface sondes (Table 4.1.1). Values generally increased slightly at the surface sondes during closed estuary conditions, with the exception of the Sheephouse Creek station (Figures 4.1.30 through 4.1.33). The Sheephouse Creek surface sonde became more variable in response to barrier beach closures, with decreases and increases appearing to reflect similar decreases and increases of DO concentrations (see Figures 4.1.24 and 4.1.33). Similarly, pH values varied at the mid-depth sondes during closures, with decreases and increases appearing to reflect similar decreases and increases of DO concentrations at these stations (see Figures 4.1.20 and 4.1.29 for example).

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[7] Acidity is controlled by the hydrogen ion H^+, and pH is defined as the negative log of the hydrogen ion concentration.

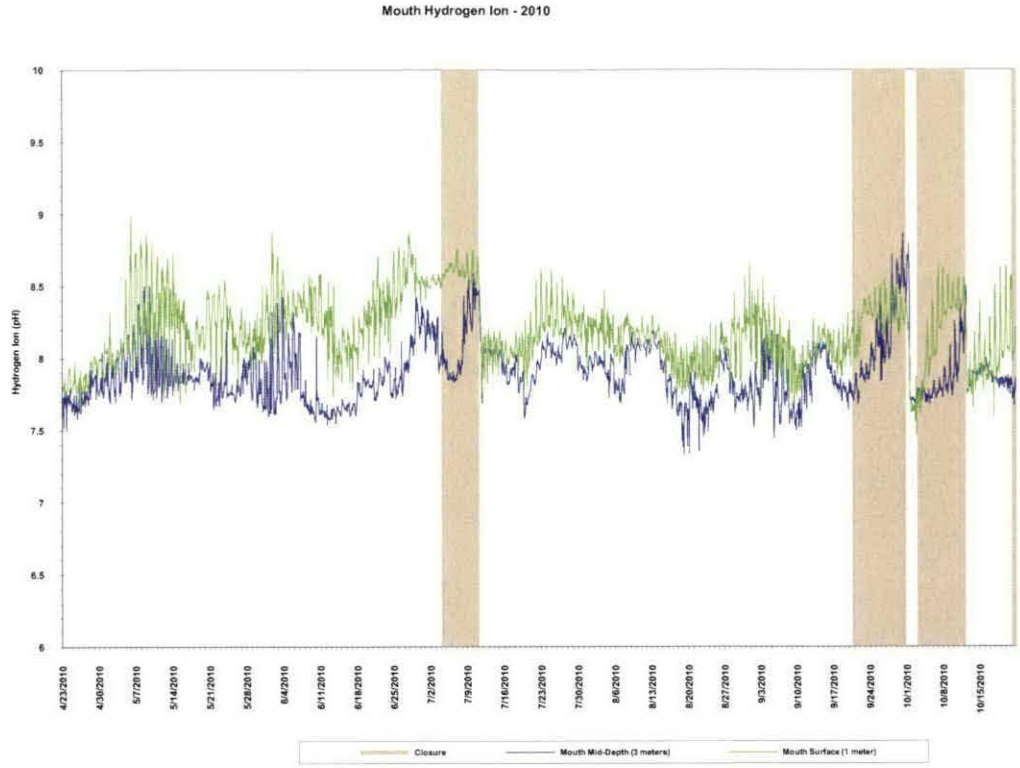

Figure 4.1.30. 2010 Russian River Mouth Hydrogen Ion Graph

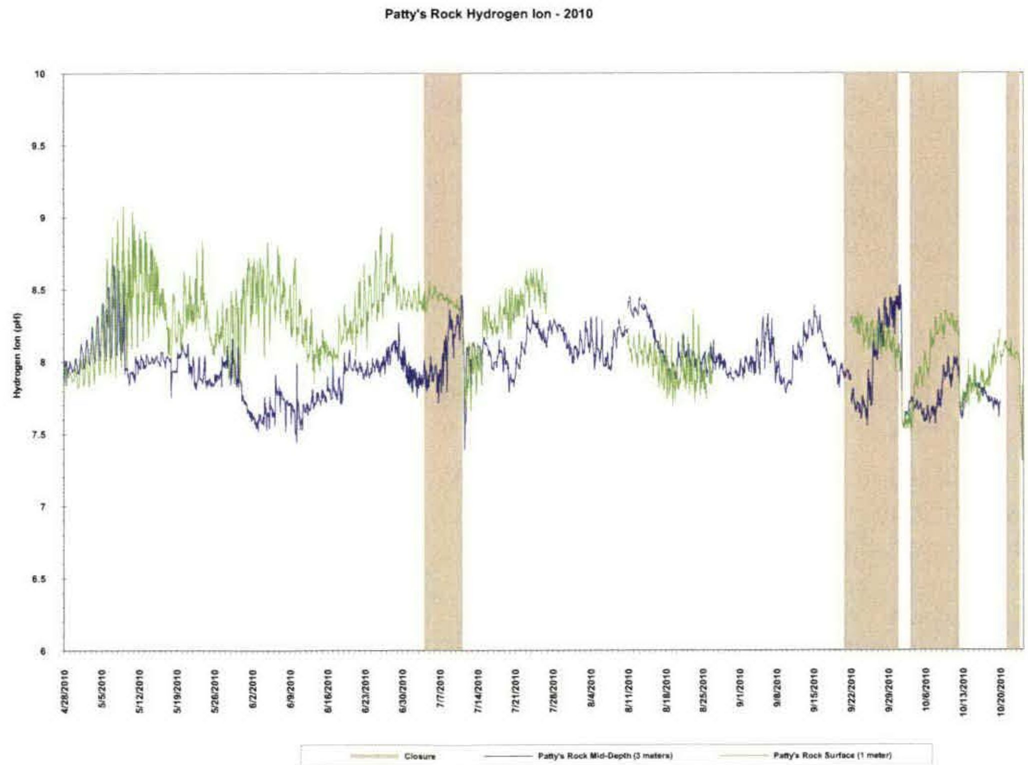

Figure 4.1.31. 2010 Russian River at Patty's Rock Hydrogen Ion Graph

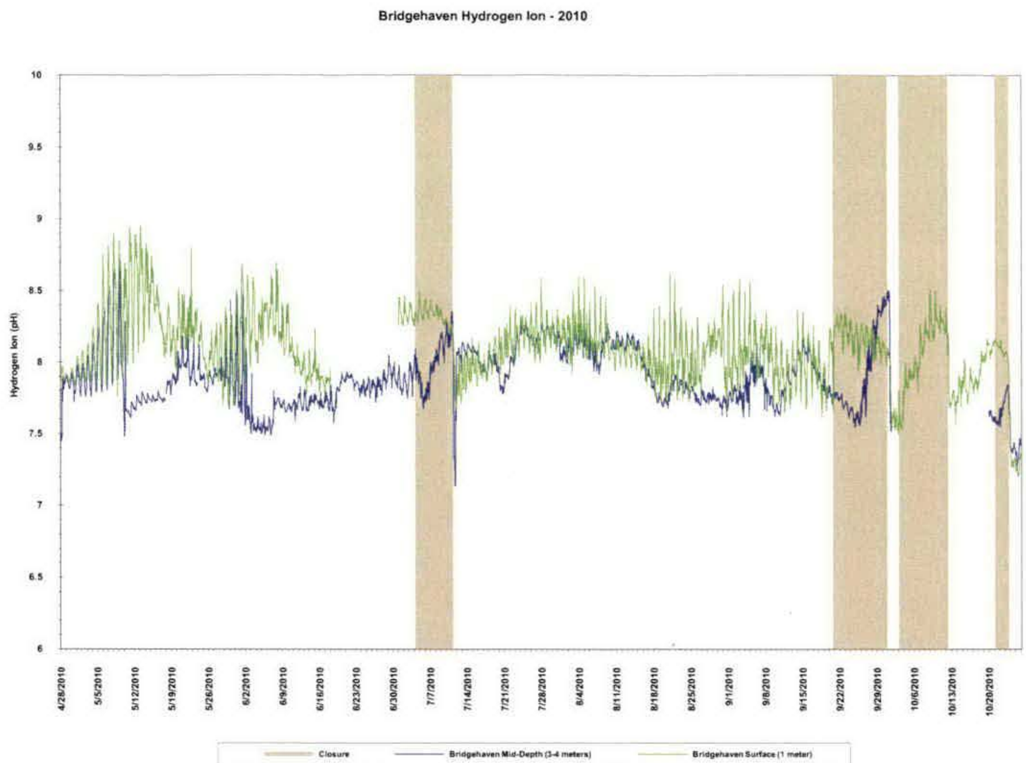

Figure 4.1.32. 2010 Russian River at Bridgehaven Hydrogen Ion Graph

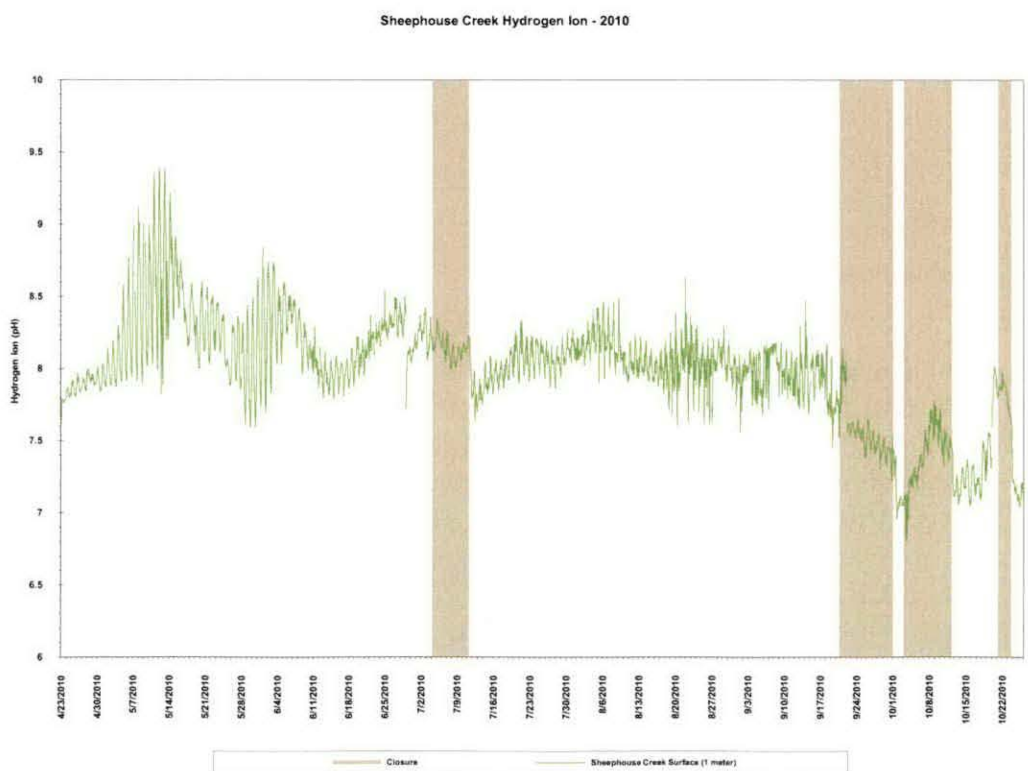

Figure 4.1.33. 2010 Russian River at Sheephouse Creek Hydrogen Ion Graph

The Willow Creek station had a mean pH value of 7.6, a maximum pH value of 9.3, and a minimum pH value of 6.5 (Table 4.1.1). Values were generally higher in saline water than in freshwater. However, the lowest values occurred after the barrier beach was breached on 1 October, as hypoxic brackish water of approximately 6 ppt was flushed out of the system and replaced with water containing less than 1 ppt of salt. The river mouth closed again on 4 October, and pH values increased as oxygenated brackish water moved back into the system (Figure 4.1.34).

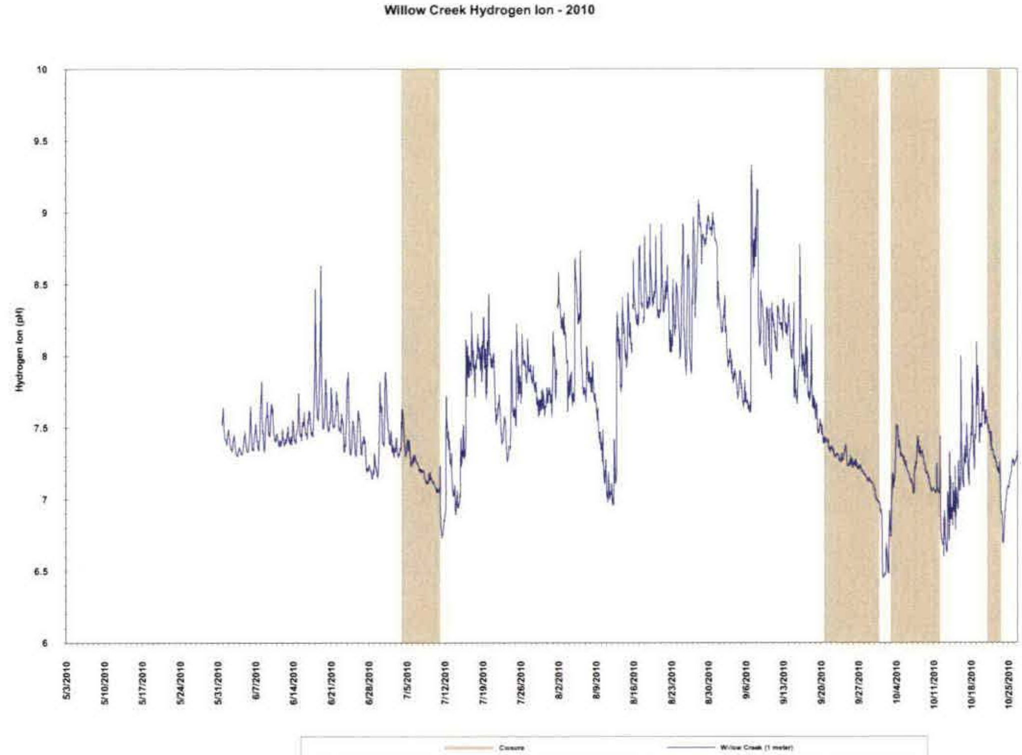

Figure 4.1.34. 2010 Willow Creek Hydrogen Ion Graph

Upper Reach pH

Minimum, mean, and maximum pH values at the Heron Rookery and Freezeout Creek mid-depth sondes were consistent with each other and with pH values observed in the lower and middle reaches of the estuary (Table 4.1.1). Whereas, pH values at the bottom sondes at Heron Rookery and Freezeout Creek were generally lower than those observed at the mid-depth sondes, including significantly lower minimum pH values (Figures 4.1.35 and 4.1.36).

Mean pH values were 8.1 at both mid-depth sondes, and 7.1 and 7.7 at the Heron Rookery and Freezeout Creek bottom sondes, respectively (Table 4.1.1). Maximum pH values were 8.9 at the Heron Rookery mid-depth sonde, 8.8 at the Freezeout Creek Mid-depth sonde, and 8.7 at both bottom sondes. Minimum pH values were observed to be 7.3 at both mid-depth sondes, and 5.5 at both bottom sondes.

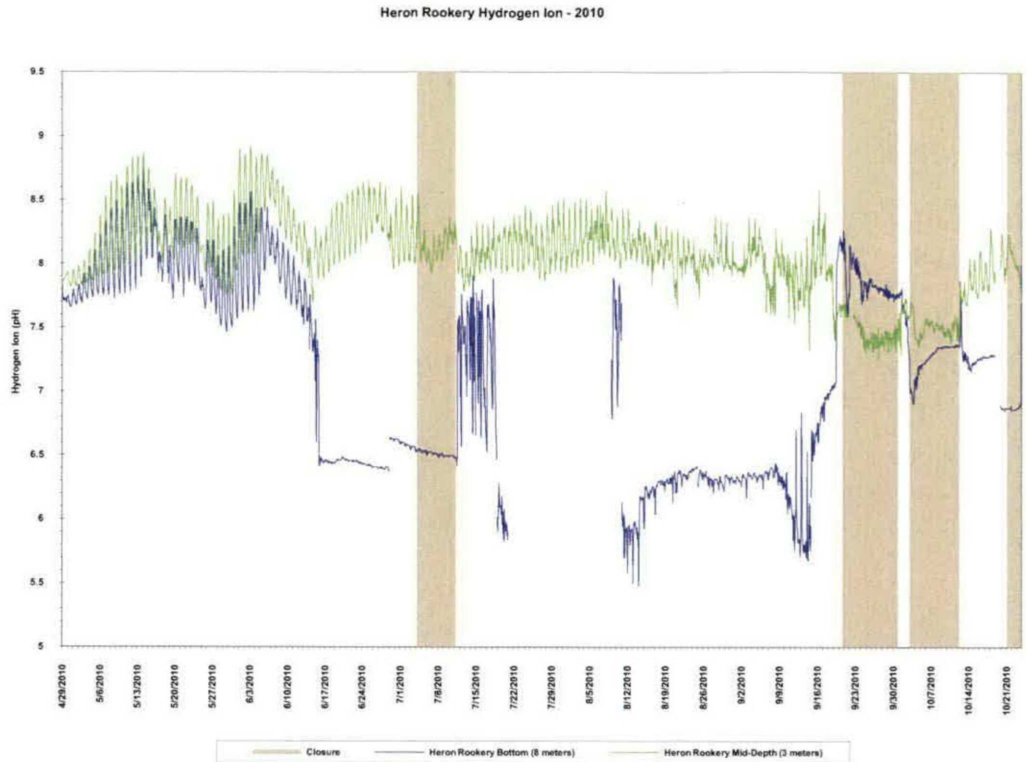

Figure 4.1.35. 2010 Russian River at Heron Rookery Hydrogen Ion Graph

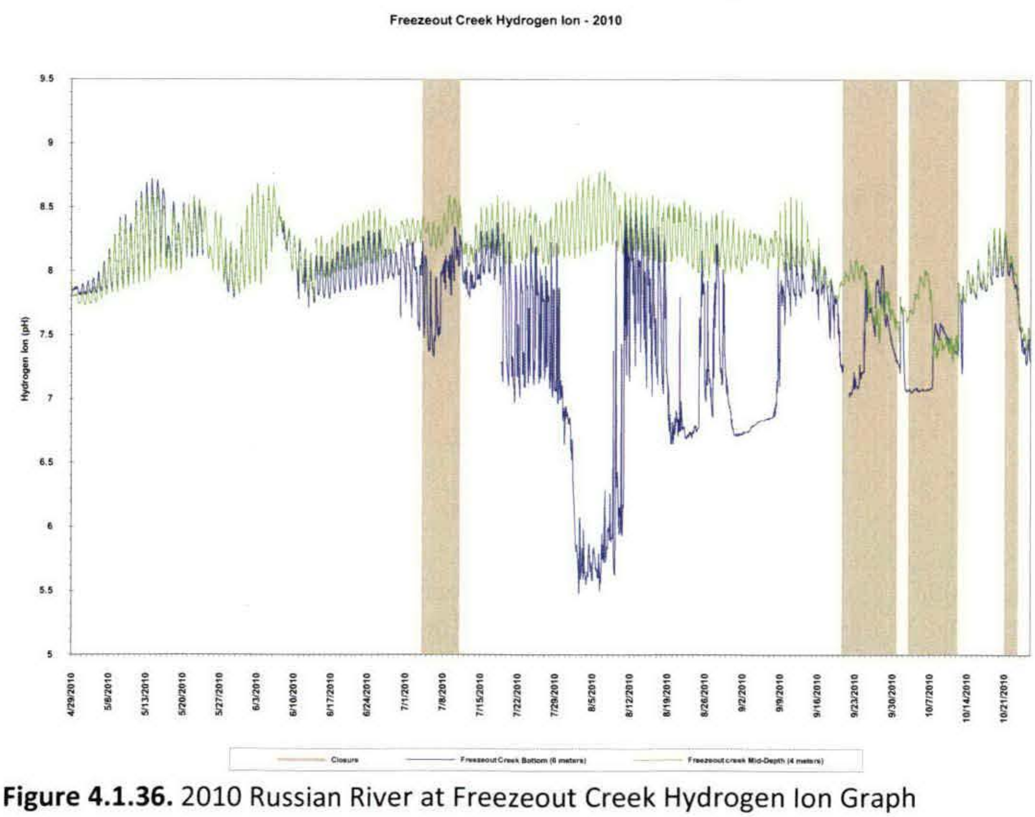

Figure 4.1.36. 2010 Russian River at Freezeout Creek Hydrogen Ion Graph

Both bottom sondes had minimum pH values of 5.5 that were observed to occur during periods of salinity intrusion and hypoxic to anoxic DO concentrations. During these anoxic events, H_2S was often released into the water column (as evidenced by large swings in DO concentrations and/or false DO supersaturation values shown in Figures 4.1.26 and 4.1.27) and likely contributed to the resulting low pH values (Figures 4.1.35 and 4.1.36).

Maximum Backwater Area pH

The Austin Creek station had a mean pH value of 7.8, a maximum pH value of 8.3, and a minimum pH value of 7.3 (Table 4.1.1). Values increased slightly during estuary closures in September and October; however response was variable during the first estuary closure in July. Although response observed during estuary closure was variable over the season, pH values continued to remain within the range of values observed during open conditions (Figure 4.1.37).

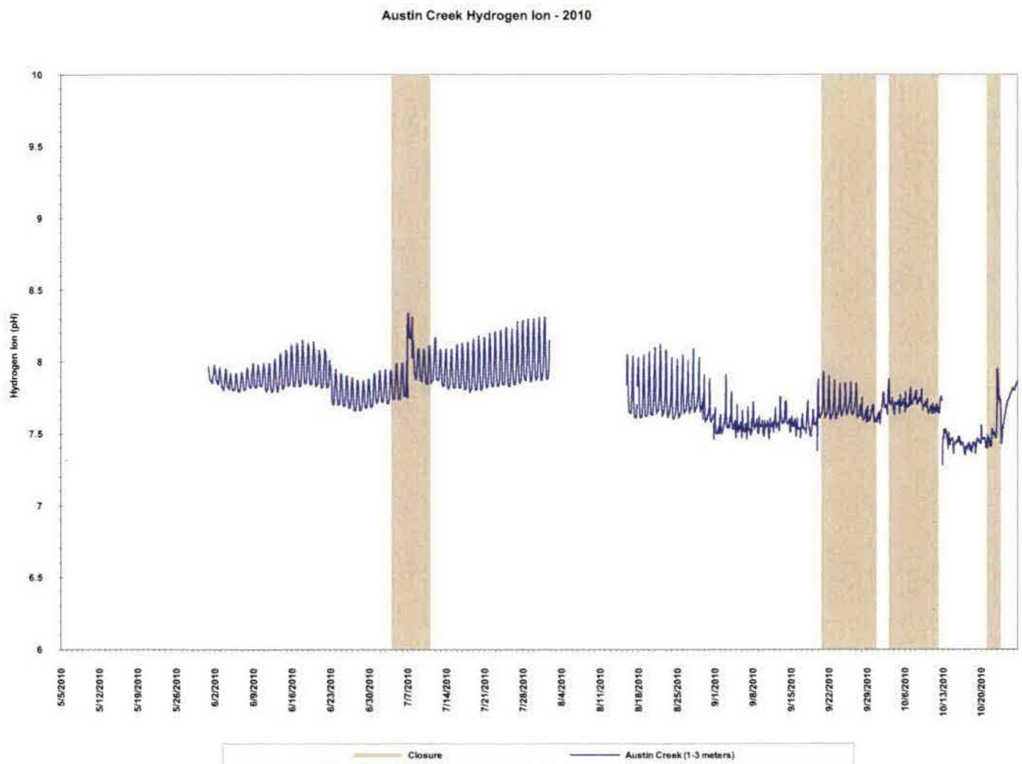

Figure 4.1.37. 2010 Austin Creek Hydrogen Ion Graph

The Monte Rio station had a mean pH value of 7.9, a maximum pH value of 9.1, and a minimum pH value of 7.2 (Table 4.1.1). Response to estuary closure was variable and fairly insignificant, with values observed to increase and decrease during closure but remain within the range of pH values observed throughout the rest of the monitoring season (Figure 4.1.38). High values coincided with high DO concentrations that occurred in June (Figure 4.1.29). Low values coincided with a storm event and increasing stream flows at the end of October.

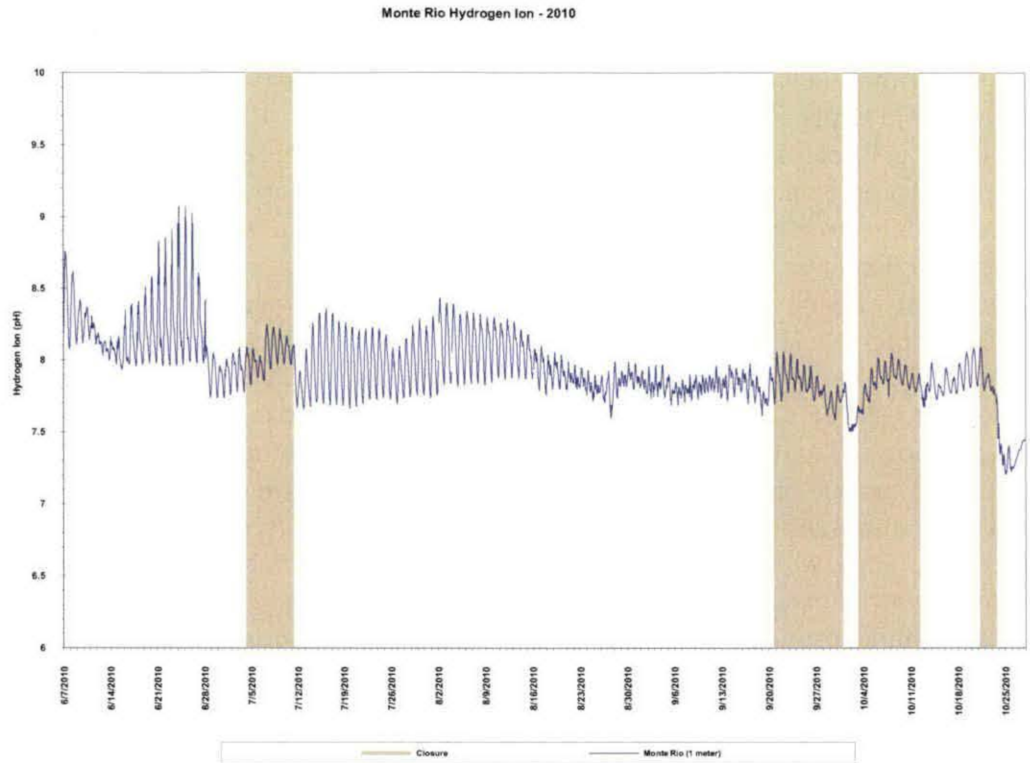

Figure 4.1.38. 2010 Russian River at Monte Rio Hydrogen Ion Graph

Grab Sampling

Grab sampling was conducted at five mainstem stations from Jenner to Monte Rio (Figure 4.1.1). Sampling was generally conducted every two weeks from 22 June to 14 October, when flows were above 125 cfs and the estuary was open. Sampling would have increased to every week if flows dropped below 125 cfs, but they remained above that level throughout the lagoon management period. Additional sampling was conducted twice weekly during estuary closure events and summer dam removal in late-September and October (Figures 4.1.2 through 4.1.6). Samples collected and analyzed for nutrients, chlorophyll *a*, and indicator bacteria are discussed below. Other sample results including organic carbon, dissolved solids, and turbidity are not analyzed, but are included as an appendix to the report.

Nutrients

The United States Environmental Protection Agency (USEPA) established section 304(a) nutrient criteria across 14 major ecoregions of the United States. The Russian River was designated in Aggregate Ecoregion III (USEPA, 2011). USEPA's section 304(a) criteria are intended to provide for the protection of aquatic life and human health (USEPA, 2011). The following discussion of nutrients compares sampling results to these USEPA criteria. However, it is important to note that these criteria are established for freshwater systems, and as such, are only applicable to the freshwater portions of the Estuary. Currently, there are no numeric nutrient criteria established specifically for estuaries.

Total nitrogen concentrations were generally below levels recommended for the protection of aquatic habitats; however total phosphorus concentrations were predominantly above recommended levels. The USEPA desired goal for total nitrogen in Aggregate Ecoregion III is 0.38 mg/L for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). Calculating total nitrogen values requires 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. Often times, nitrogen constituent results were reported as less than the Method Detection Limit (MDL). In these instances, the MDL is used for the purposes of calculating total nitrogen estimates, and the total nitrogen value is considered less than the estimate (Tables 4.1.2 – 4.1.6). Estimated total nitrogen concentrations were observed to remain below the USEPA criteria of 0.38 mg/L a majority of the time at all stations, however there were exceedances observed at each station. Most of these exceedances occurred during sampling events in June and early July, however there were a few exceedances at various stations in September and October (Tables 4.1.2 – 4.1.6). Interestingly, there were no exceedances at any stations during sampling events in August. Exceedances occurred during open and closed conditions, with the most exceedances at the Jenner Boat Ramp station. Total nitrogen concentrations that exceeded the criteria were generally observed to be 0.5 mg/L or less, but there were some instances where higher concentrations were observed, including two total nitrogen concentrations of <0.83 mg/L, recorded at the Duncans Mills station on 5 October, and at the Monte Rio station on 12 October. Both of these values were observed during closed estuary conditions; however the next highest value of 0.75 mg/L was observed during open estuary conditions at the Jenner Boat Ramp station on 14 September.

The USEPA's goal for total phosphates as phosphorus in Aggregate Ecoregion III is 21.88 micrograms per liter (µg/L), or approximately 0.022 mg/L, for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). Total phosphorus concentrations exceeded the USEPA criteria a majority of the time during both open and closed conditions at all five stations in the Estuary. Measureable levels of total phosphorus ranged from a high of 0.077 mg/L at the Bridgehaven Station on 14 October during open conditions and elevated storm flows, to a low of >0.21 mg/L at the Monte Rio Station on 12 October during closed conditions as storm flows were just starting to increase, and was the only sample collected at Monte Rio that did not exceed the USEPA criteria. The other stations also had season low values below the 0.02 mg/L MDL (<0.02) and recorded as non-detect (ND) on 12 October, and the Duncans Mills station had an ND sample result on 14 October as well. Total phosphorus concentrations were generally higher in June and July at all stations during both open and closed Estuary conditions, when late springs flows were still elevated, and tended to decrease through the rest of the season. However, total phosphorus concentrations increased during the last sampling event on 14 October compared to 12 October, except at the Duncans Mills station, which had ND sample results on both events. Samples were collected on 12 October during closed conditions and stream flows of approximately 228 cfs as measured at the Hacienda gaging station, whereas samples were collected on 14 October during open conditions and stream flows of approximately 660 cfs.

Table 4.1.2. 2010 Jenner Station Grab Sample Results

Jenner Boat Ramp*	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N (NO_3^-)	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Fecal Coliforms	Enterococcus	
MDL**	0 200	0.10	0.00010	0 030	0.020	0 10		0 020	0 000050	2.0	2 0	2.0	Estuary
Unit of Measure	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
6/22/2010	0.35	ND	--	0 15	ND	0.35	0.50	0.05	0.001	110	23	8.0	open
7/6/2010	0 273	ND	0 0086	0.13	ND	0 28	0 41	0 035	0 0033	500	240	50	closed
7/20/2010	ND	ND	ND	0.13	ND	0 40	0.53	0 041	0 00023	170	30	4.0	open
8/3/2010	0 210	ND	ND	ND	ND	0 21	0 21	0.043	0 0017	220	50	4 0	open
8/17/2010	ND	ND	ND	ND	ND	0.18	0 18	0.032	0 00071				open
8/19/2010										70	22	ND	open
8/31/2010	0 203	ND	0 0036	0.097	ND	0 24	0 34	0.039	0 0014	27	11	ND	open
9/14/2010	0.224	ND	ND	0.53	ND	0 22	0 75	0.029	0.0013	140	13	6 0	open
9/28/2010	0 231	ND	0 0032	0.081	ND	0 27	0.35	0.031	0 0015	>1600	80	500	closed
9/30/2010	ND	ND	0 0037	ND	ND	0.20	0 20	0.027	0 00097	>1600	240	1600	closed
10/5/2010	ND	ND	0 0015	ND	ND	0.18	0 18	0.033	0 00028	>1600	500	1600	closed
10/7/2010	0 217	ND	0 0010	0 084	ND	0 25	0 33	0 036	0.0017	>1600	300	1600	closed
10/12/2010	ND	ND	0 0034	0.13	ND	0 18	0 31	ND	0.0015	>1600	70	130	closed
10/14/2010	ND	ND	0 00062	0.22	ND	0 18	0 40	0 024	0 00046	300	23	8 0	open

* results are preliminary and subject to final revision.
** Method Detection Limit

Recommended EPA Criteria based on Aggregate Ecoregion III:
Total Phosporus 0 02188 mg/L (21 88 ug/L)
Total Nitrogen. 0.38 mg/L
Chlorophyll *a* 0 00178 mg/L (1.78 ug/L)
Turbidity 2 34 FTU/NTU

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels
Total coliforms 10,000 per 100 ml
Fecal coliforms· 400 per 100 ml
Enterococcus 61 per 100 ml

Table 4.1.3. 2010 Bridgehaven Station Grab Sample Results

Bridgehaven*	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N (NO_3^-)	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Fecal Coliforms	Enterococcus	
MDL**	0.200	0 10	0.00010	0 030	0.020	0 10		0.020	0.000050	2 0	2 0	2 0	Estuary
Unit of Measure	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
6/22/2010	0 238	ND	--	0 14	ND	0 24	0 38	0 044	0.0002	900	22	110	open
7/6/2010	ND	ND	0 0032	0.12	ND	0 21	0 33	0 042	0.0036	500	23	80	closed
7/20/2010	ND	0.10	0 0062	0 13	ND	0 28	0 41	0 054	0 0083	>1600	170	30	open
8/3/2010	ND	ND	0.00057	0 088	ND	0 14	0 23	0 042	0 0017	23	8 0	22	open
8/17/2010	ND	ND	0 0023	ND	ND	0 21	0 21	0 040	0 0057				open
8/19/2010										110	13	4 0	open
8/31/2010	ND	ND	0.0027	0 094	ND	0.24	0 33	0.036	0 0032	50	8 0	4 0	open
9/14/2010	ND	ND	0.00019	0 40	ND	0 18	0 58	0 039	0 0043	140	17	13	open
9/28/2010	0 301	ND	ND	0.093	ND	0 30	0.39	0 027	0 00097	>1600	50	50	closed
9/30/2010	ND	ND	0.0058	0 077	ND	0 15	0.23	0 031	0 00087	900	90	300	closed
10/5/2010	ND	ND	0 0014	ND	ND	0.21	0 21	0 038	0 00047	>1600	900	>1600	closed
10/7/2010	ND	0.10	0 0036	0 098	ND	0.21	0 31	0.057	0.00055	>1600	70	240	closed
10/12/2010	ND	ND	0 00065	ND	ND	0 18	0 18	ND	0 0015	>1600	70	130	closed
10/14/2010	ND	ND	0.00044	0 11	ND	0 10	0 21	0 077	0.0023	900	240	14	open

* results are preliminary and subject to final revision
** Method Detection Limit

Recommended EPA Criteria based on Aggregate Ecoregion III:
Total Phosporus. 0.02188 mg/L (21 88 ug/L)
Total Nitrogen 0.38 mg/L
Chlorophyll *a* : 0 00178 mg/L (1 78 ug/L)
Turbidity. 2 34 FTU/NTU

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels.
Total coliforms, 10,000 per 100 ml
Fecal coliforms 400 per 100 ml
Enterococcus. 61 per 100 ml

Table 4.1.4. 2010 Duncans Mills Station Grab Sample Results

Duncans Mills*	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N (NO_3^-)	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Fecal Coliforms	Enterococcus	
MDL**	0 200	0 10	0.00010	0 030	0 020	0.10		0 020	0 000050	2 0	2 0	2.0	Estuary
Unit of Measure	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
6/22/2010	ND	ND	--	0 18	ND	0 21	0 39	0 047	0.0005	300	8.0	4 0	open
7/6/2010	ND	ND	0 0018	0 14	ND	0 20	0 34	0.038	0 0027	50	50	30	closed
7/20/2010	ND	0.14	0.020	0 14	ND	0 14	0 28	0 041	0.00092	300	8 0	6 0	open
8/3/2010	ND	ND	0 0034	0 096	ND	0 14	0 24	0.032	0 00059	50	13	2 0	open
8/17/2010	ND	ND	0.0082	0 078	ND	0.14	0 22	0.023	0.00059				open
8/19/2010										140	13	4.0	open
8/31/2010	ND	ND	ND	0 077	ND	0 17	0 25	0 030	0.00028	47	32	4.0	open
9/14/2010	0 245	ND	ND	0.082	ND	0.24	0 32	0 034	0.0013	170	23	14	open
9/28/2010	ND	ND	0.0046	0 10	ND	0 16	0.26	0 034	0.00087	430	140	80	closed
9/30/2010	ND	ND	0.0056	0 075	ND	0.16	0 24	ND	0.0011	>1600	500	240	closed
10/5/2010	0 683	ND	0 0031	0.075	ND	0 75	0.83	0 025	0 00056	500	30	22	closed
10/7/2010	ND	ND	0.0023	0.076	ND	0.25	0 33	0.032	0.00027	130	23	17	closed
10/12/2010	ND	ND	0 0024	0.15	ND	0 21	0.36	ND	0 00055	1600	23	17	closed
10/14/2010	ND	ND	0 00089	0 12	ND	0 11	0.23	ND	0.0037	170	23	23	open

* results are preliminary and subject to final revision
** Method Detection Limit

Recommended EPA Criteria based on Aggregate Ecoregion III:
Total Phosporus 0 02188 mg/L (21.88 ug/L)
Total Nitrogen. 0 38 mg/L
Chlorophyll *a*. 0 00178 mg/L (1 78 ug/L)
Turbidity· 2 34 FTU/NTU

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels
Total coliforms· 10,000 per 100 ml
Fecal coliforms. 400 per 100 ml
Enterococcus 61 per 100 ml

Table 4.1.5. 2010 Casini Ranch Station Grab Sample Results

Casini Ranch*	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N (NO_3^-)	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Fecal Coliforms	Enterococcus	
MDL**	0 200	0.10	0 00010	0 030	0 020	0 10		0.020	0 000050	2.0	2 0	2.0	Estuary
Unit of Measure	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
6/22/2010	0.35	ND	--	0 15	ND	0.35	0 50	0 05	0 001	110	23	8 0	open
7/6/2010	0 273	ND	0 0086	0 13	ND	0.28	0 41	0 035	0.0033	500	240	50	closed
7/20/2010	ND	ND	ND	0 13	ND	0.40	0 53	0.041	0 00023	170	30	4 0	open
8/3/2010	0 210	ND	ND	ND	ND	0.21	0.21	0.043	0 0017	220	50	4 0	open
8/17/2010	ND	ND	ND	ND	ND	0 18	0.18	0.032	0 00071				open
8/19/2010										70	22	ND	open
8/31/2010	0 203	ND	0 0036	0 097	ND	0 24	0 34	0.039	0 0014	27	11	ND	open
9/14/2010	0 224	ND	ND	0.53	ND	0 22	0 75	0.029	0 0013	140	13	6 0	open
9/28/2010	0.231	ND	0 0032	0 081	ND	0 27	0 35	0 031	0 0015	>1600	80	500	closed
9/30/2010	ND	ND	0.0037	ND	ND	0 20	0.20	0 027	0 00097	>1600	240	1600	closed
10/5/2010	ND	ND	0.0015	ND	ND	0.18	0 18	0 033	0.00028	>1600	500	1600	closed
10/7/2010	0 217	ND	0.0010	0.084	ND	0 25	0 33	0 036	0.0017	>1600	300	1600	closed
10/12/2010	ND	ND	0 0034	0 13	ND	0 18	0 31	ND	0.0015	>1600	70	130	closed
10/14/2010	ND	ND	0 00062	0 22	ND	0 18	0 40	0 024	0 00046	300	23	8.0	open

* results are preliminary and subject to final revision.
** Method Detection Limit

Recommended EPA Criteria based on Aggregate Ecoregion III:
Total Phosporus· 0.02188 mg/L (21.88 ug/L)
Total Nitrogen· 0 38 mg/L
Chlorophyll *a* 0 00178 mg/L (1.78 ug/L)
Turbidity: 2.34 FTU/NTU

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels
Total coliforms: 10,000 per 100 ml
Fecal coliforms· 400 per 100 ml
Enterococcus 61 per 100 ml

Table 4.1.6. 2010 Monte Rio Station Grab Sample Results

Monte Rio*	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N (NO_3^-)	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen (calculated)	Phosphorus, Total	Chlorophyll-a	Total Coliforms	Fecal Coliforms	Enterococcus	
MDL**	0.200	0.10	0.00010	0.030	0.020	0.10		0.020	0.000050	2.0	2.0	2.0	Estuary
Unit of Measure	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN/100mL	MPN/100mL	MPN/100mL	Condition
6/22/2010	0.203	ND	--	0.20	ND	0.21	0.41	0.047	0.0012	130	8.0	30	open
7/6/2010	ND	ND	0.0029	0.13	ND	0.16	0.29	0.035	0.0025	900	170	130	closed
7/20/2010	ND	ND	0.0024	0.13	ND	ND	0.13	0.042	0.0018	30	23	7.0	open
8/3/2010	ND	ND	0.0019	0.073	ND	0.14	0.21	0.026	0.00099	170	50	9.0	open
8/17/2010	ND	ND	ND	0.074	ND	0.18	0.25	0.024	0.00071				open
8/19/2010										170	13	13	open
8/31/2010	ND	ND	ND	0.076	ND	0.17	0.25	0.030	0.00019	140	17	8.0	open
9/14/2010	ND	ND	0.00096	0.073	ND	0.18	0.25	0.028	0.00025	280	90	33	open
9/28/2010	ND	ND	0.0015	0.081	ND	0.16	0.24	0.027	0.00019	300	130	130	closed
9/30/2010	ND	ND	0.0018	0.075	ND	0.20	0.28	0.027	0.000097	>1600	350	210	closed
10/5/2010	ND	ND	0.0016	0.076	ND	0.18	0.26	0.025	ND	80	17	30	closed
10/7/2010	ND	0.14	0.0046	0.076	ND	0.25	0.33	0.029	0.00037	240	50	240	closed
10/12/2010	0.520	0.18	0.0048	0.13	ND	0.70	0.83	0.021	0.00027	300	80	300	closed
10/14/2010	ND	ND	0.0011	0.12	ND	0.20	0.32	0.027	0.0015	500	240	240	open

* results are preliminary and subject to final revision.
** Method Detection Limit

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

Single Sample Values
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
Fecal coliforms: 400 per 100 ml
Enterococcus: 61 per 100 ml

It is highly likely that phosphorus in the river substrate was re-suspended into the water column from the increasing storm flows and the flushing effects of breaching the barrier beach, leading to the increased concentrations observed at most stations on 14 October.

Chlorophyll *a*

In the process of photosynthesis, chlorophyll *a* - a green pigment in plants, absorbs sunlight and combines carbon dioxide and water to produce sugar and oxygen. Chlorophyll *a* can therefore serve as a measureable parameter of algal growth. Qualitative assessment of primary production on water quality can be based on chlorophyll *a* concentrations. A U.C. Davis report on the Klamath River (1999) assessing potential water quality and quantity regulations for restoration and protection of anadromous fish includes a discussion of chlorophyll *a* and how it can affect water quality. The report characterizes the effects of chlorophyll *a* in terms of different levels of discoloration (e.g., no discoloration to some, deep, or very deep discoloration). The report indicated that less than 10 µg/L (or 0.01 mg/L) of chlorophyll *a* exhibits no discoloration (Deas and Orlob, 1999). Additionally, the USEPA criterion for chlorophyll *a* in Aggregate Ecoregion III is 1.78 µg/L, or approximately 0.0018 mg/L for rivers and streams not discharging into lakes or reservoirs (USEPA, 2000). However, it is important to note that the EPA criterion is established for freshwater systems, and as such, is only applicable to the freshwater portions of the Estuary. Currently, there are no numeric chlorophyll *a* criteria established specifically for estuaries.

Chlorophyll *a* concentrations were less than 0.01 mg/L at all stations during all sampling events; the level recommended to prevent discoloration of surface waters (Tables 4.1.2 – 4.1.4). Estimated chlorophyll *a* concentrations were also observed to remain below the USEPA criteria of 0.0018 mg/L a majority of the time at all stations, however there were exceedances observed at each station (Tables 4.1.2 – 4.1.6). The grab sampling stations typically experienced only one or two exceedances during the entire season; however the Bridgehaven Station exceeded the criteria six times. These exceedances generally occurred during sampling events in June and early July, with all stations exceeding the criteria on the 6 July sampling event. Exceedances occurred during open and closed estuary conditions early in the season; however there were no exceedances at any station during closed estuary conditions in September and October. The Bridgehaven Station had the highest chlorophyll *a* concentration of the season, with a value of 0.0083 mg/L recorded during open conditions on 20 July, whereas the Monte Rio Station had a season low value below the 0.000050 mg/L MDL (<0.000050) and recorded as non-detect (ND) on 5 October during closed estuary conditions (Figures 4.1.3 and 4.1.6). There were also exceedances at the Casini Ranch, Duncans Mills, and Bridgehaven stations during the last sampling event on 14 October, two days after the estuary had been re-opened (Tables 4.1.3 – 4.1.5).

Indicator Bacteria

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 total coliform is 10,000 most probable numbers (MPN) per 100 milliliters (ml), and 400 MPN per 100 ml for fecal coliforms. The MPN for *Enterococcus* is 61 per 100 ml. However, it must be emphasized that these are draft guidelines, not adopted standards, and are therefore both subject to change (if it is determined that the guidelines are not accurate indicators) and are not currently enforceable. In addition, these draft guidelines were established for and are only applicable to fresh water beaches. Currently, there are no numeric guidelines that have been developed for estuarine areas.

Sampling results in 2010 indicate there is a large variation in indicator bacteria levels observed through the different sections of the Estuary (Tables 4.1.2 – 4.1.6). These variations occurred under both open and closed mouth conditions and may be seasonal as well.

Sample results in 2010 did not include an absolute value for high counts of total coliforms and were reported by the lab as being greater than 1,600 MPN (>1,600). This precludes the comparison of total coliform sample results to the draft CDPH guidelines for public recreation.

In 2010, total coliform counts were generally higher during closed conditions in September and October than during open conditions earlier in the season, although there were a few counts during open conditions as high as counts observed during closed conditions. All five stations sampled in 2010 had at least one total coliform value of >1,600 MPN, with the Bridgehaven and Jenner Boat Ramp stations having five each (Tables 4.1.2 – 4.1.6). These high counts occurred during closed estuary conditions in late September and early October following increased freshwater inflows related to upstream dam removals at the end of September and during repeated barrier beach closures in early October. Total coliform values were occasionally elevated during open conditions, with high counts of >1,600 MPN being recorded at the Bridgehaven Station on 20 July, and at the Casini Ranch Station on 14 October, two days after the mouth had been re-opened.

Fecal coliform counts were generally low during the monitoring season during open and closed estuary conditions. The Monte Rio and Casini Ranch stations had no counts above the draft CDPH guideline of 400 MPN/100 ml. The Jenner Boat Ramp and Bridgehaven stations had one high count each, of 500 MPN and 900 MPN, respectively that exceeded the draft CDPH guidelines during closed conditions on 5 October (Tables 4.1.2 and 4.1.3). The Duncans Mills station had a high count of 500 MPN that also exceeded draft CDPH guidelines during closed conditions on 30 September. These high counts occurred during closed estuary conditions in late September and early October following increased freshwater inflows related to upstream dam removals at the end of September and during repeated barrier beach closures in early October.

Enterococcus counts were higher during closed estuary conditions in September and October, and all stations exceeded draft freshwater levels during closed barrier beach conditions. The draft guidance for freshwater beach posting identifies the potential for public health concerns when *Enterococcus* levels exceed 61 MPN/100ml. The Jenner Boat Ramp Station had three counts of 1,600 MPN during closed conditions between 30 September and 7 October (Table 4.1.2). The Casini Ranch Station also had a high count of 1,600 MPN during closed conditions on 30 September and the Bridgehaven Station had a high count of >1,600 MPN during closed conditions on 5 October (Tables 4.1.5 and 4.1.3). These high counts occurred during closed estuary conditions in late September and early October following increased freshwater inflows related to upstream dam removals at the end of September and during repeated barrier beach closures in early October. Draft guideline criteria were not exceeded during open and closed conditions earlier in the season at the Jenner, Duncans Mills and Casini Ranch stations. However, draft criteria were exceeded at the Bridgehaven Station during open and closed conditions on 22 June and 6 July, respectively, and at the Monte Rio Station during the 6 July closure.

Conclusions and Recommendations

Overall, water quality conditions observed during the 2010 monitoring season were similar to conditions associated with a dynamic estuarine system observed in previous years. There were a few notable observations associated with salinity and indicator bacteria that will be discussed further below. Monitoring efforts for the 2011 season will also be discussed.

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. Salinities near the mouth (1st mile of the Estuary) are mostly similar to ocean salinities. Whereas, the middle portion of the Estuary (one to five miles from the mouth) is most subject to fluctuation in salinities throughout the water column due to ocean tides and freshwater inflow rates. In the middle reach of the Estuary, salinities can range as high as 30 ppt in the saltwater layer, with brackish conditions prevailing at the upper end of the salt wedge, to less than 1 ppt in the freshwater layer on the surface. The upper reach of the Estuary transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saline to brackish layer that migrates upstream as far as the Moscow Road Bridge in Duncans Mills during summer low flow conditions. The most upstream portion of the Estuary from Duncans Mills to Austin Creek (upper one mile of the Estuary) is the only portion where a predominance of freshwater habitat is maintained throughout the summer. River flows, tides, and wind action affect the amount of mixing at various longitudinal and vertical positions within the Estuary.

When the barrier beach forms, saltwater is trapped in the lagoon and water quality conditions can undergo abrupt alteration. After closure, salinity, DO and temperature changes occur within 24 hours. After the estuary becomes stratified, the mid-depth saltwater lens traps heats (Smith, 1990; Entrix, 2004). Through natural processes, DO becomes depleted in the bottom saline layer and anoxic conditions can develop. Salinity stratification leads to reductions in DO and increases in temperature in the lower water column following closure.

During barrier beach closures, the freshwater lens deepened at the surface. Highly saline conditions were typical in the mid-depths of the lower and middle reaches of the Estuary within a few days of barrier beach closures. However, salinity levels were observed to decrease at mid-depth over time, which may be evidence that the denser saltwater was percolating out of the Estuary through the barrier beach. Conversely, brackish water extended into the lower half of the water column during barrier beach closure as far upstream as Freezeout Creek in the upper reach, providing further evidence that the salt layer was stratifying and flattening out. As the closed Estuary continued to backwater, a reduction in the hydraulic forces of freshwater inflow also appeared to contribute to the upstream migration of the salt layer. Once the barrier beach had been reopened, salinity concentrations were generally observed to increase at the surface sondes as the freshwater layer diminished and the Estuary became tidally influenced again.

Temperature stratification coincided with the presence of the halocline, as the saltwater was typically observed to be significantly colder than the freshwater during open Estuary conditions. surface sonde temperatures were observed to have the greatest degree of fluctuation due to their location at the saltwater-freshwater interface. However, temperatures were also observed to exhibit diel fluctuations based on the heating and cooling effects of night and day, as well as longer-term seasonal heating and cooling events, including barrier beach closure and reopening.

When the barrier beach closed, temperatures were observed to increase in the saline layer and often exceed temperatures in the overlying surface freshwater layer. Over time, a three-layer system would form with a cooler saline to brackish bottom layer that is below the effects of solar heating, a hot mid-depth layer of saline to brackish water subject to the effects of solar heating, and a cooler (but still relatively warm) freshwater layer on the surface.

Mean DO levels were typically higher in the freshwater layer than in the saline layer. However, DO concentrations fluctuated significantly during the monitoring season at all stations, and fluctuations were not necessarily associated with tidal cycles or a diurnal cycle. DO levels in the Estuary depend upon factors such as the extent of diffusion from surrounding air and water movement, including freshwater inflow. DO levels are also a function of nutrients, which can accumulate in standing water during an extended period of time and promote excessive plant and algal growth that utilize DO. This can reduce DO levels leading to eutrophication and affecting overall ecological health of the Estuary. Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where runoff enters the marine environment in a confined channel.[8] Upwelling in coastal systems, which typically occurs from March to July, also promotes increased productivity by conveying deep, nutrient-rich waters to the surface and into the estuary through tidal action, where the nutrients can be assimilated by algae.

When the barrier beach closes, salinity stratification results in pronounced DO stratification in the closed lagoon. Supersaturation, hypoxic, and anoxic events were observed, with prolonged hypoxic and/or anoxic events occurring in the deeper portions of the Estuary through the duration of barrier beach closure. DO concentrations were variable in the mid-depth saline layer of the water column during barrier beach closures with decreases and increases observed. DO levels in the freshwater at the surface of the Estuary did not appear to be negatively impacted by barrier beach closure and remained similar to open conditions (7 to 10 mg/L), or increased in some instances. Similar stratified conditions were also observed when the barrier beach was open during neap tides or low river flows, indicating that the deeper portions of the Estuary may not be subject to mixing even during open tidal conditions.

In 2010, the salt wedge migrated to the Heron Rookery and Freezeout Creek stations under higher flows than were observed in 2009 (SCWA 2011). The salt wedge migrated to the Heron Rookery and Freezeout Creek stations when flows decreased to approximately 150 cfs in 2009. Whereas, in 2010, the salt wedge migrated to the Heron Rookery station when flows were above 400 cfs, and migrated to the Freezeout Creek Station when flows were approximately 200 cfs. However, it should be noted that in 2009, the Heron Rookery Bottom Sonde was not at the absolute bottom of the pool, and the salt wedge may have been at the station, but located deeper in the water column than the sonde. For the 2011 monitoring effort, the bottom sonde at Heron Rookery will continue to be placed in the deepest portion of the pool to record the timing of the upstream migration of the salt wedge.

Indicator bacteria exhibited high variability in counts between stations and seasons. During the 2009 season, indicator bacteria were observed to have high counts that exceeded draft CDPH guidelines primarily during open estuary conditions (SCWA 2011). Whereas, in 2010, indicator bacterial counts were high and exceeded draft guidelines primarily during closed estuary conditions.

Potential causes for higher counts observed during open conditions in 2009 than in 2010 include lower flows in 2009 than in 2010. However, these differences could also be caused by other variables including higher water temperatures, more nutrient availability, more days of sun, and increased recreational usage at a given station. Higher values during closed conditions in 2010 than in 2009 may be attributable to increased freshwater inflows related to upstream dam removals at the end of September, at a time when the estuary was repeatedly closing and impounding water, and when exceedances of the draft CDPH guidelines occurred.

8 *National Estuarine Eutrophication Assessment* by NOAA National Centers for Coastal Ocean Science (NCCOS) and the Integration and Application Network (IAN), 1999.

Monitoring in 2011 will continue to focus on the movement of the salt wedge within the estuary and will be expanded to include a station above the Moscow Road Bridge in Duncans Mills to track potential salinity migration above Freezeout Creek, where it has been observed to occur. Monitoring will also be expanded in 2011 to include a station in the mainstem above Austin Creek, but below Monte Rio in an effort to locate potential cold water refugia in the maximum backwater area. Finally, grab sampling will continue in 2011 at the five stations sampled in 2010 and focused sampling will occur when the estuary closes and when the summer dams are removed to gain additional information on the potential for either of these two actions to increase bacterial concentrations in the estuary.

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