Water Quality Conditions During 2007 in the Vicinity of the Klamath Hydroelectric Project

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October 14, 2008

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1.0 INTRODUCTION

This report presents the results of the monitoring of water quality conditions during 2007 in the vicinity of the Klamath Hydroelectric Project (Project), located along the upper Klamath River in Klamath County, south-central Oregon, and Siskiyou County, northern California. The objective of this monitoring was to gather information on a comprehensive suite of water quality constituents to characterize water quality conditions during 2007 in the Klamath River in the Project vicinity.

The water quality monitoring in 2007 was a continuation similar monitoring conducted by PacifiCorp in 2000, 2001, 2002, 2003, 2004, and 2005[1] to characterize water quality conditions in the Project area. Results of water quality monitoring in these previous years are described in other documents (PacifiCorp 2004a, 2004b, PacifiCorp 2006, PacifiCorp 2007b, 2007c), and data is available on PacifiCorp's Project website at http:// www.pacificorp.com/ Article/ Article82803.html.

The water quality monitoring in 2007 was one of several water quality studies conducted by PacifiCorp Energy (PacifiCorp) in the vicinity of the Project during 2007 as described in PacifiCorp (2007a). These studies were conducted to provide information for PacifiCorp's on-going assessment of reservoir management plan (RMP) actions in support of PacifiCorp's application for water quality certification for the Project from the California State Water Quality Control Board (State Water Board) and the Oregon Department of Environmental Quality (ODEQ). The purpose and approach to the water quality monitoring conducted in 2007, as well as the other studies conducted in 2007, were described in PacifiCorp (2007a). Other 2007 studies describing the fate and transport of nutrients and organic matter, the presence and distribution of phytoplankton in the Klamath River, and the feasibility analyses and testing of water quality control measures are the subject of other reports.

[1] Water quality monitoring was not conducted by PacifiCorp in 2006.

2.0 METHODS

Water quality samples were collected monthly in June through November 2007 at 17 sampling sites within the Project area. These sites consisted of 10 river sites and seven reservoir or lake sites as shown in Figure 2-1 and listed in Table 2-1. The number of samples collected from the 17 sites on various dates in 2007 are summarized in Table 2-1, including at multiple depths within J. C. Boyle, Copco, and Iron Gate reservoirs.

Sampling included instantaneous field measurements of physical parameters (with multi-probe instrumentation) and acquisition of grab samples for laboratory analysis of water chemistry. The physical parameter measurements included water temperature, pH, dissolved oxygen, specific conductance, and redox potential. In each reservoir, in-situ depth profile measurements were made at 1 m intervals to 10 m and 2 m intervals from 2 m to the bottom. The measurements are taken by lowering a multi-probe sensor unit (attached by electronic cable to the data-recording base unit) to the depth intervals indicated above. Measurements at river sites were made by placing the sensor in the flow either by suspending it from a bridge or other structure or by placing it some distance away from the bank.

Grab samples for laboratory analysis of water chemistry and phytoplankton were collected concurrent with the physical measurements. Samples were analyzed for ammonia (NH3), nitrate + nitrite (NO3), total Kjeldahl nitrogen (TKN) as N, total phosphorous (PT), orthophosphate (PO4), dissolved organic carbon (DOC), total suspended solids (TSS), and volatile suspended solids (VSS) using methods as summarized in Table 2-2. Samples were also analyzed for algae speciation, density, biovolume, and chlorophyll a.

Grab samples from the 10 river sites were collected by lowering a Kemmerer sampler into the current from a bridge, or by tossing the Kemmerer sampler into the current from the shore. Water from the sampler was dispensed directly into bottles supplied by the laboratory. When the required sample volume exceeded the capacity of the sampler, several volumes of the sampler were dispensed into a churn splitter and all sample bottles were filled from the churn while agitating the sample. Samples were kept on ice after collection until delivered to the laboratory for analysis.

Grab samples from the reservoir sites were collected at discrete depths in the reservoirs using a Kemmerer sampler. Four or five samples were generally taken from the deepest site in Copco reservoir (i.e., at the log boom), including at 0.5, 8, 16, and 24 meters below the surface, as well as at a depth approximately 1 meter above the bottom when reservoir depth exceed 27 m at the time of sampling. Six samples were generally taken from the deepest site in Iron Gate reservoir (i.e., at the log boom), including at 0.5, 8, 16, 24, 32, and 40 meters below the surface. Two samples were taken from J. C, Boyle and Keno reservoirs 0.5 meter below the surface and approximately 1 meter above the bottom.

In addition to the sampling as described above, temperature data loggers were placed at selected locations in the Klamath River and in vertical arrays in the reservoirs. As of completion of this report, evaluation of data from the temperature data loggers has not yet been completed, and will be presented in a future report.

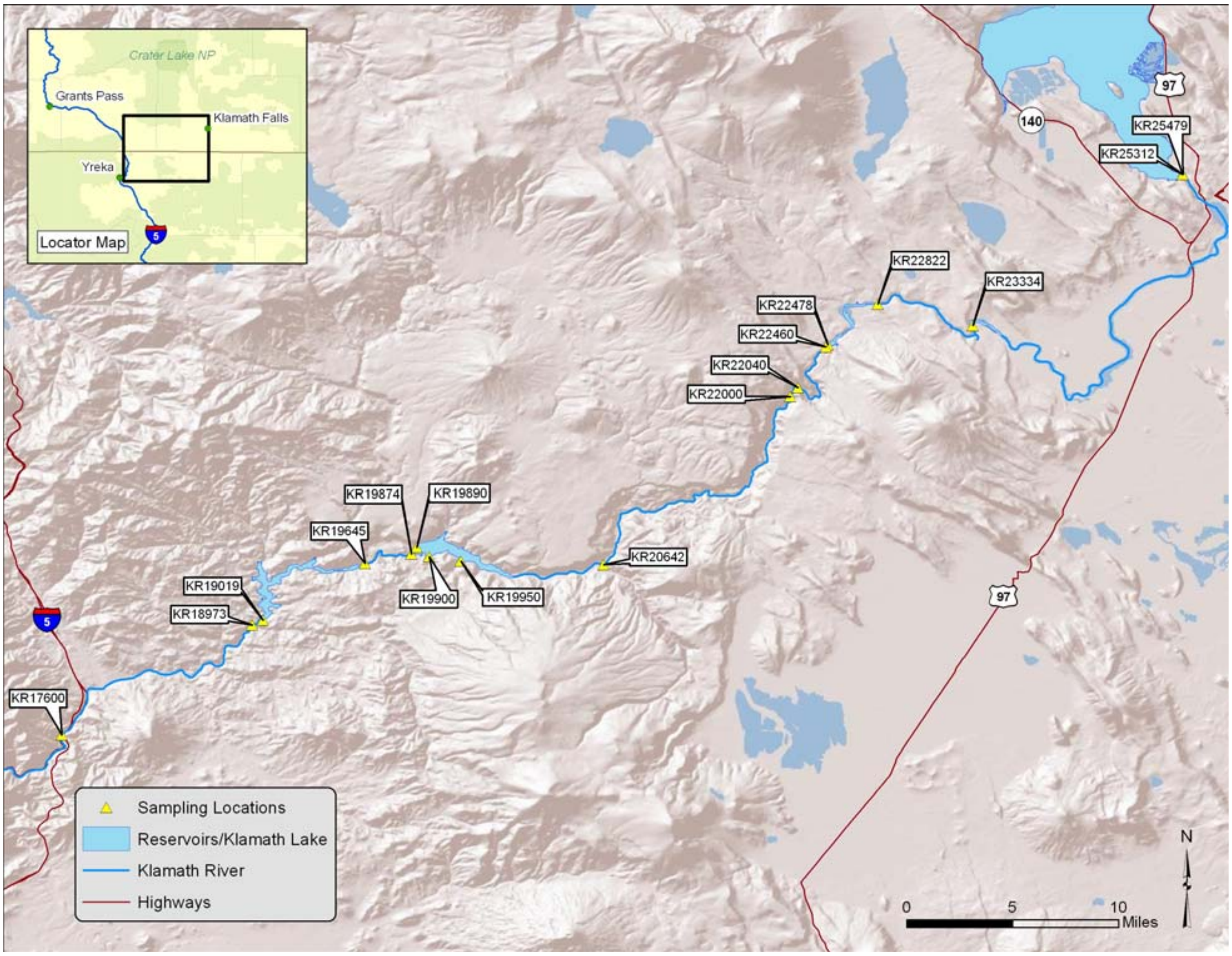


Figure 2-1. The locations of PacifiCorp water quality sampling sites during 2007 in the vicinity of the Klamath River Hydroelectric Project.

Table 2-1. The sample sites visited and number of samples collected on various dates in 2007 at a number of locations in the Klamath River in the vicinity of the Klamath Hydroelectric Project.

					DATE (week beginning)									
SITEID	RM	SITE NAME	River	Reservoir	6/5/07	6/18/07	7/1/07	7/18/07	7/31/07	8/27/07	9/24/07	10/23/07	11/27/07	Total
KR17600	176.0	Klamath River At I-5 rest area	X		1		1		1	1	1	1	1	7
KR18973	189.7	Klamath River At Iron Gate Hatchery Bridge	X		1		1		1	1	1	1	1	7
KR19019	190.2	Iron Gate Reservoir At Log Boom		X	6		6		6	6	6	6	6	42
KR19645	196.5	Klamath River Below Copco 2 Powerhouse	X		1	1	1	1	1	1	1	1	1	9
KR19874	198.7	Copco Reservoir At Boom		X	4	2	4		5	4	5	4	4	32
KR19890	198.9	Copco Reservoir In Copco Cove[1]		X	2	2	2	2						8
KR19900	199.0	Copco Reservoir In Cove Near Residences[1]		X	1	2	2	2						1
KR19950	199.5	Copco Reservoir In Mallard Cove[1]		X	2	2	2	2						8
KR20642	206.4	Klamath River above Shovel Creek	X		1	1	1	1	1	1	1	1	1	9
KR22000	220.0	Klamath River At Spring Island Landing	X		1		1		1	1	1	1	1	7
KR22040	220.4	Klamath River above JC Boyle Powerhouse	X		1		1		1	1	1	1	1	7
KR22460	224.6	Klamath River Below JC Boyle Dam	X		1		1		1	1	1	1	1	7
KR22478	224.8	JC Boyle Reservoir At Log Boom		X	2		2		2	2	2	2	2	14
KR22822	228.2	Klamath River Above JC Boyle Reservoir	X		1		1		1	1	1	1	1	7
KR23334	233.2	Keno Dam Outflow	X		1		1		1	1	1	1	1	7
KR25312	253.1	Link River At Mouth	X									1	1	2
KR25479	254.8	Upper Klamath Lake At Fremont St Bridge		X									1	1

1: The cove sites in Copco reservoir were sampled in connection with testing of solar-powered circulators. Sampling at these sites was not continued past July 18 after cessation of testing.

Table 2-2. Analytical methods for 2007 water quality sampling.

Parameter Name	**Parameter ID**	**Analysis Method**	**MDL**	**Units**
Dissolved organic carbon	DOC	E415.1	0.05	mg/L
Total Kjeldahl nitrogen (as N)	TKN	E351.2	0.01	mg/L
Ammonia nitrogen (as N)	NH3	E350.1	0.01	mg/L
Nitrate+nitrite nitrogen (as N)	NO3	E353.2	0.002	mg/L
Total phosphorus (as P)	PT	E365.1	0.02	mg/L
Orthophosphate (as P)	PO4	E365.1	0.03	mg/L
Total suspended solids	TSS	E160.2	2.0	mg/L
Volatile suspended solids	VSS	E160.4	2.0	mg/L

3.0 RESULTS

This section presents the results of the 2007 water quality monitoring in separate subsections for river sites and reservoir sites. The results are presented in this section based on summary statistics of the data, such as median, means, and box plots, unless otherwise noted. The summary statistics supporting this section are included in Appendix A. The water quality data supporting this section are included in the 2007 database available on the Project website at http://www.pacificorp.com/Article/Article82803.html.

3.1 RIVER SITES

3.1.1 Summary of Water Quality Conditions

Water quality conditions at the nine river sites (listed in Table 2-1) varied through the Project area. The variability appeared to occur in response to seasonal changes and concomitant changes in the conditions of the inflow to the Project area, primarily from Upper Klamath Lake and tributary inflows, and the 250 cfs of spring inflow in the J.C. Boyle bypass reach. The seasonal median values for water quality constituents measured in 2007 at the river sites are summarized in Table 3-1 (based on numbers of samples listed in Table 2-1). Additional statistics (e.g., minimum, maximum, mean, quartile values) are provided in Appendix A.

Table 3-1. A summary of median values for water quality constituents measured in 2007 in the Klamath River in the vicinity of the Klamath Hydroelectric Project.

Site	RM	DOC	DOCON	DOPER	NH3	NO3	pH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
	Mi	mg/L	mg/L	% sat	mg/L	mg/L	Unit	mg/L	mg/L	µS/cm	ºC	mg/L	mg/L	mg/L
KR17600	176.0	6.2	9.6	98.0	0.020	0.23	8.1	0.095	0.140	172	18.5	1.00	3.2	2.8
KR18973	189.7	6.7	7.7	84.5	0.026	0.16	8.0	0.096	0.150	165	19.0	0.87	2.8	3.4
KR20642	206.4	6.9	9.3	103.7	0.020	0.82	7.9	0.110	0.200	177	17.0	1.20	5.2	1.0
KR22000	220.0	8.0	8.1	95.2	0.150	0.56	7.5	0.150	0.190	185	20.1	1.40	3.2	1.0
KR22460	224.6	8.1	8.0	101.5	0.190	0.71	7.6	0.170	0.230	171	21.1	1.50	4.0	0.8
KR22822	228.2	8.2	7.8	98.3	0.150	0.70	7.6	0.150	0.220	172	20.1	1.80	8.0	3.6
KR23334	233.2	8.1	7.7	93.1	0.750	0.04	7.5	0.120	0.240	177	19.9	2.30	6.4	2.2
Max		8.2	9.6	103.7	0.75	0.82	8.1	0.17	0.24	185	21.0	2.30	8.0	3.6
Min		6.2	7.7	84.5	0.02	0.04	7.5	0.10	0.14	165	16.9	0.87	2.8	0.8

For the river sites, the highest median values for ammonia nitrogen, total phosphorus, and Kjeldahl nitrogen occurred at the site at the base of Keno dam (RM 233.2). The highest median values for dissolved organic carbon, suspended solids and volatile suspended solids occurred just downstream at the site above J. C. Boyle reservoir (RM 228.2). The highest median value for orthophosphate phosphorus was below J. C. Boyle dam (RM 224.6).

The J. C. Boyle bypass reach had the lowest median values for many of the measured constituents, and the highest median value for dissolved oxygen saturation and pH, in response to the large groundwater inflows and releases from J. C. Boyle dam to this reach. Excluding this site, the lowest median values for the measured constituents occurred further downstream. The lowest median value for dissolved organic carbon, ammonia nitrogen, orthophosphate- and total phosphorus occurred at the I-5 freeway crossing (RM 176.0). The lowest median values for Kjeldahl nitrogen and suspended solids occurred below Iron Gate dam (RM 189.7); however, the lowest median value for nitrate nitrogen occurred at the base of Keno dam.

3.1.1.1 Water Temperature, Specific Conductance, Dissolved Oxygen, and pH

Summary box plots[2] of the water temperature, specific conductance (SPC), dissolved oxygen (DO), and pH data measured in the field are presented in Figure 3-1. Discussion of these box plots is provided below by parameter.

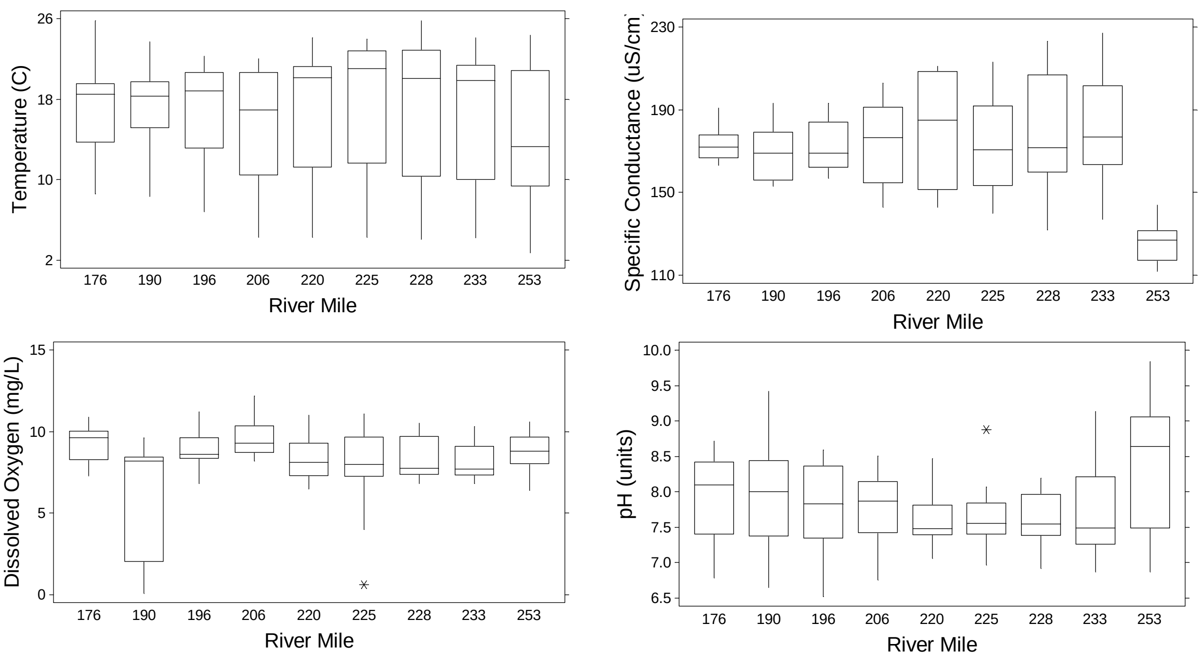


Figure 3-1. Box plots of field measurements made during 2007 in the vicinity of the Klamath Hydroelectric Project. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River. Specific RMs for these sites are listed in Table 2-1.

Temperature

The box plots for temperature (Figure 3-1) indicate that greatest variability (or spread in the data) and highest maximum temperature occurred at the site in the Klamath River above J.C. Boyle reservoir (RM 228). The least variability in temperature occurred at the site in the Klamath River below Iron Gate dam (RM 190). The lowest median temperature occurred at the site in the Klamath River above Copco reservoir (RM 206). This site is influenced by the cooling influence of groundwater inflow in the J.C. Boyle bypass reach, which discharges at a near-constant

[2] A box plot, (also known as a box and whisker diagram), is a basic graphing tool that displays the median, range, and distribution of a data set. The bottom of each box is the 25th percentile, the top of the box is the 75th percentile, and the line in the middle is the 50th percentile or median.The vertical lines above and below each box (the "whiskers") extend to maximum and minimum values to give additional information about the spread of data.

temperature at approximately 11 ºC.

The moderating influence of the groundwater inflow is evident in the month-by-month data shown in Figure 3-2. It results in a cooling of river temperatures during the warmer months of the year, and a warming of river temperature during the colder months of the year. For example, in June, July, and August, the river was warm at the upstream site below J.C. Boyle dam and cooled noticeably in the reach downstream to Copco reservoir (Figure 3-2)[3]. By contrast, in October and November, the river was cooler at the upstream sites, and warmed with distance downstream. In October and November, this warming was especially noticeable between the site above Shovel Creek (RM 206.4) and the site below Iron Gate dam (RM 189.7).

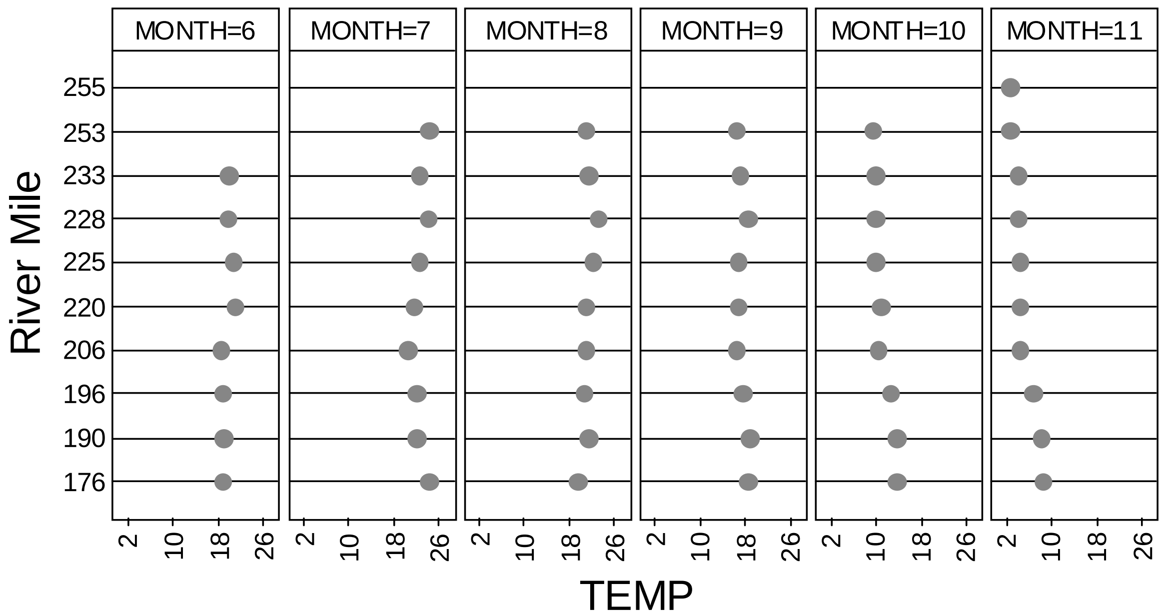


Figure 3-2. Temperatures (ºC) measured in the field during 2007 in the Klamath River in the vicinity of the Klamath Hydroelectric Project. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River, RM 255 = Upper Klamath Lake at Fremont St Bridge. Specific RMs for these sites are listed in Table 2-1.

<u>Specific Conductance</u>

The box plots for SPC (Figure 3-1) indicate that greatest variability (or spread in the data) occurred at the site in the Klamath River below Keno dam (RM 233) and above J.C. Boyle reservoir (RM 228). The least variability in SPC occurred at the site in Klamath River below Iron Gate dam (RM 190) and at the I-5 Crossing (RM 178).

SPC measurements varied substantially in the month-by-month data shown in Figure 3-3. The

[3] Values shown in these dot plots (and subsequent similar dot plots) are individual measurements typically taken over the course of a 2-day sampling event. The measurements at different sites were taken at different times of day, usually between 9:00 AM and 4:00 PM. It is possible that some difference between locations, especially for DO, pH, and temperature, could be influenced by local diurnal variation.

greatest difference was between the sites at Link River (RM 253.1) and below Keno dam (RM 233.2). These two sites are at the upstream and downstream limits, respectively, of Lake Ewauna. At Link River, which reflects conditions in the outflow from Upper Klamath Lake, median SPC was 127 µS/cm, and the range was from 112 to 144 µS/cm. In contrast, median SPC at Keno dam was 172 µS/cm with a range from 137 to 227 µS/cm. SPC at Keno dam increased throughout the period of sampling, presumably the result of agricultural return flows to Keno reservoir containing higher SPC. The effect of the change at Keno dam became evident at sites farther downstream as the season progressed.

SPC was less variable in the river below Iron Gate dam (RM 189.7). The median value (165 µS/cm) was higher than at Link River, reflecting the increases that occurred in Lake Ewauna, while the range (from 153 to 193 µS/cm) was similar. As a consequence of the changes in SPC at Keno dam, SPC increased from upstream to downstream through the Project area in June, July, and August, and decreased through the Project area from September through November.

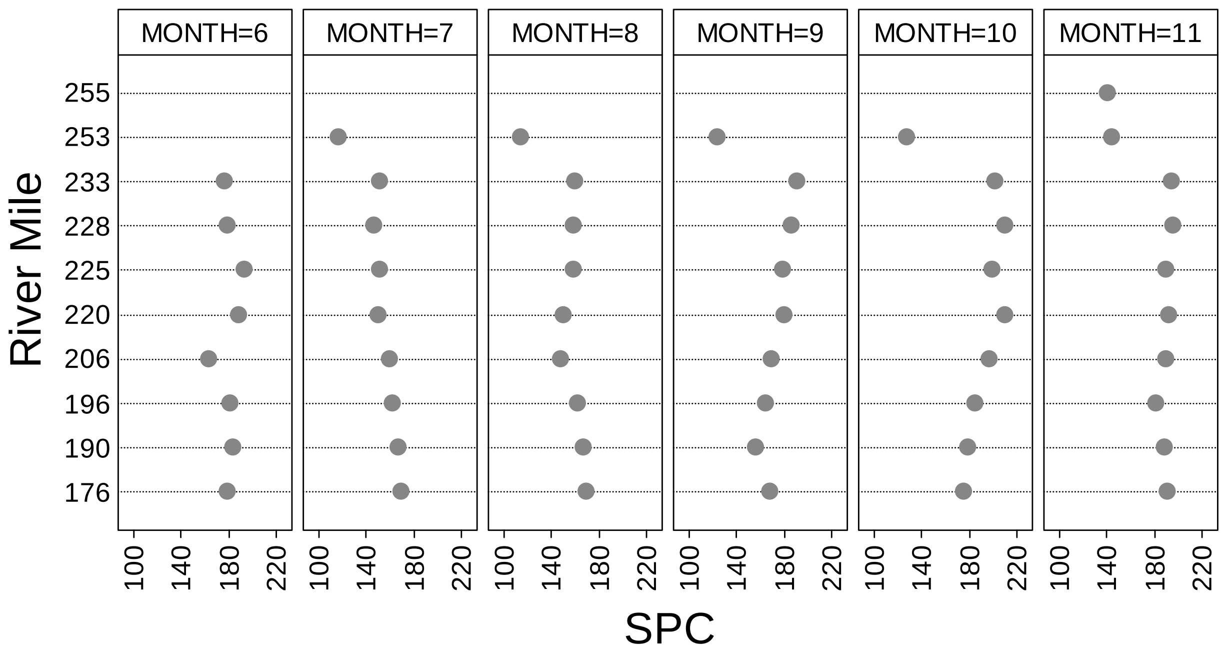


Figure 3-3. Specific conductance values (µS/cm) measured in the field during 2007 in the Klamath River in the vicinity of the Klamath Hydroelectric Project. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River, RM 255 = Upper Klamath Lake at Fremont St Bridge. Specific RMs for these sites are listed in Table 2-1.

Dissolved Oxygen

The box plots for DO (Figure 3-1) indicate that greatest variability (or spread in the data) and lowest median DO value (equal to 84.5 percent saturation) occurred in Klamath River below Iron Gate dam (RM 190). The highest median value (equal to 103.7 percent) and least variability occurred in Klamath River above Copco reservoir (RM 206).

Most of the monthly measurements, illustrated in Figure 3-4, were close to 100 percent saturation for local conditions of temperature and elevation (92 percent of measurements were above 90 percent saturation). DO values in the river below Keno dam (RM 233), below J.C. Boyle powerhouse (RM 220), below the Copco 2 powerhouse (RM 196), and below Iron Gate dam (RM 190) were occasionally less than 100 percent saturation, while DO values in the river above Copco reservoir (RM 206) were mostly slightly greater than 100 percent saturation. DO values generally increased in the river between Iron Gate dam (RM 190) and the I-5 freeway crossing (RM 176).

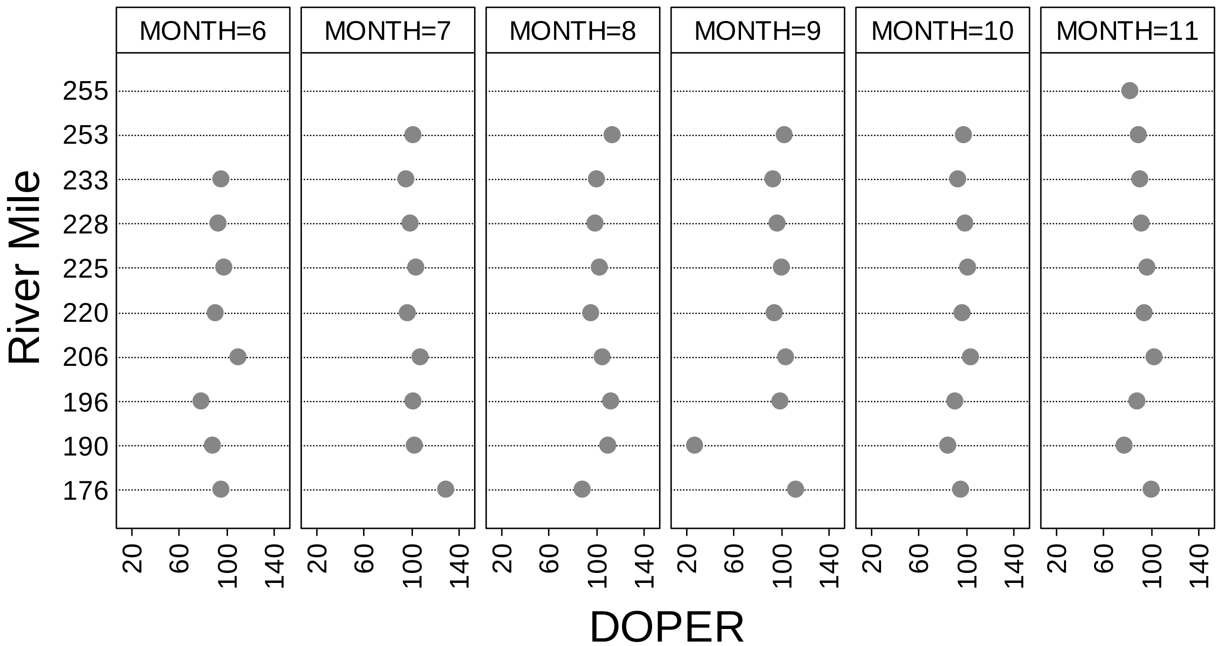


Figure 3-4. Dissolved oxygen values (percent saturation) measured in the field during 2007 in the Klamath River in the vicinity of the Klamath Hydroelectric Project. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River, RM 255 = Upper Klamath Lake at Fremont St Bridge. Specific RMs for these sites are listed in Table 2-1.

pH

The box plots for pH (Figure 3-1) indicate that greatest variability (or spread in the data) and highest median pH value (equal to about 8.7 pH units) occurred in Link River below Upper Klamath Lake (RM 253). The least variability and lowest median values (equal to about 7.6 pH units) occurred in Klamath River below J.C. Boyle dam (RM 225) and below the J.C. Boyle powerhouse (RM 220). The Klamath River is generally a poorly-buffered system, and pH values are typically higher where intense photosynthesis can occur and alter the carbonate balance. The effects of photosynthesis were especially evident at the site in Link River (RM 253), presumably due to phytoplankton blooms and photosynthesis in Upper Klamath Lake.

Monthly measurements of pH are illustrated in Figure 3-5. The highest pH values of the sampling period occurred at the site in Link River (RM 253) in July, August, and September when phytoplankton blooms were occurring in Upper Klamath Lake. pH at river sites below Copco and Iron Gate reservoirs was also influenced by conditions in the reservoirs, but not to the same extent as at Link River. There was evidence of photosynthetic activity effects on pH in the river below Iron Gate dam. At the most downstream site, where the Klamath River crosses I-5 (RM 176), pH was typically higher than at the upstream site just below Iron Gate dam (RM 190).

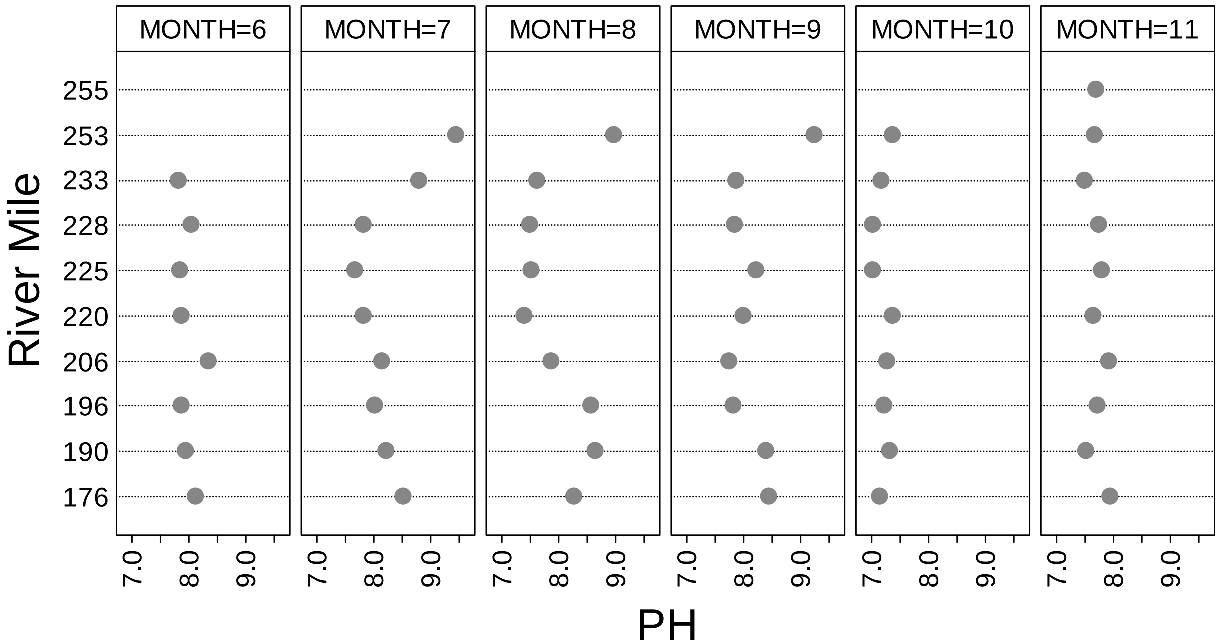


Figure 3-5. pH values (units) measured in the field by PacifiCorp in the Klamath River in the vicinity of the Klamath River hydroelectric project in 2007. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River, RM 255 = Upper Klamath Lake at Fremont St Bridge. Specific RMs for these sites are listed in Table 2-1.

3.1.1.2 Nutrients

Nitrogen

Box plots of ammonia (NH3), nitrate (NO3), and total Kjeldahl nitrogen (TKN) data obtained from river sites during 2007 in the vicinity of the Klamath Hydroelectric Project are shown in Figure 3-6. The data suggest an inverse relationship between NH3 and NO3. For the river sites (not including the J.C. Boyle bypass), the highest median value for NH3 was 0.750 mg/L (as N) below Keno dam (RM 233). The lowest median values for NH3 of 0.020 mg/L (as N) were observed in the river above Copco reservoir (RM 206) and at the I-5 crossing (RM 176). The highest median value for NO3 was 0.82 mg/L (as N) in the river above Copco reservoir (RM 206), and the lowest median value was 0.04 mg/L (as N) below Keno dam (RM 233). The highest median concentration of TKN was 2.30 mg/L (as N) in the river below Keno dam, and the lowest median concentration of TKN was 0.87 mg/L (as N) below Iron Gate dam (RM 190).

Both Total Nitrogen[4] (TN) and Total Inorganic Nitrogen[5] (TIN) decreased longitudinally from Upper Klamath Lake to downstream through the Project area (Figure 3-7). The monthly pattern of concentrations for NH3, NO3, and TKN are shown in Figure 3-8. NH3 concentrations were typically higher upstream and decreased with distance down the river to the site just above Copco reservoir (RM 206). NO3 followed a different pattern with low values occurring at the most upstream stations, and higher values occurring through the J.C. Boyle river reach from below J. C. Boyle reservoir (RM 225) to above Copco reservoir (RM 206). Concentrations of NO3 and TKN were typically lower in the river below Iron Gate dam (RM 190) than above Copco reservoir (RM 206), reflecting the nutrient retention effect of Copco and Iron Gate reservoirs as has been previously documented (PacifiCorp 2006, Kann and Asarian 2007).

Figure 3-9 shows that the seasonal change in total nitrogen and inorganic nitrogen concentrations was particularly variable in the river at Keno dam (RM 233) just upstream of the Project area. Total nitrogen concentration at this site more than doubled between early June and late August 2007, and inorganic nitrogen concentration in November was about seven times greater than the inorganic nitrogen concentration in June.

[4] Total Kjeldahl Nitrogen or TKN is the sum of organic nitrogen and ammonia. In this case, Total Nitrogen (TN) is estimated by adding together the analysis results for TKN and nitrate+nitrite.

[5] In this case, Total Inorganic Nitrogen (TIN) is estimated by adding together the analysis results for ammonia and nitrate+nitrite.

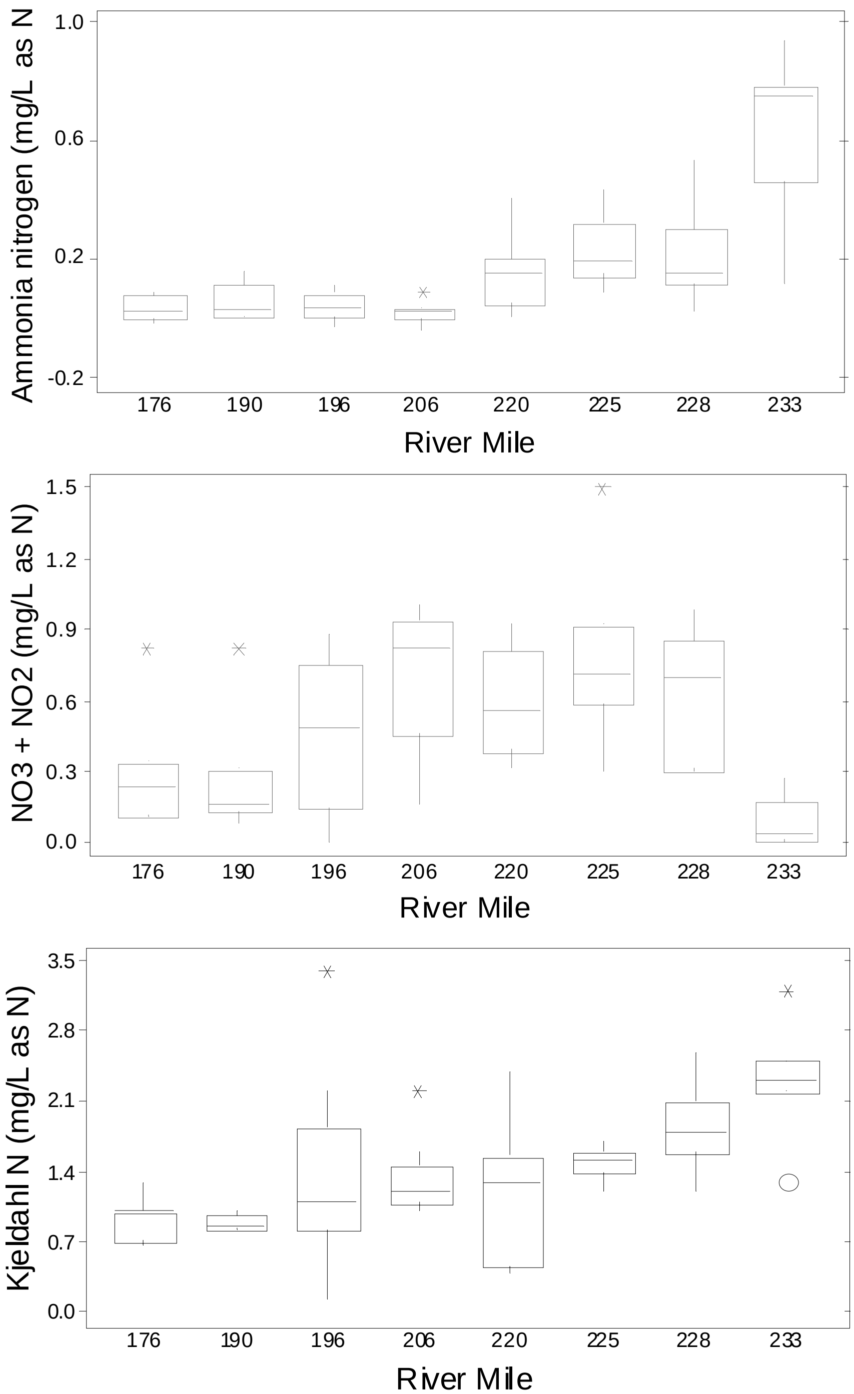


Figure 3-6. Box plots of nitrogen data obtained from river sites during 2007 in the vicinity of the Klamath Hydroelectric Project. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River. Specific RMs for these sites are listed in Table 2-1.

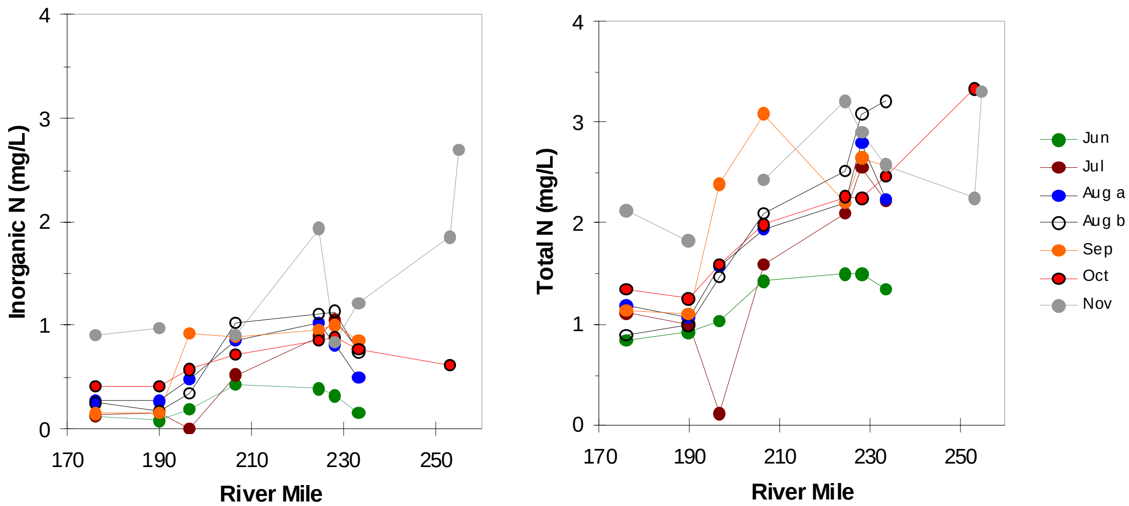


Figure 3-7. Scatter plot showing the change in inorganic and total nitrogen concentration (mg/L as N) by river mile for data collected during 2007 in the vicinity of the Klamath Hydroelectric Project. Particularly high outlier values from November have been eliminated for plotting purposes.

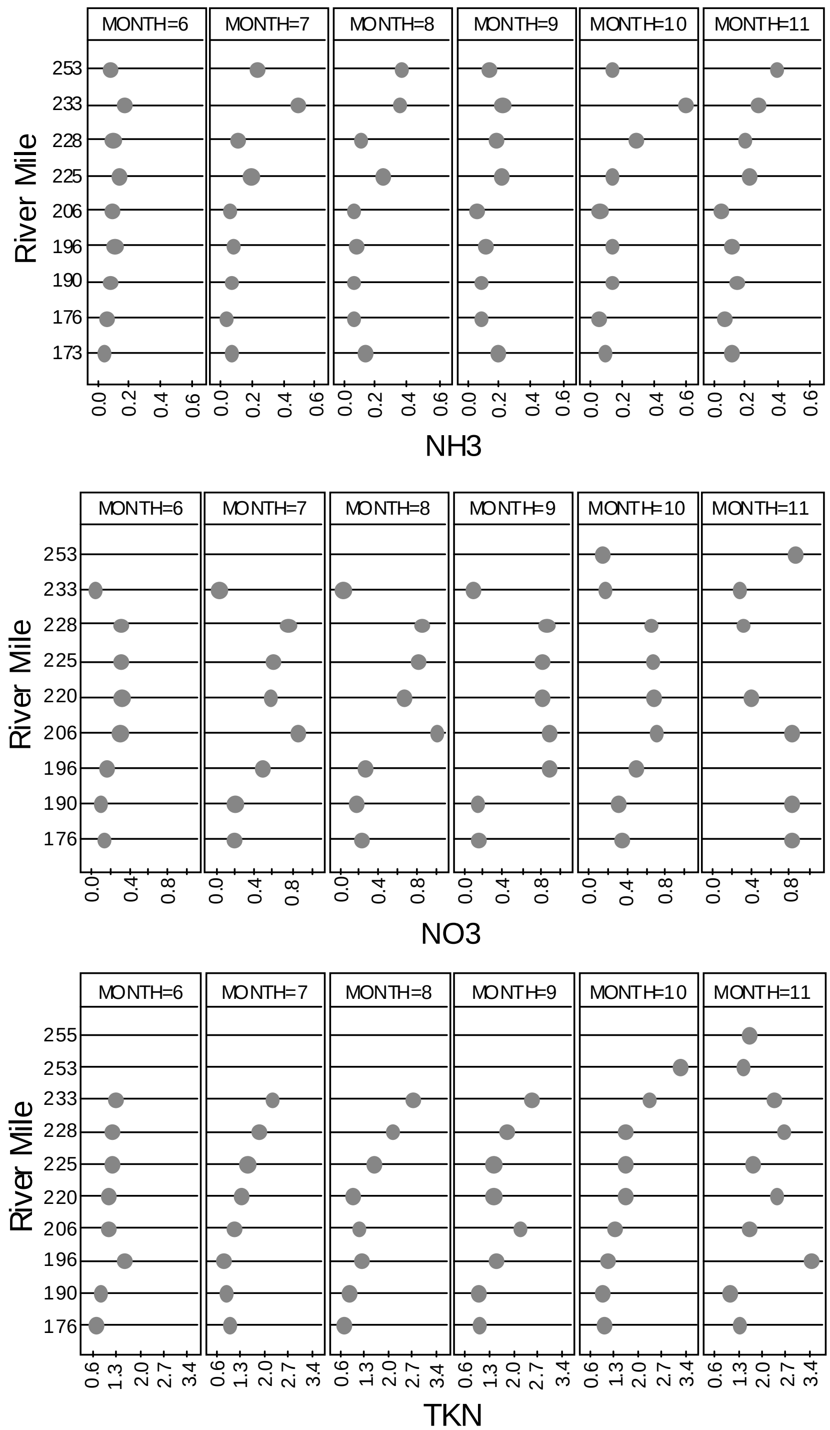


Figure 3-8. Nitrogen data obtained during 2007 in the Klamath River in the vicinity of the Klamath Hydroelectric Project. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River, RM 255 = Upper Klamath Lake at Fremont St Bridge. Specific RMs for these sites are listed in Table 2-1.

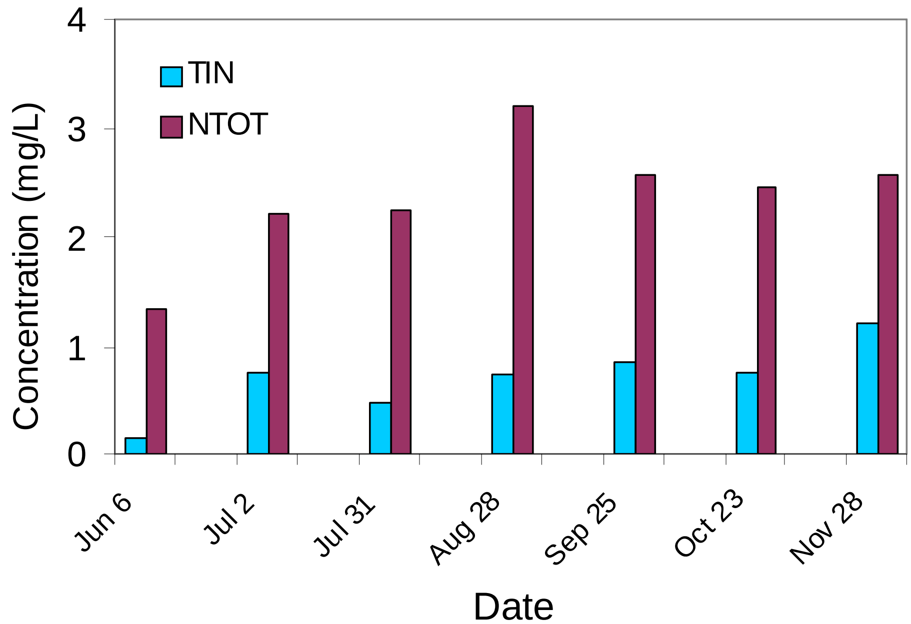


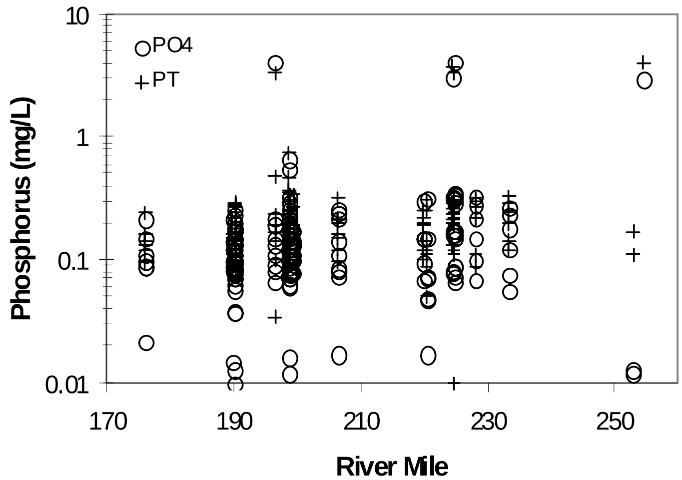
Figure 3-9. Concentrations of total nitrogen and inorganic nitrogen (mg/L as N) for the Klamath River below Keno dam in 2007.

Phosphorus

A scatter plot of total phosphorus (PT) and orthophosphate (PO4) data (upper plot) and box plots of PT data (lower plot) obtained from river sites during 2007 in the vicinity of the Project are shown in Figure 3-10. There was a strong correlation ($r^2 = 0.97$) between PT and PO4 for the sampling sites. The highest median PT concentration of 0.240 mg/L (as P) occurred in the river below Keno dam (RM 233) (Figure 3-10, bottom plot). The highest median PO4 concentration of 0.170 mg/L (as P) occurred in the Klamath River below J. C. Boyle dam (RM 225) (Table 3-1). The lowest median concentrations for PT of 0.140 mg/L and PO4 of 0.095 mg/L both occurred in the river below Iron Gate dam (RM 190) (Figure 3-10, bottom plot; Table 3-1).

Higher values for PT and PO4 generally occurred at the river sites upstream of the Project area (Figure 3-10, bottom plot; Table 3-1), notably the river at the mouth of Link River (RM 253), the river below Keno dam (RM 233), and the river below J.C. Boyle dam (RM 228). These same sites had high values for total suspended solids (TSS), suggesting that the phosphorus is associated with particulate matter in the samples.

Figure 3-11 (top plot) shows that the seasonal change in PT and PO4 concentrations was particularly variable in the river at Keno dam (RM 233) just upstream of the Project area. PT concentration below Keno dam (RM 233) increased 67 percent from early June to late August. This increase is tracked by corresponding increases in PT downstream through the Project area (Figure 3-11, bottom plot). The data indicate that PT concentration was relatively high at Keno dam, and decreased with distance downstream throughout the year (although the changes were relatively small in October and November).



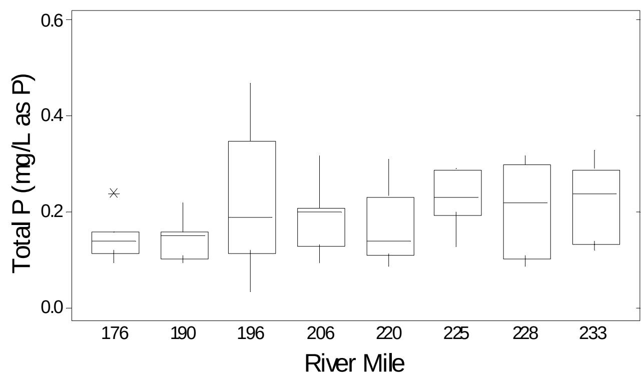
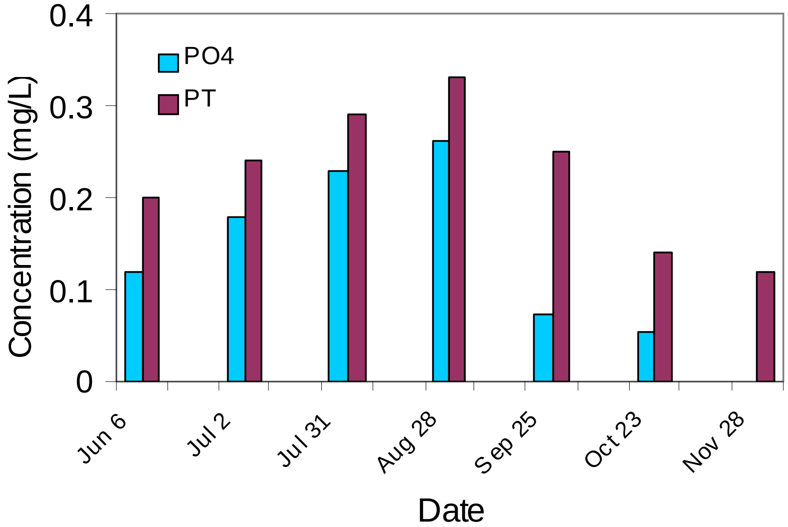


Figure 3-10. Scatter plot of PT and PO4 data (upper plot) and box plots of PT data (lower plot) obtained during 2007 in the vicinity of the Klamath Hydroelectric Project. Extreme values have been removed from the boxplot to more clearly delineate the distribution. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River, RM 255 = Upper Klamath Lake at Fremont St Bridge. Specific RMs for these sites are listed in Table 2-1.



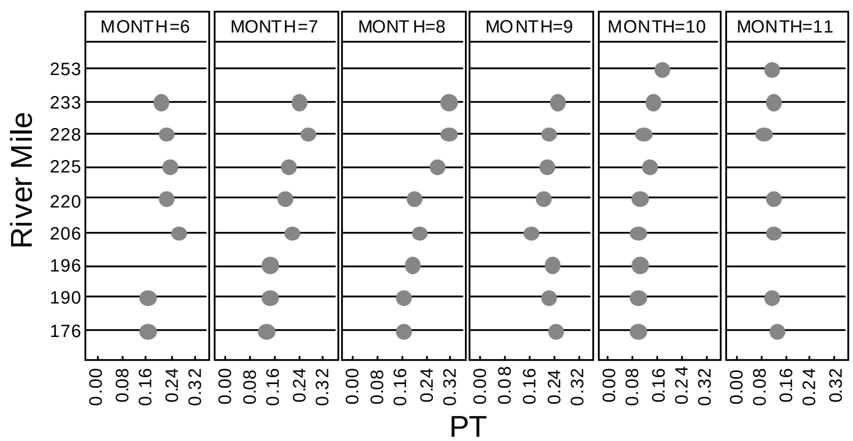


Figure 3-11. Top: Phosphorus concentrations measured in 2007 below Keno dam (RM 233) on the Klamath River. Bottom: Total phosphorus (PT) concentrations measured in the Klamath River in 2007. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River, RM 255 = Upper Klamath Lake at Fremont St Bridge. Specific RMs for these sites are listed in Table 2-1.

3.1.1.3 Particulate and Organic Matter

Figure 3-12 shows scatter plots (top plot) and box plots (middle and bottom plot) of dissolved organic carbon (DOC) and total suspended solids (TSS) measured in 2007. Median values for DOC, TSS, and volatile suspended solids (VSS) measured in 2007 at river sites are also listed in Table 3-1.

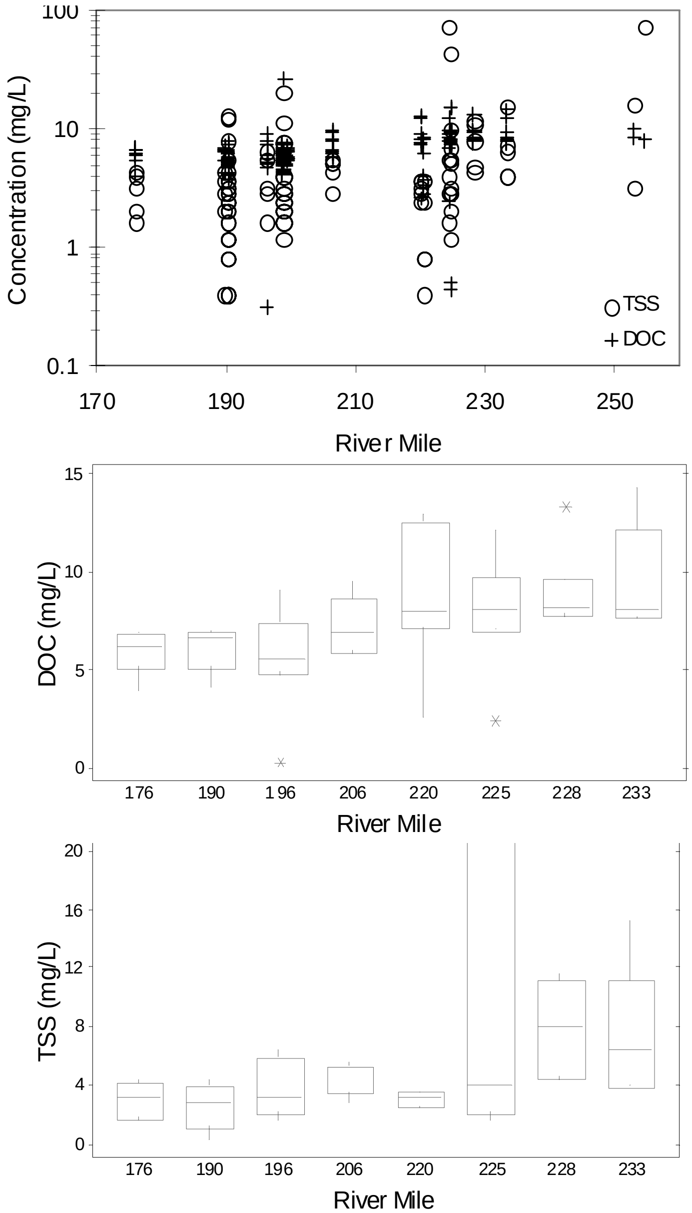


Figure 3-12. Top: Total suspended solids (TSS) and dissolved organic carbon (DOC) concentrations measured in the Klamath River in 2007. Middle: Boxplot showing the distribution of DOC values measured in the Klamath River in 2007. Bottom: Boxplot showing the distribution of TSS values measured in the Klamath River in 2007. The box at RM 225 extends beyond the scale of the graph because of a few high outlier values. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River. Specific RMs for these sites are listed in Table 2-1.

The highest median values for both TSS and VSS in the river were observed at the downstream end of the Keno reach just above J. C. Boyle reservoir (RM 228) (Table 3-1). The lowest median value for TSS was observed below Iron Gate dam (RM 190), and the lowest median value for VSS was observed below the Copco 2 powerhouse (RM 196). TSS values tended to be higher in the portion of the river above J. C. Boyle dam (RM 225), with less change at downstream sites (Figure 3-12). The highest median DOC value (8.2 mg/L) in the river was observed at the downstream end of the Keno reach just above J. C. Boyle reservoir (RM 228), but was only slightly higher than the median value (8.1 mg/L) at Keno dam (RM 233) (Table 3-1). The lowest median DOC value (5.6 mg/L) was observed below Copco 2 powerhouse (RM 196).

Figure 3-13 (top plot) shows that the seasonal change in DOC and TSS concentrations was quite variable in the river at Keno dam (RM 233) just upstream of the Project area. DOC concentration below Keno dam (RM 233) increased from 8 to 14 mg/L from early June to late August, and then decreased steadily through November (Figure 3-13, top plot). DOC showed a consistent trend in all months, in that the highest values were at the upstream stations and consistently decreased in concentration with distance downstream (Figure 3-13, bottom plot).

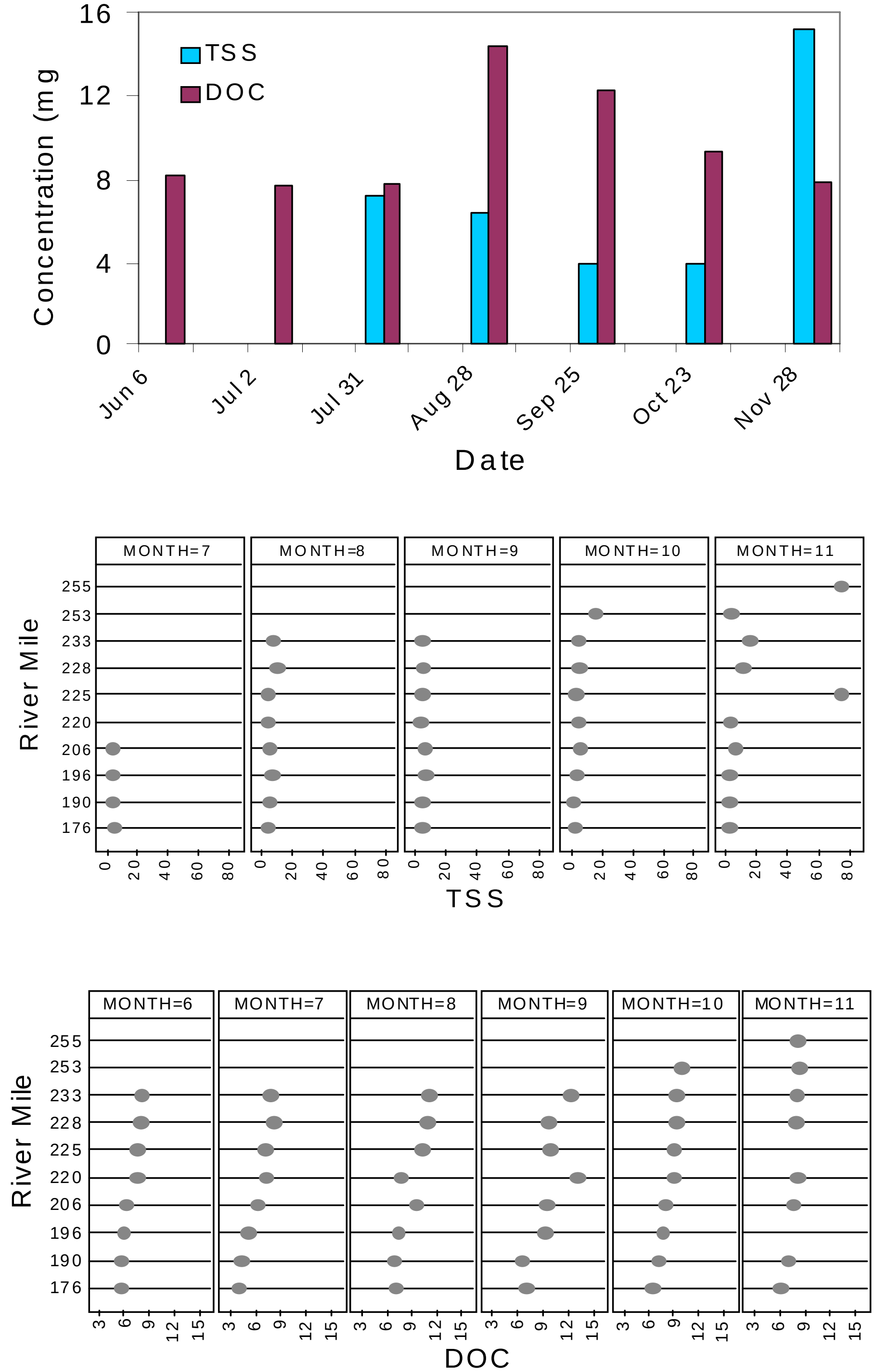


Figure 3-13. Top: Total suspended solids (TSS) and dissolved organic carbon (DOC) concentrations measured below Keno dam (RM 233) in the Klamath River in 2007. Middle: TSS values measured in the Klamath River in 2007. Bottom: DOC values measured in the Klamath River in 2007. For plotting purposes, these graphs use approximate site locations as follows: RM 176 = Klamath River (KR) at I-5 crossing, RM 190 = KR below Iron Gate dam, RM 196 = KR below Copco 2 powerhouse, RM 206 = KR above Copco reservoir, RM 220 = KR below J.C. Boyle powerhouse, RM 225 = KR below JC Boyle dam, RM 228 = KR above JC Boyle reservoir, RM 233 = KR below Keno dam, RM 253 = mouth of Link River. Specific RMs for these sites are listed in Table 2-1.

3.2 COPCO AND IRON GATE RESERVOIRS SITES

3.2.1 Summary of Water Quality Conditions

Water quality conditions in Copco reservoir at the log boom (RM 198.7) and Iron Gate reservoir at the log boom (RM 190.2) are summarized in Table 3-2. The values listed in Table 3-2 are median values for all measurements taken from the reservoirs during 2007 from multiple depths at 8 m intervals. More detailed summary statistics are provided in Appendix A.

Table 3-2. Median values for water quality constituents in Copco reservoir at the log boom (RM 198.7) and Iron Gate reservoir at the log boom (RM 190.2) in 2007.

Depth	DOC	DOPER	NH3	NO3	pH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
m	mg/L	% sat	mg/L	mg/L	unit	mg/L	mg/L	µS/cm	ºC	mg/L	mg/L	mg/L
Copco Reservoir												
1	5.1	82.4	0.044	0.06	6.5	0.01	0.08	158	7.2	0.90	1.2	-0.4
8	6.2	88.4	0.047	0.28	7.8	0.11	0.17	170	19.4	1.06	2.0	1.0
16	6.4	48.6	0.068	0.52	7.2	0.13	0.19	181	15.6	1.00	2.8	0.6
24	6.3	7.2	0.120	0.12	7.0	0.13	0.19	188	10.8	1.10	2.8	1.2
30	5.9	45.2	0.041	0.57	7.6	0.17	0.28	215	9.0	1.27	4.6	2.4
Iron Gate Reservoir												
1	6.3	115.0	0.009	0.04	8.5	0.08	0.14	173	20.9	1.00	8.0	8.0
8	6.1	67.0	0.043	0.30	7.5	0.10	0.16	171	19.5	0.87	2.8	0.8
16	5.4	46.3	0.032	0.34	7.1	0.09	0.17	186	13.6	0.73	1.6	0.2
24	5.3	33.8	0.028	0.48	7.2	0.13	0.14	193	8.1	0.75	1.2	0.8
32	4.9	9.7	0.063	0.86	7.1	0.12	0.13	205	6.1	0.90	1.2	0.4
40	5.0	1.9	0.130	0.60	7.1	0.13	0.14	215	5.9	0.75	2.8	1.2

The depths sampled in the reservoirs were chosen to provide information about conditions in different strata when the reservoirs are thermally stratified. In addition to representing different depths, the strata at these depths also represent different fractions of the reservoir volumes. As such, the sample results at various depths should not be viewed equally as to the potential effects of reservoir releases on conditions in the Klamath River downstream of the reservoirs. For example, depths below 20 m comprise less than 12 percent of the volume of Iron Gate reservoir, and only approximately 0.02 percent of the volume of Copco reservoir. By comparison, the top 12 meters contain 68 percent of the volume of Iron Gate reservoir, and 99 percent of the volume of Copco reservoir.

3.2.1.1 Water Temperature, Specific Conductance, Dissolved Oxygen, and pH

Temperature

Temperature conditions during 2007 in Copco and Iron Gate reservoirs were consistent with observations from previous years (PacifiCorp 2004a, 2004b, PacifiCorp 2006, PacifiCorp 2007b, 2007c). Thermal stratification was well-established in both Copco and Iron Gate reservoirs in June and continued throughout the summer and early fall (Figure 3-14). The eventual return to isothermal (non-stratified) conditions occurred at different times in the two reservoirs. Copco reservoir was nearly isothermal by late October. Although the depth of mixing in Iron Gate increased markedly in October, the reservoir retained some thermal stratification until about the end of November.

The relatively gradual gradient of the temperatures below about 3-4 m depth in Copco reservoir and 4-6 m in Iron Gate reservoir indicates that wind-driven mixing was not particularly strong relative to the thermal resistance to mixing of the stratified water density profile. Inflections in the temperature profile at about 2 m in Copco reservoir and at 3-4 m in Iron Gate reservoir suggest the influence of wind-driven mixing. Other inflections in the profiles at 7-8 m in Copco reservoir and 10-12 m in Iron Gate reservoir are more likely the result of thermal density currents from river inflow.

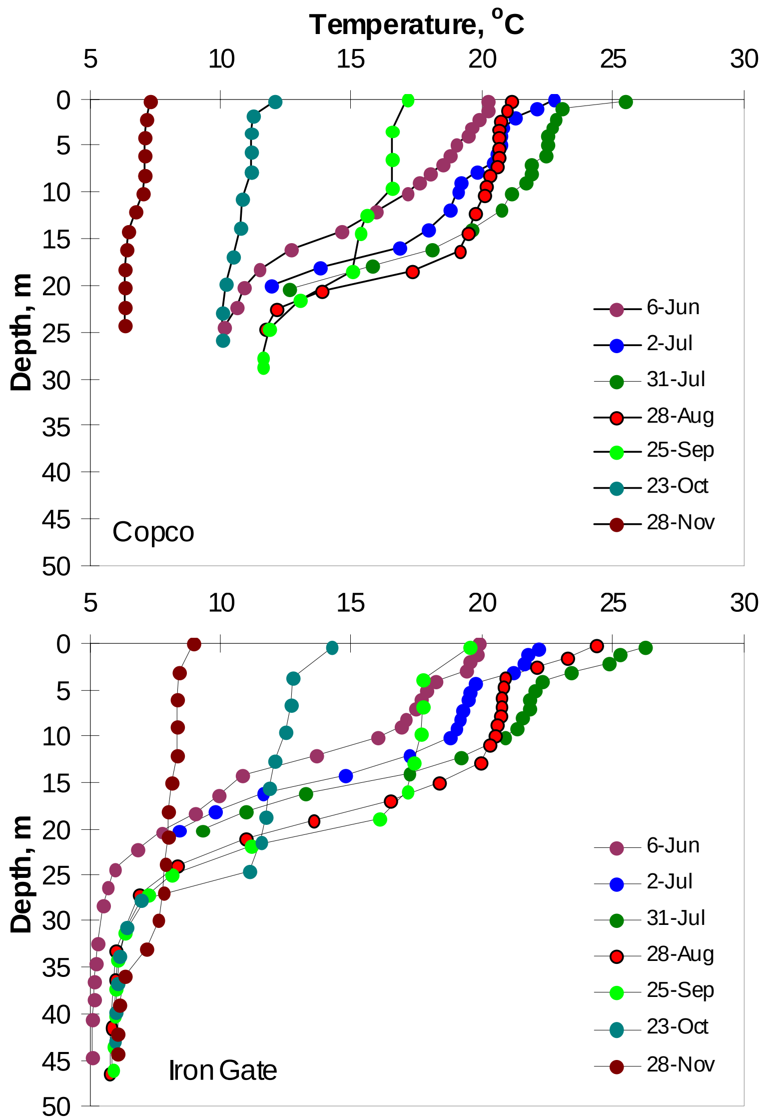


Figure 3-14. Temperature profiles measured in Copco reservoir at the log boom (top plot) and Iron Gate reservoir at the log boom (bottom plot) in 2007

Specific Conductance

SPC in Copco and Iron Gate reservoirs varied appreciably during the sampling period (Figure 3-15), and represents the effect of conditions of the inflowing water to Copco and Iron Gate reservoirs. As previously described in section 2.2.1.2, SPC varied substantially in the Klamath River entering the Project area below Keno dam. For example, monthly changes in SPC measurements at Keno dam (RM 233) were reflected in changes in SPC in both Copco and Iron Gate reservoirs (Figure 3-15). However, the change in SPC was not confined to the surface, or distributed evenly throughout the reservoirs, but rather affected specific strata. For example, during summertime thermal stratification, the inflowing water from the Klamath River was distributed to different depths in Copco reservoir depending on its temperature, because the temperature of inflowing water to the reservoir varies considerably over a 24-hour cycle.

In Iron Gate reservoir, the inflowing water was at a more constant temperature because the discharge into Iron Gate comes from about 10 m depth in Copco reservoir, and therefore the temperature was relatively constant on a daily basis. That, plus the greater volume of the hypolimnion in Iron Gate, produced a more moderate response to changes in SPC from upstream.

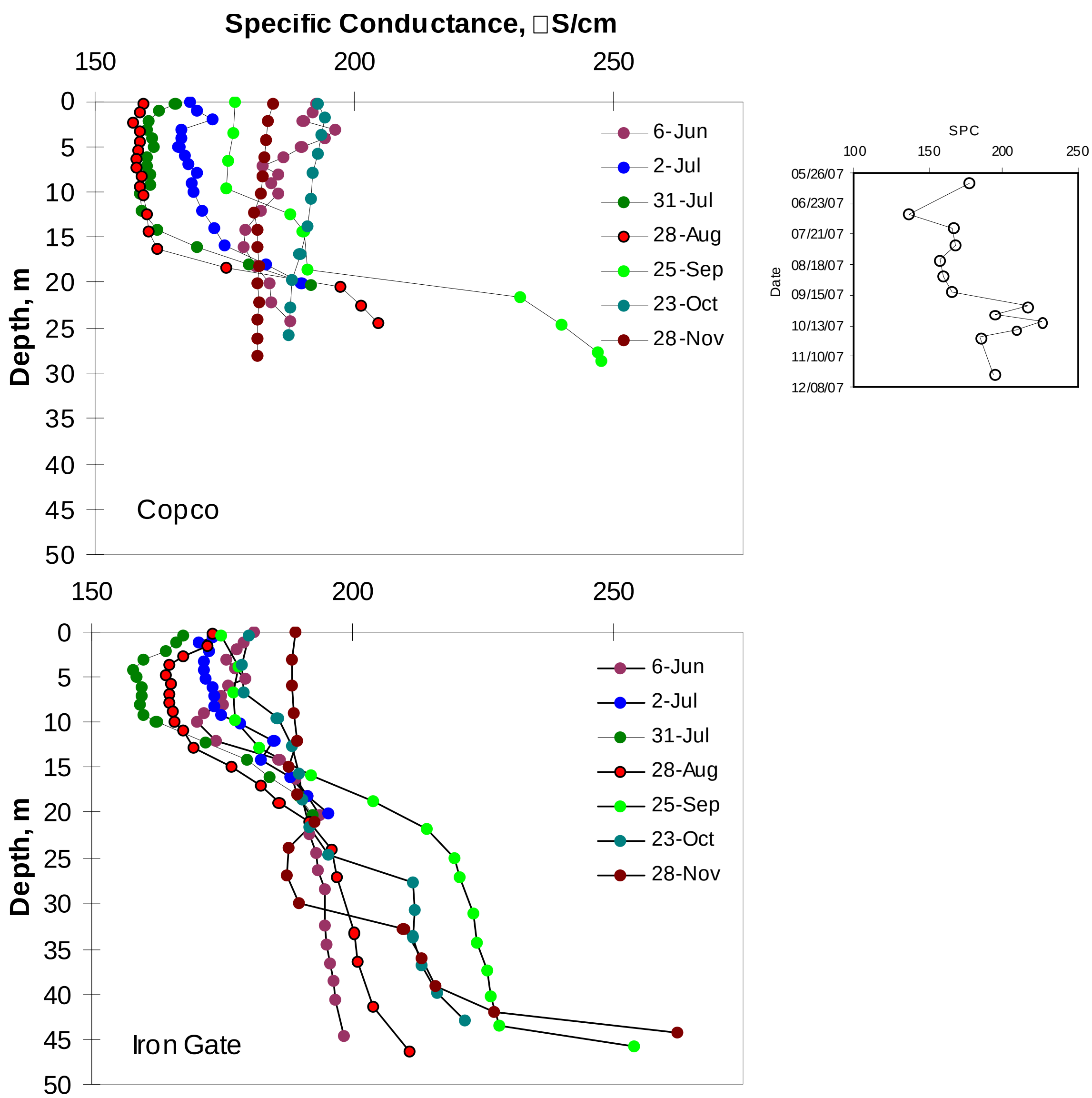


Figure 3-15. Vertical profiles of specific conductance (SPC) measured in Copco reservoir at the log boom (top plot) and Iron Gate reservoir at the log boom (bottom plot) in 2007. The accompanying graph shows the seasonal changes in SPC as measured below Keno dam (RM 233).

Dissolved Oxygen

DO conditions during 2007 in Copco and Iron Gate reservoirs were consistent with observations from previous years (PacifiCorp 2004a, 2004b, PacifiCorp 2006, PacifiCorp 2007b, 2007c). During summer, when thermal stratification isolated the deeper water of the reservoirs from the atmosphere, the hypolimnion of both Copco and Iron Gate reservoirs became depleted of DO as a result of respiration and oxidative processes occurring at depth. At the same time, the surface waters of the reservoirs were frequently supersaturated with DO as a result of primary production (photosynthesis by algae) near the surface (Figure 3-16). For example, Copco reservoir was at or above 100 percent saturation above approximately 5 m depth throughout the period of thermal stratification. However, Copco reservoir was depleted of DO below about 15 m by early July, and remained so into September. As thermal stratification subsequently dissipated by late October, the reservoir returned to a well-mixed condition in which DO was at 100 percent saturation throughout the reservoir's depth.

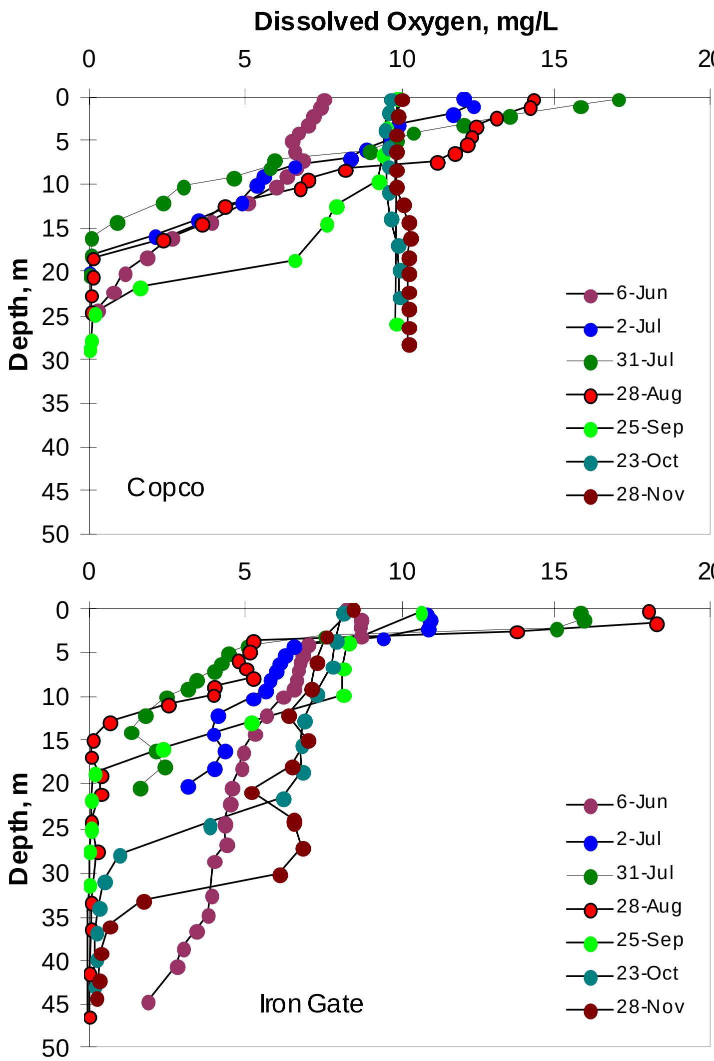


Figure 3-16. Vertical profiles of dissolved oxygen concentration measured in Copco reservoir at the log boom (top plot) and Iron Gate reservoir at the log boom (bottom plot) in 2007.

A similar pattern was observed in Iron Gate reservoir during 2007, but with some differences. DO depletion did not occur as soon as in Iron Gate reservoir. For example, in June, DO in Copco reservoir was absent below about 25 m, while Iron Gate reservoir retained measureable DO to the bottom at 45 m. However, DO was nearly absent from Iron Gate reservoir by late August at depths greater than 15 m. By comparison, as in Copco reservoir, DO was at or above 100 percent saturation in the top 3 m of Iron Gate reservoir throughout the stratification period as a result of primary production near the surface.

Unlike Copco reservoir, DO saturation in Iron Gate reservoir at depths between approximately 5 and 10 m did not exceed 100 percent saturation, but instead fluctuated in the range of 75-80 percent saturation. Also, although Copco reservoir was saturated with DO by late October, DO in the hypolimnion of Iron Gate reservoir remained absent into November. The November DO profile in Iron Gate reservoir shows a "bulge" in DO between 20 and 30 m depth, presumably the result of interflow of higher DO water entering the reservoir.

pH

The Klamath River system is well-documented to be weakly buffered (PacifiCorp 2004b, 2006, 2008b). Therefore, higher pH values between 8.0 and 9.0 near the surface in both reservoirs in June through September showed sensitivity to the effects of primary production (photosynthesis by algae) (Figure 3-17). Except for August, pH at depths below 5 m in Iron Gate did not exceed 8.0. In Copco reservoir, higher pH values extended deeper in the reservoir, with pH values of around 8.0 observed as deep as 15 m in September. At depths greater than approximately 20 m in both reservoirs, pH was mostly circumneutral near 7.0. As thermal stratification subsequently dissipated by November, the reservoirs returned to a well-mixed condition in which pH was generally uniform with depth.

Values for pH in the reservoirs also appeared to respond to changes in upstream values. For example, circumneutral pH values near 7.0 in Copco reservoir in October (Figure 3-17, top plot) correspond to the similarly circumneutral pH values measured in the river sites upstream in October (Figure 3-4, Month 10). The September pH profile in Iron Gate reservoir shows a "bulge" in pH from about 20 m depth to the bottom that corresponds to the increased SPC also concurrently observed at depth, and may have been caused by plunging river inflow at that time.

3.2.1.2 Nutrients

Nitrogen

Overall median concentrations of NH3, TKN, and TN[6] were greater in Copco reservoir (0.137, 1.16, and 1.59 mg/L as N, respectively) than in Iron Gate reservoir (0.086, 0.89, and 1.36 mg/L as N, respectively) (Table 3-1). In contrast, overall median concentrations of NO3 and TIN were slightly less in Copco reservoir (0.035 and 0.49 mg/L as N, respectively) than in Iron Gate reservoir (0.047 and 0.56 mg/L as N, respectively).

Box plots showing the vertical distribution of NH3, NO3, TIN[7], and TN measured in Copco reservoir at the log boom (RM 198.7) and Iron Gate reservoir at the log boom (RM 190.2) during 2007 are shown in Figure 3-18. Concentration of these nitrogen species varied with depth in both reservoirs. The median of NH3 concentrations generally increased with depth in both reservoirs. The median of NO3 and TIN concentrations also generally increased with depth in both reservoirs, except in the bottom-most strata where NO3 and TIN concentrations were reduced compared to the overlying strata.

Concentration of these nitrogen species not only varied with depth, but also over the months of sampling (Figure 3-19). NH3 concentrations in Copco reservoir exhibited a distinct seasonal

[6] Total Nitrogen (TN) is estimated by adding together the analysis results for TKN and nitrate+nitrite.

[7] Total Inorganic Nitrogen (TIN) is estimated by adding together the analysis results for NH3 and NO3+NO2.

increase in concentration at depth that was largely missing from Iron Gate. Other than the increase in concentration at depth, seasonal changes in NH3 concentration in Copco reservoir were relatively minor. NH3 concentration in Iron Gate reservoir fluctuated with depth, but increased through the summer at most depths. NO3 concentration increased substantially in both reservoirs in the fall. The increase in Iron Gate reservoir was not as great, and was observed about one month later than in Copco reservoir.

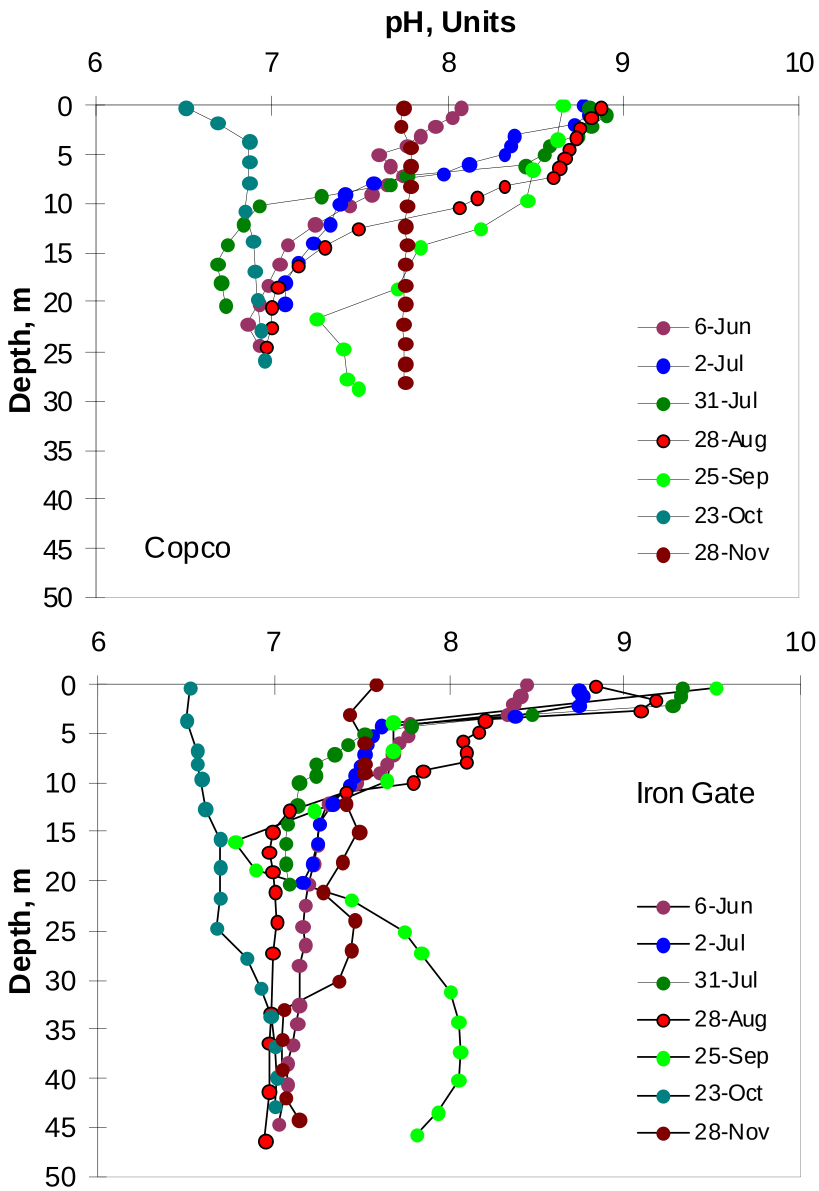


Figure 3-17. Vertical profiles of pH measured in Copco reservoir at the log boom (top plot) and Iron Gate reservoir at the log boom (bottom plot) in 2007.

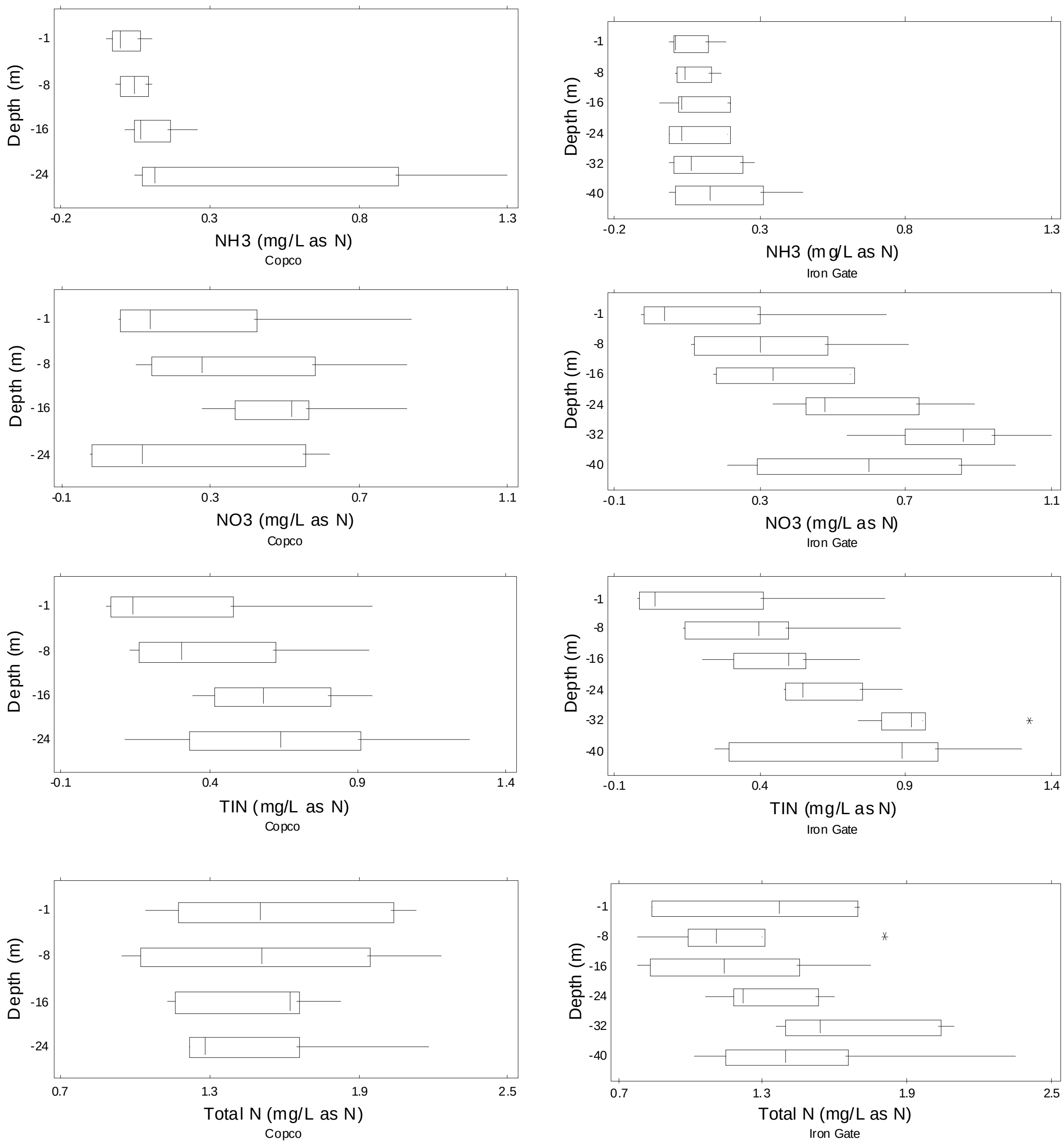


Figure 3-18. Box plots showing the vertical distribution of nitrogen species measured in Copco reservoir at the log boom (left side plots) and Iron Gate reservoir at the log boom (right side plots) in June through November 2007.

Both reservoirs showed a pattern of summertime increase in TKN concentration near the surface (Figure 3-19). The pattern was more pronounced in Iron Gate reservoir. There was a noticeable peak in TKN concentration in Copco reservoir in September at 24 m depth. TIN increased with depth in both reservoirs throughout the period of stratification, and increased in the surface layer in September through November in both reservoirs. TN increased in the surface layer of both reservoirs through the summer, and increased at all depths in September through November.

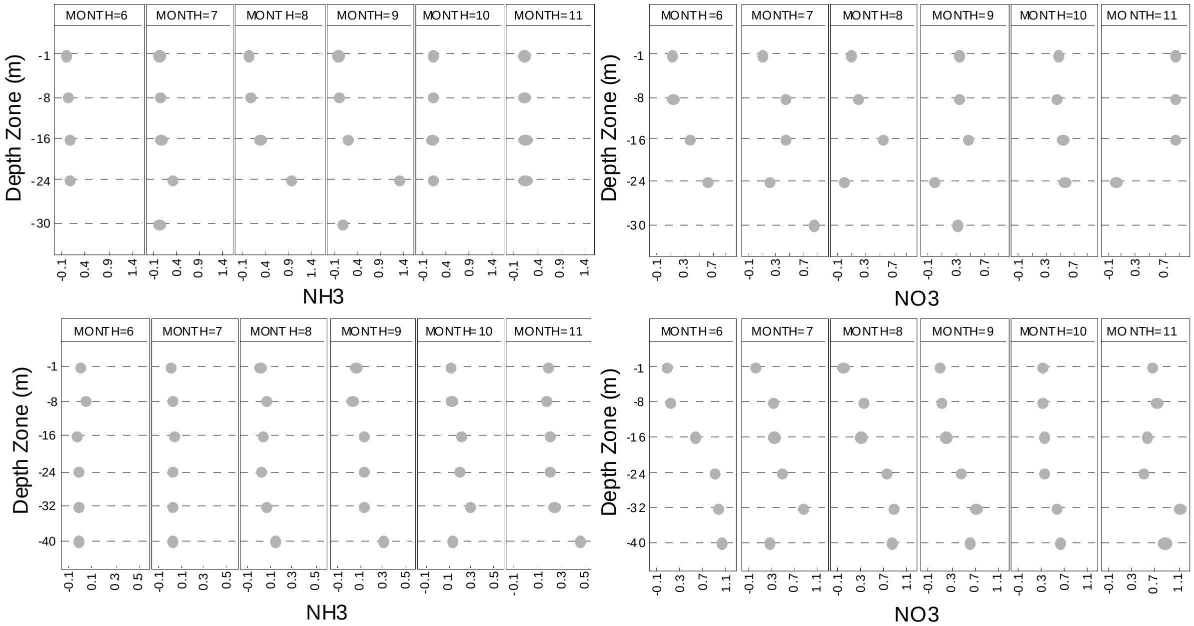


Figure 3-19. Plots depicting the concentrations of ammonia (NH3) and nitrate (NO3) nitrogen measured at various depths in Copco reservoir at the log boom (top plots) and Iron Gate reservoir at the log boom (bottom plots) in 2007.

Phosphorus

Overall median concentration of PT was greater in Copco reservoir (0.205 mg/L as P) than in Iron Gate reservoir (0.115 mg/L as P) (Table 3-1). Similarly, overall median concentration of PO4 was greater in Copco reservoir (0.152 mg/L as P) than in Iron Gate reservoir (0.115 mg/L as P).

Box plots showing the vertical distribution of PT and PO4 measured in Copco reservoir at the log boom (RM 198.7) and Iron Gate reservoir at the log boom (RM 190.2) during 2007 are shown in Figure 3-20. Concentrations of PT and PO4 varied with depth in both reservoirs. Concentrations of PT and PO4 not only varied with depth, but also over the months of sampling (Figure 3-21). The pattern of variation in concentration of PO4 and PT in Copco reservoir was nearly identical, with an increase in concentration at 24 m depth in August and September, but relatively constant concentration at other depths and other months. The patterns of change in PO4 in Iron Gate reservoir were similar to those of PT, but they diverged in August and September. PO4 concentration at 8-16 m depth in Iron Gate reservoir increased relative to PT concentration in August. In September, PO4 at depths above 24 m decreased while PT increased.

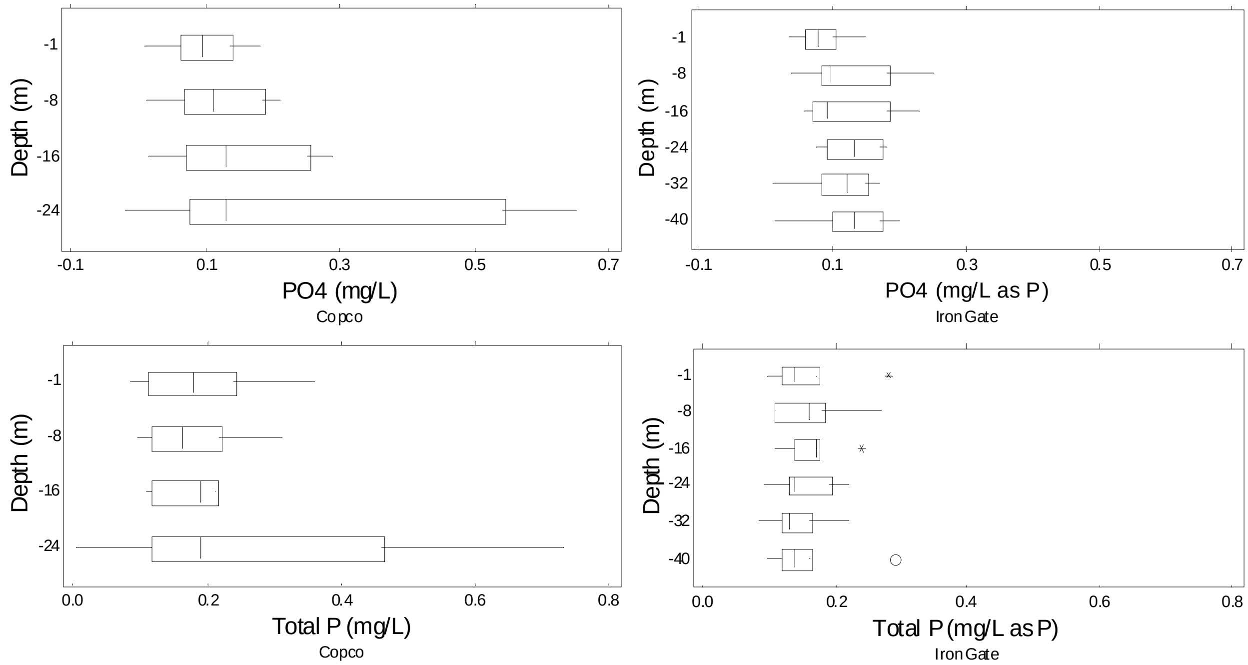


Figure 3-20. Box plots showing the vertical distribution of orthophosphate (PO4) and total phosphorus (PT) measured in Copco reservoir at the log boom (left side plots) and Iron Gate reservoir at the log boom (right side plots) in 2007.

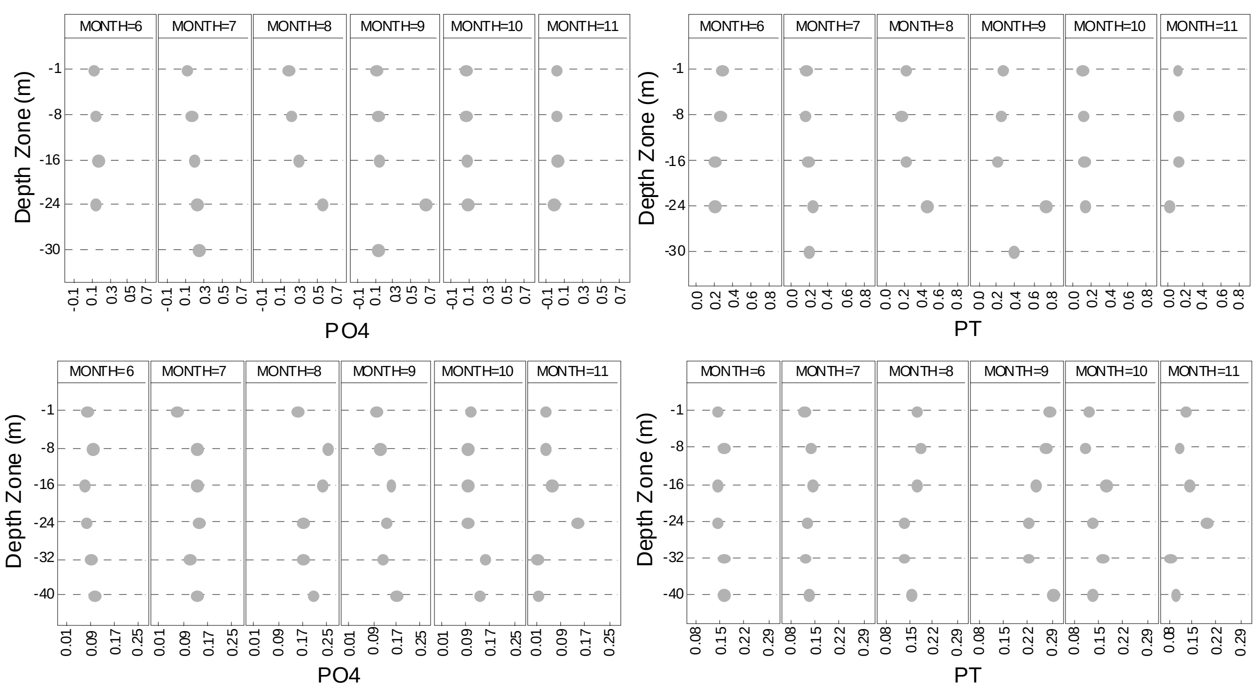


Figure 3-21. Plots depicting the concentrations of PO4 and PT measured at various depths in Copco reservoir at the log boom (top plots) and Iron Gate (bottom) reservoir at the log boom (bottom plots) in 2007.

3.2.1.3 Particulate and Organic Matter

Overall median concentrations particulate and organic matter parameters were greater in Copco reservoir than in Iron Gate reservoir. The median concentrations of TSS, VSS, and DOC in Copco reservoir (4.1 mg/L, 2.7 mg/L, and 6.2 mg/L, respectively) were higher than the concentrations in Iron Gate reservoir (2.9 mg/L, 1.8 mg/L, and 6.4 mg/L, respectively) (Table 3-1).

Box plots showing the vertical distribution of DOC and TSS measured in Copco and Iron Gate reservoirs during 2007 are shown in Figure 3-22. Concentrations of DOC and TSS varied with depth in both reservoirs, with the higher values occurring nearest the surface.

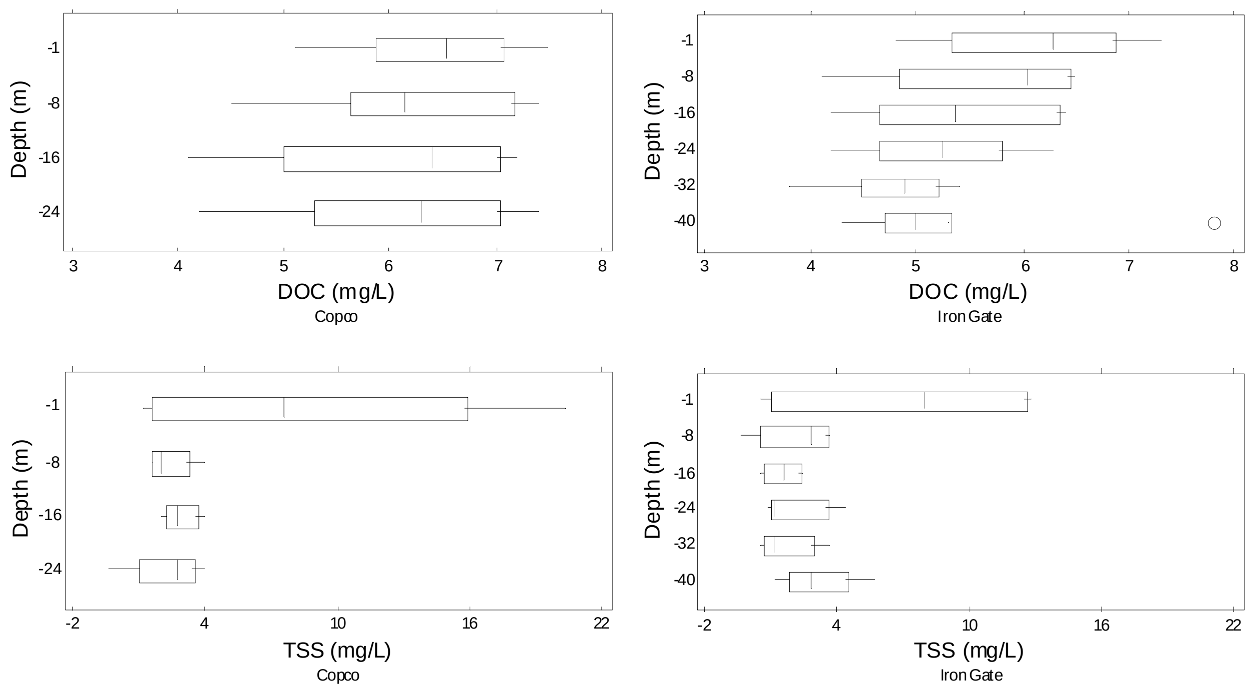


Figure 3-22. Boxplots showing the vertical distribution of dissolved organic carbon (DOC) and total suspended solids (TSS) measured in Copco reservoir at the log boom (top plots) and Iron Gate reservoir at the log boom (bottom plots) in 2007.

Concentrations of DOC and TSS not only varied with depth, but also over the months of sampling (Figure 3-23). TSS and VSS were higher near the surface in July through September in both reservoirs. In October and November, when the thermal density gradient was eroding, the concentrations of TSS and VSS became more uniform vertically. The pattern for DOC showed some similarities to those for TSS and VSS, but the vertical variation was not as large. The overall concentration of DOC tended to increase through the year in both Copco and Iron Gate.

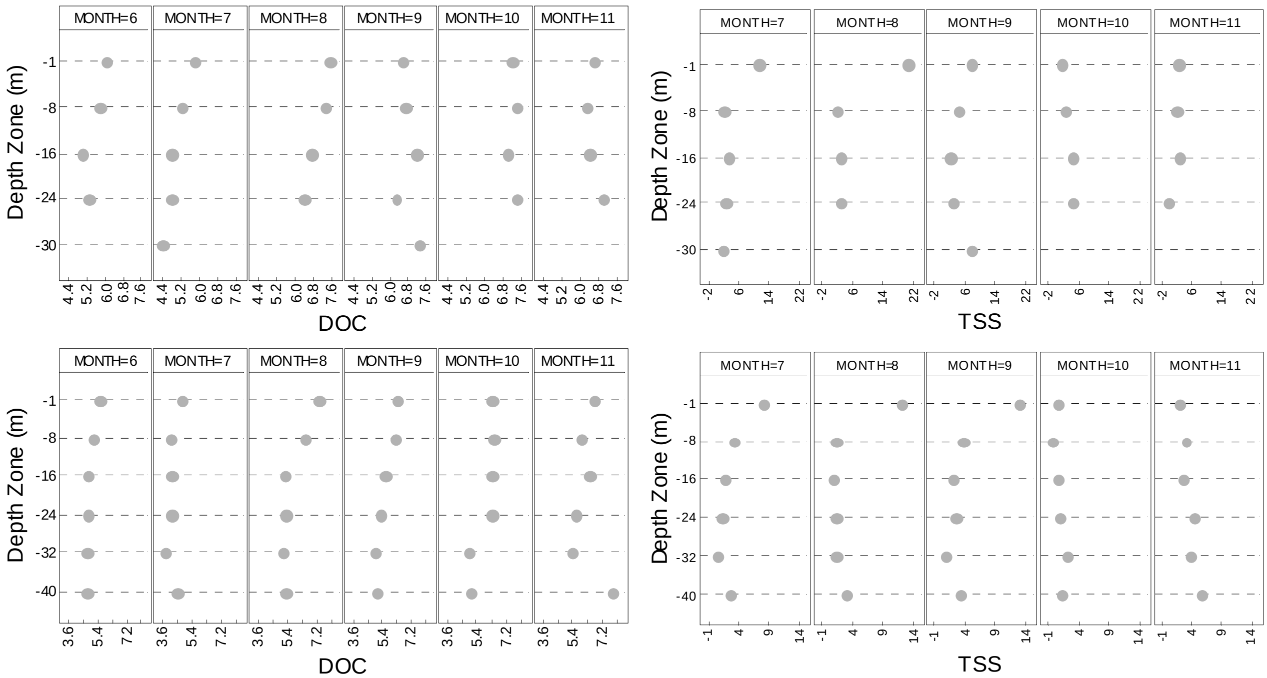


Figure 3-23. Plots depicting the concentrations of dissolved organic carbon (DOC) and total suspended solids (TSS) measured at various depths in Copco reservoir at the log boom (top plots) and Iron Gate reservoir at the log boom (bottom plots) in 2007.

3.3 GENERAL TRENDS IN 2007 RESULTS AND COMPARISON TO PREVIOUS YEARS

As shown in Figure 3-24, water quality data collected in 2007 from the Klamath River in the vicinity of the Project show a general improvement in water quality as water passes through the Project area. Suspended solids, total nitrogen, inorganic nitrogen, and phosphorus all decrease from above the Project at Keno dam to below Iron Gate dam (although some high values for total phosphorus obscure somewhat the pattern of decreasing concentration with travel downstream). Results of previous water quality sampling in 2000 through 2005 show the same overall pattern (Figure 3-24).

The major influence on water quality in the Project reservoirs is the quality of the water entering the Project area from upstream. The Klamath River is eutrophic with high concentrations of nitrogen and phosphorus that originate in Upper Klamath Lake and in the tributaries entering Keno reservoir. The high nutrient concentrations support abundant algal growth which, combined with the low buffering capacity of the river water, can result in high pH values, sometimes exceeding 9.0. Changes in water quality in the inflowing water primarily determine the water quality conditions in Copco and Iron Gate reservoirs, although the specifics of the effect are modified by conditions, such as thermal stratification, within the reservoirs themselves.

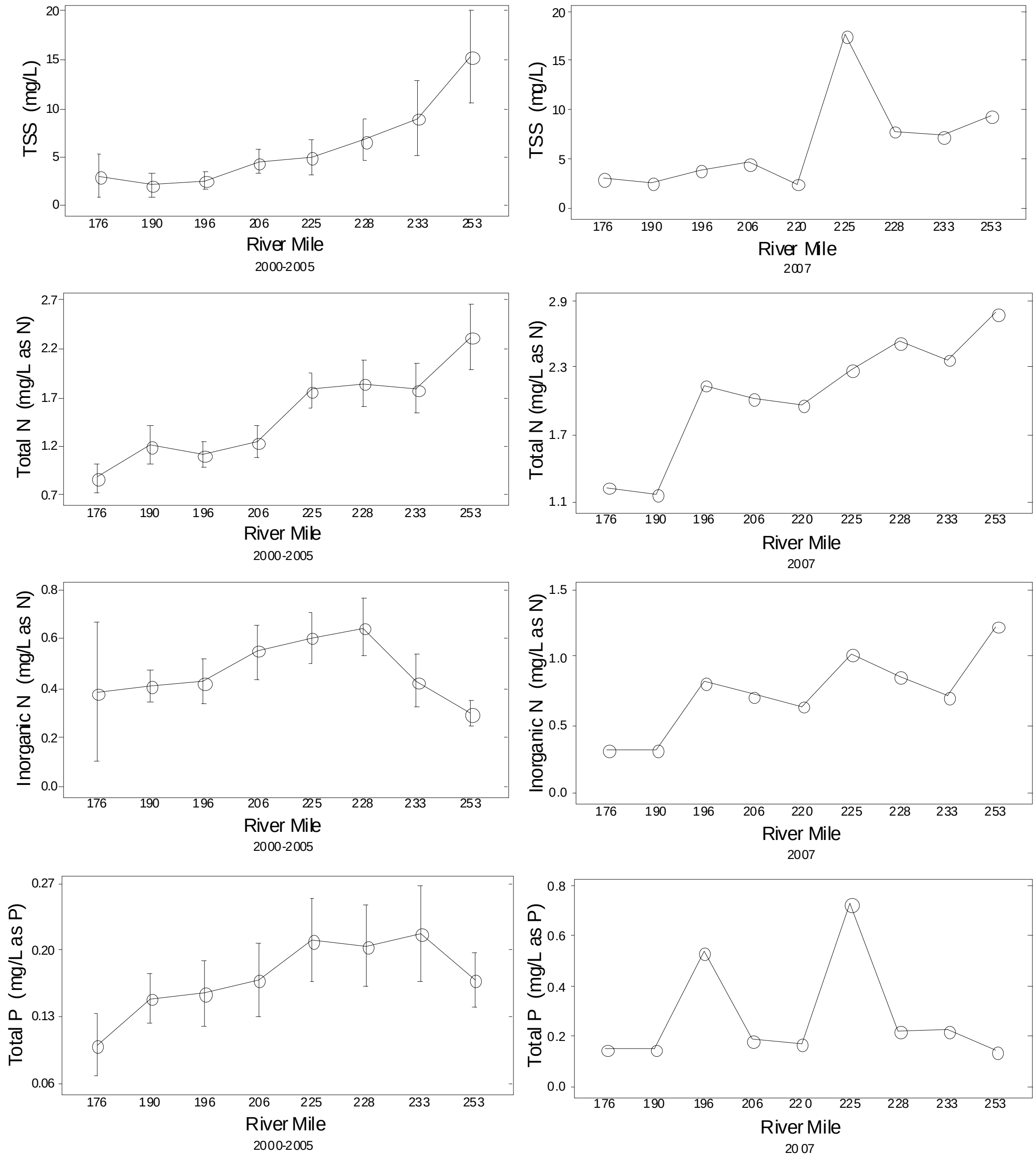


Figure 3-24. Line plots comparing the average values for various constituents measured in 2007 (right side plots) to the average of values measured in 2000 through 2007 (left side plots). The 2000-2007 results include error bars depicting the 90 percent confidence interval of the mean. Note that the scales differ among the graphs.

4.0 REFERENCES

PacifiCorp. 2004a. Final License Application. Volume 2. Exhibit E. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004b. Final Technical Report, Water Resources. Klamath Hydroelectric Project (FERC Project No. 2082). February 2004.

PacifiCorp. 2006. Causes and Effects of Nutrient Conditions in the Upper Klamath River. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. November 2006. 77 pp.

Kann, J., and Asarian, E. 2007. Nutrient Budgets and Phytoplankton Trends in Iron Gate and Copco Reservoirs, California, May 2005-May 2006. Final Technical Report to the State Water Resources Control Board, Sacramento, California

PacifiCorp. 2007a. Planned Water Quality Studies for Year 2007 for the Klamath Hydroelectric Project. PacifiCorp Energy, Portland, Oregon. May 11, 2007.

PacifiCorp. 2007b. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Klamath County, Oregon. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: Oregon Department of Environmental Quality, Portland. Prepared by: PacifiCorp, Portland, Oregon. February 2007.

PacifiCorp. 2007c. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Siskiyou County, California. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: State Water Resources Control Board, Division of Water Quality, Water Quality Certification Unit, Sacramento. Prepared by: PacifiCorp, Portland, Oregon. February 2007.

PacifiCorp. 2008a. Water Quality Studies for Year 2008 for the Klamath Hydroelectric Project. April 22, 2008. April 22. 2008. Attachment to a letter from Linda Prendergast (PacifiCorp) to Chris Stine (Oregon Department of Environmental Quality) and Jennifer Watt (California State Water Resources Control Board).

PacifiCorp. 2008b. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Klamath County, Oregon. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: Oregon Department of Environmental Quality, Portland. Prepared by: PacifiCorp, Portland, Oregon. February 2008.

PacifiCorp. 2008c. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Siskiyou County, California. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: State Water Resources Control Board, Division of Water Quality, Water Quality Certification Unit, Sacramento. Prepared by: PacifiCorp, Portland, Oregon. February 2008.

Appendix A:

Descriptive Statistics for Water Quality Conditions During 2007 in the Vicinity of the Klamath Hydroelectric Project

TABLE A-1. Summary statistics for water quality constituents in the Klamath Hydroelectric Project during 2007.

		SITEID =	KR17600	Klamath River at I-5								
	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	6	13	7	7	13	7	7	13	13	7	5	4
Mean	5.9	103.9	0.026	0.29	7.91	0.108	0.149	174	17.4	0.94	3.0	2.2
SD	1.1	14.9	0.040	0.25	0.64	0.059	0.046	9	4.7	0.21	1.2	2.1
Minimum	4.0	85.4	-0.024	0.11	6.79	0.021	0.095	163	8.6	0.66	1.6	-0.8
1st Quartile	5.1	93.1	-0.004	0.12	7.40	0.086	0.120	167	13.7	0.71	1.8	0.0
Median	6.2	98.0	0.020	0.23	8.10	0.095	0.140	172	18.5	1.00	3.2	2.8
3rd Quartile	6.9	117.6	0.077	0.34	8.44	0.150	0.160	178	19.6	1.00	4.2	3.8
Maximum	6.9	131.3	0.083	0.82	8.72	0.210	0.240	191	25.8	1.30	4.4	4.0
MAD[1]	0.7	5.6	0.024	0.11	0.53	0.015	0.020	5	2.8	0.09	1.2	0.8

[1]MAD = median absolute deviation

		SITEID =	KR18973	Klamath River below Iron Gate dam (hatchery bridge)								
	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	6	21	7	7	21	7	7	21	21	7	5	4
Mean	6.2	68.9	0.050	0.27	7.95	0.107	0.146	168	17.8	0.89	2.6	2.7
SD	1.1	40.6	0.061	0.26	0.63	0.060	0.041	13	3.5	0.08	1.5	1.9
Minimum	4.2	1.2	0.000	0.08	6.65	0.015	0.095	153	8.3	0.81	0.4	0.0
1st Quartile	5.2	20.2	0.006	0.13	7.40	0.083	0.110	155	15.6	0.83	1.2	0.7
Median	6.7	84.5	0.026	0.16	8.01	0.096	0.150	165	19.0	0.87	2.8	3.4
3rd Quartile	6.9	101.7	0.110	0.31	8.45	0.140	0.160	181	20.1	0.97	4.0	4.0
Maximum	7.0	117.9	0.160	0.82	8.93	0.210	0.220	193	23.7	1.00	4.4	4.0
MAD	0.3	22.2	0.020	0.08	0.49	0.024	0.020	10	1.3	0.06	0.8	0.6

		SITEID =	KR19019	Iron Gate reservoir at log boom								
	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	37	148	42	42	150	42	42	150	150	42	30	24
Mean	5.4	58.3	0.086	0.47	7.52	0.115	0.154	185	14.1	0.89	2.9	1.8
SD	0.9	52.3	0.105	0.31	0.68	0.054	0.049	19	6.2	0.30	3.1	3.1
Minimum	3.8	-0.6	-0.043	-.03	6.50	0.010	0.081	158	5.1	0.33	-0.4	-0.8
1st Quartile	4.8	17.7	0.007	0.20	7.06	0.081	0.120	172	8.0	0.67	1.1	0.4
Median	5.2	54.7	0.038	0.48	7.35	0.100	0.140	182	14.2	0.85	2.0	0.8
3rd Quartile	6.3	76.4	0.148	0.72	7.77	0.150	0.170	193	19.7	1.03	3.3	1.6
Maximum	7.8	241.0	0.450	1.10	9.52	0.250	0.290	262	26.2	1.70	12.8	11.6
MAD	0.5	25.0	0.054	0.24	0.34	0.030	0.020	11	5.9	0.18	1.2	0.6

		SITEID =	KR19645	Klamath River below Copco 2 powerhouse								
	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	9	12	9	9	14	9	9	14	14	9	5	4
Mean	5.7	98.8	0.038	0.78	7.79	0.559	0.536	173	17.0	1.36	3.9	0.5
SD	2.5	12.1	0.046	1.24	0.60	1.291	1.043	12	4.7	0.95	2.0	0.9
Minimum	0.3	79.2	-0.0310 -	0.01	6.52	0.065	0.034	157	6.8	0.11	1.6	-0.4
1st Quartile	4.9	89.5	0.004	0.15	7.34	0.085	0.120	162	13.1	0.83	2.2	-0.3
Median	5.6	99.5	0.034	0.48	7.83	0.130	0.190	169	18.8	1.10	3.2	0.4
3rd Quartile	7.5	105.4	0.082	0.75	8.37	0.205	0.350	184	20.7	1.85	6.0	1.4
Maximum	9.1	119.2	0.110	4.00	8.59	4.000	3.300	193	22.3	3.40	6.4	1.6
MAD	0.9	9.1	0.030	0.31	0.51	0.050	0.050	9	2.9	0.31	1.6	0.6

TABLE A-1. Summary statistics for water quality constituents in the Klamath Hydroelectric Project during 2007.

SITEID = KR19874 Copco reservoir near dam.

	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	32	122	32	32	122	32	32	122	122	32	22	18
Mean	6.2	84.8	0.137	0.35	7.73	0.152	0.205	178	16.1	1.16	4.1	2.9
SD	1.0	48.5	0.279	0.27	0.65	0.141	0.133	17	5.2	0.41	4.4	4.9
Minimum	4.1	0.1	-0.044	-.02	6.51	-0.022	0.007	158	6.3	0.34	-0.4	-2.0
1st Quartile	5.4	62.0	0.013	0.12	7.15	0.071	0.120	167	11.6	0.90	1.9	-0.1
Median	6.4	89.1	0.058	0.32	7.74	0.115	0.180	178	18.1	1.10	2.6	1.2
3rd Quartile	7.0	106.5	0.110	0.55	8.32	0.195	0.225	188	20.5	1.28	4.0	4.4
Maximum	7.5	230.2	1.300	0.84	9.14	0.650	0.730	248	25.5	2.20	20.4	18.4
MAD	0.8	20.6	0.050	0.21	0.58	0.046	0.060	10	3.1	0.20	1.0	1.6

SITEID = KR20642 Klamath River above Shovel Creek.

	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	9	13	9	9	14	9	9	14	14	9	5	4
Mean	7.3	105.6	0.017	0.70	7.78	0.135	0.186	173	15.8	1.32	4.6	1.0
SD	1.4	4.3	0.035	0.29	0.50	0.083	0.066	20	5.6	0.37	1.1	0.7
Minimum	5.8	101.7	-0.045	0.16	6.76	0.017	0.096	143	4.3	1.00	2.8	0.4
1st Quartile	6.0	103.1	-0.003	0.46	7.41	0.077	0.135	155	10.4	1.10	3.6	0.4
Median	6.9	103.7	0.020	0.82	7.87	0.110	0.200	177	17.0	1.20	5.2	1.0
3rd Quartile	8.6	108.2	0.031	0.94	8.16	0.230	0.210	192	20.7	1.45	5.4	1.6
Maximum	9.5	117.4	0.083	1.00	8.51	0.250	0.320	203	22.0	2.20	5.6	1.6
MAD	1.0	0.7	0.011	0.18	0.37	0.037	0.040	19	4.1	0.10	0.4	0.6

SITEID = KR22000 Klamath River below JC Boyle powerhouse (Spring Island)

	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	7	12	7	7	12	7	7	12	12	7	5	4
Mean	8.5	95.4	0.162	0.58	7.58	0.131	0.174	179	16.7	1.38	3.1	0.8
SD	3.5	6.8	0.128	0.23	0.39	0.093	0.055	27	6.2	0.60	0.5	0.6
Minimum	2.6	83.5	0.004	0.31	7.06	0.000	0.100	143	4.3	0.39	2.4	0.0
1st Quartile	7.2	91.4	0.051	0.39	7.38	0.068	0.120	151	11.2	1.10	2.6	0.2
Median	8.0	95.2	0.150	0.56	7.48	0.150	0.190	185	20.1	1.40	3.2	1.0
3rd Quartile	12.5	98.9	0.200	0.81	7.82	0.150	0.220	209	21.3	1.60	3.6	1.2
Maximum	12.9	110.7	0.400	0.92	8.47	0.300	0.250	211	24.1	2.40	3.6	1.2
MAD	1.0	3.7	0.050	0.17	0.13	0.057	0.050	26	3.0	0.20	0.4	0.2

SITEID = KR22040 Klamath River at bottom of J C Boyle bypass reach.

	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	7	7	7	7	7	7	7	7	7	7	5	4
Mean	5.2	104.2	0.018	0.49	8.30	0.103	0.152	158	13.8	0.78	1.6	1.0
SD	2.3	4.5	0.060	0.24	0.35	0.104	0.093	11	2.7	0.56	1.4	0.5
Minimum	2.8	99.3	-0.036	0.24	8.02	0.017	0.049	147	8.3	0.41	0.4	0.4
1st Quartile	3.3	100.1	-0.010	0.33	8.07	0.046	0.087	149	12.6	0.45	0.6	0.5
Median	4.0	105.0	0.005	0.39	8.12	0.069	0.120	157	14.4	0.46	0.8	1.0
3rd Quartile	7.9	106.8	0.009	0.79	8.52	0.150	0.250	164	15.5	1.50	3.0	1.5
Maximum	8.3	111.8	0.150	0.86	9.00	0.320	0.310	178	16.6	1.70	3.6	1.6
MAD	1.2	4.1	0.004	0.06	0.10	0.023	0.033	7	1.1	0.04	0.4	0.4

TABLE A-1. Summary statistics for water quality constituents in the Klamath Hydroelectric Project during 2007.

		SITEID =	KR22460	Klamath River below JC Boyle dam.								
	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	7	10	7	7	12	7	7	12	12	7	5	4
Mean	8.0	101.3	0.238	0.78	7.66	0.591	0.731	174	17.8	1.50	17.6	0.8
SD	3.0	4.0	0.118	0.37	0.50	1.067	1.354	24	6.6	0.16	31.6	0.9
Minimum	2.4	96.7	0.084	0.30	6.97	0.077	0.130	140	4.3	1.20	1.6	0.0
1st Quartile	7.1	97.6	0.150	0.59	7.40	0.080	0.200	153	11.6	1.40	2.2	0.0
Median	8.1	101.5	0.190	0.71	7.56	0.170	0.230	171	21.1	1.50	4.0	0.8
3rd Quartile	9.7	103.0	0.320	0.92	7.86	0.330	0.290	192	22.9	1.60	39.8	1.6
Maximum	12.2	110.2	0.430	1.50	8.88	3.000	3.800	213	24.0	1.70	74.0	1.6
MAD	1.0	1.6	0.106	0.12	0.26	0.093	0.030	20	2.4	0.10	1.6	0.8

		SITEID =	KR22478	J C Boyle reservoir at log boom.								
	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	14	65	14	14	67	14	14	67	67	14	10	8
Mean	8.2	87.9	0.258	0.82	7.44	0.446	0.427	178	15.3	1.63	8.2	1.9
SD	4.1	22.4	0.123	0.90	0.44	1.029	0.831	25	6.0	0.72	12.4	1.2
Minimum	0.4	46.1	0.076	-.01	6.82	-0.022	0.010	137	3.8	0.33	1.2	1.2
1st Quartile	7.4	76.6	0.170	0.45	7.06	0.083	0.173	151	9.1	1.30	2.6	1.2
Median	7.9	89.8	0.220	0.67	7.50	0.165	0.220	186	18.7	1.55	4.2	1.4
3rd Quartile	9.7	94.2	0.340	0.80	7.75	0.325	0.283	194	20.5	1.80	7.6	2.0
Maximum	15.1	147.3	0.500	3.80	8.38	4.000	3.300	216	24.4	3.70	42.8	4.8
MAD	1.2	7.3	0.065	0.15	0.43	0.096	0.055	23	4.0	0.25	1.8	0.2

		SITEID =	KR22822	Klamath River above JC Boyle reservoir.								
	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	7	12	7	7	12	7	7	12	12	7	5	4
Mean	9.2	97.9	0.214	0.65	7.58	0.162	0.218	178	17.5	1.89	7.9	4.1
SD	2.0	4.0	0.165	0.26	0.39	0.122	0.090	27	7.1	0.44	3.3	3.7
Minimum	7.8	91.4	0.019	0.30	6.92	-0.014	0.088	132	4.1	1.20	4.4	0.4
1st Quartile	7.9	94.4	0.120	0.31	7.37	0.068	0.110	160	10.3	1.60	4.6	0.8
Median	8.2	98.3	0.150	0.70	7.55	0.150	0.220	172	20.1	1.80	8.0	3.6
3rd Quartile	9.6	101.0	0.300	0.85	7.98	0.280	0.300	207	22.9	2.10	11.2	7.9
Maximum	13.3	103.7	0.530	0.98	8.19	0.330	0.320	223	25.8	2.60	11.6	8.8
MAD	0.4	2.7	0.080	0.15	0.21	0.082	0.080	15	4.8	0.30	3.2	2.4

		SITEID =	KR23334	Klamath River below Keno dam.								
	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	7	13	7	7	13	7	7	13	13	7	5	4
Mean	9.6	94.9	0.631	0.09	7.72	0.128	0.224	181	16.2	2.29	7.4	2.5
SD	2.6	3.7	0.271	0.10	0.64	0.101	0.076	26	6.6	0.56	4.6	2.0
Minimum	7.7	90.3	0.120	0.00	6.87	-0.022	0.120	137	4.2	1.30	4.0	0.4
1st Quartile	7.8	92.4	0.460	0.02	7.26	0.055	0.140	163	10.0	2.20	4.0	0.7
Median	8.1	93.1	0.750	0.04	7.49	0.120	0.240	177	19.9	2.30	6.4	2.2
3rd Quartile	12.2	98.7	0.780	0.17	8.22	0.230	0.290	202	21.5	2.50	11.2	4.6
Maximum	14.3	101.6	0.940	0.27	9.13	0.260	0.330	227	24.1	3.20	15.2	5.2
MAD	0.4	2.2	0.140	0.04	0.34	0.065	0.050	18	4.2	0.10	2.4	1.2

TABLE A-1. Summary statistics for water quality constituents in the Klamath Hydroelectric Project during 2007.

		SITEID =	KR25312	Mouth of Link River.								
	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	2	11	2	2	11	2	2	11	11	2	2	1
Mean	9.1	100.0	0.745	0.49	8.33	0.013	0.140	125	14.8	2.30	9.4	0.8
SD	1.1	10.9	0.361	0.51	0.99	0.000	0.042	10	7.0	1.27	8.8	
Minimum	8.3	80.8	0.490	0.13	6.87	0.012	0.110	112	2.7	1.40	3.2	0.8
1st Quartile		91.3			7.48			117	9.3			
Median	9.1	101.5	0.745	0.49	8.64	0.013	0.140	127	13.3	2.30	9.4	0.8
3rd Quartile		103.3			9.07			132	20.9			
Maximum	9.9	120.0	1.000	0.85	9.84	0.013	0.170	144	24.4	3.20	15.6	0.8
MAD	0.8	4.6	0.255	0.36	0.97	0.000	0.030	10	6.1	0.90	6.2	0.0

		SITEID =	KR25479	Upper Klamath Lake at Fremont bridge.								
	DOC	DOPER	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	1	8	1	1	8	1	1	8	8	1	1	1
Mean	8.0	114.4	0.990	1.70	8.77	2.900	4.000	122	16.6	1.60	74.0	2.4
SD		30.7			0.90			10	7.6			
Minimum	8.0	78.6	0.990	1.70	7.27	2.900	4.000	112	2.8	1.60	74.0	2.4
1st Quartile		84.3			7.92			114	10.0			
Median	8.0	117.4	0.990	1.70	8.98	2.900	4.000	119	19.6	1.60	74.0	2.4
3rd Quartile		135.4			9.39			129	23.1			
Maximum	8.0	168.5	0.990	1.70	9.98	2.900	4.000	141	24.1	1.60	74.0	2.4
MAD	0.0	25.3	0.000	0.00	0.43	0.000	0.000	6	4.4	0.00	0.0	0.0

TABLE A-1. Summary statistics for water quality constituents in the Klamath Hydroelectric Project during 2007.
Copco Reservoir

Descriptive Statistics for ZMED = -30

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	2	2	2	2	2	2	2	2	2	2	2	2
Mean	5.9	45.2	0.041	0.57	7.6	0.17	0.28	215	9.0	1.27	4.6	2.4
SD	2.1	63.8	0.043	0.37	0.2	0.08	0.13	47	3.7	0.61	4.2	6.2
Minimum	4.4	0.1	0.010	0.30	7.5	0.11	0.18	181	6.3	0.84	1.6	-2.0
1st Quartile												
Median	5.9	45.2	0.041	0.57	7.6	0.17	0.28	215	9.0	1.27	4.6	2.4
3rd Quartile												
Maximum	7.3	90.3	0.071	0.83	7.8	0.23	0.37	248	11.6	1.70	7.6	6.8
MAD	1.5	45.1	0.031	0.27	0.1	0.06	0.10	34	2.7	0.43	3.0	4.4

Descriptive Statistics for ZMED = -24

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	7	17	7	7	17	7	7	17	17	7	5	4
Mean	6.0	35.3	0.437	0.22	7.2	0.26	0.28	198	10.3	1.14	2.3	1.2
SD	1.1	44.1	0.500	0.27	0.4	0.25	0.25	21	2.5	0.55	1.6	1.3
Minimum	4.2	0.1	0.047	-0.02	6.7	-0.02	0.01	181	6.3	0.34	-0.4	-0.4
1st Quartile	5.3	0.8	0.074	-0.02	6.9	0.08	0.12	183	8.2	0.96	1.0	0.0
Median	6.3	7.2	0.120	0.12	7.0	0.13	0.19	188	10.8	1.10	2.8	1.2
3rd Quartile	7.0	90.4	0.920	0.55	7.6	0.54	0.46	204	12.0	1.30	3.4	2.4
Maximum	7.4	98.4	1.300	0.62	7.8	0.65	0.73	247	13.9	2.20	4.0	2.8
MAD	0.9	7.0	0.073	0.14	0.1	0.15	0.11	6	1.1	0.14	0.4	0.8

Descriptive Statistics for ZMED = -16

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	7	26	7	7	26	7	7	26	26	7	5	4
Mean	6.0	51.1	0.106	0.51	7.3	0.15	0.17	177	14.4	0.99	2.9	0.5
SD	1.2	35.3	0.082	0.17	0.4	0.10	0.04	10	4.6	0.15	0.8	0.7
Minimum	4.1	0.4	0.023	0.28	6.7	0.02	0.11	159	6.3	0.79	2.0	-0.4
1st Quartile	5.0	22.0	0.050	0.37	6.9	0.07	0.12	171	10.7	0.85	2.2	-0.2
Median	6.4	48.6	0.068	0.52	7.2	0.13	0.19	181	15.6	1.00	2.8	0.6
3rd Quartile	7.0	89.9	0.160	0.56	7.7	0.25	0.21	184	18.3	1.10	3.6	1.1
Maximum	7.2	98.6	0.260	0.83	8.2	0.29	0.21	191	20.7	1.20	4.0	1.2
MAD	0.8	36.7	0.045	0.07	0.3	0.06	0.02	8	3.5	0.10	0.4	0.4

Descriptive Statistics for ZMED = -8

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	8	47	8	8	47	8	8	47	47	8	5	4
Mean	6.2	93.1	0.045	0.36	7.8	0.12	0.17	173	17.9	1.14	2.3	1.4
SD	1.0	24.9	0.044	0.26	0.5	0.07	0.07	12	4.4	0.43	1.0	1.6
Minimum	4.5	36.9	-0.015	0.10	6.9	0.01	0.10	158	7.0	0.77	1.6	0.0
1st Quartile	5.6	76.2	0.003	0.14	7.6	0.07	0.12	161	17.2	0.84	1.6	0.1
Median	6.2	88.4	0.047	0.28	7.8	0.11	0.17	170	19.4	1.06	2.0	1.0
3rd Quartile	7.2	104.6	0.088	0.58	8.3	0.18	0.22	183	20.6	1.20	3.2	3.1
Maximum	7.4	152.8	0.110	0.83	8.7	0.21	0.31	194	22.5	2.10	4.0	3.6
MAD	0.6	13.6	0.038	0.16	0.3	0.04	0.05	10	1.3	0.17	0.4	0.8

TABLE A-1. Summary statistics for water quality constituents in the Klamath Hydroelectric Project during 2007.

Descriptive Statistics for ZMED = -1

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	8	30	8	8	30	8	8	30	30	8	5	4
Mean	6.5	131.6	0.017	0.26	8.3	0.10	0.19	174	18.6	1.32	8.5	8.8
SD	0.8	39.8	0.051	0.27	0.7	0.05	0.09	13	4.8	0.41	7.8	7.7
Minimum	5.1	82.4	-0.044	0.06	6.5	0.01	0.08	158	7.2	0.90	1.2	-0.4
1st Quartile	5.9	95.6	-0.024	0.06	7.8	0.06	0.11	165	16.2	0.98	1.6	1.6
Median	6.6	123.9	0.003	0.14	8.5	0.09	0.18	171	20.4	1.20	7.6	8.6
3rd Quartile	7.1	157.7	0.060	0.42	8.8	0.14	0.24	186	21.5	1.73	15.8	16.2
Maximum	7.5	230.2	0.110	0.84	9.1	0.18	0.36	196	25.5	2.00	20.4	18.4
MAD	0.4	30.9	0.028	0.08	0.3	0.03	0.07	10	1.7	0.27	5.6	5.0

Iron Gate Reservoir

Descriptive Statistics for ZMED = -40

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	7	18	7	7	18	7	7	18	18	7	5	4
Mean	5.3	6.4	0.149	0.62	7.2	0.12	0.16	217	5.8	0.87	3.0	1.1
SD	1.2	10.3	0.171	0.29	0.4	0.06	0.06	19	0.4	0.31	1.6	0.9
Minimum	4.3	-0.6	-0.016	0.21	7.0	0.01	0.10	196	5.1	0.58	1.2	0.0
1st Quartile	4.7	0.1	0.007	0.29	7.0	0.10	0.12	200	5.6	0.65	1.8	0.2
Median	5.0	1.9	0.130	0.60	7.1	0.13	0.14	215	5.9	0.75	2.8	1.2
3rd Quartile	5.3	8.3	0.300	0.85	7.3	0.17	0.16	227	6.0	0.94	4.4	1.9
Maximum	7.8	30.1	0.450	1.00	8.1	0.20	0.29	262	6.3	1.50	5.6	2.0
MAD	0.3	2.0	0.123	0.25	0.1	0.03	0.02	13	0.2	0.17	0.4	0.6

Descriptive Statistics for ZMED = -32

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	6	10	7	7	10	7	7	10	10	7	5	4
Mean	4.8	17.9	0.101	0.83	7.3	0.11	0.14	205	6.2	0.81	1.6	0.4
SD	0.5	19.8	0.115	0.19	0.4	0.05	0.04	12	0.8	0.23	1.3	0.3
Minimum	3.8	-0.4	-0.016	0.54	6.9	0.01	0.08	189	5.2	0.49	0.4	0.0
1st Quartile	4.5	0.3	0.003	0.70	7.0	0.08	0.12	195	5.4	0.60	0.6	0.1
Median	4.9	9.7	0.063	0.86	7.1	0.12	0.13	205	6.1	0.90	1.2	0.4
3rd Quartile	5.2	34.7	0.230	0.94	7.5	0.15	0.16	215	6.6	1.00	2.8	0.7
Maximum	5.4	54.1	0.280	1.10	8.1	0.17	0.22	224	7.6	1.10	3.6	0.8
MAD	0.2	10.0	0.060	0.13	0.2	0.03	0.03	10	0.5	0.20	0.8	0.2

Descriptive Statistics for ZMED = -24

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	6	20	7	7	20	7	7	20	20	7	5	4
Mean	5.2	26.8	0.073	0.55	7.2	0.13	0.15	197	8.8	0.77	2.0	0.9
SD	0.7	23.0	0.092	0.19	0.3	0.04	0.04	11	2.2	0.27	1.5	0.5
Minimum	4.2	0.0	-0.016	0.34	6.7	0.08	0.09	186	5.7	0.33	0.8	0.4
1st Quartile	4.7	1.5	-0.016	0.43	7.0	0.09	0.13	192	7.0	0.63	1.0	0.5
Median	5.3	33.8	0.028	0.48	7.2	0.13	0.14	193	8.1	0.75	1.2	0.8
3rd Quartile	5.8	45.3	0.190	0.73	7.4	0.17	0.19	197	11.1	1.10	3.4	1.4
Maximum	6.3	62.1	0.190	0.89	7.8	0.18	0.22	220	13.3	1.10	4.4	1.6
MAD	0.4	24.9	0.044	0.05	0.2	0.04	0.02	3	1.2	0.12	0.4	0.2

TABLE A-1. Summary statistics for water quality constituents in the Klamath Hydroelectric Project during 2007.

Descriptive Statistics for ZMED = -16

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	6	29	7	7	29	7	7	29	29	7	5	4
Mean	5.4	40.0	0.079	0.36	7.1	0.12	0.16	185	13.7	0.82	1.4	0.1
SD	0.9	25.0	0.094	0.16	0.2	0.06	0.04	7	3.6	0.27	0.8	0.8
Minimum	4.2	0.9	-0.043	0.17	6.6	0.06	0.11	170	8.0	0.50	0.4	-0.8
1st Quartile	4.7	18.1	0.019	0.18	6.9	0.07	0.14	181	10.9	0.58	0.6	-0.7
Median	5.4	46.3	0.032	0.34	7.1	0.09	0.17	186	13.6	0.73	1.6	0.2
3rd Quartile	6.3	62.0	0.190	0.55	7.3	0.18	0.17	190	17.2	1.10	2.2	0.8
Maximum	6.4	78.3	0.200	0.55	7.5	0.23	0.24	204	20.0	1.20	2.4	0.8
MAD	0.8	21.3	0.075	0.16	0.2	0.04	0.03	4	2.9	0.23	0.8	0.6

Descriptive Statistics for ZMED = -8

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	6	42	7	7	43	7	7	43	43	7	5	4
Mean	5.7	64.7	0.063	0.31	7.6	0.12	0.16	170	18.4	0.86	2.1	1.2
SD	0.9	15.1	0.061	0.22	0.4	0.07	0.06	8	3.4	0.18	1.7	1.4
Minimum	4.1	30.0	0.006	0.11	6.6	0.04	0.11	158	8.3	0.67	0.4	0.0
1st Quartile	4.9	52.6	0.014	0.12	7.4	0.08	0.11	164	17.1	0.68	0.4	0.2
Median	6.1	67.0	0.043	0.30	7.5	0.10	0.16	171	19.5	0.87	2.8	0.8
3rd Quartile	6.4	75.2	0.120	0.48	7.8	0.18	0.18	177	20.8	1.00	3.4	2.6
Maximum	6.5	95.0	0.170	0.71	8.6	0.25	0.27	188	22.3	1.10	3.6	3.2
MAD	0.4	9.3	0.029	0.18	0.2	0.01	0.05	6	1.7	0.17	0.8	0.4

Descriptive Statistics for ZMED = -1

	DOC	DOPR	NH3	NO3	PH	PO4	PT	SPC	TEMP	TKN	TSS	VSS
N	6	29	7	7	30	7	7	30	30	7	5	4
Mean	6.2	135.4	0.049	0.15	8.4	0.08	0.15	173	19.5	1.19	7.0	7.0
SD	0.9	57.0	0.072	0.25	0.9	0.04	0.06	7	4.6	0.37	5.8	4.8
Minimum	4.8	67.2	-0.013	-0.03	6.5	0.04	0.10	160	8.4	0.80	0.4	0.4
1st Quartile	5.3	88.4	0.002	-0.02	7.5	0.06	0.12	167	16.4	0.83	1.0	2.0
Median	6.3	115.0	0.009	0.04	8.5	0.08	0.14	173	20.9	1.00	8.0	8.0
3rd Quartile	6.9	195.1	0.110	0.29	9.2	0.10	0.17	178	23.0	1.60	12.4	11.0
Maximum	7.3	241.0	0.180	0.65	9.5	0.15	0.28	189	26.2	1.70	12.8	11.6
MAD	0.6	33.0	0.022	0.06	0.8	0.02	0.02	6	2.5	0.20	4.8	2.4