2009 Monitoring Report

Araujo Fish Passage and Water Quality Improvements Project

SWQCB Agreement #07-541-550-1, Component #2.1

Shasta Valley Resource Conservation District

Submitted
October 2009

Introduction

The Shasta Valley Resource Conservation District (SVRCD) has contracted to implement the Araujo Fish Passage and Water Quality Improvements Project for the State Water Resources Control Board. Additional funding for this project is from California Department of Fish and Game, Natural Resources Conservation Service, U.S. Fish and Wildlife Service, National Fish and Wildlife Foundation, and the County of Humboldt.

The monitoring of pre-construction and post-construction water quality and fish passage parameters is outlined in the Monitoring Plan submitted as part of the contract. Monitoring is an essential component of improvement projects by providing documentation and quantitative measures of the success of the project.

Project Background

The Araujo Fish Passage and Water Quality Improvements Project is located on the Shasta River, a tributary to the Klamath River, in Siskiyou County, California. The Shasta River channel is typically low-gradient and meandering, with flows dominated by upper cold-water springs. Agricultural use is common throughout the Shasta River Watershed; flow is highly influenced by irrigation diversions and tailwater return flow during the irrigation season.

The Araujo Dam, a summer flashboard diversion structure with an associated impoundment, was identified as a high priority project for remediation in the North Coast Regional Water Quality Control Board (NCRWQCB) Total Maximum Daily Load (TMDL) for the Shasta River (2006) and the Recovery Strategy for California Coho Salmon (2004). The dam contributed to poor water quality conditions in the river that included low dissolved oxygen content and high water temperatures, both of which are critical factors in fish survival. The dam also obstructed both juvenile and adult passage to colder waters upstream. Implementation of the flashboard dam removal project is a major step that will assist the RCD, NCRWQCB and California Department of Fish and Game in meeting their goals of improving water quality and restoring coho, Chinook, and steelhead in the Shasta River.

The Araujo Dam project implementation included replacing the existing dam with a boulder weir that provides fish passage to juvenile and adult salmonids as well as reduces the volume of impounded water necessary to supply agricultural water to the five landowners. The pre-project gravity-fed irrigation system was replaced by a pumping system that includes a new fish screen and pumping station. Existing irrigation ditches used to transport water were replaced with underground piping in order to reduce ditch losses and avoid the use of herbicides that were used to maintain the ditches.

Project-specific pre-construction monitoring data was collected from June 2007 through early October 2007. The construction phase of the project was implemented in the fall of 2007. Post-construction monitoring began just prior to the beginning of the irrigation season, in late March 2008 and continued through September 2008, the end of the 2008 irrigation season. A second irrigation season of post-construction monitoring began in late March 2009 and continued through August 2009. This monitoring report presents data collected in 2009 with some comparisons to 2007 and 2008 data where applicable. Details on the 2007 and 2008 monitoring data can be found in the 2007 and 2008 Monitoring Reports submitted to the NCRWQCB by the Shasta Valley Resource Conservation District. Determining current conditions and identifying trends in the project area to date will aid the RCD in determining the degree to which the water quality and fish passage goals have been met.

Monitoring procedures in 2009 were followed as directed in the contract Monitoring Plan and the Quality Assurance Project Plan. All Quality Assurance/ Quality Control protocol were followed. Although the contract provided for monitoring through the field season of 2009, the NCRWQCB and SVRCD are developing plans to continue post-construction monitoring during 2010 and 2011.

In addition to monitoring the water quality and fish passage components of the project, data was also captured to document costs to the diverters before and after implementation.

Monitoring Details and Methods

Parameters that were monitored in 2009 include water temperature, dissolved oxygen, and width of wetted channel within the project area. Fish passage was also monitored, as well as electric power and ditch maintenance costs. Digital photos were taken at established photo points in August 2009. The 2009 data collection period began in March 2009 and extended through August 2009. See Figure 1 for the sampling locations.

Water temperature

Continuous water temperature data was collected at six sites. In order to make direct comparisons, the six sites used in 2009 were the same as the six temperature monitoring sites of the previous two years. Zebra-Tech D-Optologgers, which record both dissolved oxygen and temperature, were installed at four sites within the project area in March 2009. These sites are numbered sequentially going upstream, beginning with Site 1 one hundred feet below the old dam site, Site 2 approximately fifty feet upstream of the old dam site, Site 3 just upstream of the new pumping station and approximately 600 feet upstream of Site 2, and Site 4 approximately 1600 feet upstream of Site 3 at the Highway 3 Bridge. The D-Optologgers were not used in 2007 due to funding delays and unavoidable interference to the devices from construction activities; all 2007 temperature data was measured with Onset/HOBO Tidbit probes.

The two remaining temperature collection sites were located downstream outside of the project area in order to document changes due to project implementation. Two Onset/ HOBO Tidbit temperature probes were deployed in March 2009. One probe was located at site 6, approximately 0.7 miles downstream of the project area upstream of the Oregon Slough confluence. Site 7 was located approximately 1.7 miles downstream of the project area near the Yreka-Ager Bridge at site 7. See Figure 1 for monitoring locations.

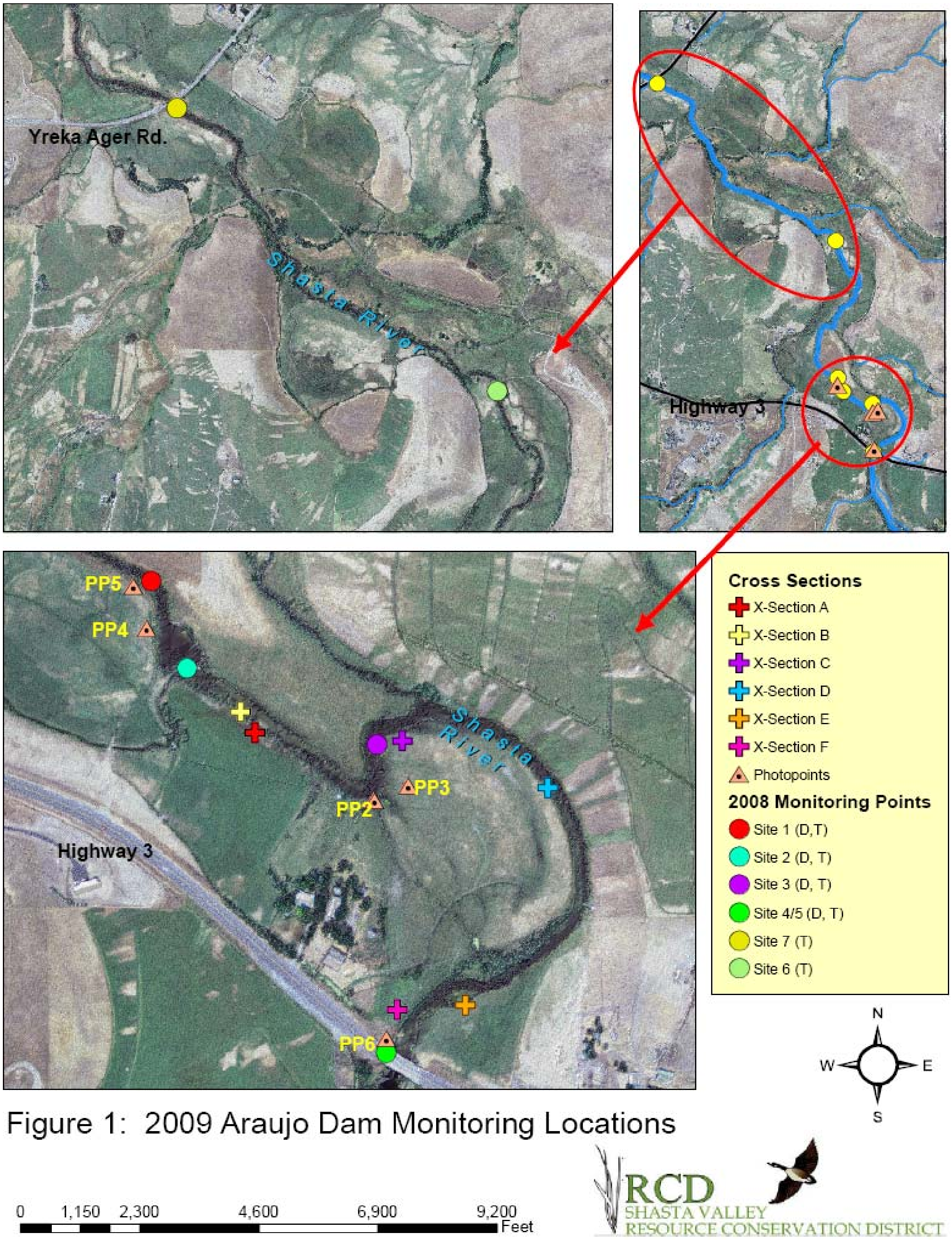


Figure 1: 2009 Araujo Dam Monitoring Locations

The D-Optologgers and HOBO probes recorded continuous hourly water temperature readings throughout the irrigation season. The probes were housed in a shading device where they were not exposed to direct sunlight, and were closely monitored to best assure submersion during low flow periods. As directed in the monitoring plan, the Fish, Farms, and Forest Communities protocol was followed for calibration of the Onset/ HOBO instruments. Calibration and maintenance procedures from the manufacturer's manual were followed for the D-Optologgers. The accuracy of the Onset/ HOBO probe is +/- 0.2 °C while the accuracy of the D-Optologger is +/- 0.1 °C.

In addition, an Onset/HOBO temperature probe was installed at the project site on a tree near the pumping station to collect continuous air temperature data. This probe recorded hourly readings in a shaded location from March 2009 through August 2009. As directed in the monitoring plan, the Fish, Farms, and Forest Communities protocol was followed for calibration of the instrument.

Dissolved Oxygen

Dissolved oxygen (DO) data was collected by the four Zebra-Tech D-Optologgers that were simultaneously recording water temperature data. Installed in 2008 and 2009 at the same four sites that were measured twice for dissolved oxygen in 2007, the D-Optologgers recorded continuous hourly dissolved oxygen readings. These sites are numbered sequentially going upstream, beginning with Site 1 one hundred feet below the old dam site, Site 2 fifty feet upstream of the old dam site, Site 3 just upstream of the new pumping station and approximately 600 feet upstream of Site 2, and Site 4 approximately 1600 feet upstream of Site 3 at the Highway 3 Bridge (see Figure 1). The D-Optologger utilizes fluorescence to measure dissolved oxygen which provides accurate readings over a long period of time, particularly as compared to membrane-type DO meters. The D-Optologgers were not installed in 2007 due to funding delays and unavoidable interference to the devices from construction activities; therefore, limited dissolved oxygen data was collected in 2007 with which to make comparisons. Calibration and maintenance procedures from the D-Optologger manual were followed. The accuracy of the D-Optologger is +/- 0.02 ppm.

In addition, grab samples using a Yellow Springs Instruments YSI-55 meter were occasionally collected in 2008 and 2009 in order to compare readings to those recorded by the D-Optologgers. Calibration and maintenance procedures outlined in the YSI-55 manual were followed. Measurements were taken in areas where water was flowing at a level recommended by the manufacturer for accurate sampling. The accuracy of the YSI-55 meter is +/- 0.5 ppm.

Width of Wetted Channel

Six permanent cross-sections had been established in 2007 throughout the project area with permanently installed T-posts and reference stakes. Using a horizontal string-line as a reference point, coupled with a tape measure for horizontal distance, depth measurements were taken of the channel depth, including the top and bottom of any sediment deposits. The procedure used in 2007 and 2008 to collect cross-section data was duplicated for the 2009 data collection.

Aerial photos were used to visually examine changes in wetted channel as a result of the project. No aerial photos or imagery was taken in 2009; therefore, a pre-construction NRCS National Agriculture Imagery Program (2005) photo was compared to a post-construction image obtained from 2008 LiDAR data. It is important to note that these two images are constructed from very different technology, as LiDAR is formulated from laser point data rather than photography. The LiDAR data that was used in the comparison shows only the bare earth surface without the vegetation component. The appearance of surface characteristics differs between the two images, and this difference should be considered when comparing the two images.

Photo Points
Photo points were documented and tagged in August 2007 to facilitate annual photo-monitoring of the project area. Digital photographs were taken both upstream and downstream at the five established photopoints on August 5, 2009. Annual photos at each photopoint will help document changes in channel configuration, flow characteristics, and vegetation due to the implementation of the project. Photo point protocol followed the Photopoint Monitoring Handbook (PNW-GTR-526, USFS 2005).

Improved Fish Passage
One of the main goals of the project was to remove a flashboard dam at the Araujo site in order to provide for improved fish passage. Project implementation plans included the construction of a boulder weir upstream of the old dam site to provide a minimum amount of ponding at the new pump and screen site to assure proper pump operation. Digital photographs were taken during low summer flow to document a maximum jump height of twelve inches at the boulder weir.

Ditch Maintenance/ Electrical Demand
Prior to project implementation, the irrigation ditches throughout the project area were open, earthen ditches. These ditches required maintenance by the landowner, including herbicide treatment to minimize vegetation growth. One element of the project included installing piping in existing irrigation ditches to improve water delivery efficiency and eliminate the amount of herbicides needed to maintain the ditches. The ranchers within the project area were asked to record ditch labor and herbicide costs for 2007, 2008, and 2009 to monitor changes in maintenance costs for their delivery system.

Upon completion, the project replaced a four-diversion, largely gravity-fed irrigation water diversion and delivery system with a single-diversion pumped system. This change created a new electrical cost for the ranchers that did not exist pre-project. To account for the project costs, ranchers were asked to track the electrical costs throughout the post-project irrigation seasons to help quantify the fiscal effect of the improved system.

Monitoring Results
All data is stored on a Shasta Valley Resource Conservation District computer hard drive and back-up drive, as well as on a CD stored at the main SVRCD office. The 2009 data and photos are provided with this report, either as electronic files or on a CD. Results of

each parameter are summarized in this report. The pre-construction monitoring data provides a short but valuable baseline to which post-construction monitoring data can be compared. Post-construction monitoring data, while limited to just two years to date, provides information that facilitates the evaluation of the success of the project.

Continuous monitoring data was collected throughout the 2009 irrigation season and verified for accuracy. Some data gaps occurred due to normal download and calibration procedures. Other data gaps occurred due to extremely low flow levels, causing the meters to be exposed to air for a period of time, or occurred when the meters were fouled by vegetation which was wrapped around the meter, temporarily impeding its performance.

Water temperature

Water temperature data from the four D-Optologgers and the two Onset/ HOBO temperature probes is summarized in Table 1 and shown graphically in Appendix A. In comparing the six sites in 2009, the highest maximum temperature reading of 29.57°C was measured downstream outside of the project area at Site 7. This site, near the Yreka-Ager Bridge, also had the highest maximum daily average temperature as well. This is consistent with the expected results, as the river temperature generally increases in a downstream direction from the headwaters to the mouth. Site 6 was also located downstream outside of the project area, but the HOBO temperature probe had been placed in a shallow part of the river channel and did not record reliable instream measurements after July 8, 2009. Since usable data was only collected there early in the season, the data is therefore not comparable to peak temperature data collected all season at the other sites.

Table 1
WATER TEMPERATURE SUMMARY
Pre-construction 2007 and Post-construction 2008 - 2009

Site #	Continuous Monitoring Location	2009		2008		2007	
		Maximum Temp °C	Maximum Daily Avg Temp °C	Maximum Temp °C	Maximum Daily Avg Temp °C	Maximum Temp °C	Maximum Daily Avg Temp °C
1	Downstream Araujo Dam Site	28.81	26.01	27.09	24.87	25.95	24.93
2	Upstream Araujo Dam Site	27.77	25.86	27.17	24.80	LD	LD
3	Upstream Pump	28.15	25.99	27.32	24.82	LD	LD
4	Highway 3 Bridge	28.74	25.88	27.47	24.79	NS	NS
5	Upstream Highway 3 Bridge	NS	NS	NS	NS	LD	LD
6	Upstream Oregon Slough Confluence	26.72*	24.33*	28.20	24.93	LD	LD
7	Upstream Yreka-Ager Rd. Bridge	29.57	26.27	28.84	24.92	NS	NS

NS *Not Sampled*
LD *Limited Data; sampled after peak temps, from 8/17 - 9/7*
* *Sampled prior to peak temps, from 3/18 - 7/5*

The remaining four water temperature sites, Sites 1 through 4, were all within the project area. As shown in Table 1, little variation in values was apparent among the maximum temperature readings. Within the project area, the highest maximum temperature in 2009 was measured at Site 1, the site just downstream of the old dam location, at 28.81°C. The lowest maximum reading of 27.77°C was taken at Site 2, just above the old dam site. The maximum daily averages also showed little variation between the four project area sites, with the highest again below the old dam site and the lowest just above the old dam. A graph of the daily average water temperatures for all six sites in 2009 is shown in Figure 2. Plots of the daily average temperature for 2008 and 2009 for each of the six sites are included in Appendix A. The graph for Site 1 also includes a period of 2007 data.

Figure 2
Daily Average Water Temperature 2009
Araujo Sites 1, 2, 3, 4, 6 and 7

Water temperature data from 2007, 2008 and 2009 is compared in Table 1. The 2007 and 2008/2009 monitoring sites were the same with the exception of the Highway 3 temperature sites, as the 2007 site (Site 5) was approximately three hundred feet upstream of the 2008/2009 site (Site 4). Due to the short monitoring period in 2007, the ability to compare the 2008 and 2009 water temperature data to the 2007 data is limited. The common sampling period for both years for all four sites within the project area is from August 17 to August 31 of each year and is summarized in Table 2.

Table 2

WATER TEMPERATURE SUMMARY DURING COMMON SAMPLING PERIOD

Pre-construction 2007 and Post-construction 2008-2009

Site #	Continuous Monitoring Location	Common Sampling Period Aug 17 - Aug 31					
		2009		2008		2007	
		Maximum Temp °C	Maximum Daily Avg Temp °C	Maximum Temp °C	Maximum Daily Avg Temp °C	Maximum Temp °C	Maximum Daily Avg Temp °C
1	Downstream Araujo Dam Site	24.2	22.5	24.7	22.9	22.5	20.8
2	Upstream Araujo Dam Site	24.3	22.3	24.9	22.9	23.2	20.7
3	Upstream Pump	24.6	22.5	25.1	23.0	23.2	20.6
4,5	Highway 3 Bridge/ Upstream Bridge	25.2	22.4	25.0	22.9	24.4	20.7
6	Upstream Oregon Slough Confluence	NS	NS	24.8	23.1	NS	NS
7	Upstream Yreka-Ager Rd. Bridge	26.1	22.9	25.0	23.1	NS	NS

NS *Not Sampled*

The maximum temperature and maximum daily average temperature measured at each site during the common sampling period for all three years is shown in Table 2. All values presented in the table showed an increase in temperature from the pre-construction period to the post-construction periods. However, the maximum temperatures and maximum daily average temperatures decreased slightly from 2008 to 2009 during this period. Annual differences in air temperature and irrigation practices may have influenced the overall increase in water temperature post-project versus post-project.

Analysis of the range of seasonal maximum temperatures among the four project-area sites, Sites 1 through 4, may help identify flow changes throughout the project area. As shown in Table 2, the maximum temperature recorded at each site in 2007 varied from 22.5°C to 24.4°C, a range of 1.9°C. In 2008 and 2009, the variation among sites of the maximum temperature at each site had a range of 0.4°C and 1.0°C, respectively. This reduction in range of temperature as a result of project activities may indicate progress towards improving water quality within a reach. However, it should be noted that water temperatures are still near upper lethal thresholds for both coho and Chinook (>25°C)[1], which indicates that further investigations are needed in order to identify other contributors to high water temperatures.

Air temperature was measured near the pump station throughout the 2009 irrigation season. This data is shown graphically in Appendix A.

[1] NCRWQCB, *Draft Klamath TMDL. Appendix 4 "Effects of Temperature, Dissolved Oxygen/Total Dissolved Gas, Ammonia, and pH on Salmonids"*. July 2008.

Dissolved Oxygen

Dissolved oxygen (DO) measurements were taken continuously at hourly increments with the four Zebra-Tech D-Optologgers within the project area. This data is shown for each site in graphed form in Appendix B. A summary of the minimum, maximum, and average DO concentration measured at each site during the entire season is shown in Table 3. The 2009 lowest minimum and lowest seasonal average were recorded at Site 2, the site just upstream of the dam location. The highest minimum and highest seasonal average in 2009 were measured at the most upstream site, Site 4, at the Highway 3 Bridge. Although data that was known to be inaccurate, due to a problem such as vegetation wrapped around a meter or a lack of submersion, was not used in the analysis, it is possible that the remaining extreme lows and highs might be due to a similar unidentified situation. The dissolved oxygen graphs in Appendix B provide an overall visual display of the data readings throughout the season.

Table 3
DISSOLVED OXYGEN SUMMARY
Pre-construction 2007 Grab Samples and Post-construction 2008 - 2009 Continuous Data

Site #	Location	Post-Construction 2009 Continuous Data Collection			Post-Construction 2008 Continuous Data Collection			Pre-Construction 2007 Grab Samples	
		2009 Minimum DO ppm	2009 Maximum DO ppm	2009 Average DO ppm	2008 Minimum DO ppm	2008 Maximum DO ppm	2008 Average DO ppm	6/12/2007 Pre-Dawn DO ppm	7/9/2007 Pre-Dawn DO ppm
1	Downstream Araujo Dam Site	1.31	21.59	9.64	1.98	18.21	9.35	5.59	4.33
2	Upstream Araujo Dam Site	0.55	26.28	8.27	2.22	29.67	9.48	5.26	4.18
3	Upstream Pump/ Screen Site	1.82	28.04	9.71	2.55	21.37	9.84	5.44	3.91
4	Highway 3 Bridge Site	2.18	25.29	9.92	1.56	17.44	9.39	5.93	3.89

Table 3 includes post-construction continuous dissolved oxygen data collected in 2008 and 2009, as well as DO grab sample data that was collected in 2007 using a YSI-55 meter at pre-dawn on two different days. Dissolved oxygen fluctuates diurnally, and at pre-dawn photosynthesis by aquatic vegetation is at a minimum, resulting in minimum dissolved oxygen levels. The days during which grab samples were taken were chosen based on extended hot summer days during the mid to late irrigation season in order to capture some of the lowest DO measurements for the season. However, these few data points provide for limited comparisons to the 2008 and 2009 data, as many variables affect daily dissolved oxygen levels and no direct comparisons can be made between the 2007 grab samples and the 2008 and 2009 continuous measurements.

In comparing the 2008 and 2009 data in Table 3, the minimum DO readings were lower in 2009 than 2008 at three of the four sites. The seasonal average DO level was lower at two sites, and higher at two sites, in 2009. Seasonal maximum DO readings were higher at three out of the four sites in 2009. Since both years are post-project, such differences may be due to new heavy vegetation growth that was observed across the channel profile in many areas, low flow levels, and/or other current channel and flow characteristics.

Table 4
DISSOLVED OXYGEN SUMMARY BY MONTH
ARAUJO 2008 AND 2009

Site #	Continuous Monitoring Location	Year	April				May				June				July				August			
			Month Min	Month Max	Month Avg	# Days DO < 6 ppm at least 1 hr	Month Min	Month Max	Month Avg	# Days DO < 6 ppm at least 1 hr	Month Min	Month Max	Month Avg	# Days DO < 6 ppm at least 1 hr	Month Min	Month Max	Month Avg	# Days DO < 6 ppm at least 1 hr	Month Min	Month Max	Month Avg	# Days DO < 6 ppm at least 1 hr
1	Downstrm Dam Site	2008	6.43	18.08	11.08	0	3.91	18.21	9.53	17	2.80	18.00	9.38	17	1.98	16.29	8.52	31	2.12	15.59	8.41	31
		2009	3.76	21.59	11.83	5	2.58	18.95	10.01	17	2.60	15.55	8.71	19	1.31	15.51	7.96	29	2.65	17.77	8.86	26
2	Upstrm Dam Site	2008	5.27	20.36	10.98	1	3.64	29.67	9.38	21	3.01	17.66	9.37	17	2.30	20.42	10.02	31	2.22	18.29	8.93	31
		2009	1.53	26.28	8.30	24	0.67	23.92	10.20	20	0.55	13.66	7.20	29	1.57	17.33	7.86	30	2.44	16.52	7.81	31
3	Upstrm Pump Stn	2008	6.53	17.18	10.82	0	2.55	18.65	9.32	17	2.93	16.90	9.25	17	3.05	19.20	9.66	31	2.99	21.37	9.72	30
		2009	4.46	28.04	11.98	3	3.69	24.92	12.02	11	3.02	18.22	8.74	18	1.82	14.08	7.17	31	1.89	15.16	7.94	30
4	Hiway 3 Bridge	2008	6.30	17.26	10.73	0	INC	INC	INC	INC	2.85	16.08	9.31	16	2.46	17.44	9.13	31	1.56	16.61	8.36	31
		2009	4.43	25.29	12.89	3	3.01	23.11	10.95	15	3.11	15.26	8.80	13	2.18	15.46	7.76	31	2.64	14.63	8.31	30

INC *Incomplete record for month*

The minimum, maximum, and average dissolved oxygen concentrations per month for the four sites are summarized in Table 4. The 2009 lowest monthly minimum DO reading occurred in June while the lowest monthly average occurred in July. Based on the data presented in the summary, relative DO concentrations between the sites appeared to vary randomly, with no one site appearing to be consistently lowest or highest. However, Site 2, the site upstream of the dam, did have the lowest monthly minimums and averages during April, May, and June 2009 for unexplained reasons. In many 2008/2009 comparisons displayed in Table 4, a decrease in dissolved oxygen readings is predominant but not consistent.

Although a dissolved oxygen lethal threshold for salmonids is dependent on other habitat conditions, studies have shown that juvenile and adult salmonids show symptoms of DO deprivation at DO levels below 6.0 ppm.[2] The number of days per month that had at least one DO reading below 6.0 ppm is shown in Table 4 to gain a better understanding of when critical DO levels are more likely to occur. In 2009, DO readings below 6.0 ppm occurred most frequently in July and August.

Daily average dissolved oxygen concentrations for the 2009 season were calculated for each site and are shown graphically in Figure 3. Daily minimum dissolved oxygen readings for 2009 were also graphed for each site and are shown in Figure 4. These plots show that the site upstream of the dam site, Site 2, tended to have the lowest levels. The area above this site was impounded prior to dam removal; the remaining sediment and new heavy vegetation growth upstream of this site after implementation may contribute to differences in dissolved oxygen at this site, especially early in the season. See Appendix C for Cross-section profiles B and A, which are just upstream of Monitoring Site 2, for a plot of the sediment depths in that area both pre- and post-project.

[2] Bjornn, T.C. and D.W. Reiser, 1991. "Habitat requirements of salmonids in streams." *American Fisheries Society Special Publication 19: 83-138.*

Figure 3
Daily Average Dissolved Oxygen 2009
Araujo Sites 1,2,3 and 4

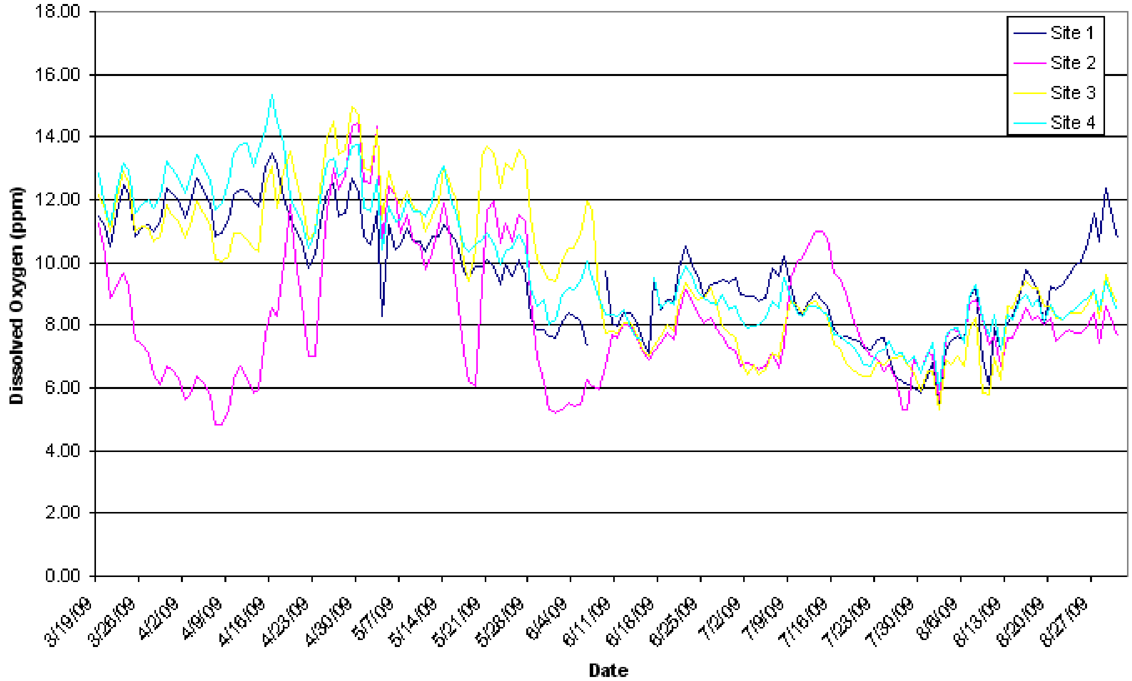
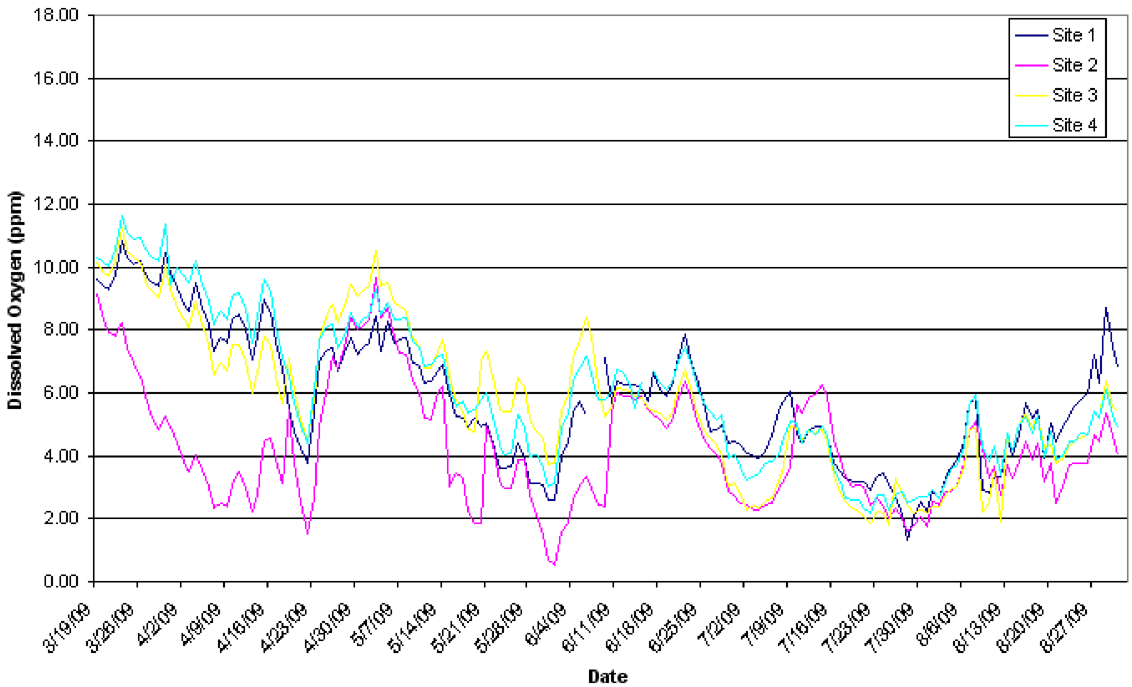


Figure 4
Daily Minimum Dissolved Oxygen 2009
Araujo Sites 1, 2, 3 and 4



Dissolved oxygen grab sample data was also collected in 2009 in order to compare readings between the YSI-55 and the D-Optologger continuous meter. This data is presented in Table 5, comparing the grab samples to the nearest sample in time taken by the D-Optologger, and is shown graphically in Appendix A. Considering an accuracy of +/- 0.5 ppm with the YSI-55 meter and +/- 0.02 ppm with the D-Optologger, the readings from the two instruments are generally very similar, providing validity to the dissolved oxygen monitoring methods.

Table 5
2009 CONTINUOUS DATA AND GRAB SAMPLE DATA COMPARISON

Sampling Date 7/24/09

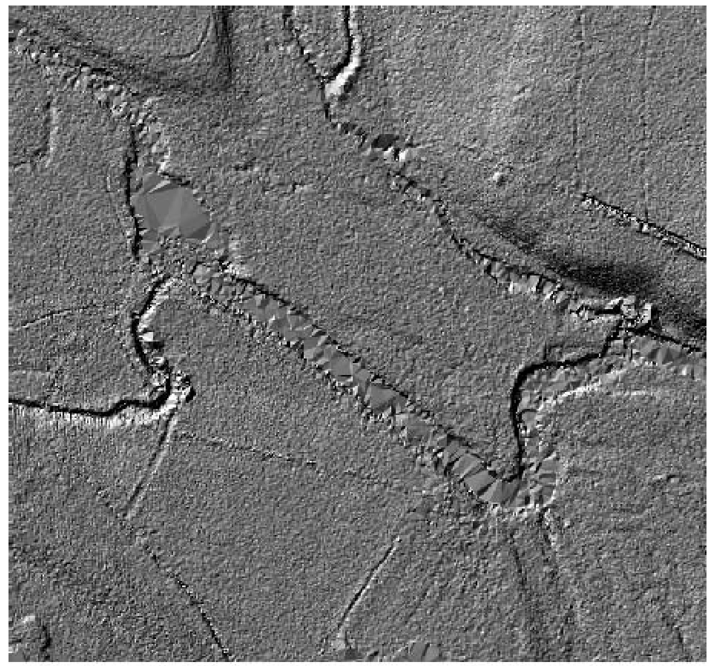
Site #	Location	Continuous Hourly Data			YSI-55 Grab Samples		
		Time	DO ppm	Temp °C	Time	DO ppm	Temp °C
1	Downstream Araujo Dam Site	6:00 AM	3.43	23.2	5:39 AM	3.21	23.3
2	Upstream Araujo Dam Site	6:00 AM	2.38	22.8	5:33 AM	2.53	22.6
3	Upstream Pump/ Screen Site	5:00 AM	2.28	22.9	5:22 AM	3.31	22.6
4	Highway 3 Bridge Site	5:00 AM	2.78	22.7	5:11 AM	3.11	22.5

Width of Wetted Channel
Cross-sections of the river channel, including depth of sediment deposits, were measured in July/August 2009 at six permanent locations throughout the project area. The resulting profiles of the riverbank were then graphed over the profiles taken in 2007 for comparison (Appendix C). Measuring a change in width of wetted channel, or ponded surface area, will help determine whether a reduction in surface area available to aquatic vegetation and fine sediment, both of which reduce dissolved oxygen in the river, has occurred as a result of the project. However, the cross-section profile is only a snapshot in time and may not reflect long-term changes in the project area. No major differences were observed between profiles, as any significant channel changes are expected to take many years to evolve.

An aerial photo taken in 2005 is shown alongside a LiDAR image taken in January 2008 (Figure 5). As discussed in the Methods section, technology differences must be kept in mind when comparing the two very different images. Other than the removal of the dam, no major differences in channel configuration are apparent from the pre- and post-construction image comparison.

Figure 5: Pre-Construction Aerial Photograph and Post-Construction Bare Earth LiDAR Image of Araujo Project

2005 NAIP Aerial Photograph



2008 Bare Earth LiDAR image

Photopoints

Post-construction photographs were taken from the established photopoints on August 5, 2009. Photos were taken both upstream and downstream. A pre- and post- construction comparison from three photopoints is shown in Appendix D. Visual documentation of the project site before and after construction is useful in determining post-construction changes in the channel configuration, flow characteristics, and vegetation growth.

Improved Fish Passage

Digital photographs were taken upon completion of the boulder weir as well as during a period of low flow (20 cfs) to document that the weir structure provided a maximum jump height of twelve inches. These photos are shown in Figure 6.

Figure 6: Araujo Boulder Weir

December 2007

August 2009

Ditch Maintenance/ Electrical Demand

As described in the 2007 Monitoring Report, the ranchers involved with the project reported a total cost of $7,000 for herbicides and labor for pre-construction ditch maintenance in 2007. This responsibility fell on the water users that utilized the ditches to transport the water to their property. After the open earthen ditches were replaced with underground pipeline as part of the project, they reported that they had no costs for ditch maintenance in 2008 or 2009. The intent of the new pipeline is to not only keep the water cleaner and cooler and reduce water loss, but also to reduce the need for labor and herbicide treatment for ditch weed control.

Implementation of the project resulted in electrical pumping costs that did not exist with the previous no-cost gravity-fed irrigation system. For the westside diversion which serves five users, the ranchers reported a total 2009 electrical cost of $3425. Power costs for the three remaining diversions, which serve one user each, were reported at a total of $5536 in 2009. These figures resulted in a total annual cost of $8961 for electrical power to run the new pumping system during 2009.

By subtracting the pre-project annual ditch maintenance cost of $7000 from the post-project power cost of $8961, the project-wide net difference in costs to the five diverters is a total increase of $1961 in 2009. Since ditch maintenance was the responsibility of only those using the ditches, and individual pumping requirements differ, individual net cost reductions or increases vary to make up the total overall increase of $1961.

Future Monitoring

Recognition of the value of continued monitoring of the Araujo Fish Passage and Water Quality Improvements Project has prompted the NCRWQCB and SVRCD to develop plans to monitor during the 2010 and 2011 irrigation seasons. The river water quality parameters that will be monitored will again include water temperature and dissolved oxygen, some of which will take place at the same sites used in 2007 through 2009. Photo monitoring will also be performed at the established photopoints to document changes each year. Monitoring protocol as outlined in the current Quality Assurance Project Plan will be followed. Changes to the Monitoring Plan for future monitoring will be approved by the NCRWQCB prior to implementation.

Summary

Pre-construction monitoring data collected in 2007 and post-construction monitoring data collected in 2008 and 2009 for the Araujo project has helped facilitate evaluation of the success of the project. Due to the lack of a well-documented baseline and a short monitoring period in 2007, direct comparison between pre-construction and post-construction data is limited. However, as discussed in the Results section of this report, general trends in improved water quality may be emerging from the interpretation of the data. Streamflow appears to be flowing more consistently through the project area due to the removal of the flashboard dam and associated impoundment, bringing more consistent temperatures throughout. Fish passage is clearly improved after the replacement of the dam with the boulder weir.

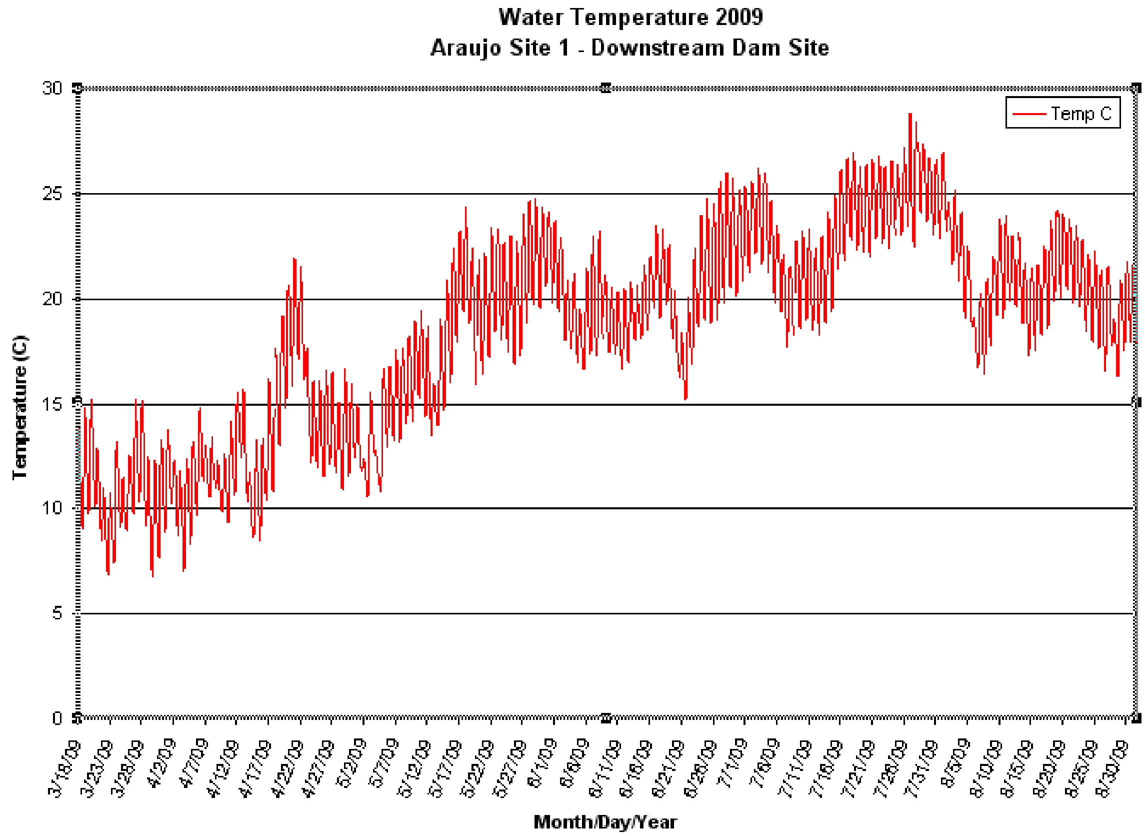
An observed increase in aquatic vegetation across the channel profile in many sections of the project area may be the result of decreased water depth above the dam site, allowing plants to grow where access to sunlight was previously limited due to the pre-project ponding. This increase in vegetation growth may have resulted in lower dissolved oxygen levels in some areas. This indicates that perhaps restoration efforts need to include more than dam removal in low-gradient areas with heavy aquatic vegetation growth in order to improve the river system as a whole.

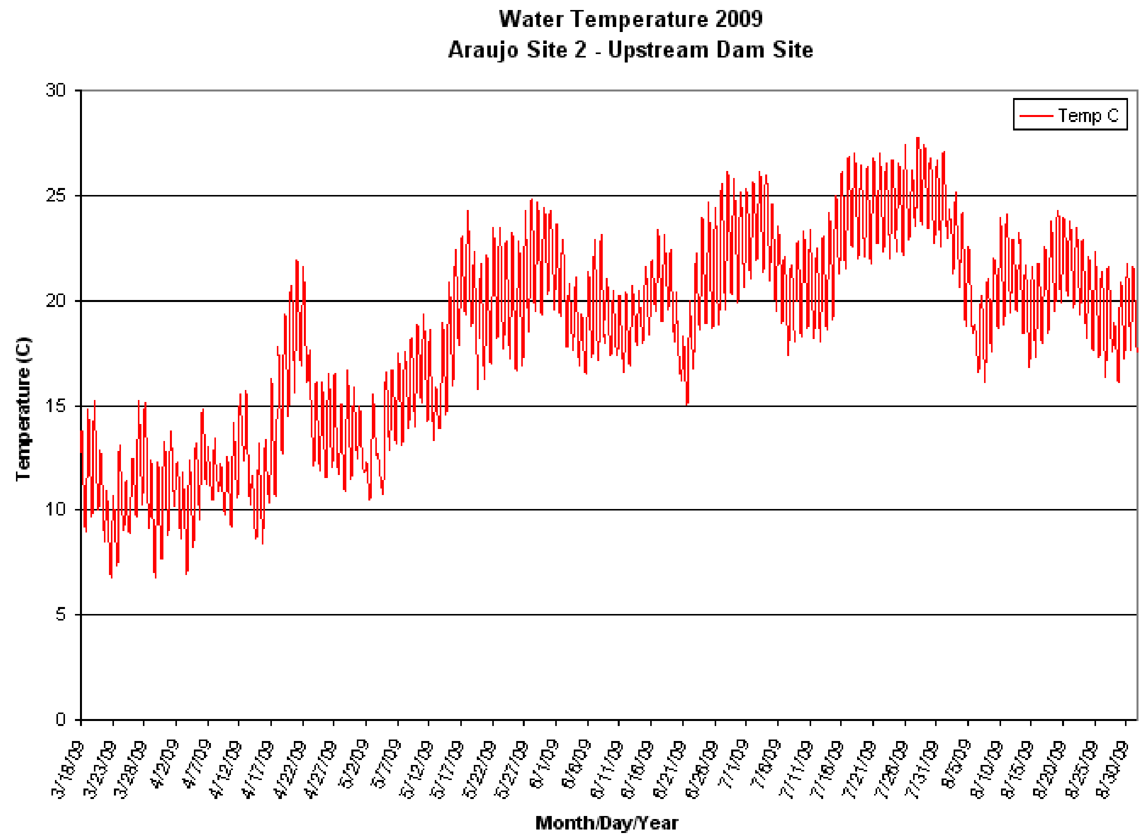
This project data will also provide interesting points of comparison for older grab sampling data captured by the NCRWQCB and the Shasta Valley RCD at the upstream end of the project area at the Highway 3 Bridge. Data from that site was intermittently collected between 1992 and the initiation of this project, and can be found in the final TMDL staff report for the Shasta River.

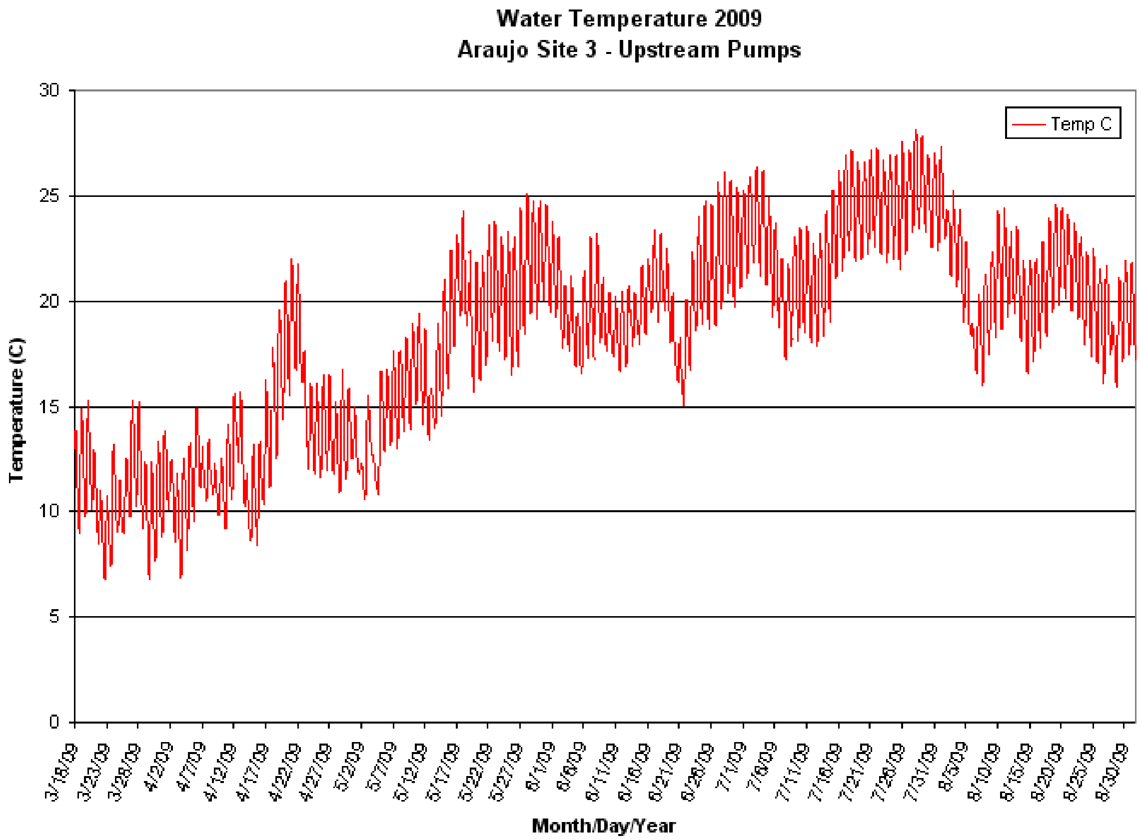
While monitoring during the two-year post-construction period has been useful for documenting trends and immediate changes within the project area, many river processes occur slowly over time and may not be measurable for many years. Continued monitoring within the basin by the Shasta Valley RCD will facilitate the collection of quality data to help determine the effects of the diversion removal project on the river system and the habitat it provides.

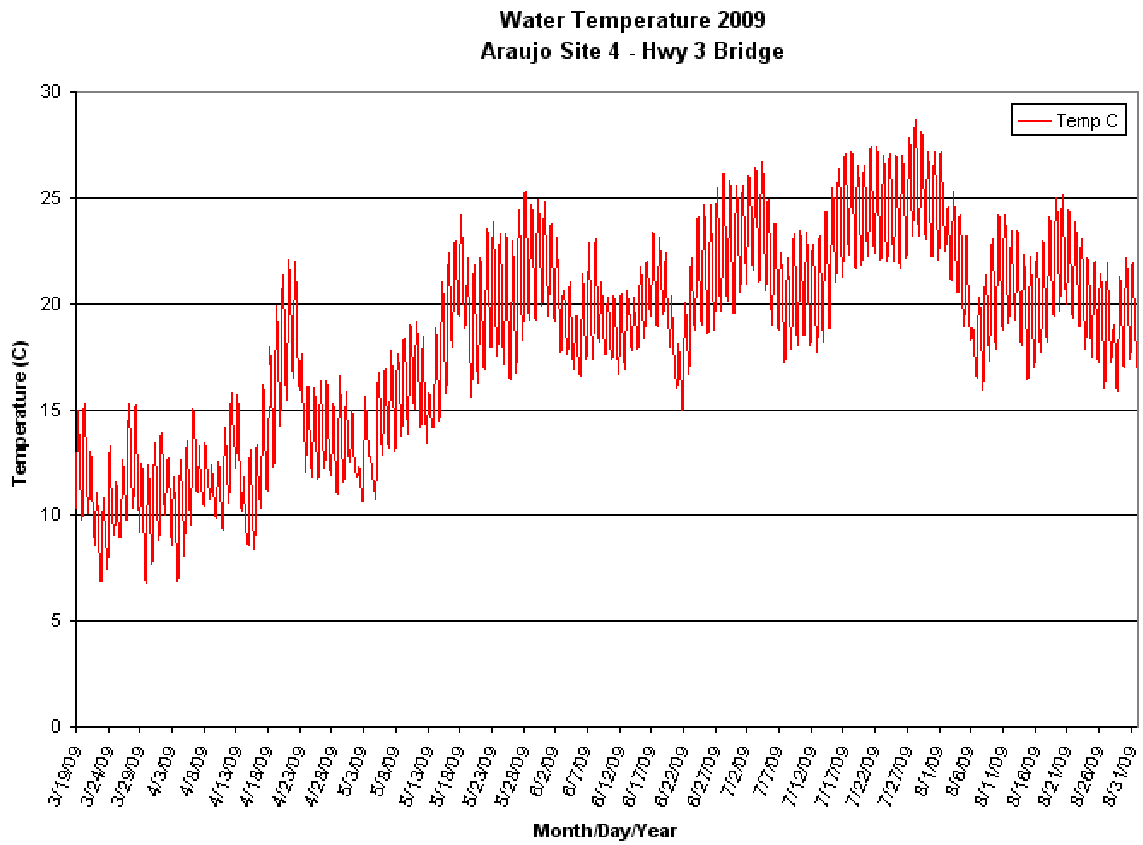
The Shasta River is a unique river system with its spring-fed, low-gradient characteristics and agricultural influences. Much progress has been made in the last decade by various agencies to study and understand its processes. Projects such as the Araujo Dam removal not only meet short-term goals to improve water quality, habitat, and passage, but also contribute to the base of knowledge needed for sound resource management of our rivers.

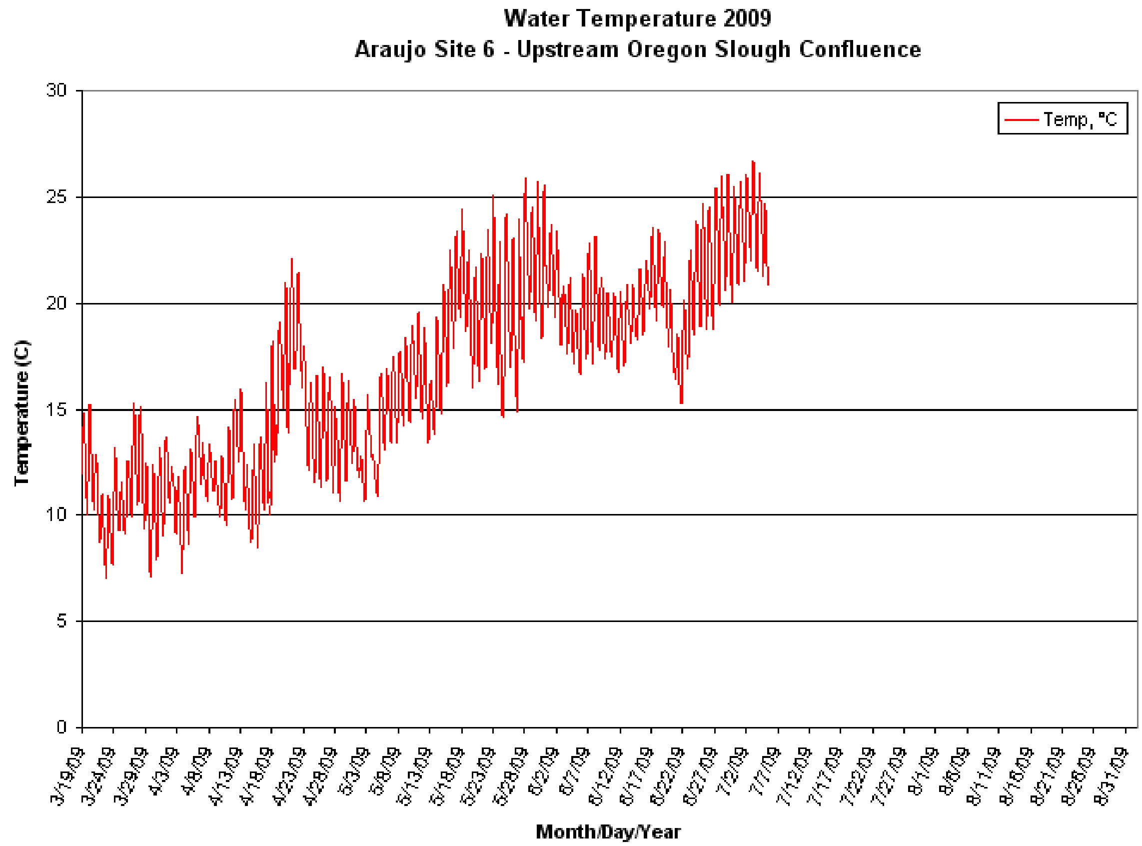
Appendix A. Temperature Graphs

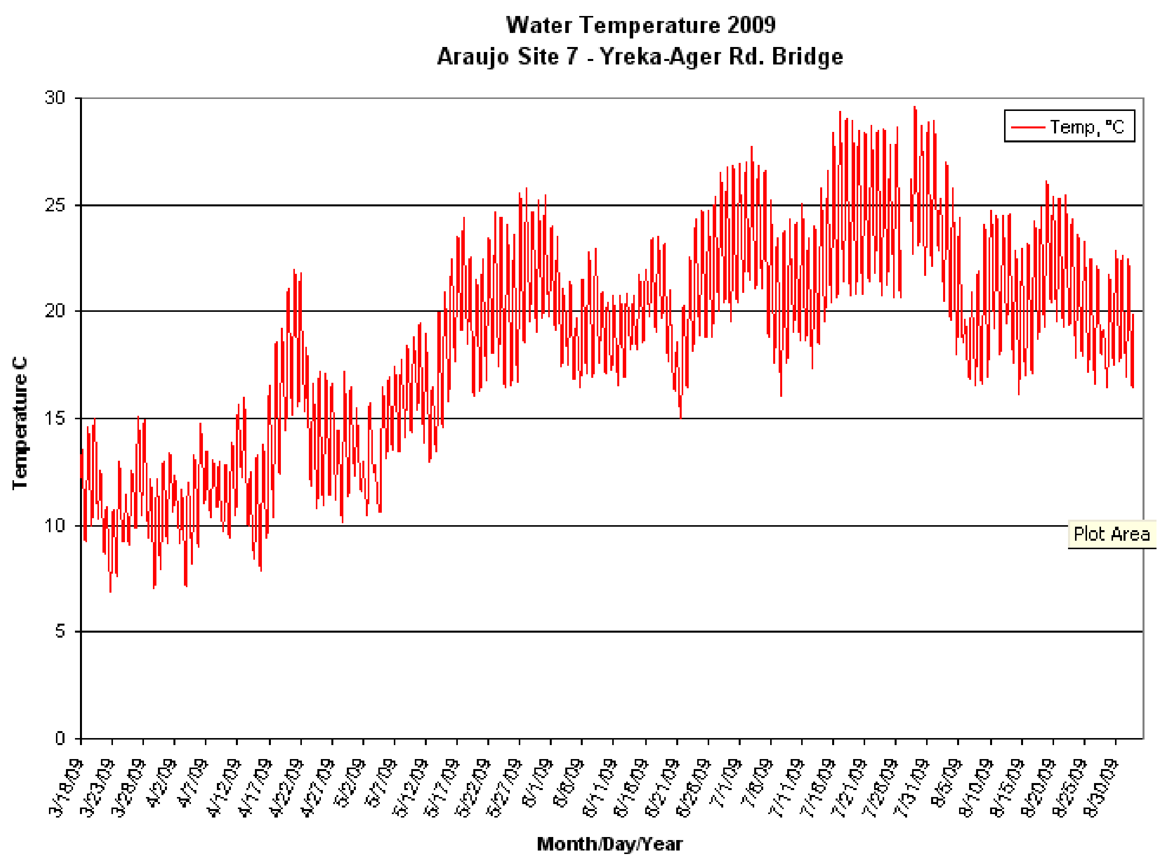




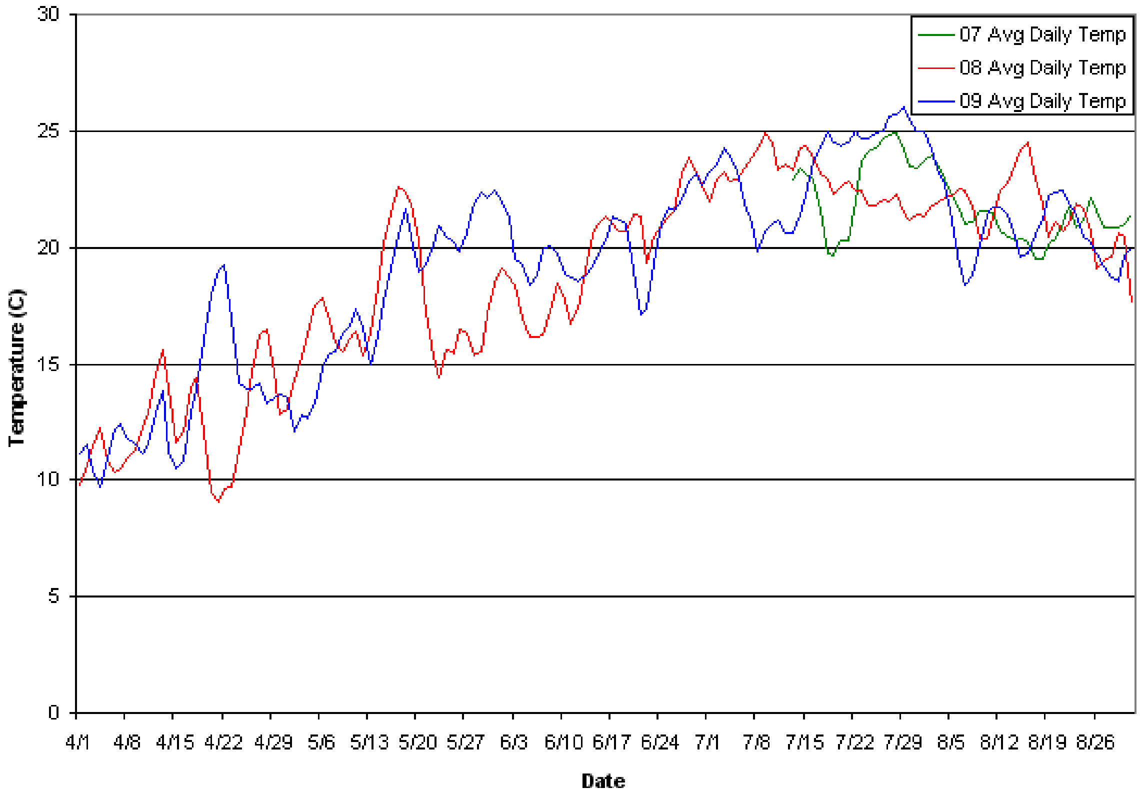

Water Temperature 2009
Araujo Site 3 - Upstream Pumps
Temp C
Temperature (C)
30
25
20
15
10
5
0
3/18/09
3/23/09
3/28/09
4/2/09
4/7/09
4/12/09
4/17/09
4/22/09
4/27/09
5/2/09
5/7/09
5/12/09
5/17/09
5/22/09
5/27/09
6/1/09
6/6/09
6/11/09
6/16/09
6/21/09
6/26/09
7/1/09
7/6/09
7/11/09
7/16/09
7/21/09
7/26/09
7/31/09
8/5/09
8/10/09
8/15/09
8/20/09
8/25/09
8/30/09
Month/Day/Year


Water Temperature 2009
Araujo Site 4 - Hwy 3 Bridge
Temp C
Temperature (C)
30
25
20
15
10
5
0
3/19/09
3/24/09
3/29/09
4/3/09
4/8/09
4/13/09
4/18/09
4/23/09
4/28/09
5/3/09
5/8/09
5/13/09
5/18/09
5/23/09
5/28/09
6/2/09
6/7/09
6/12/09
6/17/09
6/22/09
6/27/09
7/2/09
7/7/09
7/12/09
7/17/09
7/22/09
7/27/09
8/1/09
8/6/09
8/11/09
8/16/09
8/21/09
8/26/09
8/31/09
Month/Day/Year

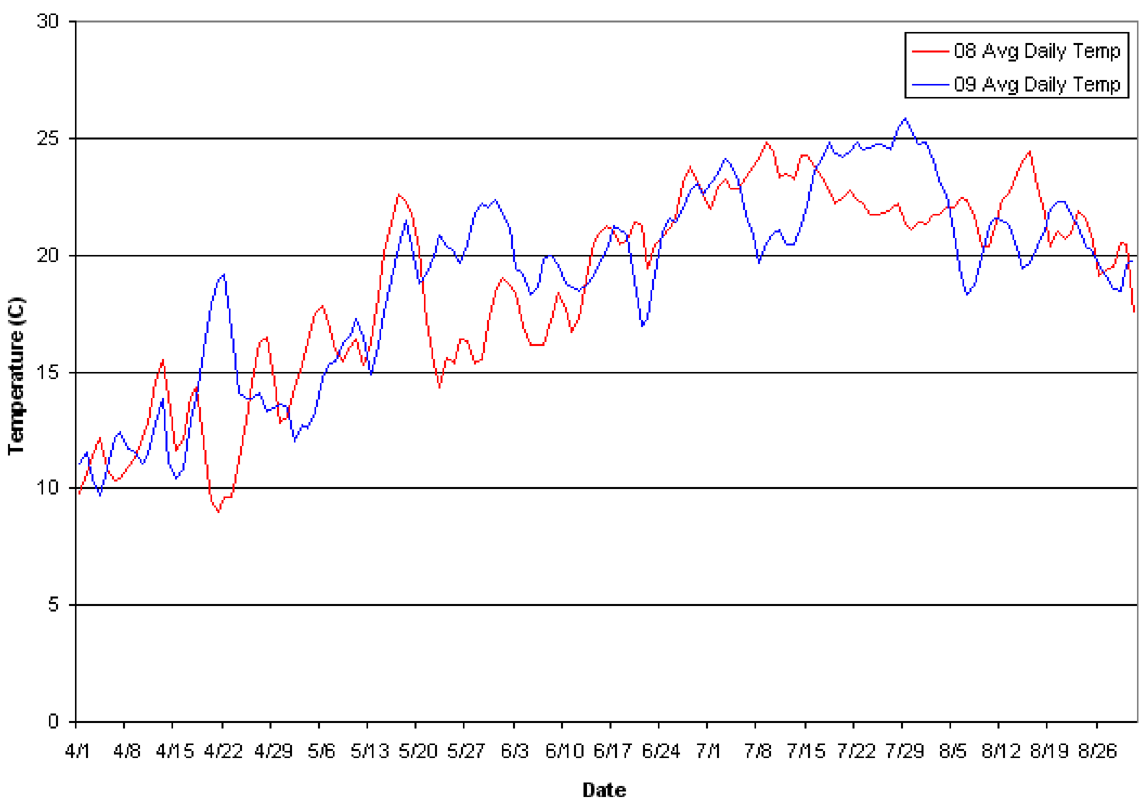

Water Temperature 2009
Araujo Site 6 - Upstream Oregon Slough Confluence
Temp, °C
Temperature (C)
Month/Day/Year


Water Temperature 2009
Araujo Site 7 - Yreka-Ager Rd. Bridge
Temp, °C
Temperature C
Plot Area
Month/Day/Year

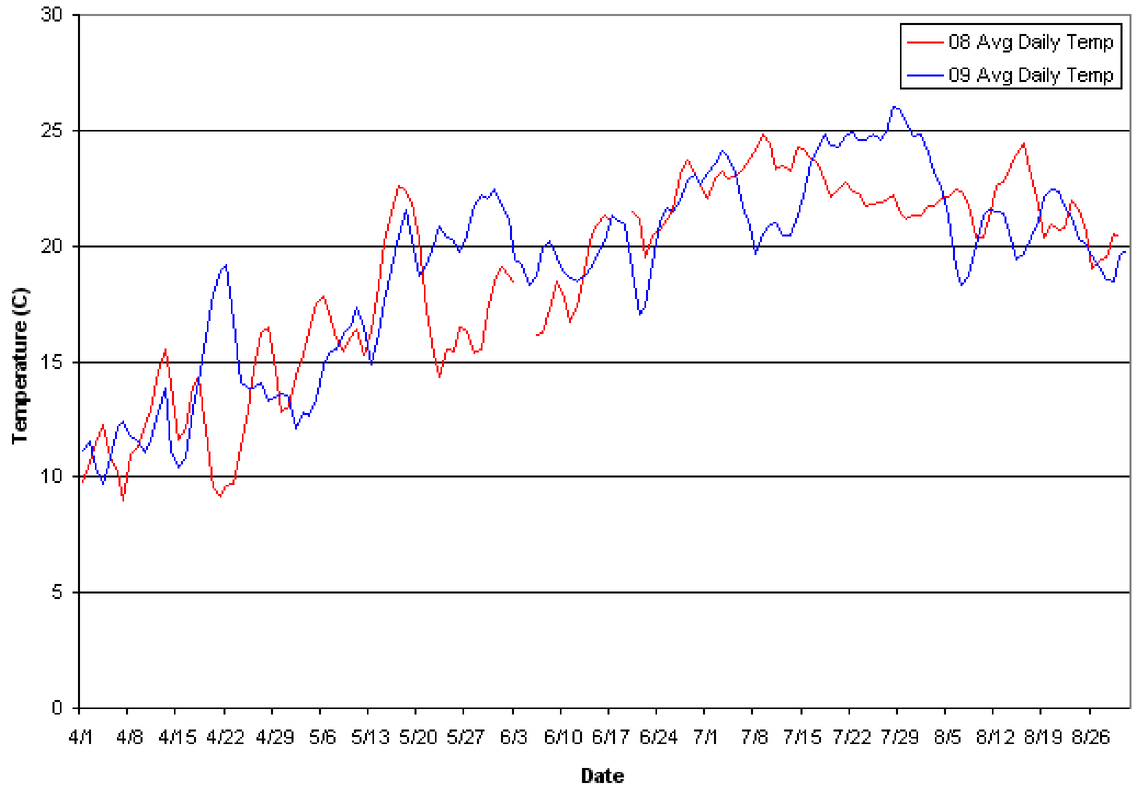
Daily Average Water Temperature 2007 - 2009
Araujo Site 1 - Downstream Dam Site



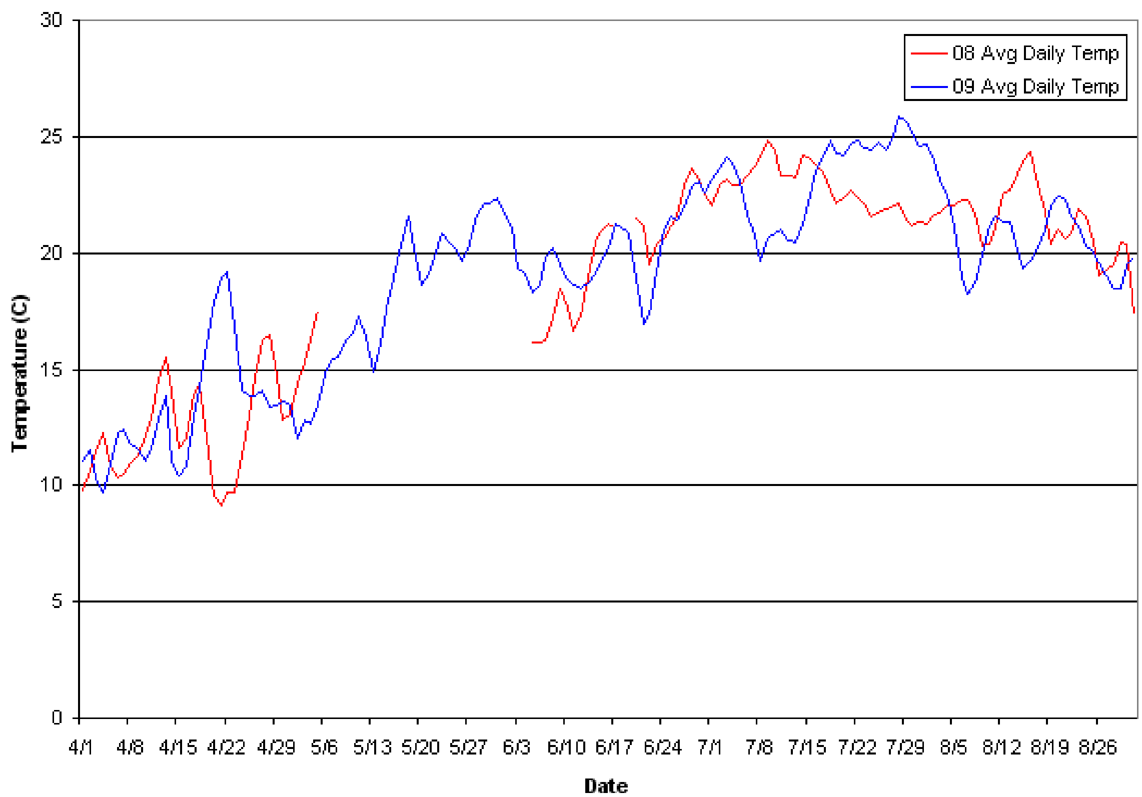
Daily Average Water Temperature 2008 and 2009
Araujo Site 2 - Upstream Dam Site

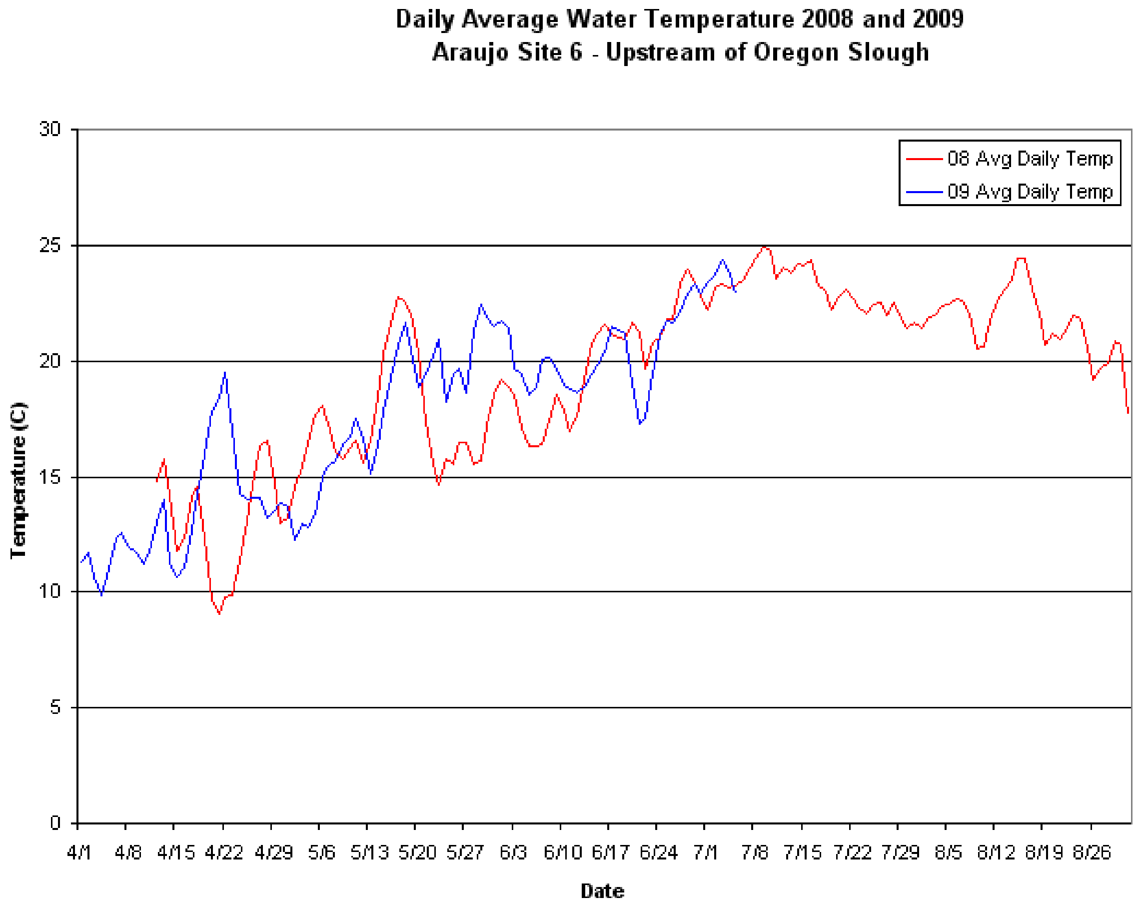


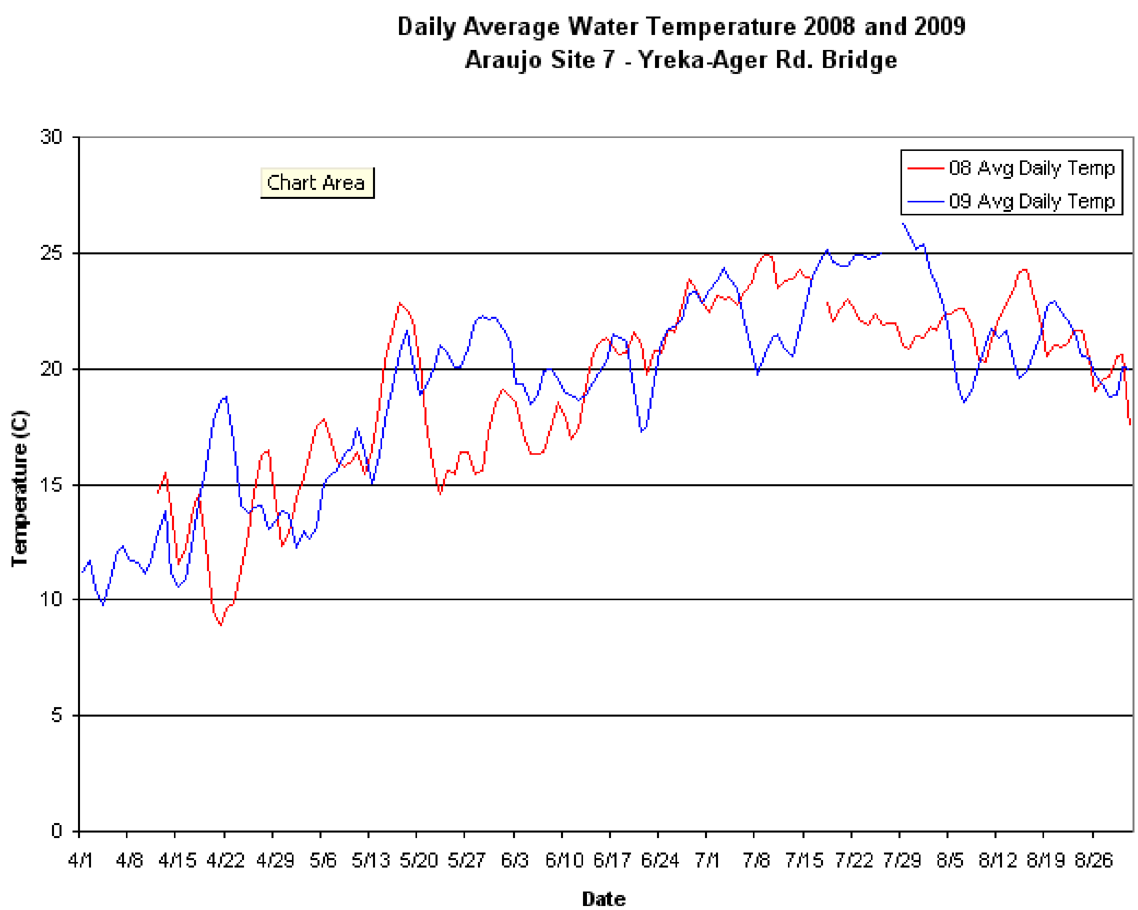
Daily Average Water Temperature 2008 and 2009
Araujo Site 3 - Upstream Pump

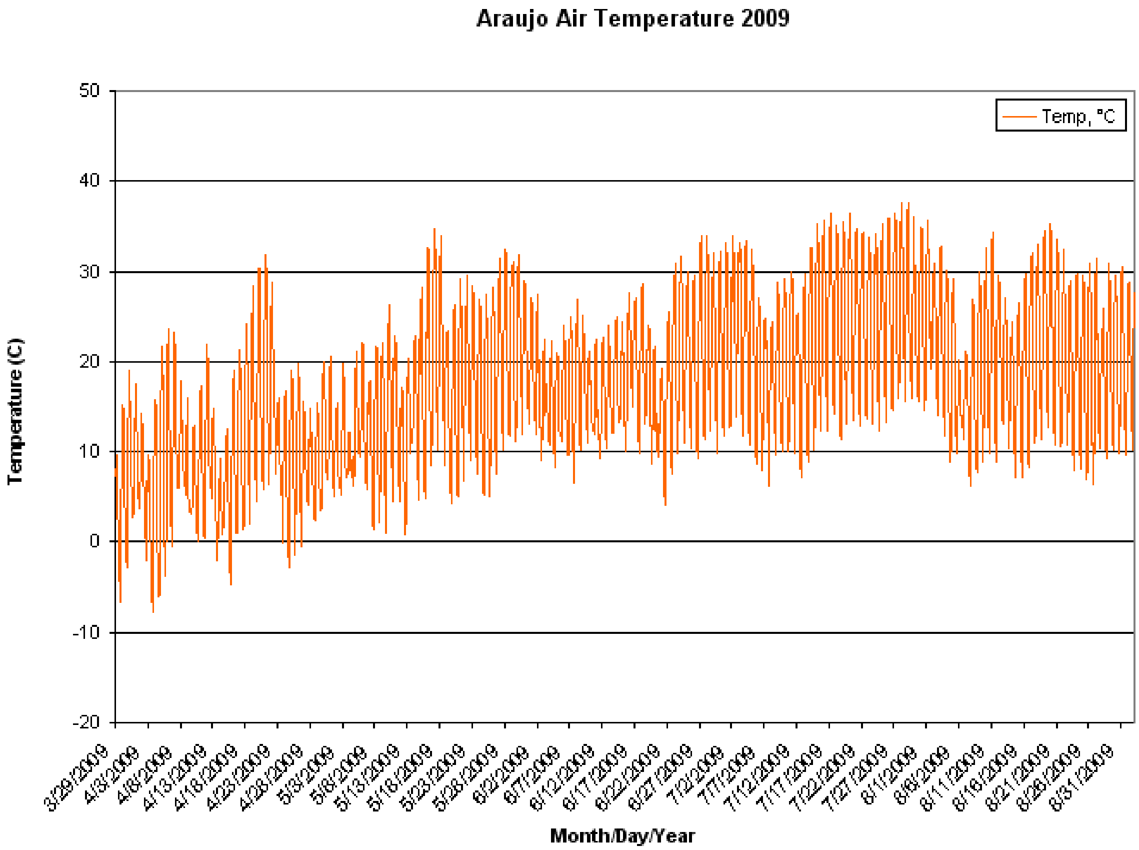


Daily Average Water Temperature 2008 and 2009
Araujo Site 4 - Highway 3 Bridge



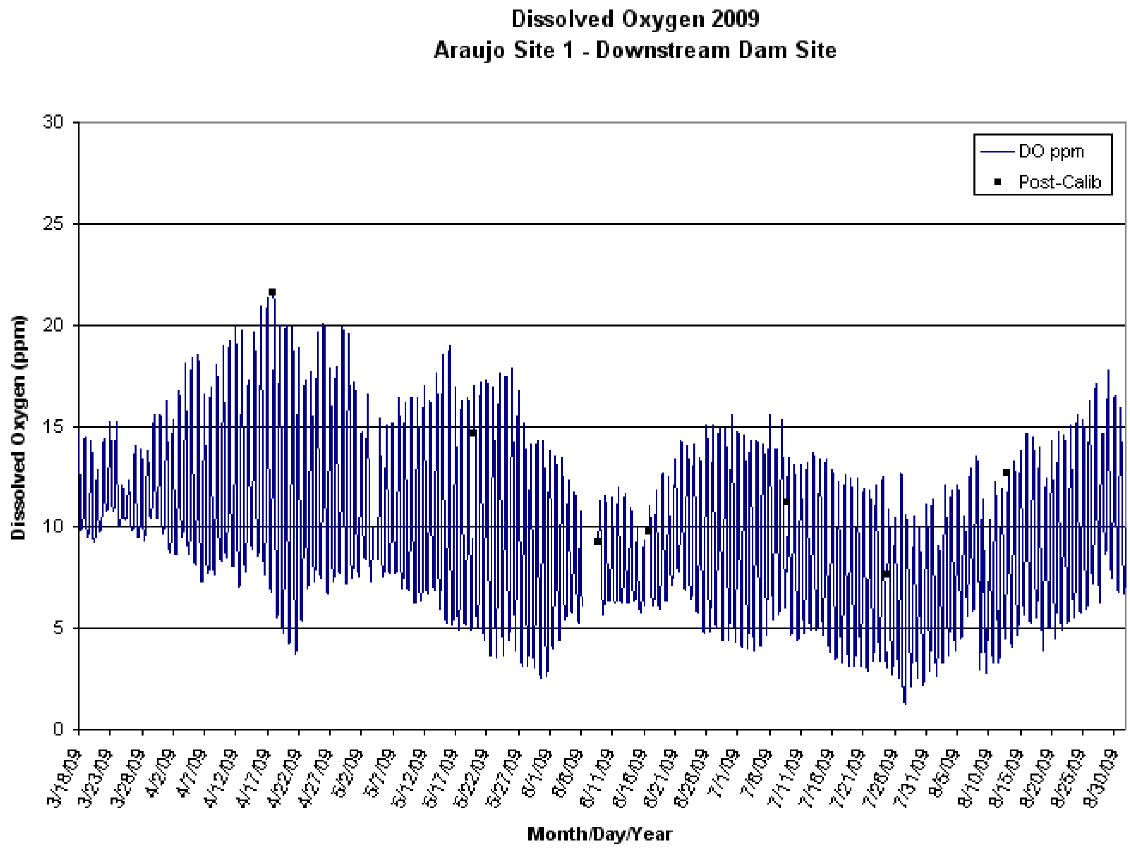

Daily Average Water Temperature 2008 and 2009
Araujo Site 6 - Upstream of Oregon Slough
08 Avg Daily Temp
09 Avg Daily Temp
Temperature (C)
30
25
20
15
10
5
0
4/1 4/8 4/15 4/22 4/29 5/6 5/13 5/20 5/27 6/3 6/10 6/17 6/24 7/1 7/8 7/15 7/22 7/29 8/5 8/12 8/19 8/26
Date

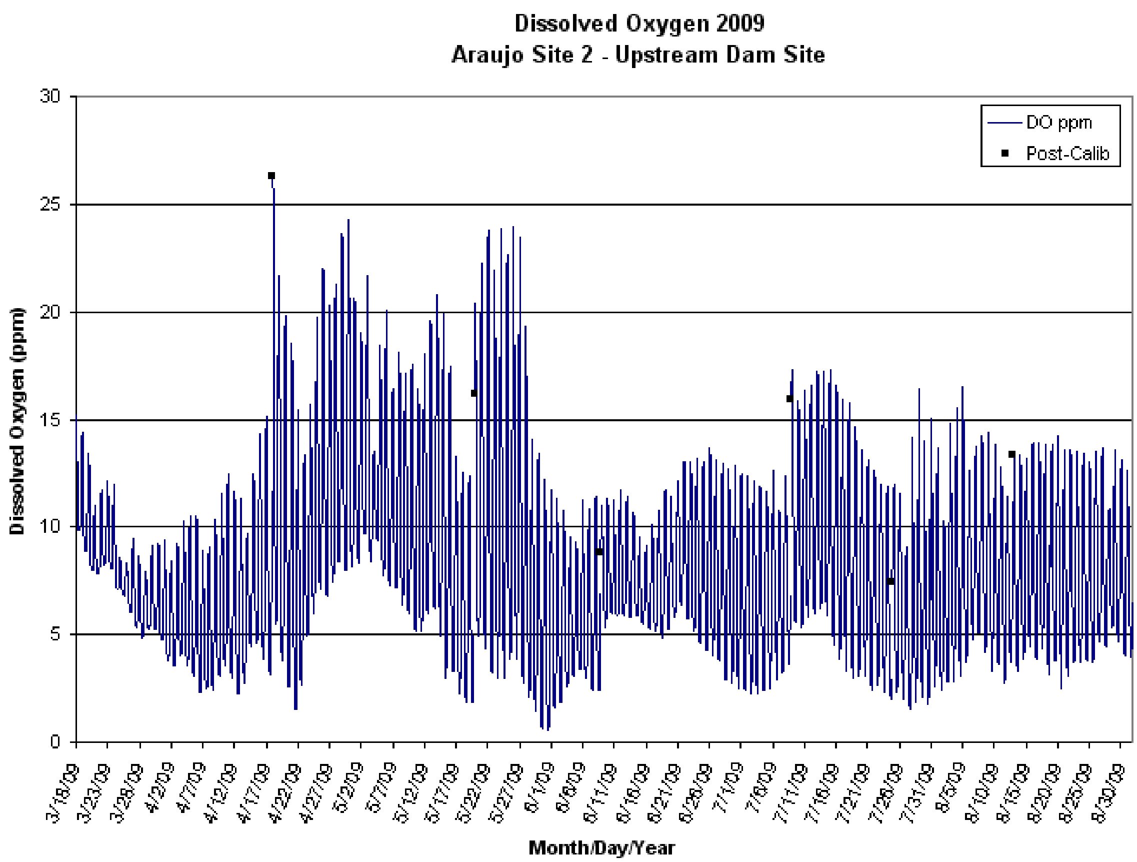

Daily Average Water Temperature 2008 and 2009
Araujo Site 7 - Yreka-Ager Rd. Bridge
Chart Area
08 Avg Daily Temp
09 Avg Daily Temp
Temperature (C)
30
25
20
15
10
5
0
4/1 4/8 4/15 4/22 4/29 5/6 5/13 5/20 5/27 6/3 6/10 6/17 6/24 7/1 7/8 7/15 7/22 7/29 8/5 8/12 8/19 8/26
Date

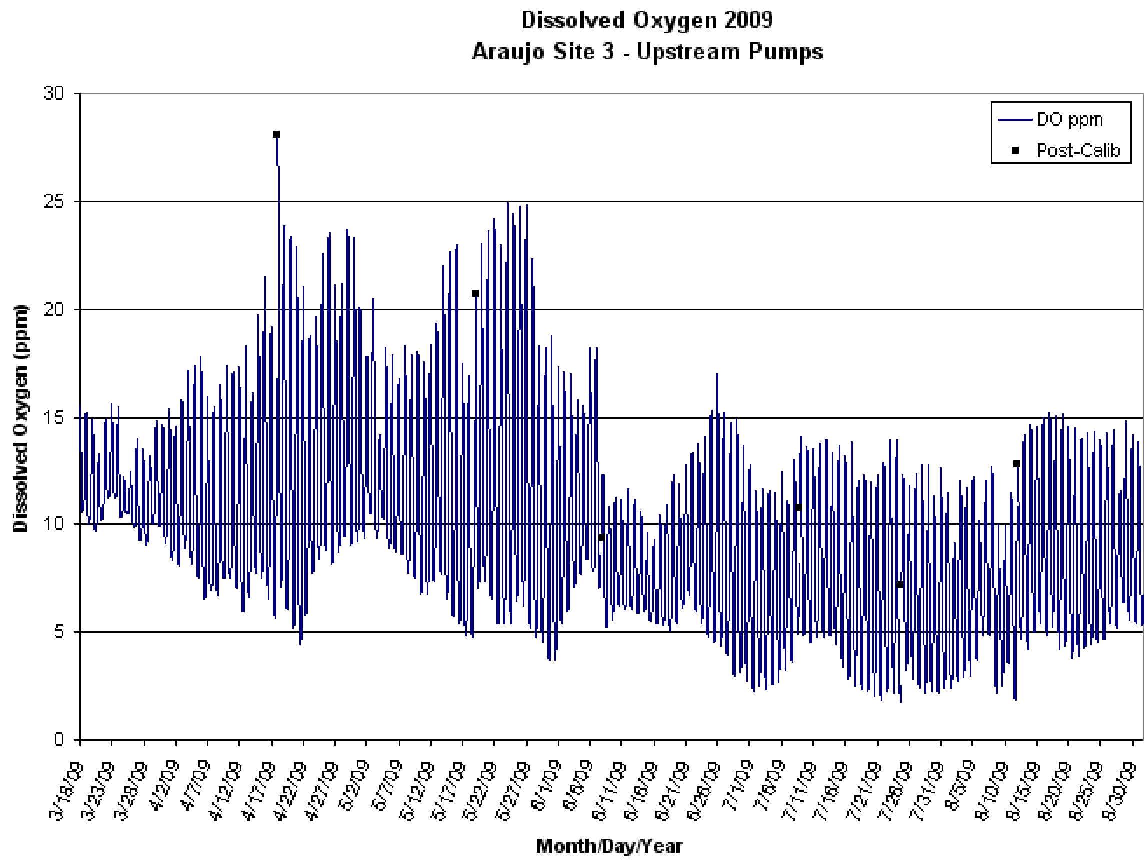


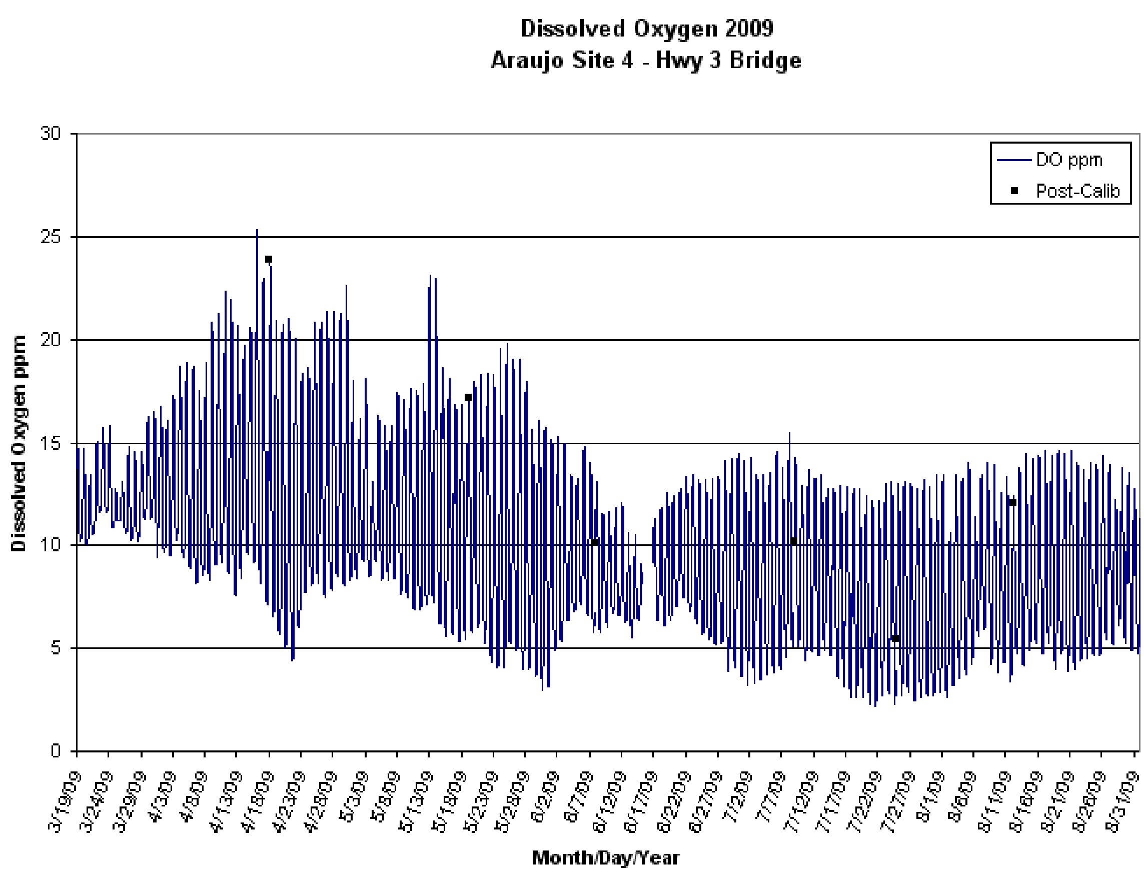
Araujo Air Temperature 2009
Temp, °C
Temperature (C)
50
40
30
20
10
0
-10
-20
3/29/2009
4/3/2009
4/8/2009
4/13/2009
4/18/2009
4/23/2009
4/28/2009
5/3/2009
5/8/2009
5/13/2009
5/18/2009
5/23/2009
5/28/2009
6/2/2009
6/7/2009
6/12/2009
6/17/2009
6/22/2009
6/27/2009
7/2/2009
7/7/2009
7/12/2009
7/17/2009
7/22/2009
7/27/2009
8/1/2009
8/6/2009
8/11/2009
8/16/2009
8/21/2009
8/26/2009
8/31/2009
Month/Day/Year

Appendix B. Dissolved Oxygen Graphs

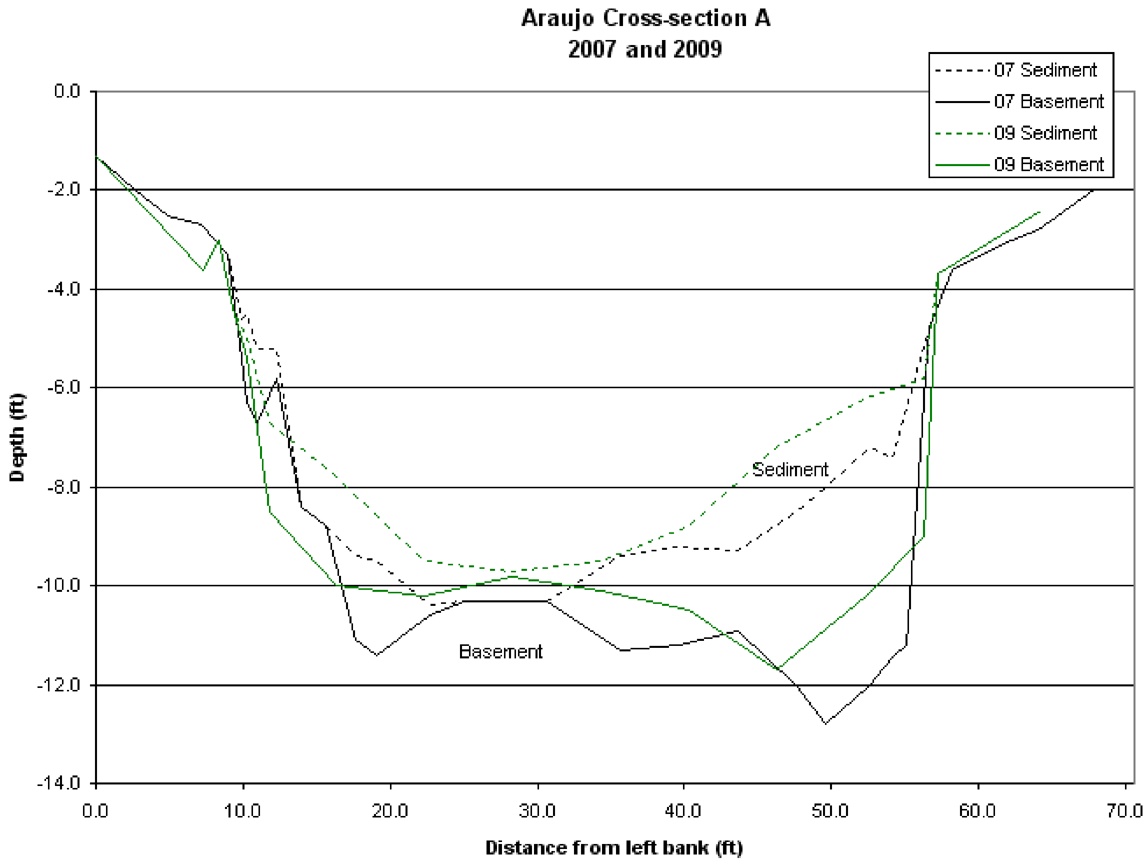


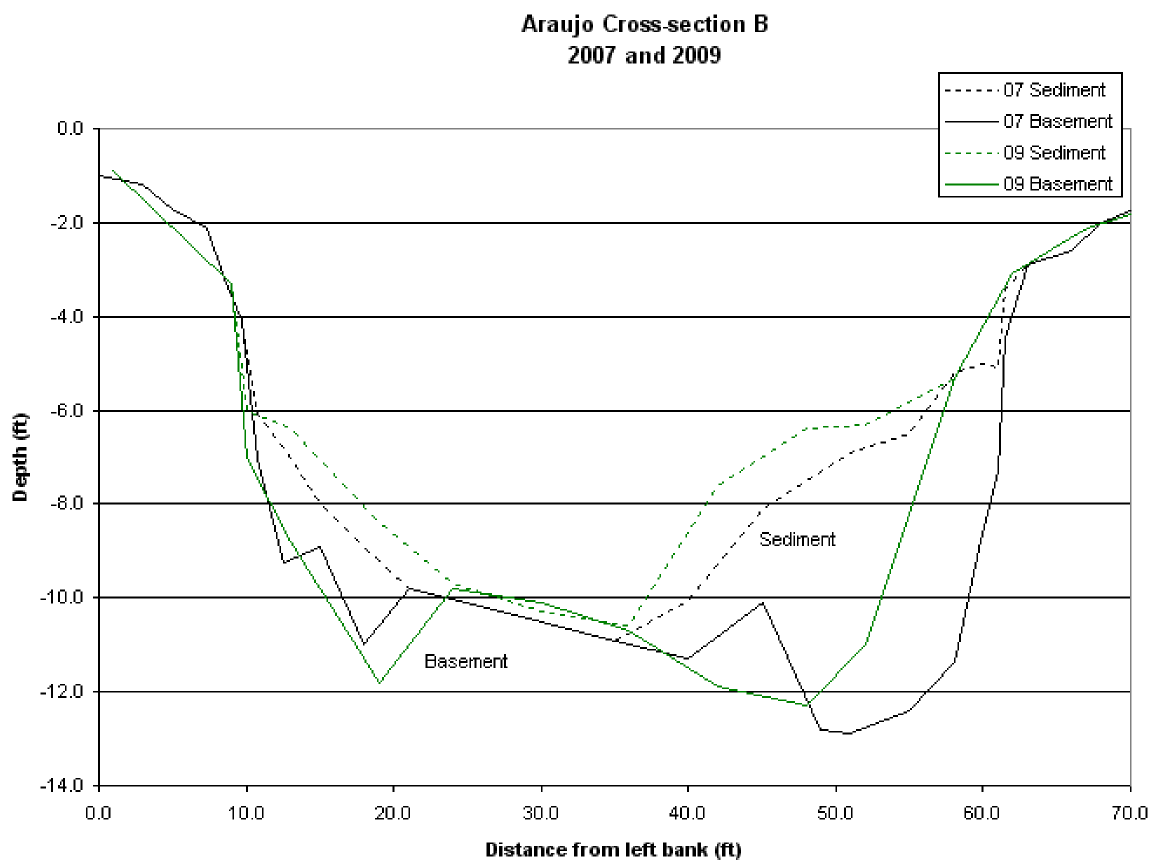


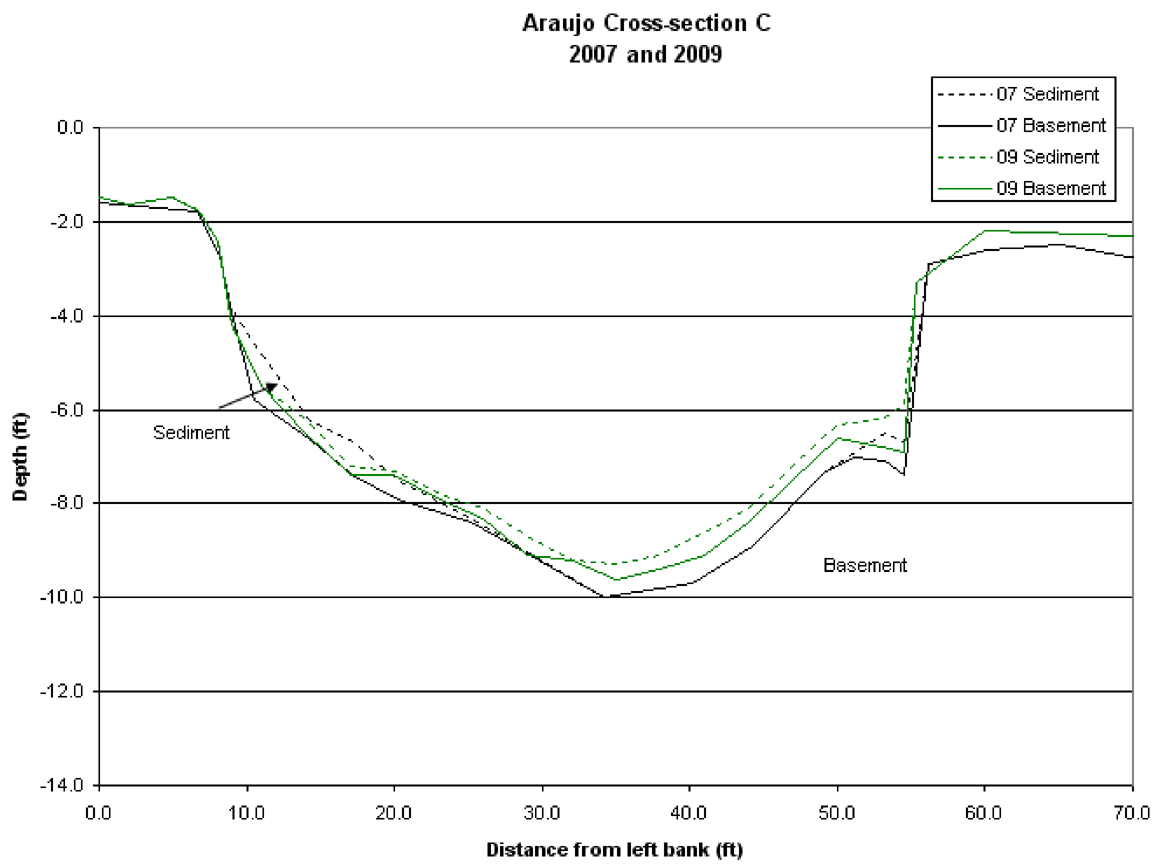

Dissolved Oxygen 2009
Araujo Site 3 - Upstream Pumps
DO ppm
Post-Calib
Dissolved Oxygen (ppm)
Month/Day/Year

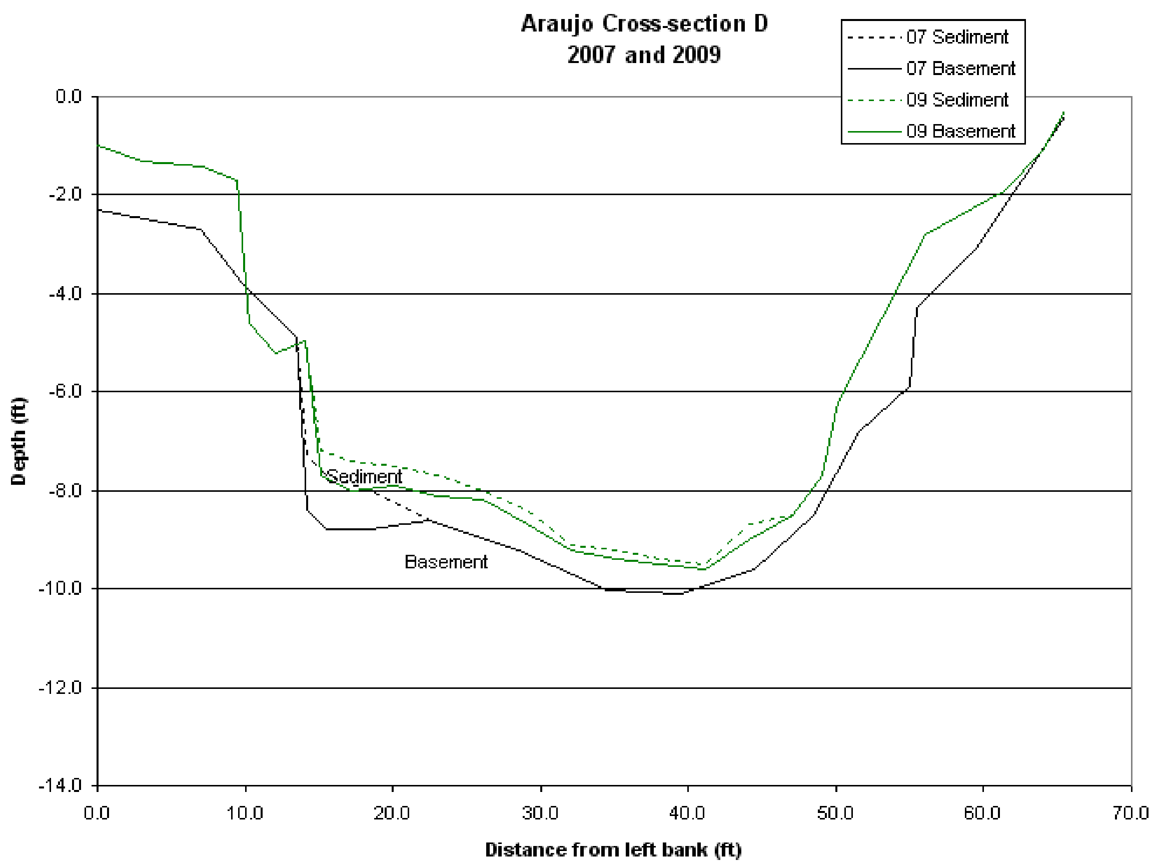

Dissolved Oxygen 2009
Araujo Site 4 - Hwy 3 Bridge
DO ppm
Post-Calib
Dissolved Oxygen ppm
Month/Day/Year

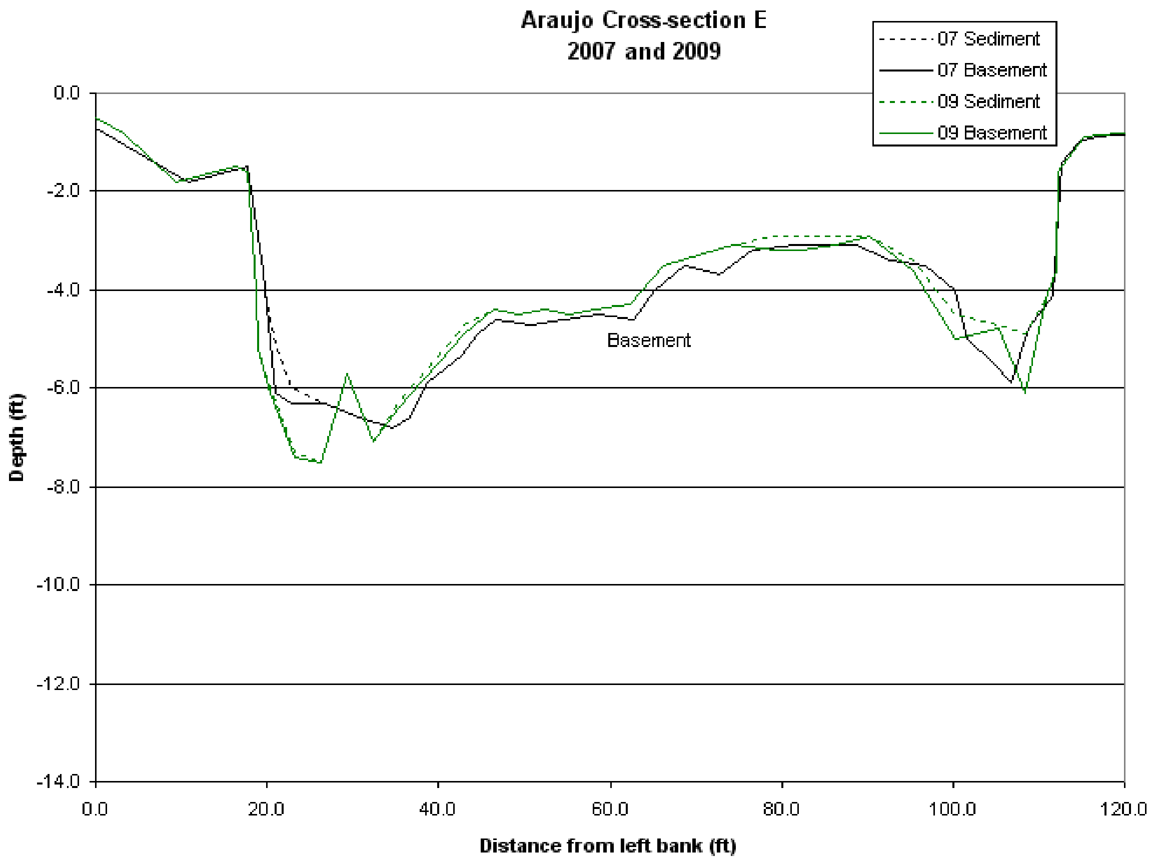
Appendix C. Cross Section Profiles

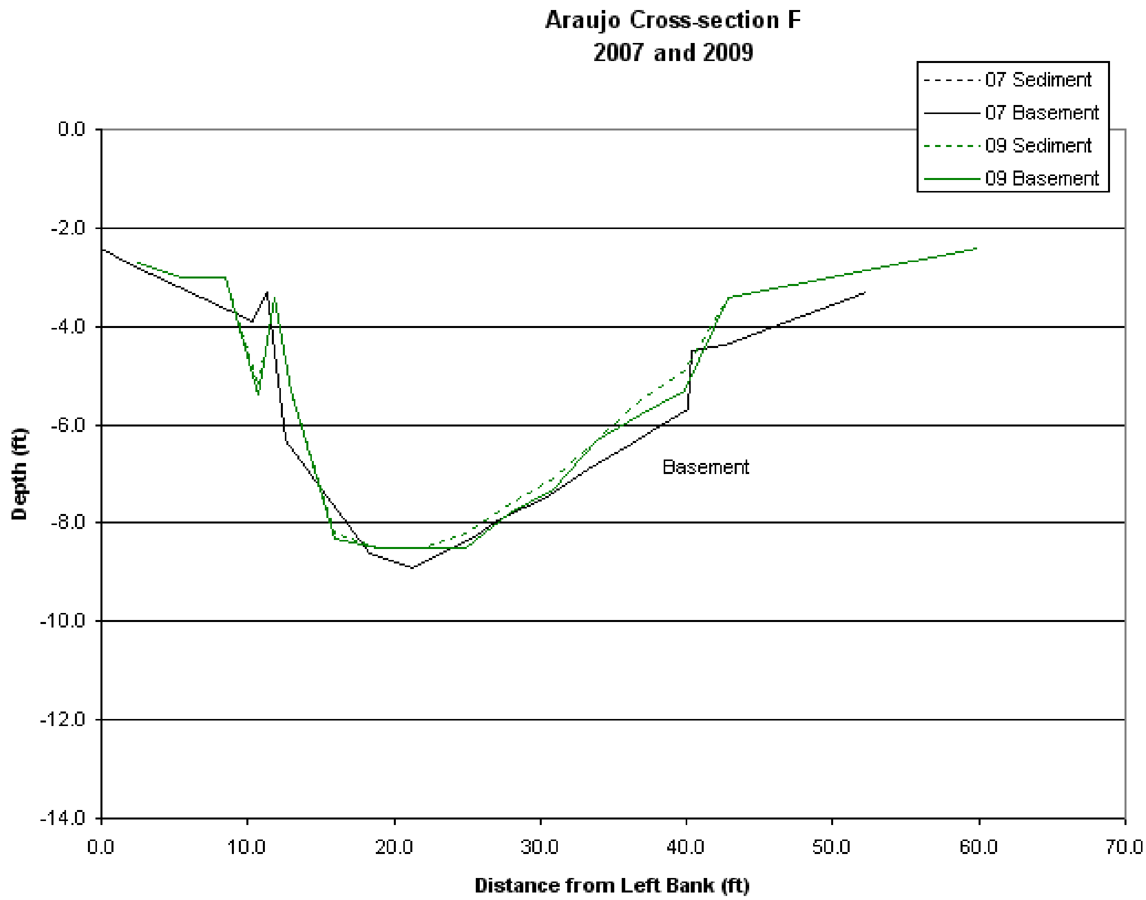





Araujo Cross-section C
2007 and 2009
07 Sediment
07 Basement
09 Sediment
09 Basement
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
-14.0
Depth (ft)
Sediment
Basement
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Distance from left bank (ft)


Araujo Cross-section D
2007 and 2009
07 Sediment
07 Basement
09 Sediment
09 Basement
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
-14.0
Depth (ft)
Sediment
Basement
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Distance from left bank (ft)


Araujo Cross-section E
2007 and 2009
07 Sediment
07 Basement
09 Sediment
09 Basement
Basement
Depth (ft)
Distance from left bank (ft)
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
-14.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0


Araujo Cross-section F
2007 and 2009
07 Sediment
07 Basement
09 Sediment
09 Basement
Basement
Depth (ft)
Distance from Left Bank (ft)
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
-14.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0

Appendix D. Photo Monitoring 2007 and 2009


Photo Point 2: Downstream 2007 2009


Photo Point 2: Upstream 2007 2009


Photo Point 3: Downstream 2007 2009


Photo Point 5: Upstream 2007 2009