

# **FINAL 2009 Klamath River Nutrient Summary Report**



**Yurok Tribe Environmental Program:  
Water Division**

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## **Acknowledgements**

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## **I. Introduction**

This report summarizes the presence and concentration of commonly occurring nutrients on the Klamath River during the 2009 sampling season. The Yurok Tribe Environmental Program (YTEP) collected water samples at several monitoring sites from Weitchpec to the Klamath River Estuary on a bi-weekly interval starting in mid-May and ending in mid-October, followed by monthly sampling in November and December. This sampling was performed in an effort to track both temporal and spatial patterns on the lower reaches of the Klamath River during the sampling period. This data was added to previous years' nutrient data as part of an endeavor to build a multi-year database on the Lower Klamath River. This nutrient summary is part of YTEP's comprehensive program of monitoring and assessment of the chemical, physical, and biological integrity of the Klamath River and its tributaries in a scientific and defensible manner. Sample events were coordinated with the Karuk and Hoopa Tribes, PacifiCorp, and the Bureau of Reclamation to collect samples during the same day and with comparable methods to expand our understanding of the nutrient dynamics in the Klamath basin.

## **II. Background**

### ***The Klamath River Watershed***

The Klamath River system drains much of northwestern California and south-central Oregon (Figure 2-1). Thus, even activities taking place on land hundreds miles off the Yurok Indian Reservation (YIR) can affect water conditions within YIR boundaries. For example, upriver hydroelectric and diversion projects have altered natural flow conditions for decades. The majority of water flowing through the YIR is derived from scheduled releases of impounded water from the Upper Klamath Basin that is often of poor quality with regards to human needs as well as the needs of fish and wildlife.

Some historically perennial streams now have ephemeral lower reaches and seasonal fish migration blockages because of inadequate dam releases from water diversion projects along the Klamath and Trinity Rivers. The releases contribute to lower mainstem levels and excessive sedimentation which in turn causes subsurface flow and aggraded deltas. Additionally, the lower slough areas of some of the Lower Klamath

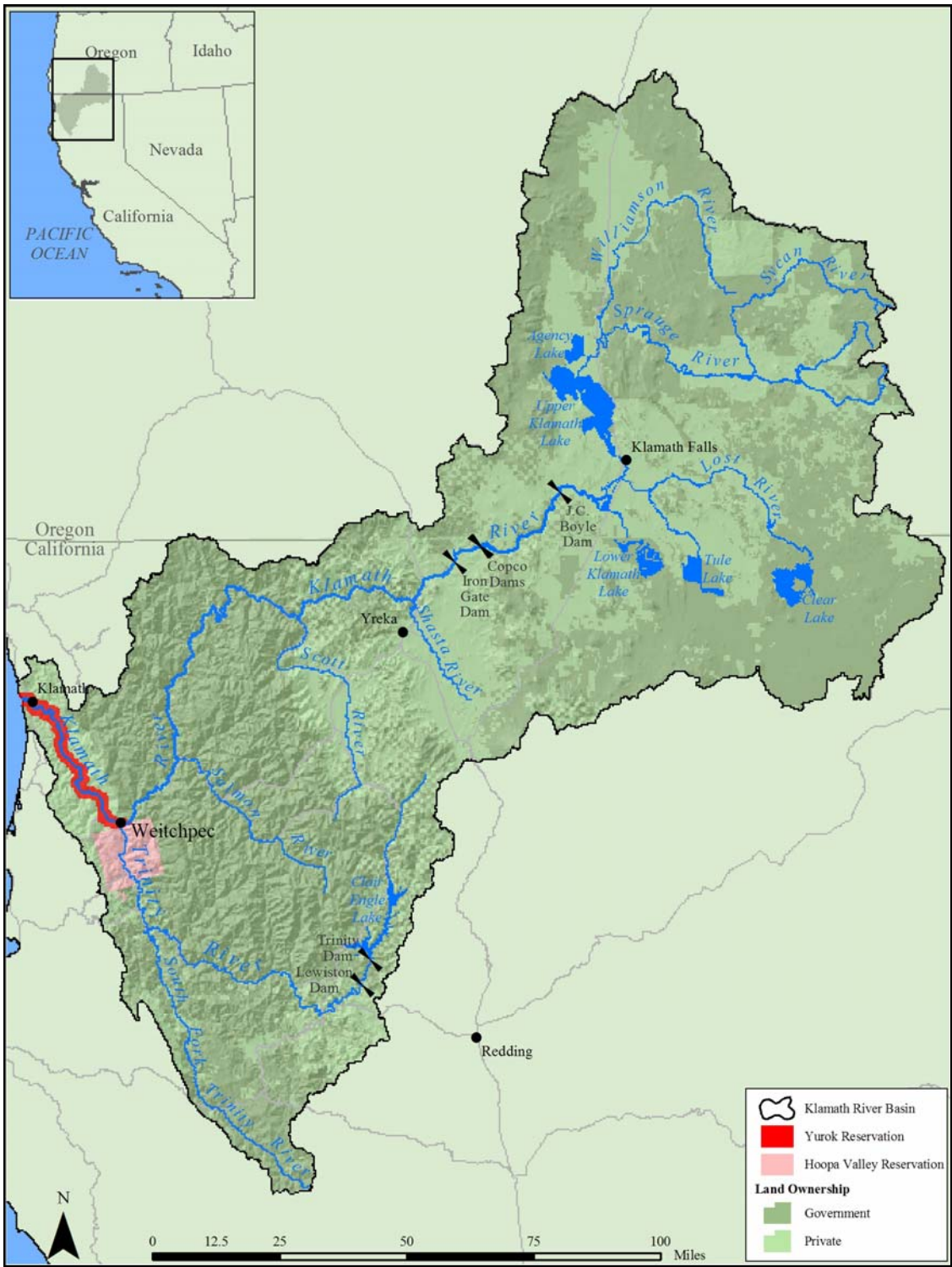


Figure 2-1. Klamath River Basin Map

tributaries that enter the estuary experience eutrophic conditions during periods of low flow. These can create water quality barriers to fish migration when dissolved oxygen levels are inadequate for migrating fish. The Klamath River is on California State Water Resource Control Board's (SWRCB) 303(d) List as impaired for temperature, dissolved oxygen, and nutrients and portions of the Klamath River were recently listed as impaired for microcystin and sedimentation in particular reaches.

The basin's fish habitat has also been greatly diminished in area and quality during the past century by accelerated sedimentation from mining, timber harvest practices, and road construction, as stated by Congress in the Klamath River Act of 1986. Management of private lands in the basin (including fee land within Reservation boundaries) has been, and continues to be, dominated by timber harvest.

### ***The Klamath River***

The health of the Klamath River and associated fisheries has been central to the life of the Yurok Tribe since time immemorial fulfilling subsistence, commercial, cultural, and ceremonial needs. Yurok oral tradition reflects this. The Yurok did not use terms for north or east, but rather spoke of direction in terms of the flow of water (Kroeber 1925). The Yurok word for salmon, *nepuy*, refers to "that which is eaten". Likewise, the local waterways and watershed divides have traditionally defined Yurok aboriginal territories. Yurok ancestral land covers about 360,000 acres and is distinguished by the Klamath and Trinity Rivers, their surrounding lands, and the Pacific Coast extending from Little River to Damnation Creek.

The fisheries resource continues to be vital to the Yurok today. The September 2002 Klamath River fish kill, where a conservative estimate of 33,000 fish died in the lower Klamath before reaching their natal streams to spawn, was a major tragedy for the Yurok people.

### ***The Yurok Indian Reservation***

The current YIR consists of a 59,000-acre corridor extending for one mile from each side of the Klamath River from just upstream of the Trinity River confluence to the Pacific Ocean, including the channel and the bed of the river (Figure 2-2). There are



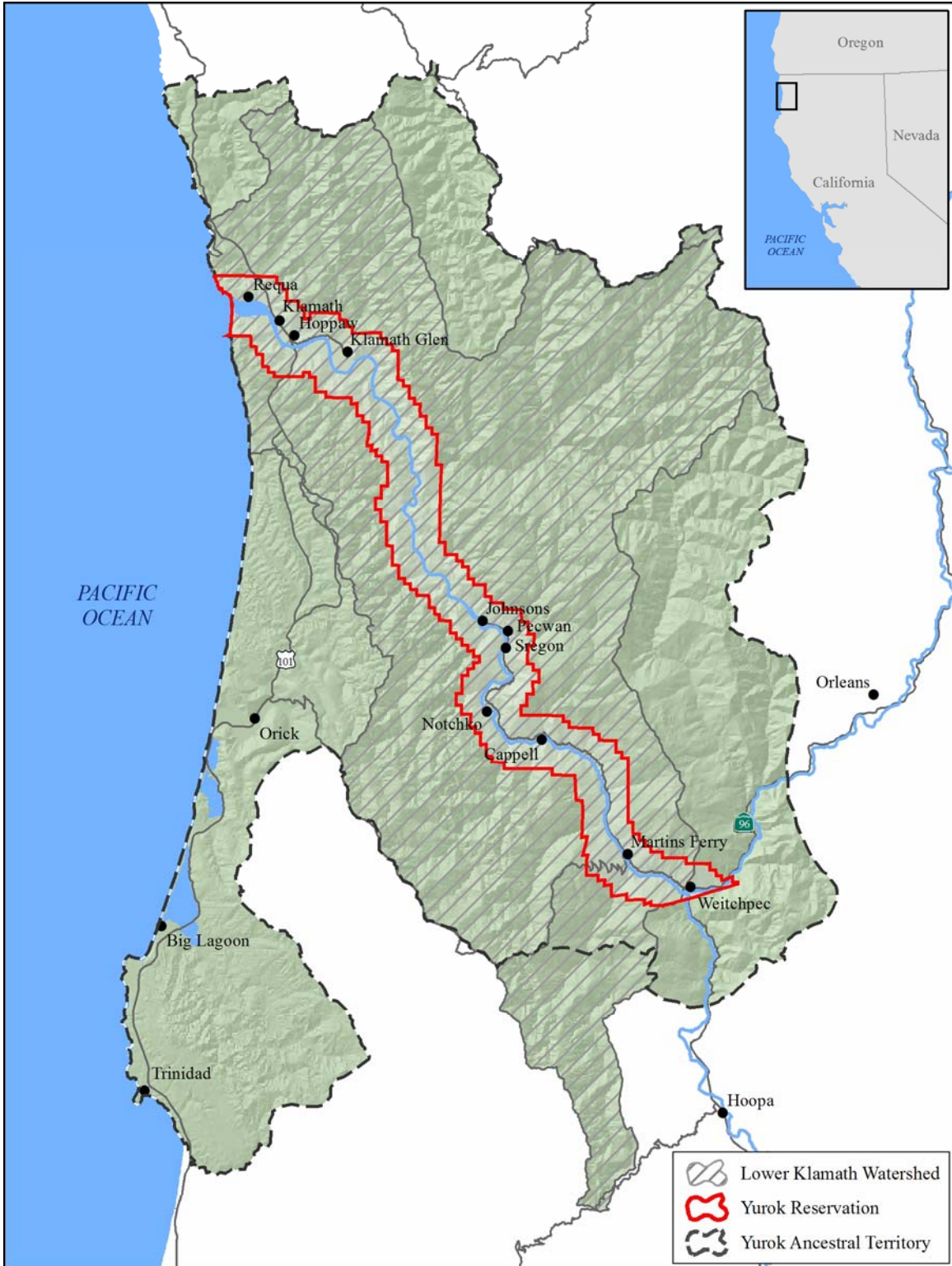


Figure 2-2. Yurok Indian Reservation and Yurok Ancestral Territory Map



approximately two dozen major anadromous tributaries within that area. The mountains defining the river valley are as much as 3,000 feet high. Along most of the river, the valley is quite narrow with rugged steep slopes. The vegetation is principally redwood and Douglas fir forest with little area available for agricultural development. Historically, prevalent open prairies provided complex and diverse habitat.

### ***Yurok Tribe Water Monitoring Division***

In 1998, YTEP was created to protect and restore tribal natural resources through high quality scientific practices. YTEP is dedicated to improving and protecting the natural and cultural resources of the Yurok Tribe through collaboration and cooperation with local, private, state, tribal, and federal entities such as the Yurok Tribe Fisheries Program (YTFP), US Fish and Wildlife Service (USFWS), the United States Environmental Protection Agency (USEPA), Green Diamond Resource Company, the NCRWQCB, and the United States Geological Survey (USGS). A USEPA General Assistance Program (GAP) Grant and funding allocated under the Clean Water Act Section 106 and funding from PacifiCorp primarily fund YTEP's water monitoring activities.

### **III. Methods**

Grab samples, discreet surface water samples, were collected during the sampling season twice a month beginning in May and ending in October, followed by monthly sampling in November and December. Samples were delivered to the same lab during the 2009 season in an effort to maintain consistency in laboratory methods. Samples were delivered to Aquatic Research Inc. in Seattle, WA. The parameters sampled are shown in Table 3-1.

Upon arrival at each site, a sampling churn was rinsed three times with distilled water. After rinsing with distilled water, the churn was rinsed three times with stream water. The churn was then fully submerged into the stream and filled to the lid with sample water. Completely filling the churn allowed for all samples to be filled from one churn; thereby minimizing differences in water properties and quality between samples.

Proper use of the churn guaranteed the water was well mixed before the sample was collected. The churn was stirred at a uniform rate by raising or lowering the splitter at approximately 9 inches per second. This mixing continued while the bottles were being filled. If filling had stopped for some reason, the stirring rate was resumed before the next sample was drawn from the churn.

The sample bottles and chemical preservatives used were provided by the contract lab and were considered sterile prior to field usage. Sample bottles without chemical preservatives were rinsed with stream water from the churn once before filling with sample water. In the case of bottles that contained chemical preservatives, bottles were not rinsed before sample collection and care was taken to avoid over-spillage that would result in chemical preservative loss. Collected samples were placed in coolers on wet ice for transport to the contract lab for analysis.

**Table 3- 1. Parameters sampled on the Klamath River during 2009**

<b>Analytes</b>
Nitrate + Nitrite
Total Nitrogen
Ammonia
Total Phosphorus
Soluble Reactive Phosphorous
Total Alkalinity
Chlorophyll-a
Pheophytin-a
Non-Filterable Residue
Volatile Suspended Solids
Dissolved Organic Carbon
Total Organic Carbon

Additional quality control measures were included in the sampling. At one site during the May and August sampling events duplicate split samples were sent to the laboratory to assess laboratory precision and to gain improved confidence in the data.

Discrete environmental information was also recorded at the time water samples were collected. This information was collected using YSI 6600EDS multiparameter sondes equipped with specific conductivity/temperature, pH, ROX and phycocyanin probes. ROX probes detect concentrations of dissolved oxygen in bodies of water, while

phycocyanin probes are designed to detect the presence of an accessory pigment known to occur in *Microcystis aeruginosa*. The data included water temperature, pH, specific conductance, dissolved oxygen and blue-green algae, as well as other observational notes. Chain-of-custody (COC) sheets were also filled out to document the handling of the samples from the time of collection to the time of laboratory analysis. This is a standard procedure for handling samples.

#### **IV. Site Selection**

The sampling area includes the lower 44 river miles of the mainstem Klamath River on the YIR and the Trinity River above its convergence with the Klamath near the southern boundary of the YIR. In general, the various sampling locations were chosen in order to represent the average ambient water conditions throughout the water column. The sites listed below in bold indicate established sampling locations for the collection of water samples for nutrient analysis May through December.

YTEP collected water samples for nutrient analysis at the following mainstem Klamath River locations (Figure 4-1) (river miles are approximate):

- **WE - Klamath River at Weitchpec (upstream of Trinity River) – RM 43.5**
- **TC - Klamath River above Tully Creek – RM 38.5**
- **TG - Klamath River at Turwar Boat Ramp – RM 6**
- **LES - Lower Estuary Surface – RM 0.5**

YTEP collected water samples for nutrient analysis at the following major tributary locations:

- **TR - Trinity River near mouth (above Klamath River confluence) – RM 0.5**

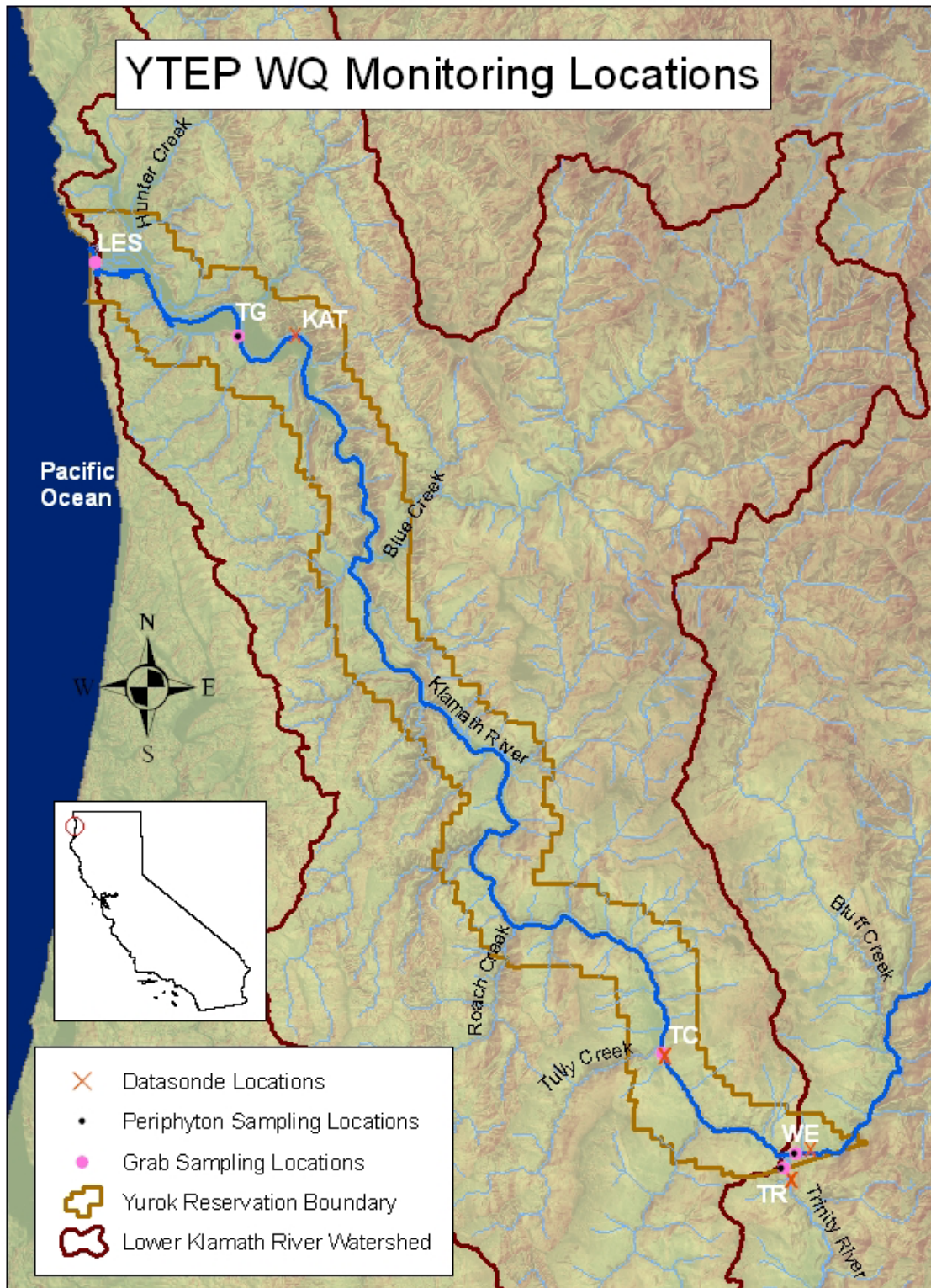


Figure 4-1. Nutrient “Grab” Sampling Sites for WY09 (as indicated by the pink dots)

## V. Quality Assurance

During this study, many quality assurance and quality control (QA/QC) measures were undertaken to ensure the grab sample data that was collected was of the highest quality. YTEP performs all surface water quality monitoring activities consistent with its Quality Assurance Program Plan that was approved by the USEPA in April 2001. In June of 2008 USEPA approved YTEP's *Lower Klamath River Nutrient, Periphyton, Phytoplankton and Algal Toxin Sampling and Analysis Plan (SAP)*. This document characterizes the quality control of the collection, preparation and analysis of water samples for presence of nutrients and related analytes. QA/QC was achieved by following a standard water sample collection protocol using a churn sampler and submitting samples to labs that follow strict protocol that have QA/QC measures.

All field personnel that were involved in collection of water samples have been trained appropriately by the Water Division Program Manager and are properly supervised to ensure proper protocol is followed consistently throughout the monitoring season. Each field visit requires that staff fill out field data sheets and label samples appropriately in the field. Sampling is always conducted by at least two staff for safety reasons and to maintain consistency. Field crews collecting samples ensured representativeness of samples by selecting sites that have free-flowing water from established sampling locations and using a churn splitter to mix sample water once collected. All samples were transported to the appropriate laboratories following chain of custody procedures to ensure proper handling of the samples.

Field duplicate samples were collected by either the Yurok, Karuk, or Hoopa tribes on a rotating basis every month to evaluate crew performance. Field duplicates were collected by splitting samples in the field using the churn splitter. One of the split samples was sent with its associated split with a different ID code for analysis of both nutrients and related analytes so as to not alert lab staff of the fact that the samples were duplicates. Replicate sample results indicate the lab's precision is within the stated goals of this sampling project with 90% of samples meeting the relative percent difference of + or - 20%.

Equipment blank samples were not collected in 2009 due to limited resources. It is not believed that cross contamination between sites influences results because the

stream sample will overwhelm any minute presence of nutrients and related analytes that could be present after the churn is rinsed three times with distilled water and with stream water at the next sampling site. True blank samples were prepared in 2009 by pouring distilled water into sample containers provided by the laboratory and sent with a different ID code for analysis of both nutrients and related analytes so as to not alert lab staff of the fact that the samples were a true blank. True blank sample results from the 2009 sampling season indicate that there is no significant issue with contamination of samples in the field or laboratory.

Data is thoroughly reviewed once received from the laboratory. YTEP is the primary organization responsible for data review, although the professional laboratories analyzing water quality samples will also note potential problems with outliers or other anomalies in sample results. Information regarding QA/QC procedures for the laboratory is available upon request. One hundred percent of laboratory-generated data was checked on receipt by the Project Manager for consistency and acceptability, including whether duplicates are within specified targets and meet data quality objectives. Data is reviewed and finalized once data are merged or entered into a database,

The data manager will visually inspect all entered data sets to check for inconsistencies with original field or laboratory data sheets. Where inconsistencies are encountered, data will be re-entered and re-inspected until the entered data is found to be satisfactory or results will be discarded. Any unusual values outside the range of norm will be flagged and all aspects of field data sheets, shipping handling and laboratory handling and testing will be reviewed. Outliers will be identified and removed from the dataset if deemed necessary by the QA Officer. The Project Manager will maintain field datasheets and notebooks in the event that the QA Officer needs to review any aspect of sampling for QA/QC purposes. Water temperature, conductivity, pH and dissolved oxygen are measured in the field when samples are collected and values of these hand-held measurements can be used to check field conditions at the time of sampling.

The Yurok Tribe received a grant under the Environmental Information Exchange Network Program and used it to develop the Yurok Tribe Environmental Data Storage System (YEDSS). Nutrient data covered in this report have been entered in YEDSS, and

will be uploaded to USEPA's WQX database. The metadata associated with each data type are also stored within the system and can be easily accessed when questions arise.

## **VI. Results**

### ***Sampling Results***

#### ***Nitrite + Nitrate***

Nitrite plus nitrate levels for all sites fluctuated very little from mid-May to early October with all sites yielding results of less than 0.050 mg/L during this period (Table 6-1, Figure 6-1). After October 1<sup>st</sup>, concentrations at all sites except TR began to increase sharply into mid-October. WE and TC continued to increase into mid-November, while LES and TG decreased slightly until late October, after which they also increased into mid-November. All sites except TR experienced peak concentrations in mid-November, after which they began to decline into mid-December. Meanwhile TR concentrations began to increase after mid-November, returning its highest concentrations during the last sampling event on December 17, 2009.

Nitrite plus nitrate concentrations at the 2009 monitoring sites ranged from less than 0.010 mg/L to 0.334 mg/L. The site with the lowest reportable concentration was the Klamath River at Weitchpec (WE) on May 13, 2009, with a reading of 0.010 mg/L. The site that yielded the highest concentration was the Klamath River at Weitchpec (WE) on November 12, 2009, with a reading of 0.334 mg/L. The reporting limit for nitrate plus nitrite was 0.010 mg/L. If a site generated a reading below this number, ND (No Detect) was entered into the database for this date and parameter, indicating that the results were below the reporting limit. For graphing purposes, ½ of the reporting limit (0.005 mg/L) was used when this occurred.

#### ***Total Nitrogen***

All sites except TR exhibited similar trends for total nitrogen with concentrations generally rising throughout the sampling season. A sharp peak in concentrations occurred in mid-October, at which time WE, TC, and TG experienced the highest concentrations of the season. The peak in October was followed by a decline until mid-November, at which time concentrations at LES, TG, and TC increased, while WE continued to decrease, until sampling was suspended in mid-December (Table 6-1, Figure



6-2). TR concentrations fluctuated very little throughout most of the season, but did experience the same peak as all other sites in mid-October, followed by a drop to results below the reporting limit in late October and mid-November, followed again by an increase in total nitrogen concentrations into mid-December. Both TR and LES yielded their highest concentrations in mid-December. As the sampling season progressed, upriver sites tended to experience higher concentrations of total nitrogen than downriver sites, this was especially evident during the peak in mid-October and after. The exception to this pattern was TR which consistently returned the lowest concentrations of all sites until the final sampling event in mid-December.

Total nitrogen concentrations at the 2009 monitoring sites ranged from less than 0.050 mg/L to 1.05 mg/L. The site with the lowest reportable concentration was the Trinity River above the mouth (TR) on September 17, 2009, with a reading of 0.053 mg/L. The site with the highest concentration was the Klamath River at Weitchpec (WE) on October 15, 2009, with a reading of 1.05 mg/L. The reporting limit for total nitrogen was 0.050 mg/L. If a site generated a reading below the reporting limit, ND (No Detect) was entered into the database for this date and parameter, indicating that the results were below the minimum reporting value. For graphing purposes,  $\frac{1}{2}$  of the reporting limit (0.025 mg/L) was used when this occurred.

### ***Ammonia***

Ammonia results for all sites except for the Lower Estuary Surface (LES) exhibited concentrations below the reporting limit of 0.010 mg/L for the majority of the season (Table 6-1, Figure 6-3). If a site generated a reading below this number, ND (No Detect) was entered into the database for this date and parameter, indicating that the results were below the reporting limit. For graphing purposes,  $\frac{1}{2}$  of the reporting limit (0.005 mg/L) was used when this occurred. LES was the site that most commonly produced measurable quantities of ammonia. However, LES fluctuated greatly throughout the sampling season, exhibiting no clear trend in ammonia concentrations. The other anomaly was TG with an initial result of 0.012 mg/L on May 13, 2009. After late October all sites except TR yielded concentrations above the reporting limit. TR reached this point in mid-November. Ammonia concentrations at the 2009 monitoring

sites ranged from less than 0.010 mg/L to 0.041 mg/L. The highest concentration for the sampling season was 0.041 mg/L at LES on September 17, 2009. The lowest reportable concentration for the 2009 season was 0.011 mg/L on August 20, September 3, October 1, and October 29, at LES, and on November 11, and December 17 at TC.

### ***Total Phosphorous***

Total phosphorous trends were similar for WE, TC, TG, and LES, with concentrations generally increasing from mid-May until concentrations for WE, TC, and TG peaked in mid-October. After mid-October, concentrations for WE, TC, and TG fell until mid-November, at which time TC, and TG began rising and continued to climb until sampling was suspended in mid-December (Table 6-1, Figure 6-4). Concentrations at WE, however, continued to fall into mid-December. After yielding a small peak in mid-October, LES experienced dropping concentrations from mid to late October, subsequently shifting to increasing concentrations of total phosphorous, returning its highest concentrations of the season when sampling was suspended in mid-December. Trinity River above the mouth (TR) yielded results that were near the reporting limit of 0.002 mg/L and fluctuated very little throughout most of the sampling season except for the spike which all sites experienced on October 15, 2009. After this peak, TR decreased to levels near the reporting limit in late October and mid-November, then increased, exceeding all other sites and yielding its highest concentrations of the sampling season in mid-December.

Total phosphorous concentrations at 2009 monitoring sites ranged from a low of 0.005 mg/L at TR on November 12, to high of 0.189 mg/L at WE on October 15. As with total nitrogen, upriver sites tended to yield higher concentrations than downriver sites, with WE exhibiting the highest concentrations and LES or TG the lowest concentrations. As with most parameters in this report, the anomaly in this pattern occurred at TR, which, other than the final sampling event in mid-December, consistently yielded the lowest results. No sites produced results below the reporting limit of 0.002 mg/L for this parameter.

### ***Soluble Reactive Phosphorous (SRP)***

SRP for all sites except TR exhibited comparable trends with generally rising concentrations occurring throughout the summer (Table 6-1, Figure 6-5). WE and TC returned slightly decreasing results from early to mid October, but then increased into late October. All site except TR experienced peak concentrations of soluble reactive phosphorous in late October. After late October, concentrations at all sites except TR sharply decreased until sampling was suspended in mid-December. Concentrations at TR fluctuated very little throughout the sampling season, with results near or below the reporting limit of 0.001 mg/L.

SRP concentrations at the 2009 sites ranged from less than 0.001 mg/L to 0.079 mg/L. WE yielded the highest concentration during the 2009 season on October 15, with a reading of 0.079 mg/L, while TR produced the lowest reportable concentration of 0.002 mg/L on May 28, June 25, July 9, and September 3, 2009. Throughout the sampling season upriver sites generally yielded higher SRP concentrations than downriver sites with WE yielding the highest concentrations and LES or TG the lowest. As with most parameters the exception was TR, which returned the lowest results at every sampling event throughout the season with concentrations hovering around the reporting limit of 0.001 mg/L for most of the season. If a site generated a reading below the reporting limit, ND (No Detect) was entered into the database for this date and parameter, indicating that the results were below the minimum reporting value. For graphing purposes,  $\frac{1}{2}$  of the reporting limit (0.0005 mg/L) was used when this occurred.

### ***Alkalinity***

Trends and results for alkalinity concentrations during the 2009 monitoring season were very similar throughout the entire monitoring term, with concentrations generally rising from mid-May to mid-July, followed by steady concentrations from mid-July to early October. After early October all sites experienced a decrease in mid-October, followed by increasing concentrations until late October, after which results at all sites decreased until mid-December. (Table 6-2, Figure 6-6). Alkalinity concentrations at the 2009 sites ranged from a low of 53.8 mg/L CaCO<sub>3</sub> at WE on May

13, to a high of 94.8 mg/L CaCO<sub>3</sub> at LES on July 23. No sites produced results below the reporting limit of 1.0 mg/L CaCO<sub>3</sub> for this parameter.

### ***Chlorophyll-a***

Chlorophyll-*a* trends were broadly similar for all sites except TR, with a small peak in late May, generally increasing concentrations until late August, a small decrease in early September, and a large peak in mid-October in which all sites, except LES yielded the highest concentrations of the sampling season (Table 6-2, Figure 6-7). After mid-October, all sites decreased until mid-November, after which concentrations increased until sampling was suspended in mid-December, at which time LES experienced the highest concentrations of the season. As with most parameters, the anomaly for chlorophyll-*a* was TR, which fluctuated very little from mid-May to early October, then experienced a similar pattern as all other sites with a large spike in mid-October, decreasing concentrations until early November, followed by increasing concentrations until mid-December.

Chlorophyll-*a* concentrations for the 2009 sampling season ranged from 0.8 µg/L to 27 µg/L. TC and TG produced the highest concentration of 27 µg/L on October 15, 2009, while TR yielded the lowest concentration of 0.8 µg/L on August 20, 2009. No sites produced results below the reporting limit of 0.1 µg/L for this parameter.

### ***Pheophytin-a***

Pheophytin-*a* results and trends were broadly similar for all sites during the 2009 sampling season (Table 6-2, Figure 6-8). Concentrations gradually increased from the beginning of the sampling period until early October. At that time, concentrations at all sites peaked sharply in mid-October, with WE, TC, and TG yielding their highest concentrations of the season. After this, concentrations at all sites decreased into November, after which all sites increased into mid-December, with LES and TR yielding their highest concentrations of the season. TR exhibited a similar pattern as other sites, yet consistently returned some of the lowest concentrations during the 2009 sampling season

Pheophytin-*a* concentrations for the 2009 sampling season ranged from 0.1 µg/L to 23 µg/L. The lowest concentration of 0.1 µg/L was produced at TR on August 6 and November 11, 2009, while the highest concentration of 23 µg/L was returned at TG on October 15, 2009. No sites produced results below the reporting limit of 0.1 µg/L for this parameter.

### ***Volatile Suspended Solids (VSS)***

Trends and results for volatile suspended solids concentrations during the 2009 monitoring season were similar among most sites with results fluctuating between the reporting limit of 0.50 mg/L and just above 2.0 mg/L until early October (Table 6-2, Figure 6-9). In mid-October all sites except LES experienced a sharp spike in concentrations, at which time WE, TC, and TR returned their highest concentrations, followed by a sharp decrease in concentrations in late October. From mid-November on, all sites yielded increasing concentrations of volatile suspended solids until sampling was suspended in mid-December, at which time TG and LES returned their highest results for the season.

Volatile suspended solids concentrations for the 2009 sampling season ranged from less than 0.50 mg/L to 11 mg/L. TR returned the highest concentration of 11 mg/L on October 15, 2009, while also yielding the lowest reportable concentration of 0.50 mg/L on June 11, 2009. If a site generated a reading below the reporting limit, ND (No Detect) was entered into the database for this date and parameter, indicating that the results were below the minimum reporting value. For graphing purposes, ½ of the reporting limit (0.25 mg/L) was used when this occurred.

### ***Non-Filterable Residue (TSS)***

Non-filterable residue, also known as total suspended solids (TSS), trends for all sites were similar with the concentrations starting out around 10 mg/L during the first sampling event and then dropping to below 5 mg/L and fluctuating around 1.5 mg/L and 5 mg/L into October (Table 6-2, Figure 6-10). In mid-October all sites experienced a large peak in concentrations, in which WE yielded its highest results of the season, followed by a sharp decline in late October. After this, all sites continued to return

increasingly high concentrations until sampling was suspended in mid-December, at which time LES, TG, TC, and TR experienced the highest concentrations of the season. During the peak in mid-October, upriver sites returned higher concentrations than downriver sites, with TR yielding the highest concentration of all sites.

TSS concentrations for the 2009 sampling season ranged from less than 0.50 mg/L to 51.00 mg/L. The lowest reportable concentration for the sampling period was 0.63 mg/L at TR on September 3, 2009, while the highest concentration was 51.00 mg/L at TG on December 17, 2009. The reporting limit for TSS was 0.50 mg/L. If a site generated a reading below this number, ND (No Detect) was entered into the database for this date and parameter, indicating that the results were below the reporting limit. For graphing purposes, ½ of the reporting limit (0.25 mg/L) was used when this occurred.

#### ***Dissolved Organic Carbon (DOC)***

Dissolved organic carbon concentrations for all sites exhibited very similar trends throughout the sampling season (Table 6-2, Figure 6-11). Concentrations generally increased until early September, after which concentrations dipped slightly in mid-September. After mid-September all sites exhibited a small peak, at which time all sites except TR yielded their highest results of the season, after which concentrations decreased until mid-November. Results at each site subsequently increased until sampling was suspended in mid-December, at which time TR experienced its highest concentration of the sampling season. Throughout the sampling season, upriver site tended to return higher results than downriver sites. The exception was TR, which yielded the lowest concentrations throughout the whole sampling season until the final sampling event. DOC concentrations for the 2009 sampling season ranged from a low of 0.558 mg/L at TR on July 23, to a high of 3.77 mg/L at WE on October 15, 2009. No sites produced concentrations below the reporting limit of 0.250 mg/L during the 2009 sampling season.

#### ***Total Organic Carbon (TOC)***

TOC trends were broadly similar for all sites except TR throughout the sampling period with the lowest concentrations produced in mid-May, followed by gradually rising

concentrations with all sites except TC and TR yielding their highest concentrations in mid-October (Table 6-2, Figure 6-12). WE's highest results, however, were produced during a short spike in mid-September. As with most parameters, TR consistently produced the lowest concentrations and fluctuated very little throughout the sampling period. It did show a similar pattern to other sites with a small spike in mid-October, but yielded the highest concentrations in mid-December. Throughout most of the 2009 sampling season, but especially after late July, upriver sites produced higher concentrations than downriver sites with WE yielding the highest results and LES or TG the lowest.

TOC concentrations for the 2009 sampling season ranged from a low of 0.567 mg/L at TR on July 23, to a high of 3.87 mg/L on October 15, 2009 at WE. No sites produced concentrations below the reporting limit of 0.250 mg/L during the 2009 sampling season.

### ***Discrete Sonde Measurements***

Below is a summary of the discrete sonde measurements that were taken at the sampling sites when surface water samples were collected.

#### ***Temperature***

Temperatures at all sites during the 2009 season displayed similar trends (Table 6-3, Figure 6-13). Measurements at all sites showed increasing temperatures from mid-May to late July, with temperatures peaking at TC, WE, and TR in late July, while peaking at LES in early August, and TG in late August. After this peak, all sites returned decreasing temperatures throughout the rest of the sampling period. From mid-May to mid-September upriver sites tended to have higher temperature readings than downriver sites. After early October, downriver sites returned higher temperatures than upriver sites. Temperatures for the 2009 sampling season ranged from a low 6.67 °C on December 17, to a high of 22.66 °C on July 23, 2009. Both of these temperatures were recorded at the WE sampling site.



### ***Dissolved Oxygen (mg/L)***

Dissolved oxygen measured in mg/L during the 2009 sampling season showed similar trends at all sites throughout the season (Table 6-3, Figure 6-14). Results at all sites generally dropped from mid-May to late July. After late July, results at all sites generally increased until sampling was suspended in mid-December, at which time LES, TG, TC, and WE yielded their highest concentrations of the season. TR, however, yielded its highest result in mid-November. LES went against this trend on two occasions, with small spikes measured on July 23 and October 1, 2009. Throughout the sampling season upriver sites tended to return higher concentrations of dissolved oxygen than downriver sites, with WE and TR yielding the highest results and LES or TG yielding the lowest results. Concentrations of dissolved oxygen during the 2009 sampling season ranged from a low of 7.20 mg/L at TG on July 23, to a high of 12.1 mg/L at WE on December 17, 2009.

### ***Dissolved Oxygen (%)***

Dissolved oxygen concentrations measured in percent for the 2009 sampling season exhibited similar trends for upriver sites, while downriver sites returned different patterns (Table 6-3, Figure 6-15). TC, WE, and TR all showed steady to slightly falling percentages from mid-May to mid-June. After mid-June upriver sites increased until early July, at which time WE returned its highest measurement of the sampling season. After early July results at all upriver sites dropped until late July/early August, followed by increasing percentages until mid-September. After mid-September, results at all upriver sites again dropped until mid-October, after mid-October all upriver sites increased until mid-November, at which time TC and TR yielded their highest results of the sampling season. After mid-November percentages at all upriver sites dropped until sampling was suspended in mid-December. TG had steady results from mid-May to late June, followed by dropping percentages until late July. After late July, results at TG steady generally increased until sampling was suspended in mid-December, at which time it returned its highest percentage measurement of the season. LES returned falling results from mid-May to early July, a small spike in late July, a small, flat spike in late August/early September, a spike in early October, which was the highest percentage of

the season for LES, and a small spike in late October. Throughout the sampling season, upriver sites tended to return higher percentages of dissolved oxygen than downriver sites, with WE and TR returning the highest results and LES and TG the lowest. The highest percentage of dissolved oxygen measured during the 2009 sampling season was 107.6% at WE on July, 9, while the lowest percentage measured was 80.3% at TG on July 23, 2009.

### ***Specific Conductivity***

Specific conductivity at all sites except LES exhibited similar trends during the 2009 sampling season (Table 6-3, Figures 6-16 and 6-17). Results increased from mid-May until late July, after late July results held steady or dropped slightly until mid-October, at which time all sites except LES experienced a sharp decline in specific conductivity results. After mid-October these sites increased until late October, at which time TG, TC, WE, and TR returned their highest measurements of the sampling season. After mid-October, results at these four sites decreased until mid-December. Specific conductivity results at LES increased slightly from mid-May until mid-June. After mid-June results fluctuated greatly with large spikes in late July and mid-October, and small spikes in late August, mid-September, and mid-November. Measurements for specific conductivity, disregarding LES, for the 2009 sampling season ranged from a low of 116  $\mu\text{S}/\text{cm}$  at WE on May 13, to a high of 184  $\mu\text{S}/\text{cm}$  at WE on October 29, 2009. At LES measurements ranged from a low of 126  $\mu\text{S}/\text{cm}$  on May 13, to a high of 22,340  $\mu\text{S}/\text{cm}$  on October 15, 2009.

### ***pH***

Trends for pH during the 2009 sampling season were similar for upriver sites. Downriver sites, however, tended to exhibit individual patterns for most of the sampling season (Table 6-3, Figure 6-18). pH at TC, WE, and TR decreased from mid to late May, subsequently increasing into early July, at which time all three sites returned the highest pH measurements of the sampling season. After early July, pH at all upriver sites decreased slightly then held steady until mid-October. In mid-October, all sites, including TG and LES, experienced a sharp decrease in pH, followed by a sharp increase

in late October. After late October pH at all sites except TR gradually declined until sampling was suspended in mid-December. TR continued to increase into mid-November, then decreased into mid-December. pH at TG held steady with a slight decrease from mid-May to late June, subsequently dropping sharply into late July. After late July, TG increased into late August, yielding its highest pH of the season, after which it held steady into early October, exhibiting the same trend as the upriver sites for the rest of the sampling season. pH at LES decreased slightly from early May to late June, increasing slightly into early July, and subsequently holding steady until early September. There was a decrease into mid-September, followed by a sharp increase in pH in early October, yielding the highest pH of the season for LES at this event. After late September, LES exhibited a similar trend as the upriver sites for the rest of the sampling season. As with many other parameters, upriver sites tended to return higher pH measurements than downriver sites. The lowest pH measured during the 2009 sampling season was 7.44 at LES on December 17, while the highest pH measured was 8.50 at WE on July 9, 2009.

### ***Blue-green Algae***

Blue-green algae trends were similar for all sites except TR for the 2009 sampling season (Table 6-3, Figure 6-19). Measurements were near zero from mid-May to early July, subsequently increasing into early August. After early August, results decreased until early September, at which time all sites except WE increased into mid-October, at which time these sites yielded their highest results of the season. Results at WE increased in early September until early October, at which time it yielded its highest blue-green algae results of the season. After this peak all sites decreased until mid-November, at which time they increased when sampling was suspended in mid-December. Discrete blue-green algae measurements at TR were not recorded on a regular basis throughout most of the 2009 sampling season. However, when they were recorded on a regular basis beginning in mid-September, they exhibited similar patterns as all other sites for the rest of the sampling season, with the highest results returned in mid-October. The lowest reading for blue-green algae during the 2009 sampling season was -650 cells/mL at TR on October 29 and TG on November 12, while the highest reading was 4900 cells/mL at WE on October 1, 2009.

**Table 6-1. Nutrient Results, Yurok Reservation 2009**

<b>Nutrients</b>																	
		<b>Date</b>															
		<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
<b>Nitrate +Nitrite</b> mg/L; Report Limit: 0.010	<b>LES</b>	0.040	ND	ND	0.012	0.013	0.015	0.012	0.018	0.012	0.019	ND	0.193	0.149	0.200	0.196	
	<b>TG</b>	0.049	0.011	0.014	0.018	0.042	0.022	0.034	0.013	ND	ND	0.014	0.219	0.184	0.229	0.162	
	<b>TC</b>	0.018	ND	ND	ND	ND	ND	ND	ND	ND	0.025	0.015	0.160	0.220	0.241	0.158	
	<b>WE</b>	0.010	ND	ND	ND	ND	ND	ND	0.011	ND	0.049	0.020	0.259	0.304	0.334	0.213	
	<b>TR</b>	0.019	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.114
<b>Total Nitrogen</b> mg/L; Report Limit 0.050	<b>LES</b>	0.088	0.160	0.142	0.203	0.279	0.286	0.277	0.230	0.241	0.413	0.375	0.580	0.423	0.440	0.694	
	<b>TG</b>	0.109	0.155	0.110	0.194	0.201	0.224	0.320	0.248	0.234	0.268	0.398	0.801	0.411	0.395	0.698	
	<b>TC</b>	0.111	0.143	0.112	0.188	0.162	0.224	0.311	0.259	0.277	0.273	0.506	0.823	0.509	0.447	0.775	
	<b>WE</b>	0.152	0.218	0.182	0.215	0.182	0.337	0.241	0.354	0.376	0.393	0.594	1.05	0.677	0.575	0.518	
	<b>TR</b>	0.064	0.084	ND	0.072	ND	0.072	0.073	0.057	0.058	0.053	0.075	0.595	ND	ND	0.675	
<b>Ammonia Nitrogen</b> mg/L; Report Limit: 0.010	<b>LES</b>	0.014	ND	ND	ND	0.014	0.022	ND	0.011	0.011	0.041	0.011	0.025	0.011	0.033	0.026	
	<b>TG</b>	0.012	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.012	0.019	
	<b>TC</b>	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.011	0.011	
	<b>WE</b>	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013	ND	
	<b>TR</b>	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013	
<b>Total Phosphorous</b> mg/L; Report Limit: 0.002	<b>LES</b>	0.029	0.073	0.032	0.034	0.026	0.028	0.038	0.035	0.037	0.065	0.051	0.089	0.070	0.091	0.115	
	<b>TG</b>	0.039	0.024	0.030	0.032	0.021	0.027	0.042	0.042	0.038	0.054	0.049	0.148	0.067	0.044	0.119	
	<b>TC</b>	0.027	0.026	0.036	0.041	0.027	0.042	0.049	0.050	0.053	0.060	0.059	0.140	0.077	0.050	0.101	
	<b>WE</b>	0.034	0.038	0.055	0.057	0.040	0.054	0.070	0.072	0.070	0.086	0.084	0.189	0.104	0.067	0.063	
	<b>TR</b>	0.028	0.010	0.007	0.008	0.006	0.006	0.007	0.006	0.006	0.006	0.006	0.006	0.092	0.006	0.005	0.148
<b>Soluble Reactive Phosphorous</b> mg/L; Report Limit: 0.001	<b>LES</b>	0.010	0.010	0.015	0.017	0.011	0.014	0.022	0.019	0.022	0.033	0.035	0.047	0.049	0.038	0.012	
	<b>TG</b>	0.010	0.009	0.016	0.014	0.009	0.012	0.021	0.020	0.023	0.031	0.032	0.046	0.046	0.033	0.011	
	<b>TC</b>	0.010	0.012	0.019	0.022	0.018	0.024	0.036	0.033	0.041	0.043	0.041	0.031	0.056	0.041	0.011	
	<b>WE</b>	0.019	0.019	0.032	0.036	0.029	0.037	0.051	0.054	0.055	0.063	0.058	0.048	0.079	0.056	0.017	
	<b>TR</b>	0.006	0.002	0.003	0.002	0.002	0.003	ND	ND	0.002	ND	ND	ND	ND	0.003	0.005	

ND= No Detect

**Table6-2. Other Analytes Results, Yurok Reservation 2009**

<b>Other Analytes</b>																
<b>Date</b>																
<b>Alkalinity</b> mg/L CaCO <sub>3</sub> ; Report Limit: 1.0	<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
	<b>LES</b>	59.2	61.2	75.0	81.8	83.0	94.8	87.3	90.0	87.9	88.6	84.0	82.1	91.5	89.0	59.9
	<b>TG</b>	62.0	63.2	75.0	80.4	88.3	86.5	86.2	85.9	85.3	84.7	84.8	78.4	92.2	84.6	62.8
	<b>TC</b>	59.5	62.5	74.8	81.8	86.3	83.5	84.3	87.6	86.0	83.6	83.8	73.8	89.3	85.7	64.3
	<b>WE</b>	53.8	62.2	78.7	82.5	87.9	86.9	86.4	85.8	88.1	86.9	87.1	71.0	91.4	83.7	57.5
	<b>TR</b>	62.3	64.8	73.0	77.1	84.3	83.0	83.6	80.0	80.2	76.1	76.9	81.7	88.9	85.4	75.7
<b>Chlorophyll a</b> µg/L; Report Limit: 0.1	<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
	<b>LES</b>	1.9	4.3	1.6	1.9	2.9	3.2	NS	3.5	1.2	5.3	4.3	8.0	1.6	1.6	17
	<b>TG</b>	2.4	4.5	1.6	2.7	4.3	5.1	5.6	6.1	3.5	7.7	5.1	27	2.9	2.3	19
	<b>TC</b>	2.4	4.3	1.4	1.9	2.9	2.7	4.5	4.5	2.7	4.5	6.4	27	3.5	2.9	14
	<b>WE</b>	2.9	6.7	2.3	1.9	1.9	4.0	5.0	5.9	3.5	5.6	9.1	26	4.0	3.7	9.6
	<b>TR</b>	1.6	1.3	1.6	1.1	1.9	1.3	1.6	0.8	0.9	1.6	1.6	24	0.9	1.5	19
<b>Pheophytin a</b> µg/L; Report Limit: 0.1	<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
	<b>LES</b>	1.3	1.7	0.9	1.7	3.4	2.0	NS	1.9	2.2	3.8	2.3	9.9	2.3	4.8	16
	<b>TG</b>	0.8	1.1	0.8	1.8	3.2	2.6	3.0	2.3	3.1	5.0	3.5	23	6.0	4.5	14
	<b>TC</b>	0.6	1.0	0.9	1.1	1.5	3.3	1.6	1.6	2.0	3.5	3.5	18	4.9	3.2	10
	<b>WE</b>	0.4	1.2	0.8	1.5	2.2	2.7	2.1	1.6	2.3	4.3	4.0	20	5.5	4.3	7.2
	<b>TR</b>	0.5	0.2	0.3	1.0	0.4	1.1	ND	0.5	0.4	0.6	0.6	11	1.1	0.1	12
<b>Volatile Suspended Solids (VSS)</b> mg/L; Report Limit: 0.50	<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
	<b>LES</b>	1.5	2.3	0.63	1.4	1.0	0.75	0.88	ND	1.0	2.7	1.5	2.8	0.75	1.5	8.0
	<b>TG</b>	0.75	1.3	1.0	1.3	1.0	1.3	1.5	1.8	0.87	1.5	1.7	7.3	0.75	1.0	7.5
	<b>TC</b>	1.3	1.0	0.87	0.62	1.3	1.5	0.75	1.8	0.75	1.1	1.7	10	0.88	0.63	6.5
	<b>WE</b>	1.0	1.4	1.0	0.87	1.0	1.8	1.3	2.1	1.3	1.5	2.0	9.8	1.0	0.63	3.7
	<b>TR</b>	2.0	1.0	0.50	0.75	ND	0.87	0.87	0.88	ND	0.63	ND	11	ND	ND	7.5
<b>Non-Filterable Residue (TSS)</b> mg/L; Report Limit: 0.50	<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
	<b>LES</b>	13	18	3.3	3.5	3.4	2.4	2.0	2.1	2.0	3.8	2.5	13	1.6	17	42
	<b>TG</b>	11	4.9	2.5	5.0	3.0	2.0	4.0	2.8	2.3	3.8	2.5	30	1.5	2.1	51
	<b>TC</b>	11	4.0	2.5	1.5	2.0	2.5	2.3	2.5	1.8	1.9	2.5	34	1.9	1.9	38
	<b>WE</b>	4.1	4.0	3.0	1.9	2.0	2.8	2.8	3.3	2.0	2.8	3.0	34	1.8	1.9	11
	<b>TR</b>	11	2.4	1.4	1.6	1.0	0.87	1.0	1.0	0.63	0.75	ND	35	ND	ND	48

ND= No Detect

NS= Sample not received by lab

**Table 6-2(contd.). Other Analytes Results, Yurok Reservation 2009**

<b>Dissolved Organic Carbon (DOC)</b> mg/L; Report Limit: 0.250		Site	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
<b>LES</b>			1.17	1.24	1.49	1.82	1.76	1.61	1.78	1.97	2.27	2.06	2.42	2.82	2.26	1.88	1.90
<b>TG</b>			1.04	1.08	1.44	1.42	1.44	1.46	1.63	1.87	2.10	1.96	2.26	2.51	1.98	1.65	1.97
<b>TC</b>			1.27	1.33	1.54	1.71	1.66	2.04	2.10	2.23	2.36	2.01	2.66	2.83	2.56	2.09	2.24
<b>WE</b>			1.52	1.64	2.07	2.26	2.42	2.58	2.71	2.82	2.93	2.92	3.27	3.77	2.94	2.66	2.77
<b>TR</b>			0.691	0.732	0.741	0.607	0.604	0.558	0.745	0.820	0.871	0.784	0.915	1.47	0.787	0.761	2.36

<b>Total Organic Carbon (TOC)</b> mg/L; Report Limit: 0.250		Site	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
<b>LES</b>			1.06	1.10	1.40	1.78	2.01	1.63	1.85	2.07	2.14	2.35	2.48	2.63	2.17	2.23	1.85
<b>TG</b>			1.16	1.13	1.33	1.38	1.59	1.53	1.70	1.85	2.02	2.15	2.35	2.64	2.16	1.68	2.12
<b>TC</b>			1.11	1.53	1.54	1.58	1.90	1.95	2.07	2.08	2.29	3.46	2.58	3.13	2.48	2.04	2.28
<b>WE</b>			1.43	1.72	2.14	2.29	2.48	2.63	2.66	2.75	3.48	3.02	3.29	3.87	3.02	2.62	2.61
<b>TR</b>			0.801	0.907	0.709	0.733	0.742	0.567	0.662	0.826	0.728	1.13	0.917	1.88	0.888	0.806	2.63

**Table 6-3. Discrete Datasonde Measurements, Yurok Reservation 2009**

<b>Discrete Datasonde Results</b>																	
		<b>Date</b>															
		Site	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
<b>Temperature</b> °C	<b>LES</b>		12.59	16.50	16.91	19.14	19.32	19.50	21.59	20.70	19.54	18.96	16.80	14.01	12.77	9.93	7.10
	<b>TG</b>		12.84	16.59	17.03	18.96	19.04	20.72	21.26	21.47	20.01	20.01	16.21	13.78	12.67	10.20	7.01
	<b>TC</b>		11.78	16.91	17.21	19.88	19.68	22.52	21.94	22.38	20.57	19.99	15.72	13.44	11.53	9.73	6.75
	<b>WE</b>		12.09	17.38	17.45	20.15	20.21	22.66	21.83	22.09	20.38	19.78	15.49	13.29	11.48	9.75	6.67
	<b>TR</b>		11.80	16.38	16.69	19.82	20.17	22.47	21.68	22.32	20.00	19.84	18.41	13.51	11.54	9.92	6.83
<b>Dissolved Oxygen</b> mg/L	<b>LES</b>		10.32	9.28	8.94	8.21	7.81	8.12	7.59	7.87	8.18	7.84	9.71	9.12	10.05	10.13	11.5
	<b>TG</b>		10.26	9.40	9.13	8.96	8.07	7.20	7.33	7.65	8.19	8.13	9.01	9.57	9.65	10.71	11.73
	<b>TC</b>		10.93	9.68	9.43	9.00	9.14	8.40	8.41	8.58	8.82	9.08	9.77	10.03	10.74	11.73	11.95
	<b>WE</b>		11.08	9.57	9.61	9.39	9.74	8.94	8.88	9.02	9.22	9.48	10.04	10.18	10.88	12.03	12.1
	<b>TR</b>		10.94	9.62	9.65	9.40	9.54	8.73	8.92	8.98	9.43	9.56	10.25	10.11	11.01	12.04	11.88
<b>Percent Dissolved Oxygen</b>	<b>LES</b>		97.1	95.1	92.4	89.4	86.7	92.9	86.4	89.2	89.8	86.1	100.0	89.2	95.0	91.9	95.0
	<b>TG</b>		97.0	96.5	94.5	96.5	87.1	80.3	82.6	86.7	90.2	89.5	91.7	92.5	90.9	95.3	96.7
	<b>TC</b>		101.0	100.1	98.0	98.8	100.0	97.1	96.1	98.8	98.1	99.8	98.5	96.2	98.7	103.3	97.8
	<b>WE</b>		103.1	99.8	100.4	103.5	107.6	103.6	101.2	103.4	102.2	103.9	100.7	97.3	99.9	106.0	98.8
	<b>TR</b>		101.1	98.3	99.2	103.1	105.3	100.8	101.4	103.4	103.7	104.8	101.2	97.1	101.2	106.5	97.4

**Table 6-3 (cont)**

<b>Specific Conductivity</b>		<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
$\mu\text{S/cm}$	<b>LES</b>	126	127	183	2512	7050	14,150	3200	5150	2235	5850	246	22,340	346	7140	162	
	<b>TG</b>	120	123	148	163	177	178	176	175	174	174	173	167	183	171	128	
	<b>TC</b>	118	122	148	164	174	181	174	174	173	173	172	158	183	172	131	
	<b>WE</b>	116	123	153	169	178	181	178	179	181	180	181	152	184	171	117	
	<b>TR</b>	122	122	140	154	165	167	164	163	158	157	153	167	180	178	158	
<b>pH</b>		<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
	<b>LES</b>	8.16	8.05	8.03	8.01	8.15	8.17	8.13	8.18	8.18	8.18	8.01	8.35	7.83	8.23	7.89	7.44
	<b>TG</b>	8.13	8.07	8.05	8.09	7.71	7.68	7.85	8.26	8.25	8.19	8.21	7.87	8.11	7.84	7.61	
	<b>TC</b>	8.29	8.07	8.2	8.27	8.34	8.32	8.21	8.26	8.22	8.2	8.31	7.85	8.14	8.14	7.68	
	<b>WE</b>	8.33	8.11	8.24	8.40	8.5	8.32	8.25	8.24	8.19	8.2	8.23	7.92	8.25	8.21	7.63	
	<b>TR</b>	8.34	8.03	8.16	8.33	8.38	8.24	8.27	8.28	8.18	8.27	8.22	7.95	8.21	8.3	7.9	
<b>Blue-green Algae</b>		<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
<b>cells/mL</b>	<b>LES</b>	DNR	-100	-100	-150	-200	825	1450	750	-200	1675	2425	2500	400	-525	1750	
	<b>TG</b>	DNR	-300	-195	0	-200	1550	1950	550	250	1750	1780	3500	0	-650	1950	
	<b>TC</b>	DNR	125	-135	-165	350	750	850	800	150	775	2800	2900	350	-400	1350	
	<b>WE</b>	DNR	100	125	100	75	775	1750	1225	375	1450	4900	3225	615	-150	750	
	<b>TR</b>	DNR	DNR	-285	700	DNR	DNR	DNR	DNR	DNR	-250	-425	2400	-650	-550	1250	

DNR= Did Not Record



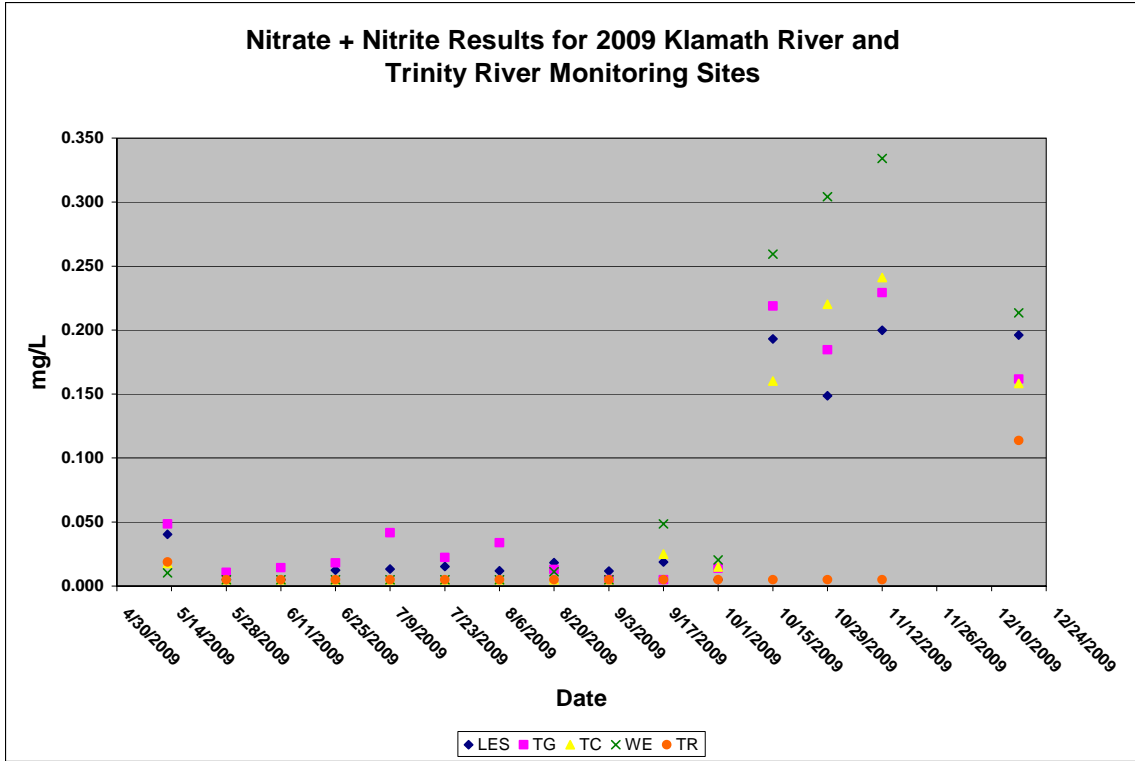


Figure 6-1. Nitrite + Nitrate Results 2009

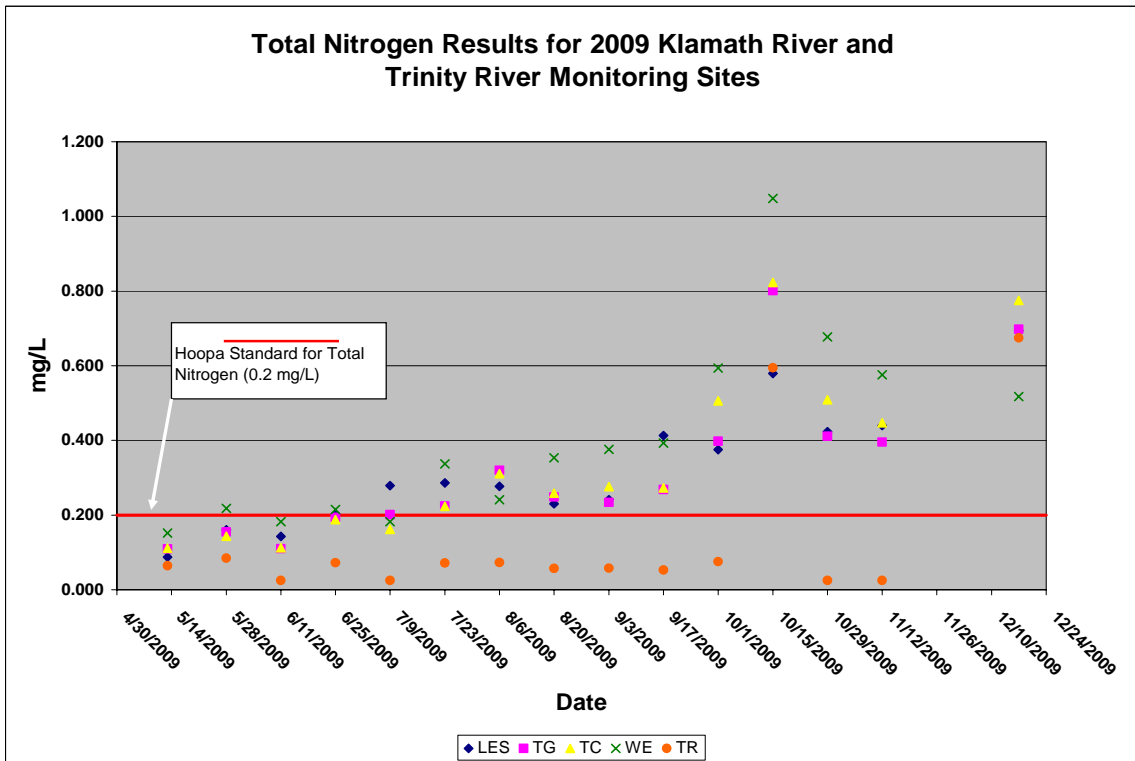


Figure 6-2. Total Nitrogen Results 2009

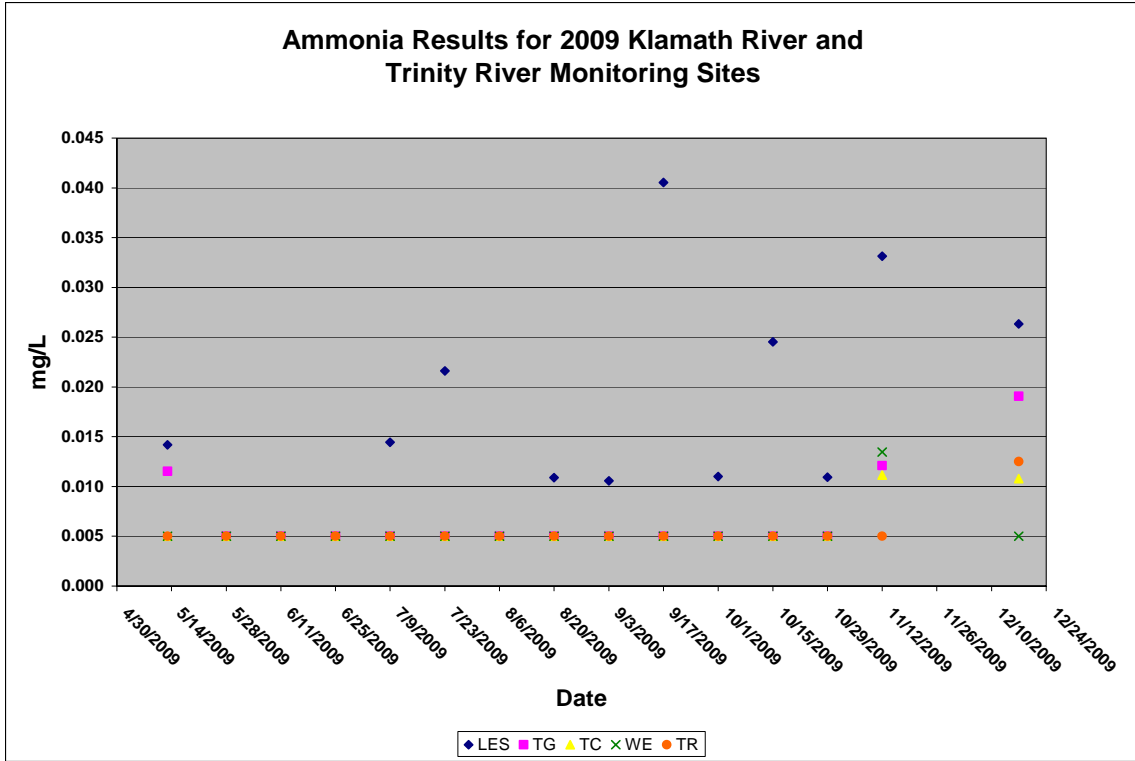


Figure 6-3. Ammonia Results 2009

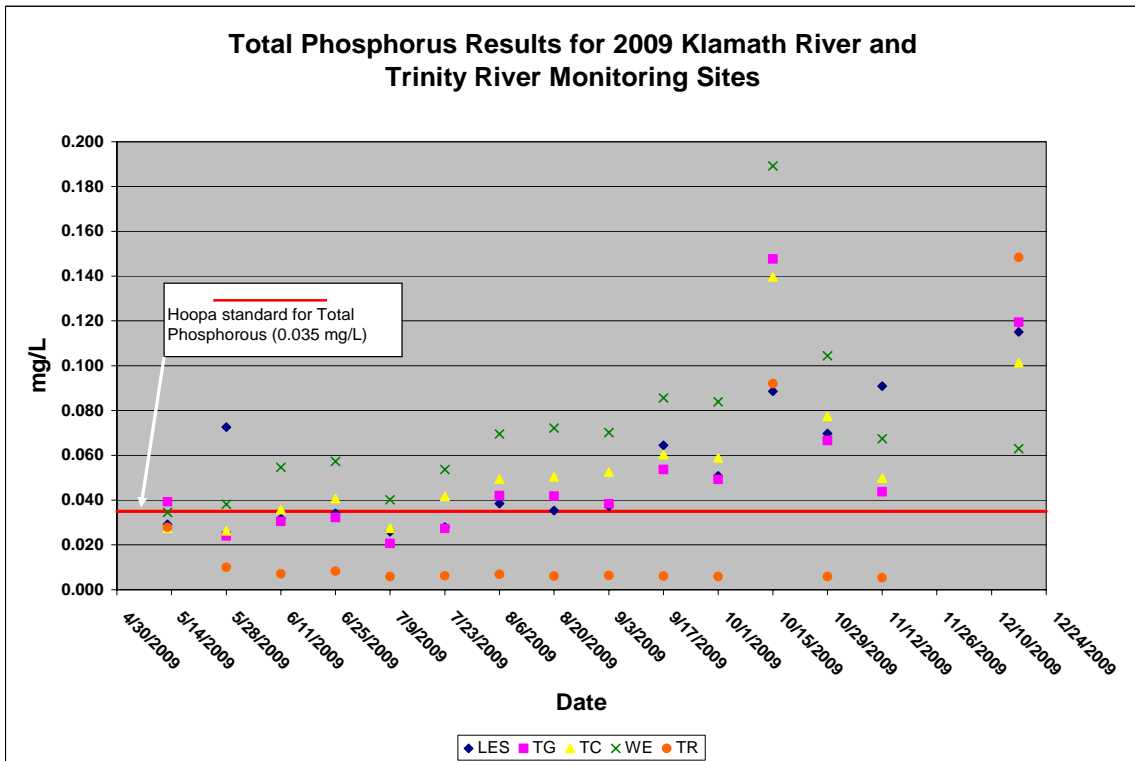


Figure 6-4. Total Phosphorous Results 2009

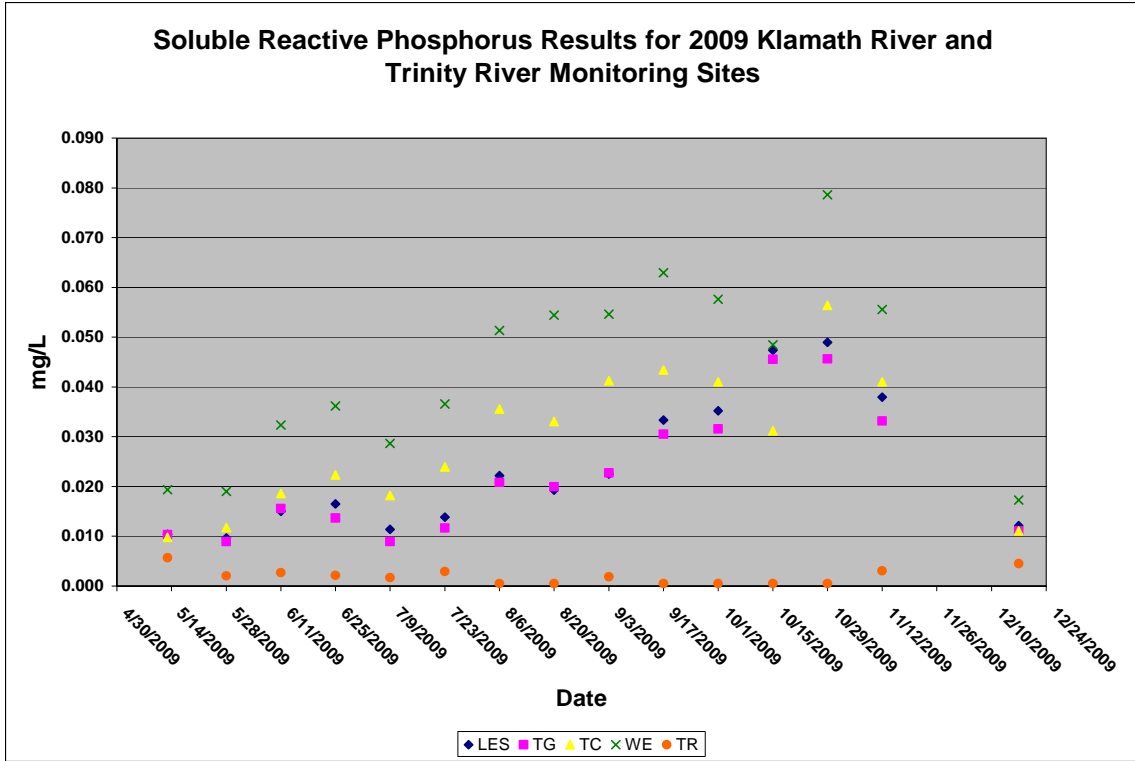


Figure 6-5. Soluble Reactive Phosphorous Results 2009

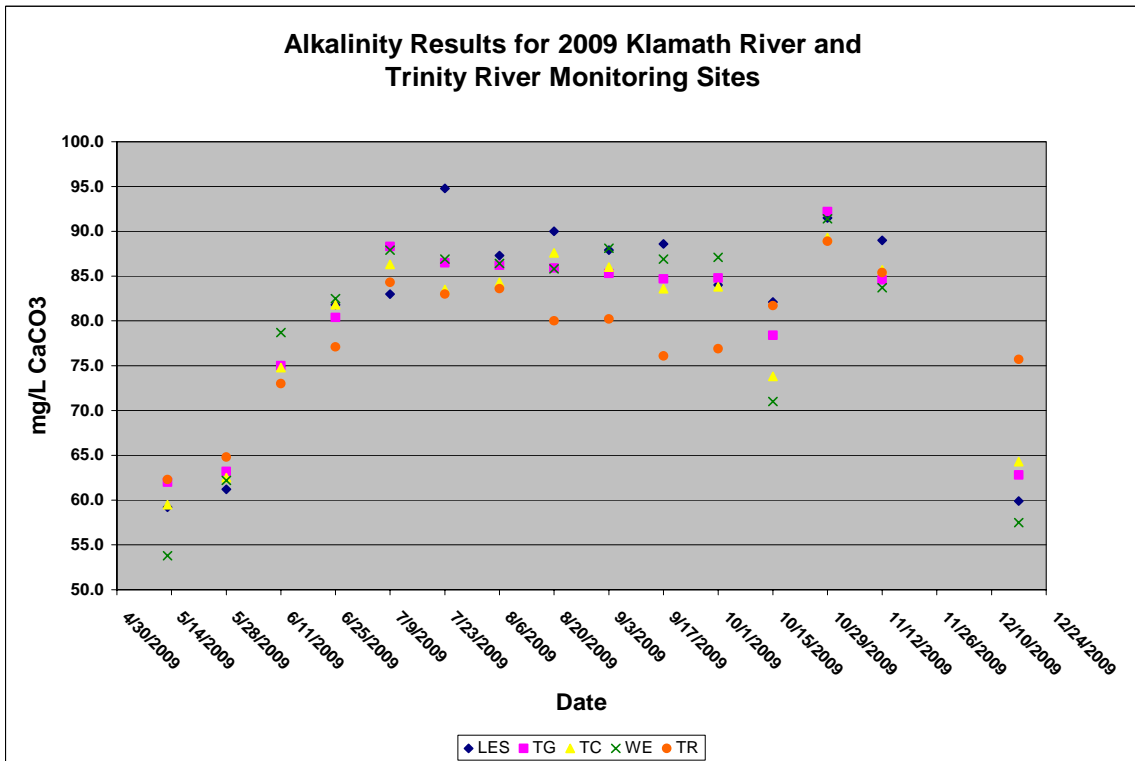


Figure 6-6. Alkalinity Results 2009

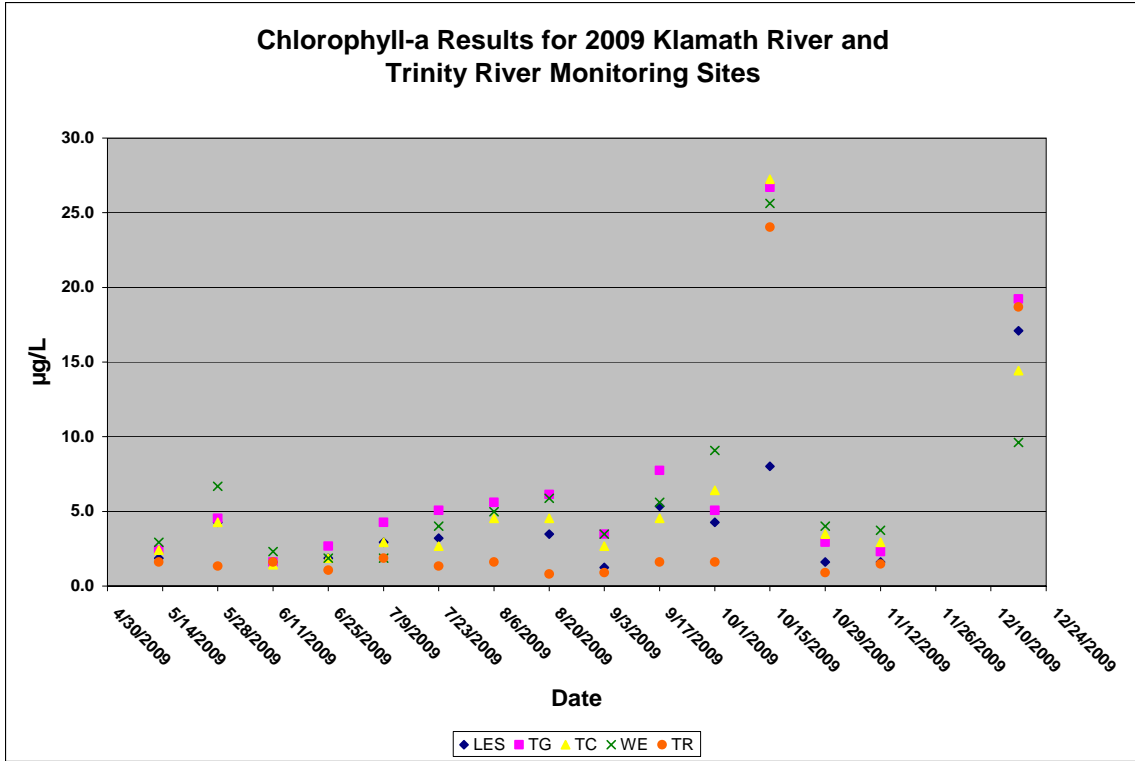


Figure 6-7. Chlorophyll-a Results 2009

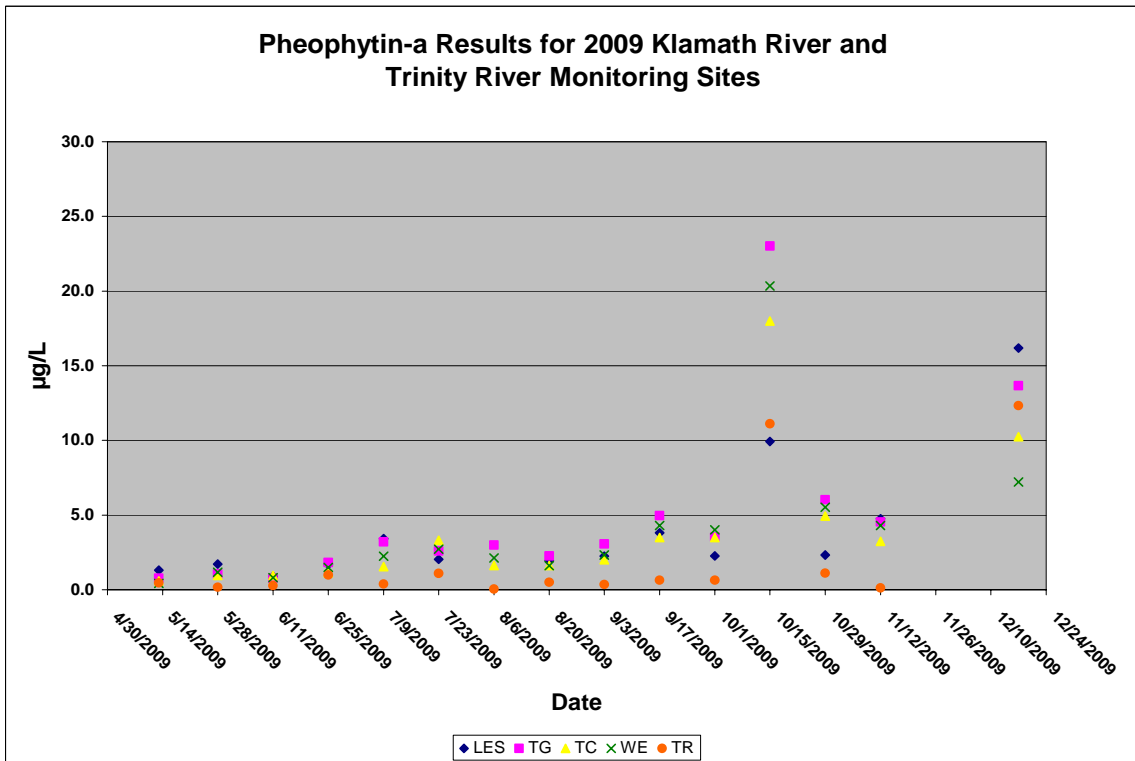


Figure 6- 8. Pheophytin-a Results 2009

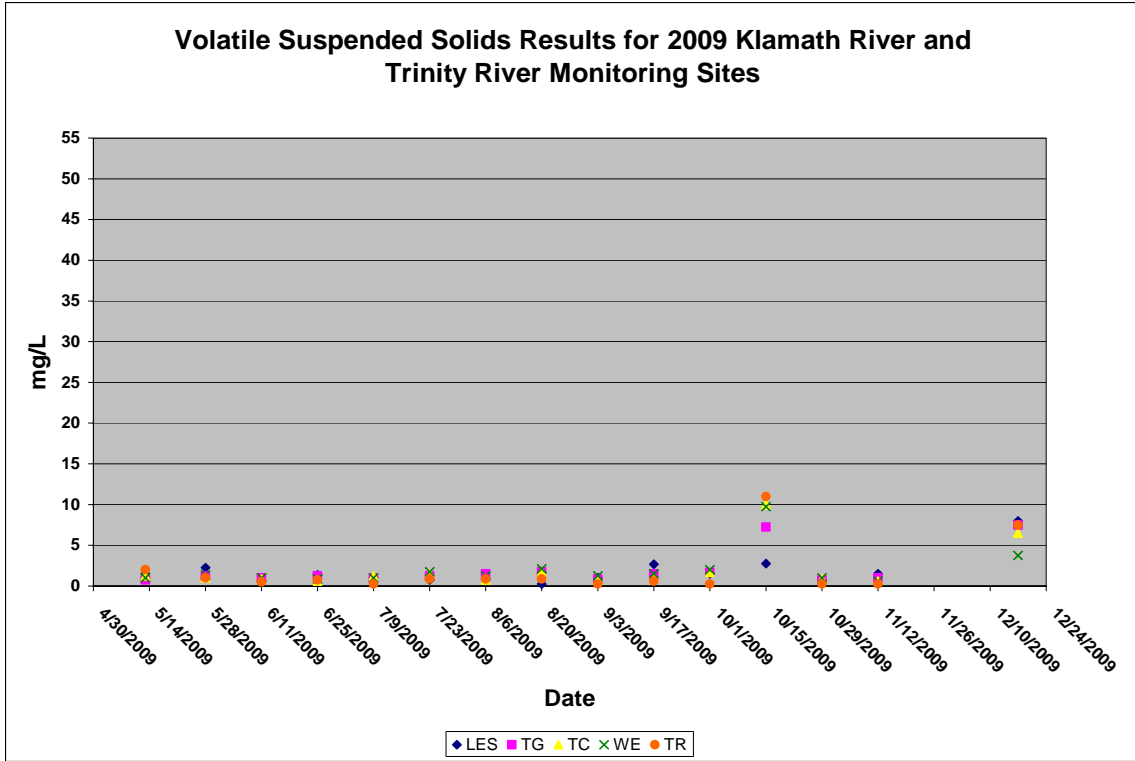


Figure 6-9. Volatile Suspended Solids Results 2009

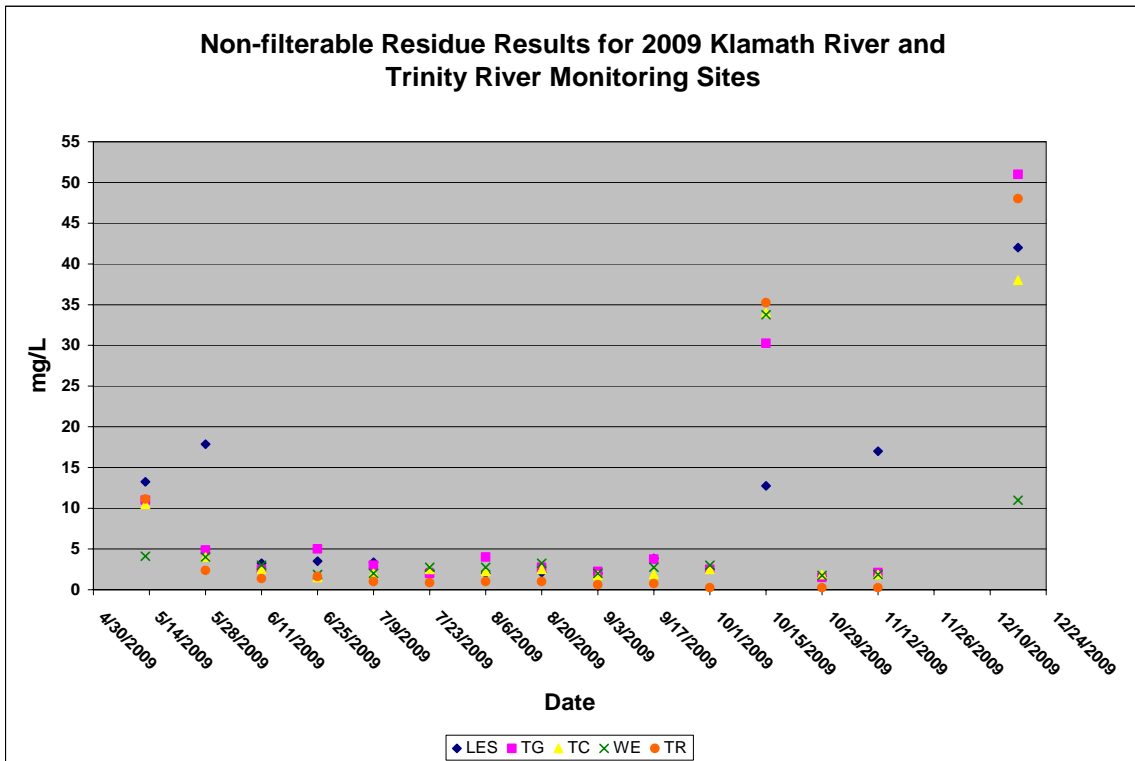


Figure 6-10. Non-Filterable Residue Results 2009

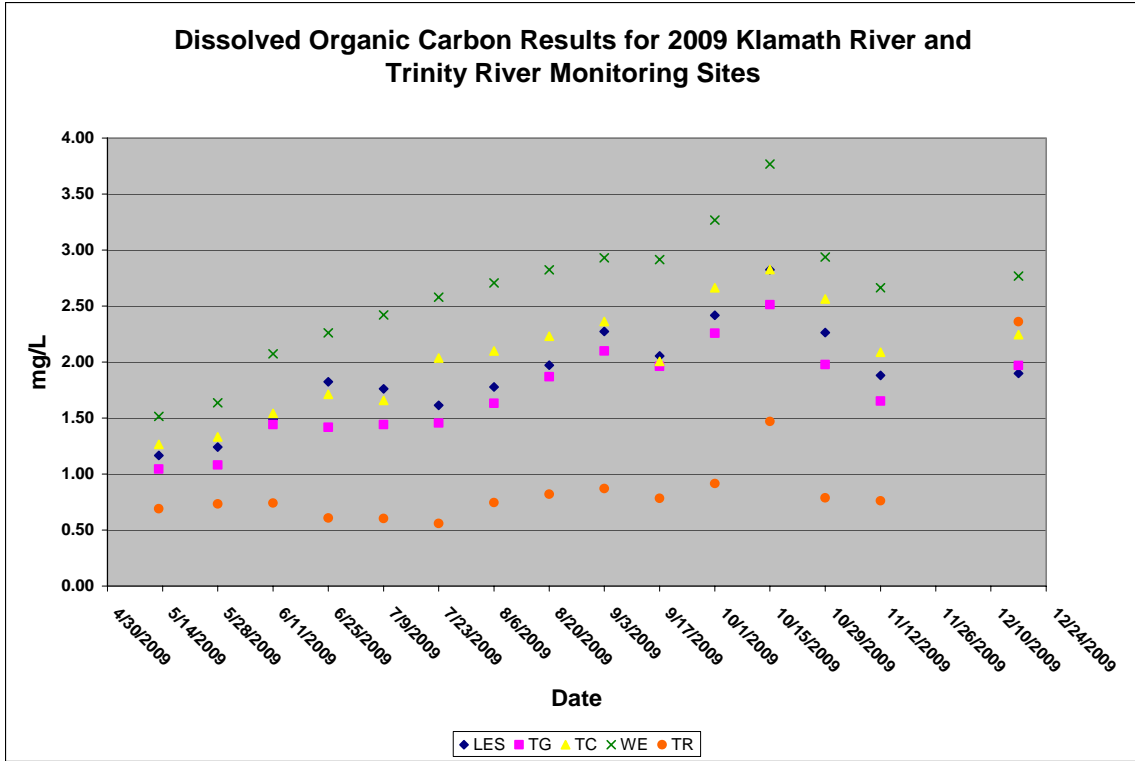


Figure 6-11. Dissolved Organic Carbon Results 2009

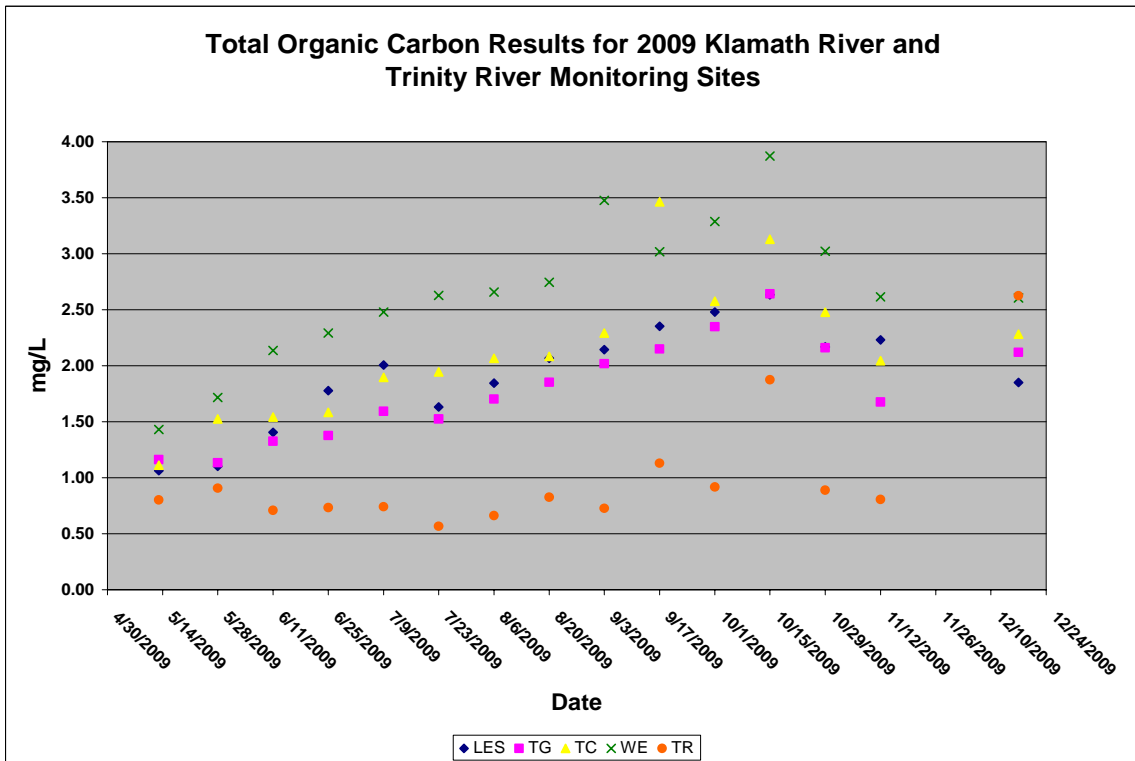


Figure 6-12. Total Organic Carbon Results 2009

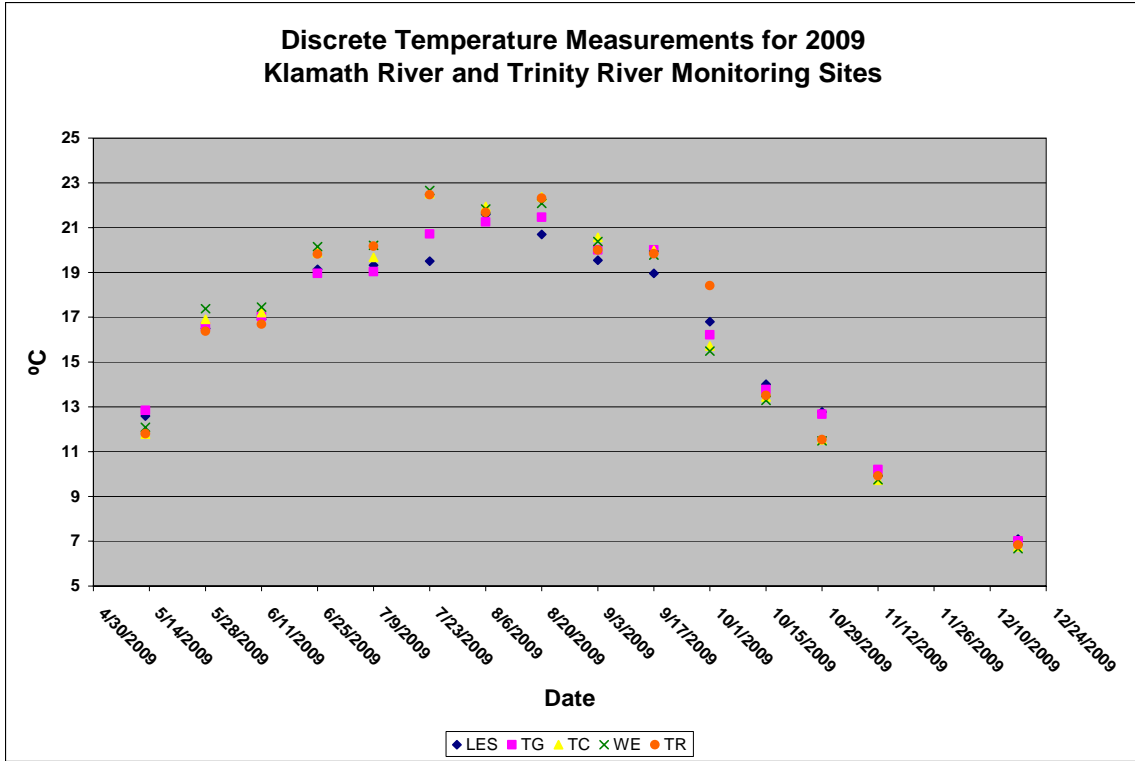


Figure 6-13. Discrete Temperature Measurements 2009

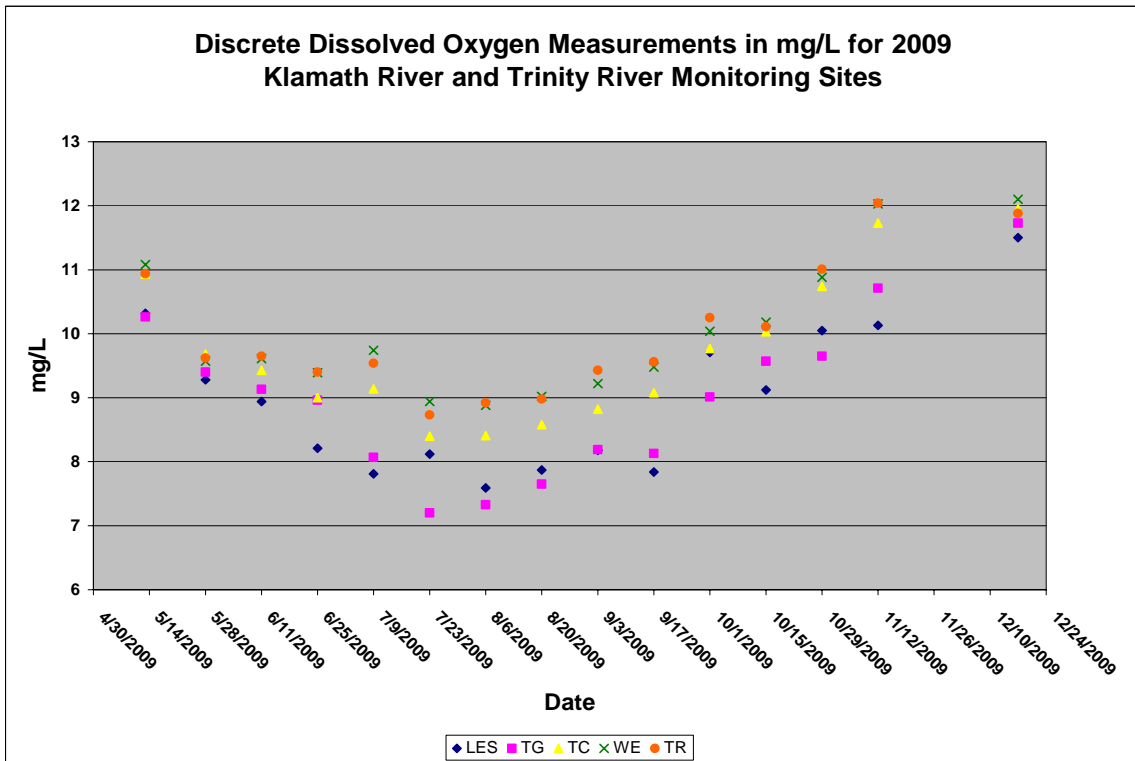


Figure 6-14. Discrete Dissolved Oxygen Measurements in mg/L 2009

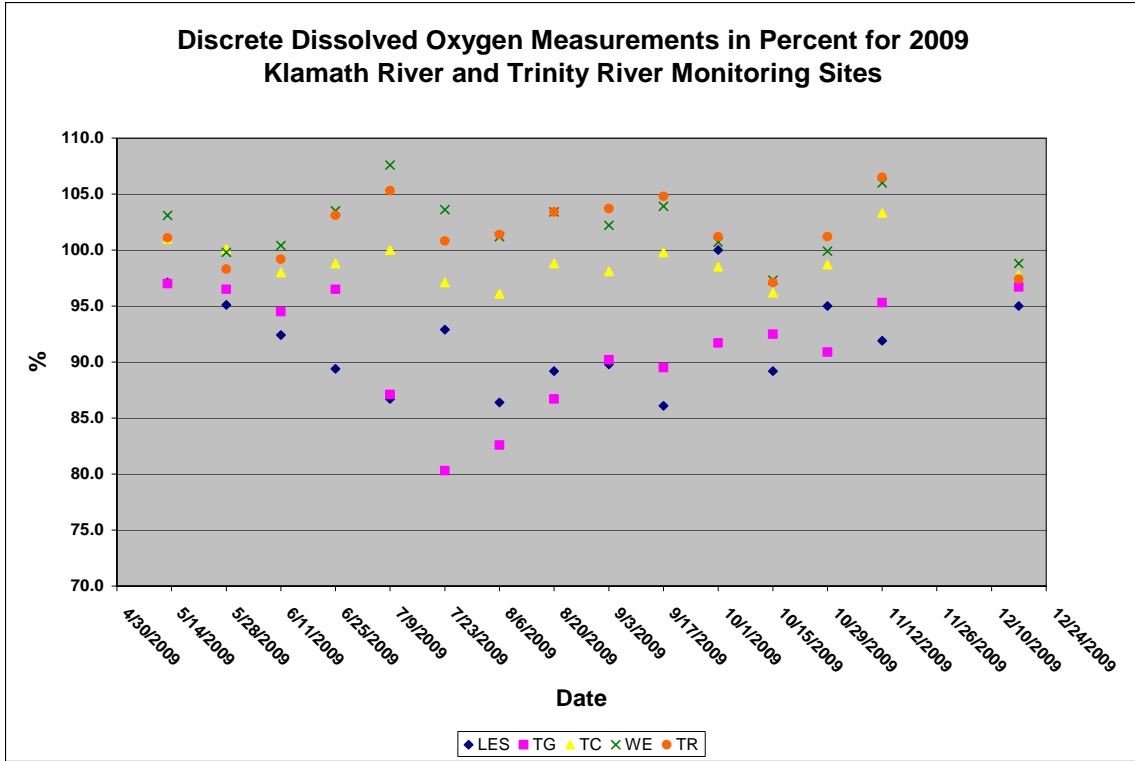


Figure 6-15. Discrete Dissolved Oxygen Measurements in Percent 2009

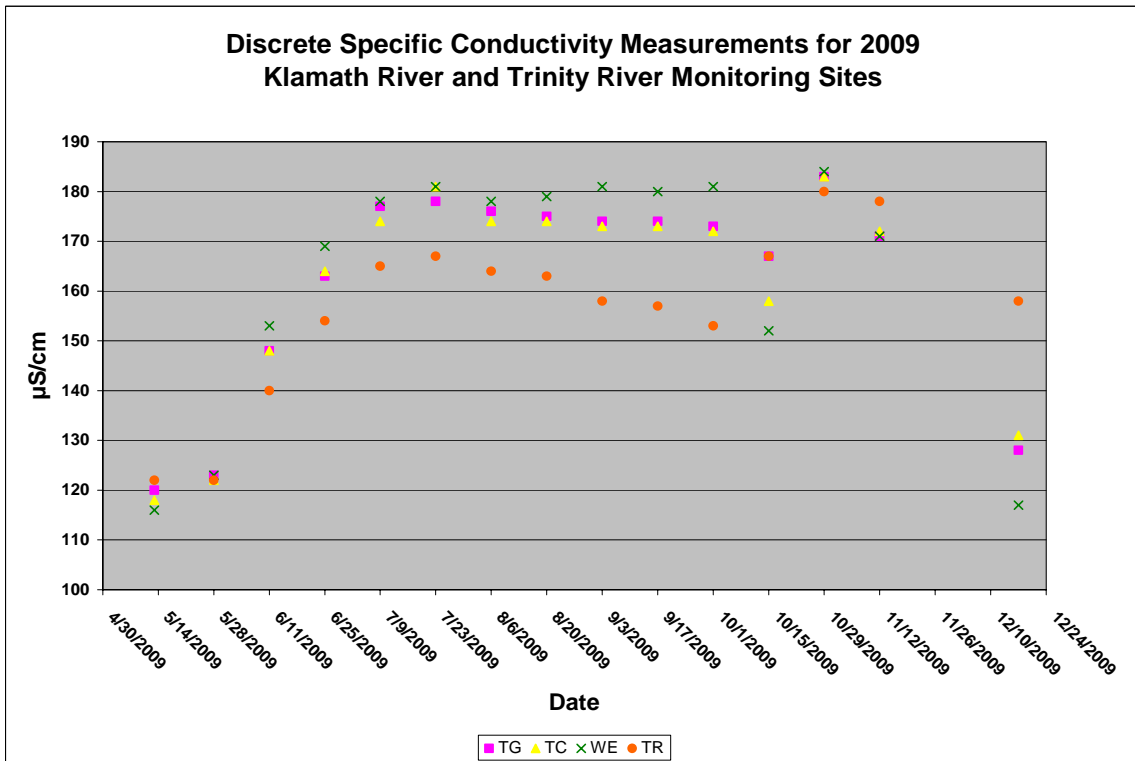


Figure 6-16. Discrete Specific Conductivity Measurements 2009



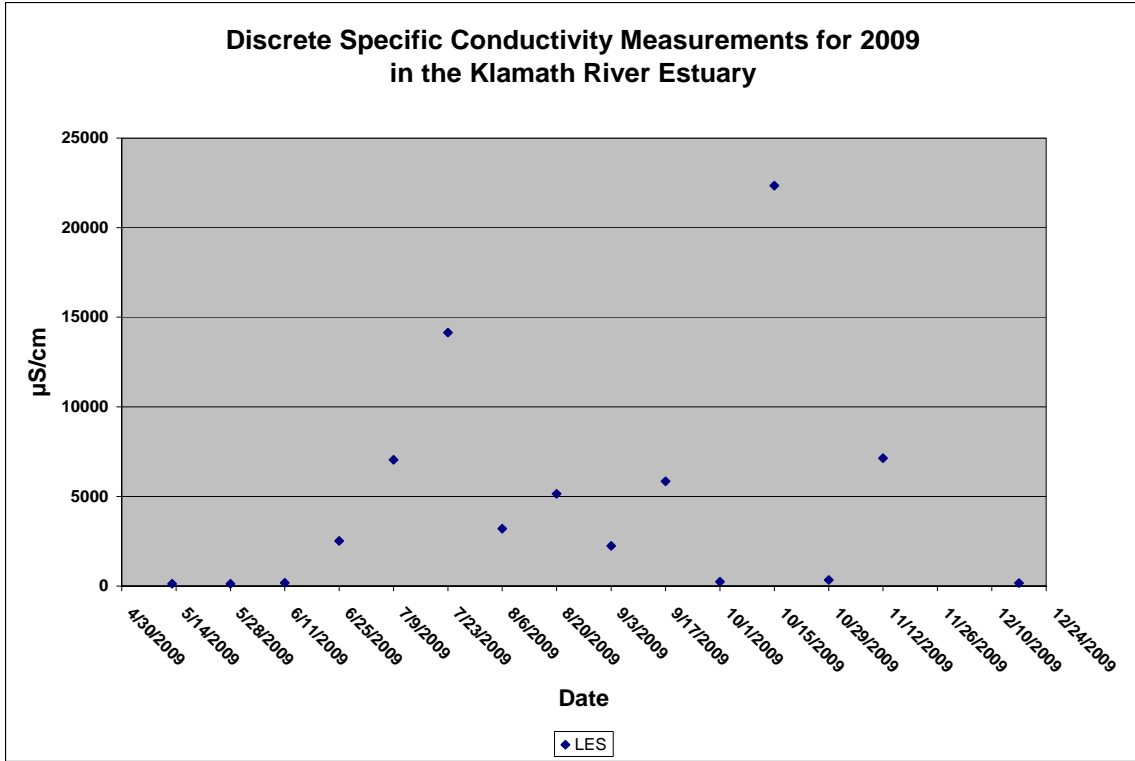


Figure 6-17. Discrete Specific Conductivity Measurements at Klamath River Estuary 2009

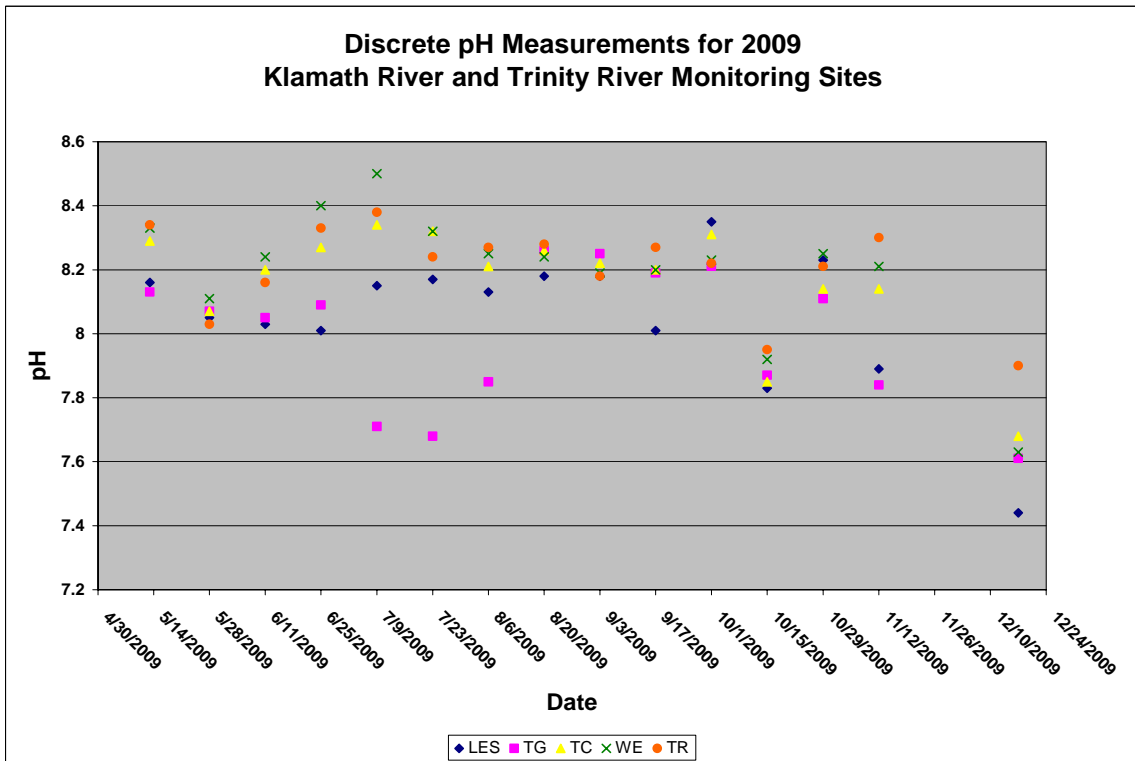


Figure 6-18. Discrete pH Measurements 2009

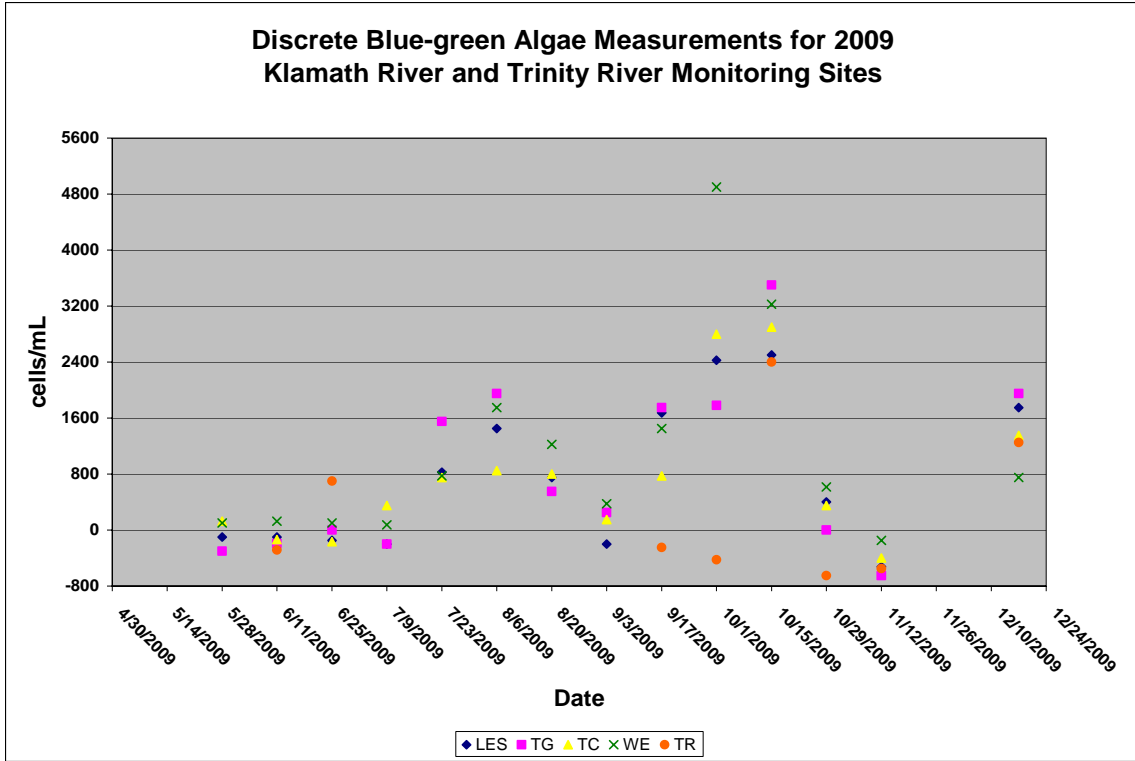


Figure 6-19. Discrete Blue-green Algae Measurements 2009

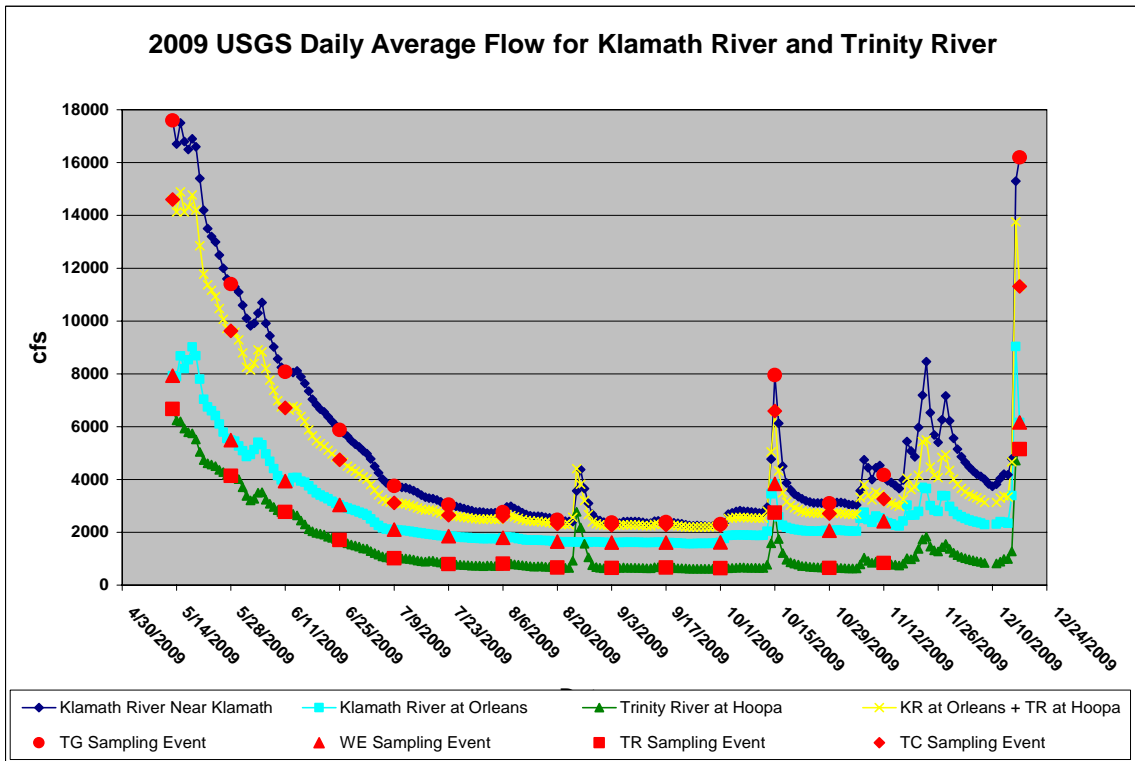


Figure 6-20. Daily Average Flow 2009 (From USGS)

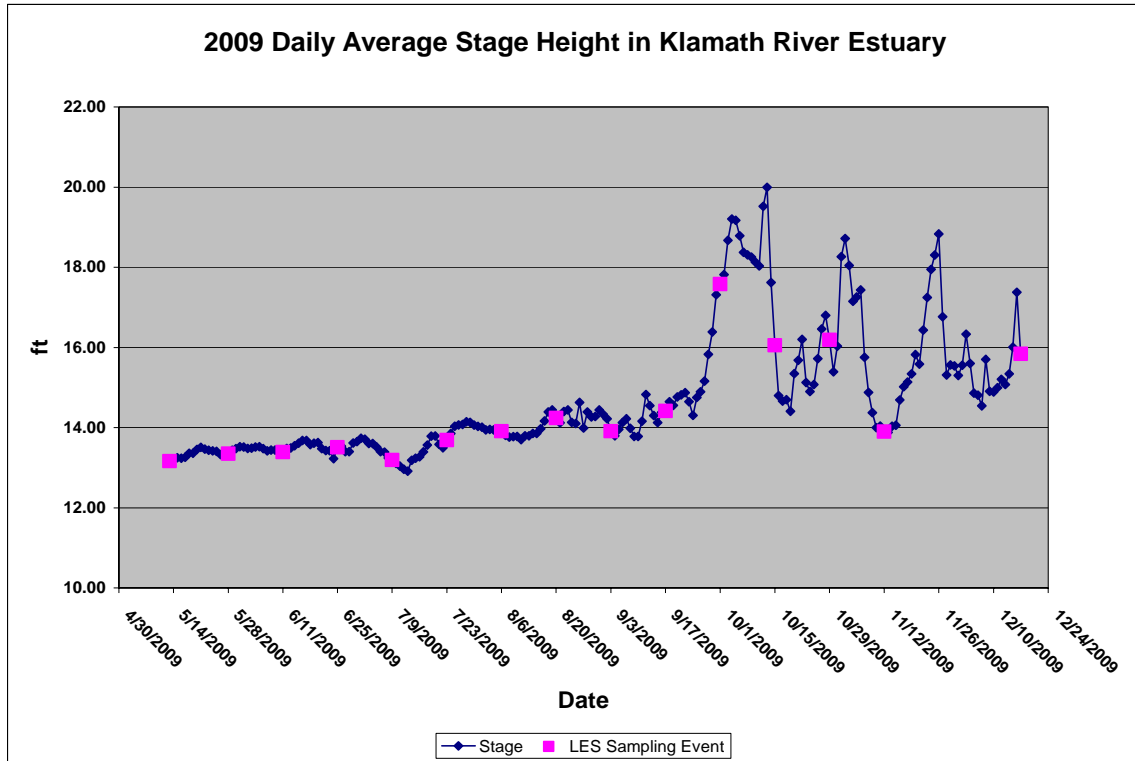


Figure 6-21. Klamath River Estuary Daily Average Stage Height 2009

## VII. Discussion

### *Organic Carbon*

Organic matter plays a major role in aquatic systems. It affects biogeochemical processes, nutrient cycling, biological availability, and chemical transport and interactions. Organic matter content is typically measured as total organic carbon (TOC) and dissolved organic carbon (DOC), which are essential components of the carbon cycle. Dissolved organic carbon is the fraction of the total organic carbon that can pass through a filter. During certain sampling events, DOC results were higher than TOC results (Table 6-2, Figures 6-11 and 6-12). This occurs because at the low levels of carbon that are being detected in the samples throughout the sampling season, most of the organic carbon in the system is in the dissolved form, causing TOC and DOC results to be essentially equal. This characteristic of the water being sampled, combined with the possibility of variation during DOC filtration, can sometimes lead to results in which DOC is higher than TOC. Results from these events are still valid because the differences between DOC and TOC are less than the reporting limit of 0.250 mg/L.

Throughout the sampling season the ratio of DOC to TOC fluctuated very little, with ratios at most sites near 100% for most sampling events (Table 7-1, Figure 6-22). This ratio held up even on the two dates (October 15 and December 17) in which significant rainfall had occurred. Only three samples from the 2009 sampling season returned ratios less than 80%. They were TG on September 1, and TR on September 1, and October 15. As discussed in the previous paragraph, ratios of more than 100% are possible because on certain dates and at certain sites, DOC results were higher than TOC results. These results indicate that throughout the sampling season, DOC constitutes almost all of the TOC found at the sampling sites.

### ***Suspended Solids***

Suspended solids refers to small solid particles which remain in suspension in water due to the motion of the water. Total suspended solids (TSS) are the amount of filterable solids in a water sample. Samples are run through a filter, which is then dried and weighed to determine the amount of total suspended solids in mg/l of sample. Volatile suspended solids (VSS) are those suspended solids lost on ignition (heating to 550 degrees C). They give an indication of the amount of organic matter present in the solid, suspended fraction of water.

The ratio of VSS to TSS fluctuated throughout the year (Table 7-2, Figure 6-23). At the beginning of the sampling season, ratios ranged from 6.8% at TG to 24.2% at WE. As the sampling season wore on, the ratio of VSS to TSS steadily increased until mid-September, at which time ratios ranged from 40.0% at TG to 83.3% at TR. Subsequently ratios generally decreased until sampling was suspended in mid-December, at which time ratios ranged from 14.7% at TG to 34.1% at TR. This temporal pattern is to be expected as the quantity of organic matter in suspended solids increases in the summer due to increased biological activity in aquatic organisms and then decreases as the activity of those organisms decreases in the fall and winter. The rain events on October 15 and December 17 had considerable impacts on the ratio of VSS to TSS. While the total amount of both VSS and TSS in the water increased, the ratio decreased significantly, indicating that a smaller portion of the suspended solids in the system was coming from volatile suspended solids.

The highest ratio of VSS to TSS was 100.0% at TR on July 23, while the lowest ratio was 6.8% at TG on May 14, 2009. On several dates the ratio was 0%. On these dates, VSS returned results that were below the reporting limit of 0.50 mg/L.

### ***Spatial Patterns***

In a large watershed such as the Klamath Basin, in which water coming out of Upper Klamath Lake and that being released from upriver dams in the summer is very low quality, full of algae, and high in nutrients; nutrient concentrations decline as the river flows downstream. This decline in nutrient concentration occurs for three reasons: dilution, periphyton growth, and denitrification.

### **Dilution**

This process has the largest affect on the concentration of nutrients in the Klamath River. In general, nutrient concentrations decline as the river flows downstream due to an influx of cleaner, cooler, higher-quality water from tributaries downstream of Iron Gate Dam.

### **Periphyton Growth**

Periphyton, also known as benthic or attached algae, removes nutrients dissolved in water to facilitate biochemical processes involved in cellular growth. Periphyton can improve water quality by removing nutrients from the water and can also contribute to water quality degradation by re-releasing the nutrients into the river system during decomposition (Water Quality Control Plan: Hoopa Valley Reservation, 2008). Luxuriant periphyton growth also causes large swings in pH and dissolved oxygen over the course of the day as biochemical processes increase and decrease in accordance with the rise and fall of the sun.

**Table 7-1. Ratio of DOC to TOC, Yurok Reservation 2009**

<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
<b>LES</b>	109.7	112.5	106.0	102.6	87.7	98.9	96.3	95.4	106.0	87.3	97.4	107.2	104.4	84.3	102.5
<b>TG</b>	89.9	95.2	108.7	103.0	90.5	95.4	95.8	100.9	104.0	91.2	96.1	95.1	91.6	98.4	92.9
<b>TC</b>	114.0	87.3	100.0	108.1	87.3	104.7	101.6	107.1	103.1	57.9	103.3	90.3	103.4	102.1	98.3
<b>WE</b>	105.8	95.3	97.0	98.7	97.7	98.2	101.8	102.8	84.3	96.6	99.4	97.3	97.2	101.9	106.3
<b>TR</b>	86.2	80.8	104.4	82.8	81.5	98.4	112.5	99.3	119.7	69.5	99.8	78.4	88.6	94.5	89.9

**Table 7-2. Ratio of VSS to TSS, Yurok Reservation 2009**

<b>Site</b>	5/13/2009	5/28/2009	6/11/2009	6/25/2009	7/9/2009	7/23/2009	8/6/2009	8/20/2009	9/3/2009	9/17/2009	10/1/2009	10/15/2009	10/29/2009	11/12/2009	12/17/2009
<b>LES</b>	11.3	12.6	19.2	39.3	29.6	31.6	43.8	0.0	50.0	69.6	60.0	21.6	46.2	8.8	19.0
<b>TG</b>	6.8	25.6	40.0	25.0	33.3	62.5	37.5	63.6	38.9	40.0	66.7	24.0	50.0	47.1	14.7
<b>TC</b>	11.9	25.0	35.0	41.7	62.5	60.0	33.3	70.0	42.9	60.0	66.7	29.4	46.7	33.3	17.1
<b>WE</b>	24.2	34.4	33.3	46.7	50.0	63.6	45.5	65.4	62.5	54.5	66.7	28.9	57.1	33.3	34.1
<b>TR</b>	18.0	42.1	36.4	46.2	0.0	100.0	87.5	87.5	0.0	83.3	0.0	31.2	0.0	0.0	15.6

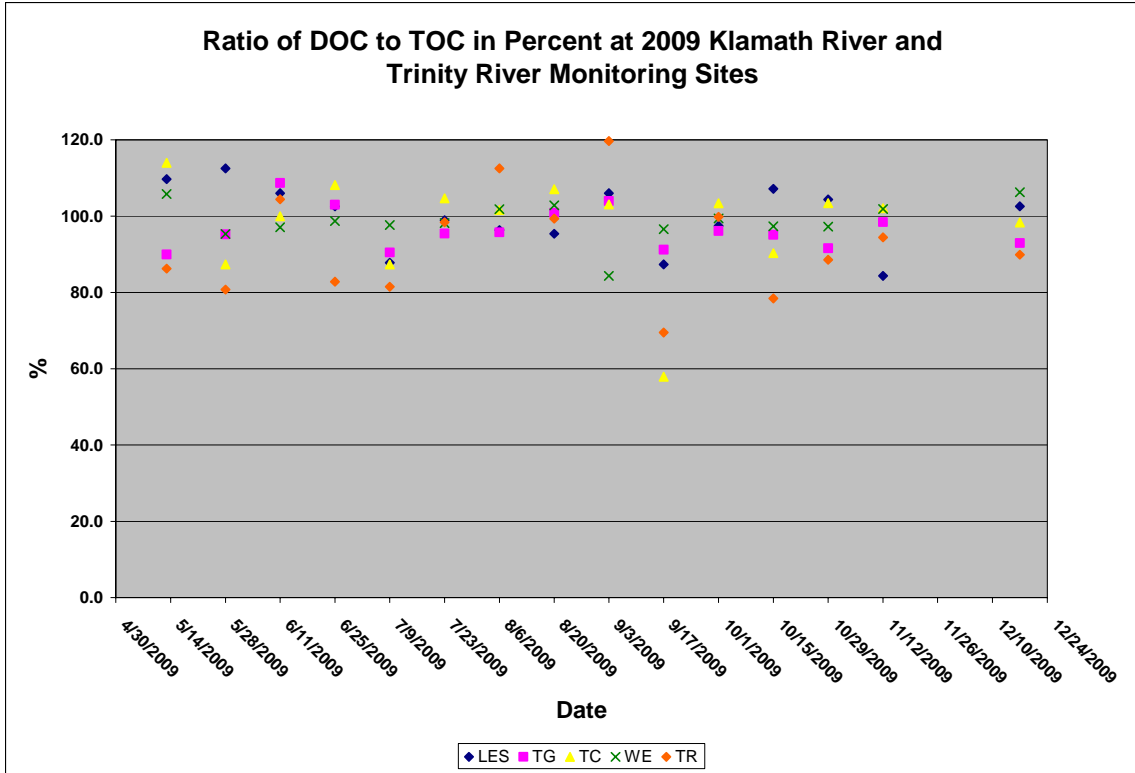


Figure 6- 22. Ratio of DOC to TOC 2009

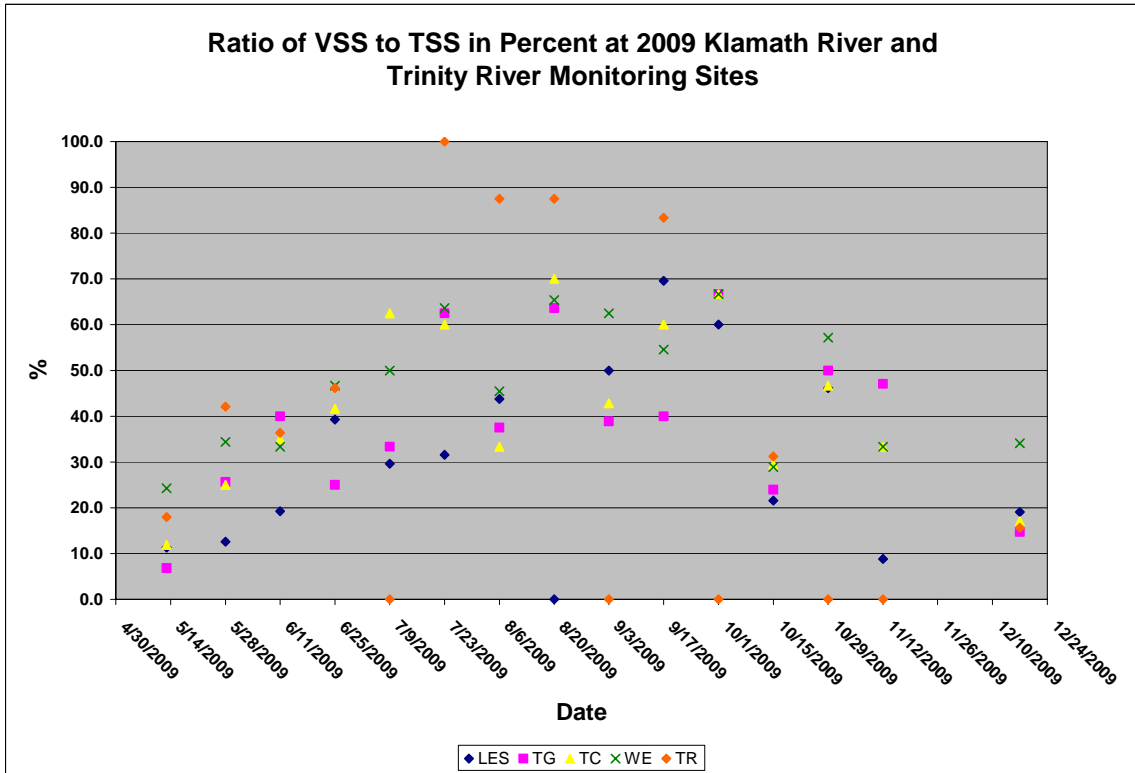


Figure 6- 23. Ratio of VSS to TSS 2009

## **Denitrification**

Denitrification occurs when aquatic organisms convert nitrate ( $\text{NO}_3$ ) to atmospheric nitrogen ( $\text{N}_2$ ). This change from a usable form of nitrogen (nitrate) into an unusable form (atmospheric nitrogen) limits and reduces productivity for organisms that require the usable form of nitrogen for growth and reproduction.

## ***Temporal Patterns***

The Klamath River's nutrient concentrations also vary over time. In the Klamath Basin, the principal source of nutrient loading in rivers and streams during months with large quantities of rainfall is from runoff originating from agricultural land. In this type of system, an increase in precipitation initiates an increase in runoff and associated streamflows, which subsequently leads to an increase in nutrient concentrations (Mueller et al., 2006; Sprague et al., 2008). The Klamath Basin receives most of its rain from November to April, and as can be seen in Figures 6-1 through 6-12, concentrations of all parameters except alkalinity and ammonia in the Klamath River dramatically increased in mid-October, corresponding with the first large rain event (Figure 6-20). After this event, concentrations decreased, yet remained at some of the highest levels of the entire sampling season, then increased again during a subsequent rain event in mid-December (Figure 6-20). During months with little rainfall, however, the principal source of nutrient loading in the Klamath River is from Upper Klamath Lake. In Upper Klamath Lake the source of nutrients during the spring and summer is largely due to internal loading from lake sediments (Lindenberg et al. 2008). Therefore, a drop in water levels does not correspond with a drop in nutrient levels. As can be seen in Figures 6-1 through 6-12, this corresponds to increasing levels of nutrients in the Klamath River as the summer progresses and river levels drop.

## ***Nutrient Criteria***

In this report, Hoopa Valley Tribal EPA nutrient criteria standards are applied to the information collected in 2009. The Hoopa Valley Tribe has not set standards for all nutrients analyzed by YTEP, therefore, nutrient standards to be discussed will be limited to total nitrogen and total phosphorous.



### **Total Nitrogen**

The Hoopa Valley Tribal EPA has set the water quality standard for total nitrogen at 0.2 mg/L (Table 7-1, red line in Figure 6-2). As can be seen in Table 7-1 and Figure 6-2, after late July, all sites except TR exceeded this standard. By early October, and continuing for the remainder of the sampling season, the sites were yielding results that were 2-5 times greater than the standard of 0.2 mg/L. The WE site, however, exceeded this threshold by late May, preceding the other sites by nearly two months. TR exceeded this threshold on two sampling events after significant rainfall occurred, the first in mid-October, and the second in mid-December.

### **Total Phosphorous**

The Hoopa Valley Tribal EPA has set the proposed standard for total phosphorous at 0.035 mg/L (Table 7-1, red line in Figure 6-4). As can be seen in Table 7-1 and Figure 6-4, in late May WE was the first site to exceed this threshold. The TC site followed in mid-June, while LES and TG exceeded this standard in early August. After early August until sampling was suspended in mid-December, all sites except TR maintained concentrations above this standard. From early October to mid-December WE yielded concentrations that were 2-5 times greater than the standard of 0.035 mg/L. All other sites except TR yielded concentrations that were 2-4 times greater than the standard from mid-October until sampling was suspended in mid-December. The exceptions were TC and TG on November 11, 2009. TR exceeded the threshold on two sampling events after significant rainfall occurred, the first in mid-October, and the second in mid-December.

**Table 7-3. Nutrient Standards for the Klamath River (based on data from Hoopa Valley Indian Reservation)**

<b>Parameter</b>	<b>Proposed Standard (mg/L)</b>
Total Nitrogen	0.2
Total Phosphorous	0.035

The results from total nitrogen and total phosphorous indicate that nutrient levels in the Lower Klamath River exceed water quality standards recognized as acceptable levels to meet beneficial uses.

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- Lindenberg, M.K., Hoilman, Gene, and Wood, T.M., 2009, *Water Quality Conditions in Upper Klamath and Agency Lakes, Oregon, 2006*. U.S. Geological Survey Scientific Investigations Report 2008-5201, 54 p.
- Mueller, David K., and Spahr, Norman E., 2006, *Nutrients in Streams and Rivers Across the Nation—1992–2001*. U.S. Geological Survey Scientific Investigations Report 2006–5107, 44 p.
- Norton, Ken, Pliny McCovey Jr., Curtis Miller, Louisa McConnell, Mike Orcutt, Nolan Colgegrove, Mark Higley. *Water Quality Control Plan: Hoopa Valley Indian Reservation*. 2008
- Sprague, L.A., Mueller, D.K., Schwarz, G.E., and Lorenz, D.L., 2009, *Nutrient Trends in Streams and Rivers of the United States, 1993–200*. U.S. Geological Survey Scientific Investigations Report 2008–5202, 196 p.

## Appendix

### *Grab Sample Protocol*

'Grab sampling' refers to water samples obtained by dipping a collection container into the upper layer of a body of water and collecting a water sample (USGS File Report -00213). For quality assurance/quality control (QA/QC) purposes replicate, and blank bottle sets will be prepared and collected for one site each sampling period. These additional bottle sets will be handled, prepared and filled following the same protocol used for regular bottle sets and samples. General water quality parameters will also be measured with a freshly calibrated portable multi-probe water quality instrument during grab samples and recorded onto data sheets.

Upon arrival at each site, the sampling churn will be rinsed three times with distilled water. The goal of rinsing is 'equipment decontamination – the removal from equipment, residues from construction and machining and the removal of substances adhering to equipment from previous exposure to environmental and other media' (USGS Open File Report 00213). After rinsing with D.I. water, the churn will be rinsed three times with stream water. The churn is then fully submerged into the stream and filled to the lid with sample water. Completely filling the churn allows for all samples to be filled from one churn; thereby minimizing differences in water properties and quality between samples.

Proper use of the churn guarantees the water is well mixed before the sample is collected. The churn should be stirred at a uniform rate by raising or lowering the splitter at approximately 9 inches per second (Bel-Art Products, 1993). This mixing must continue while the bottles are being filled. If filling is stopped for some reason, the stirring rate must be resumed before the next sample is drawn from the churn. As the volume of water in the churn decreases, the round trip frequency increases as the velocity of the churn splitter remains the same. Care must be taken to avoid breaking the surface of the water as the splitter rises toward the top of the water in the churn.

Sample bottles and chemical preservatives used were provided by associated laboratories and were considered sterile prior to field usage. Sample bottles without chemical preservatives were rinsed with stream water from the churn 2-3 times before filling with sample water. In the case of bottles that contained chemical preservatives, bottles were not rinsed before sample collection and care was taken to avoid over-spillage that would result in chemical preservative loss. Collected samples will be placed in coolers on ice or dry ice for transport to contracted laboratories for analysis.

### *QA/QC – Duplicate, Blank and QA Reference Standard Bottle Sets*

To ensure laboratory and sampling accuracy, one site every sampling period was randomly selected to receive two additional QA/QC bottle sets. These bottle sets contains duplicate and blank water samples. Duplicate samples are obtained using the same process as regular samples. This information is used to assure the laboratory maintains precision within results. True blank samples were collected by pouring distilled water straight into the sample bottles. These are disguised so the lab does not

know which samples are blank samples. All bottle sets are then placed on ice and are transported to the associated laboratories by mailing a cooler via Fed Ex. All grab samples were processed within 24 hours or within known laboratory holding periods.

### *Bibliography*

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