Methods of Water Quality Data Collection and Preparation
Redwood National and State Parks

Quality Assurance Project Plan

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This document is submitted to the California State Water Resources Control Board, in lieu of a Quality Assurance Project Plan (QAPP), to accompany our data submittal. The format follows State Boards "Notice" of November 3, 2016, Enclosure 2, Section 3e, describing a QAPP-equivalent document. Redwood National and State Park's (RNSP) stream discharge and sediment and stream temperature monitoring are described separately.

Stream Discharge and Sediment Monitoring

1. Objectives of the monitoring program: Our objectives for this monitoring are to quantify water and sediment discharges at gaging stations in the Redwood Creek watershed for the purposes of: 1) assessing watershed conditions through time; 2) evaluating the success of watershed restoration efforts toward sediment reduction in the basin; 3) evaluating the effects of large storms, timber harvesting, roads, and other land uses in the basin.

2. Methods for sample collection and handling: The methods for collection of water and sediment discharges closely follow those of the US Geological Survey, a cooperator in our data collection program. The methods are described in the US Geological Survey's "Techniques of Water Resource Investigations" (TRWI) publication, Book 9, which can be obtained at:

   http://water.usgs.gov/owq/FieldManual/index.html

   Redwood National and State Parks contracts with the US Geological Survey, Eureka Field Office to measure discharge and sample suspended sediment for 2-3 high winter flows per year at two mainstem stations (Redwood Creek at Orick (Orick), #11482500 and Redwood Creek near Blue Lake (O'Kane), #11481500), and to maintain the upper gaging station.

   Suspended sediment samples are collected during high flow conditions using isokinetic sampling device that is deployed from a bridge or cableway using a weighted cable and winch. We use paid observers to collect sediment samples at the mainstem stations. Paid observers are commonly used by the USGS to supplement sampling at gaging stations in the United States. They are trained by both USGS staff and our hydrologic technician. Samples collected by observers at Orick consist of "box" sample which consists of two samples collected within 15 minutes at a single point on the gaging section. Samples collected at O'Kane are at three designated points along a cableway. The box and cableway sample locations are determined by the USGS. Suspended sediment samples are transport to our Orick sediment laboratory and where they are stored in a cool, dark storage facility (to prevent algae growth) until they can be analyzed.

3. Laboratory methods: As with field data and sample collection, our laboratory methods follow USGS protocols outlined in their TWRI. Prior to filtration, the turbidity of each sample is read with a Hach 2100N turbidimeter. We use vacuum filtration through 50 micron filters to measure fine suspended sediment concentration (SSC). A "sand break" is also measured for all samples where the sediment is passed through a 0.063 mm sieve to filter out sand size particles. The material retained on the sieve is transferred to a filter and both coarse and fine filters are dried and weighed. The total weight of sediment is divided by the original sample volume to derive suspended sediment concentration in mg/l. Laboratory methods are described in the enclosed report titled "Redwood National Park Sediment Laboratory Procedures for Analyzing Suspended Sediment." (filename: REDW_SedimentLabProcedures.docx)

4. Data management and analysis:

   The USGS maintains stage-discharge rating curves and provides 15-minute discharge data, mean daily and peak flow data at the two mainstem stations. All data are published on the USGS website.

   The two to three suspended sediment samples per year are collected and analyzed by the USGS using their staff, equipment and lab facilities. The other samples are collected by either the hydrologic technician or by paid observers and analyzed in the parks sediment laboratory facility.

   The chain of custody for our suspended sediment samples typically consists of just two links: the hydrological technician retrieves samples from the field and transports them directly to the laboratory where they are stored until analysis. For our observers, they collect sediment samples and store them until either transferred to the hydrological technician for delivery to the lab or they drop them off directly to the laboratory. At all stages, care is taken to keep the samples in cool, dark environments to prevent algae growth prior to analysis.

   Laboratory data is entered into a spreadsheet include the gaging station, sample date and time, lab turbidity, sample volume, filter weight(s) (samples with relatively high Suspended Sediment Concentration (SSC) require more than a single filter), sediment weight(s), and calculated SSC. These data are then entered into a database, checked for possible errors, and corrected or removed if necessary. Once data review is completed, it is uploaded for suspended sediment yield computations.

   Computation of suspended sediment loads is estimated using the USGS GCLAS (Graphical Constituent Load Analysis System) software by the RNSP hydrology technician. GCLAS provides a discharge-SSC transport curve useful in the process of estimating continuous suspended sediment concentration for unsampled periods.

5. Quality assurance and control: In addition to the quality control measures mentioned above, the RNSP hydrologic monitoring program also includes the following:

   a) Annual calibration of our sediment laboratory scale and turbidimeter

   b) Duplicate suspended sediment sampling at mainstem gaging stations

   c) Identify samples with excessive sand indicating the sampler dug into the stream bottom and evaluate paired SSC samples to identify divergent values.

6. <u>Statement certifying QAPP</u>: I certify that the quality assurance and control program used in the hydrologic monitoring at RNSP is fully adequate for producing accurate and scientifically credible results.

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7. Training
   a) Hydrology technician completed a one week USGS GCLAS training and consults with USGS for any issues that arise in sediment yield computation.
   b) All staff are trained and follow a Standard Operational Procedure (SOP) for analyzing suspended sediment samples in the laboratory.
   c) Sediment observers are trained by the hydrologic technician, provided a SOP for sampling suspended sediment, and instructed on how to store samples until transferred to the RNP sediment laboratory for analysis.

Stream Temperature Monitoring

1. Objectives of the monitoring program: The objectives of the program is to acquire long-term stream and air temperature information for the mainstem of Redwood Creek and selected tributaries, to evaluate trends in stream temperature both spatially and temporally, and to attempt to explain any trends detected by changing watershed conditions. The program currently focuses on monitoring summer stream and air temperatures (June to September).

2. Methods for sample collection and handling: Continuous stream temperature data was collected using ONSET data loggers (www.onsetcomp.com). The model, temperature range, and accuracy of data loggers used by RNSP since 2010 are listed in the table below.

Water Quality Data Loggers		
Data Logger	Temperature Range °C	Accuracy °C
TidbiT StowAway TBI32	-5°C to 37°C	±0.2
TidbiT V2 UTBI-001	-20°C to +70°C	±0.2
Hobo Temperature ProV2 H20-001	-40°C to 70°C	±0.2

Monitoring Sites:

- Mainstem Redwood Creek: The location of the long-term Redwood Creek mainstem monitoring sites were validated from thermal infrared data (TIR) of surfaced water temperatures collected along the main channel of Redwood Creek in 2003. Based on the TIR data, the monitoring sites were representative of the thermal conditions and reaches in Redwood Creek (Madej et.al. 2006).
- Redwood Creek Tributaries: Tributaries to Redwood Creek that supported a diversity of anadromous salmonids were monitored.

Field Deployment:

- Sampling Period: Data loggers are deployed from June 1 to September 30. Emphasis is placed on monitoring stream temperatures for the core period from July1 to August 30. Past stream temperature monitoring has shown that peak stream temperatures on Redwood Creek usually occur during the last week of July and the first week of August.
- Data loggers are set to start sampling on June 1 12:00 am and with a sample interval of 1 hour.
- Field Site: Data loggers are deployed in the stream in:
  - areas of mixed water
  - suspended in the water column deep enough to remain underwater through the monitoring period
  - shaded areas of the stream

Two probes are deployed side-by-side at stream sites and a single probe is used for air temperature. Data loggers are deployed in white perforated PVC pipe housing units that allow for water and air circulation while protecting the sensor from direct solar radiation.

A field sheet is filled out when deploying and retrieving the temperature probes and includes the temperature probe serial number(s), air or water deployment, a temperature measurement at the top, middle, and bottom of the water column to confirm the probe is in a well-mixed are of the stream and that there is no thermal stratification. The wetted channel width, total water depth and data logger depth below the water surface are measured. The site is also photo documented and a GPS point taken.

3. Laboratory methods (data logger temperature validation): All data loggers are checked pre and post deployment to verify that they measure within ±0.2°C of a NIST calibrated thermometer and that there is no time drift in the data loggers. Prior to field deployment, all probes have a two-point temperature check– 17-18°C (room temperature) and 0°C (ice bath). All temperature probes passing validation are graded and then assigned to field sites. Since 2014, a one-point (0°C) temperature validation of probes occurs after retrieval from the field. The temperature validation protocol is described in Attachment A

4. Data management and analysis (error screening): After data loggers are retrieved from the field, temperature data is downloaded using Box Car and Hoboware software. The data is truncated to remove temperature data collected prior to and following removal of the temperature probes from the stream.

   For sites where paired water probes are deployed, the temperature difference between the probes is calculated for the period of record. Temperature differences greater than ±0.2°C is investigated further. Typically data from the primary probe is used since it is the higher graded probe.

   Data are evaluated for outliers which includes summer temperature observations that fall below 10°C or are greater than 30°C, or if the rate of change is greater than 3°C in one hour. Data outliers are flagged and these observations are re-evaluated by checking field notes, talking to staff that deployed and retrieved the probes, and then reexamining the data. The A visual inspection of the plot of temperature data over the period of interest helps identify data anomalies. Data are removed when there is an obvious issue (ie water probe found in the air). An exception is the Redwood Creek estuary which provides a dynamic environment with interactions between ocean and freshwater. Data outlier criteria may not necessarily apply depending on the circumstances.

   Temperature data are analyzed using Aquarius software and completed using an established workflow in Aquarius which calculates stream temperature metrics. For each monitoring site, a stream temperature and air (if available) summary report is prepared that includes:

   - Plot of temperature data for the period of record
   - Data outliers: identifies sites with a change in temperature >3°C within one hour
   - Period of Record used for analysis: July 1 to August 31
   - Summary statistics:

  - average, maximum and minimum temperature and associated date/time
  - maximum and minimum diurnal range and associated date/time
- 7-day Moving Average – Maximum Weekly Average Temperature (MWAT) and Maximum Weekly Maximum Temperature (MWMT)
- Consecutive risk characterization - Consecutive time in hours the stream temperature exceeded a specified temperature and the total time above a specified temperature.
- Filename and location of data used in analysis

5. <u>Quality assurance and control</u>: In addition to the quality control measures mentioned above, the RNSP stream temperature monitoring program also includes the following:

    - Two water temperature probes are deployed at each monitoring site to provide a back-up in case one probe fails and to provide QA/QC of the water temperature data collected in the field.

6. <u>Statement certifying QAPP</u>: I certify that the quality assurance and control program used in the temperature monitoring at RNSP is fully adequate for producing accurate and scientifically credible results.

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7. <u>Training:</u>
    a. Hydrology technician and geologist each completed one week of Aquarius software training for water quality and hydrology data analysis.

Attachment A: Stream Temperature Data Logger Validation

Prior to deployment, all data loggers are tested in the office using a two-point temperature check; 0°C (ice bath) and 17-18°C (room temperature). The purpose of the test is to validate that data loggers are operating within the manufacture specified temperature accuracy and identify non-functioning data loggers.

A NIST certified laboratory thermometer (± 0.05°C) is used to measure the temperature of the water bath.

Method:

1. Launch Probes: Synchronize all data loggers to the same current date and time using the data logger software. Use an accurate clock to set CPU time (http://www.time.gov/). Make sure to synchronize the watch/clock used during the test to the same time as the data loggers. Set the data loggers to record data every 10 minutes.

2. Room temperature test (about 17-18°C): Fill an insulated container with water and let sit overnight to reach ambient room temperature. Place probes in water bath and make sure the temperature sensors are completely submerged throughout the test. Stir the water bath to achieve a constant temperature and prevent thermal stratification. Continue stirring water bath throughout the test. Allow 10 minutes for the data loggers to stabilize in the water bath. Begin measuring water temperature every 20 minutes using a calibrated laboratory thermometer and record the time and reference thermometer temperature for at least 2 hours. Remove data loggers from the water bath.

3. Ice Bath test (0°C): Fill an insulated container about 2/3 full of water and add enough ice (about 30 lb) to the insulated container to bring the water temperature down to nearly freezing. This may take about an hour. Stir the ice bath to achieve a constant temperature and continue stirring water bath throughout the test. Place the data loggers in the ice bath so that the temperature sensors are completely submerged. Allow 10 minutes for the data loggers to stabilize in the ice bath. Begin measuring water temperature every 10 minutes using a calibrated laboratory thermometer and record the time and reference thermometer temperature. After 2 hours remove data loggers from the ice bath.

4. Download temperature probes and compare the recorded data against the reference thermometer data. Import data logger data into the TestResults_template or create a worksheet with columns: Date/Time, NIST Thermometer Reading (°C), Data Logger "SN". Calculate the Average (°C), Maximum (°C), and Minimum (°C) for all the data loggers. Compare these results with the data from the reference thermometer. Water temperature should be within ± 0.2°C of the reference thermometer.

5. Discontinue using data loggers not operating within the accuracy range specified by the manufacturer or data loggers that exhibit time lag problems.